Contemporary Review of the Regional Plan for Argentina's Countryside by Grupo Austral

Comparative analysis between typologies in 4 different climates

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ABSTRACT: This paper presents 4 rural housing typologies designed by Grupo Austral in 1939 for the countrymen of Argentina. Each dwelling was adapted to a different climatic region of the country, ranging from warm subtropical to cold desert. The designs represent an outstanding start in environmental awareness in Argentina, though ignored by the community of architects and any of the government plans for housing. In this paper the design features of these housing designs are evaluated using contemporary simulation tools and the original specifications are compared to current building practices. Comparison with contemporary housing projects by government agencies shows the Grupo Austral's design to be superior in all environmental aspects.
KEYWORDS: Rural Housing, Modern Architecture, Grupo Austral, Argentina´s Countryside, Comfort Analysis,

1. INTRODUCTION

"Grupo Austral" was an association of architects founded from within Le Corbusier's studio in 1938. They aimed at translating the European avant-garde discourse into a rapidly modernizing Argentina whilst revalorizing the local imprint (1). Rural urbanism was the topic of their second manifesto, published in 1939 in "Nuestra Arquitectura", a wide spread magazine of the time (2). It presented a regional plan and four dwelling typologies for the countryside of Argentina. Each one corresponded to a different climatic region, ranging from warm regions in the North to desert cold zones in the South. They were designed with prefabricated materials to enable the supply of houses to a larger number of families in less time. Design variations responded solely to climatic adaptations.

The current situation of the rural dwellings of Argentina is critical as social housing plans impose generic solutions without responding to local conditions. Even though the designs by Grupo Austral were not carried out and their plan faded into oblivion, their sensitivity to climatic adaptation was never achieved again nor picked up in any subsequent plan for housing. This paper will present a critical review of the four designs using the theoretical knowledge acquired since as well as advanced simulation tools. A comparison will also be drawn with current housing typologies to assess the relevance of the Grupo Austral's proposals today. The aim of this research is to contribute to a future housing plan aimed at designing dwellings that are environmentally conscious and energy efficient.

2. METHODOLOGY

Weather data were obtained from Meteonorm 7.0. The Grupo Austral design typologies were assessed using geometric criteria, solar radiation data processed by Ladybug, daylight analysis carried out with Radiance through Honeybee, thermal simulations performed with Energy Plus, and wind simulations performed with Butterfly and OpenFOAM. Simulated free-running zone operative temperatures were evaluated against the adaptive comfort zone based of EN 15251 (category III). The annual number of hours with indoor temperatures within the comfort range were estimated as weighted averages of living room and bedroom temperatures.

3. THE REGIONAL PLAN

The initiative was issued from a public competition for rural housing (3). The objective was to provide to the countrymen with a new home with a contemporary, economic and easy-to-implement design approach. They studied the landscape, techniques, lifestyle and climates of the different areas. The focus was on prefabrication, as any element manufactured "cleverly and scientifically". Material selection was based on criteria such as durability, thermal properties, maintenance, waste reduction, cost, execution time, ease of construction, local availability and local workforce.

4. THE CLIMATES

The climatic regions considered represent the entire spectrum of Argentina's climates, ranging from warm subtropical to desert cold. The data employed by Grupo Austral are presented in Table 1 together with contemporary information. Tucuman is the representative city for the warmer climate, with an annual average temperature of 19.8ºC. 9 de Julio in Buenos Aires was picked by Grupo Austral for both temperate climates. However, to get more distinctive results, Oliveros in Santa Fe was considered as Temperate-warm -annual average of 17.9 ºC- and 9 de Julio as temperate-cool -annual average of 16.2ºC-. Colonia Sarmiento was the original choice for cold climate, but due to the lack of an appropriate weather file, data for Paso de los Indios was used instead, which has an annual average temperature of 10.6 ºC.

Although standard procedures to represent climatic data did not exist at the time, the sunpath and wind rose diagrams employed by Astral appear to be accurate. Temperature data show a variation with more recent historical data.

5. REVIEW OF BUILDING TYPOLOGY

Design typologies, geometric analysis and simulation results are summarised Domus 1-4 in Table 2.

Grupo Austral described Domus 1 as: "Open towards the fresh winds and eternally in the shade. The house is on pilotis as the solution for the warm region. In the semi-outdoor space formed a large part of domestic life will take place during spring, summer, and autumn." Elevating the house is justified by the shaded space generated below. The house itself is also shaded by the slab projections, and the living room allows cross ventilation. The larger openings are facing south to prevent the sun from reaching the interior. The design relies on wind, shade, and thermal mass to cool down temperatures during the hottest periods.

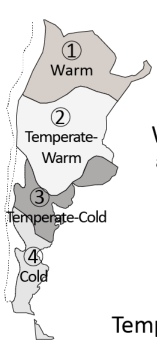
Domus 2 and 3 are described as: "The courtyard as the main element. The house as the extension of the courtyard. On it, the larger number of hours elapses. Space open to the sky but limiting the horizon." Both typologies are adapted to seasonal variations, with outdoor spaces for summer and sunny living rooms for winter. Extended walls protect both indoor and outdoor spaces from prevailing winds. Even if the main concept is the same, design variations show that each house is tailored either to warmer or colder conditions. The one in the warmer climate is split, to make room for more outdoor space, allow more heat losses, and a better ventilation. Also, living room and bedroom are protected from the west sun through the kitchen and barn respectively. The Domus 3 is much more compact, and fully open to the north to allow solar access.

Domus 4 was conceived by Grupo Austral as: "Compact house. The southern climate turns fire into a vital element of the house. The entire household takes place around it." The kitchen is placed in the centre, as a heat source for the whole house. Windows of the living room are north oriented, without any element causing shade. Also, there is a large clerestory facing west, which has multiple functions: it captures the highest amount of solar radiation, but its height prevents the occupants from suffering from glare and from the chilly effect of the strong prevailing wind.

The four designs are simple, austere, sensitive, in line with the modern movement philosophy, and also deeply rooted in their respective climate.

Table 1: Climate analysis by Grupo Austral and contemporary correlation

	1. WARM	2. TEMPERATE-WARM	3. TEMPERATE-COOL	4. COLD
Reference city / latitude	Tucumán 27°	Oliveros 32.5°	9 de julio 35°	C. Sarmiento 45° Paso Indios 44°
Sun Path solar angles	39º 86º / 39º 86º	31º 78º / 46º 83º	31º 78º / 31º 78º	21º 68º / 22º 69º
Wind Rose average speed	1m/s / 2 m/s	3m/s / 3 m/s	3m/s / 3 m/s	5m/s / N/A check m/s
Annual Temperatures	Average temperatures January: 32° July: 6° avg year 19.8°C	Average temperatures January: 32° July: 3° avg year 17.8°C	Average temperatures January: 32° July: 3° avg year 16.2°C	Average temperatures January: 25° July: 1° avg year 10.6°C



Climate division given by Grupo Austral

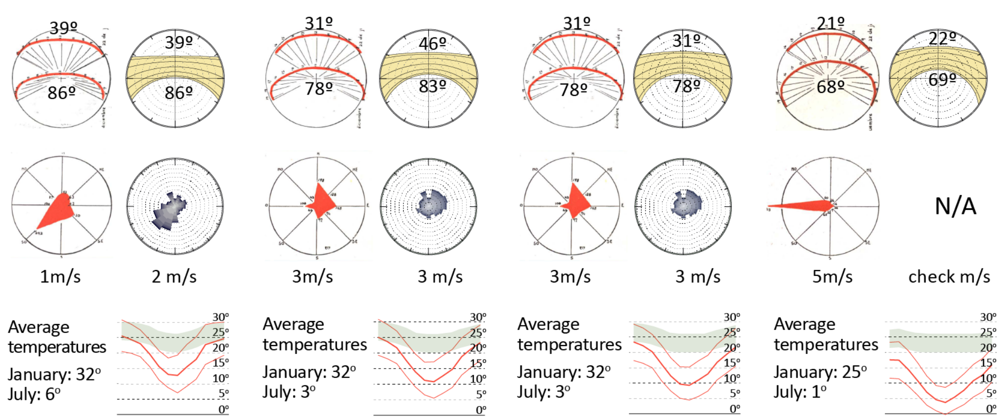
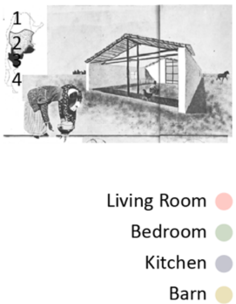
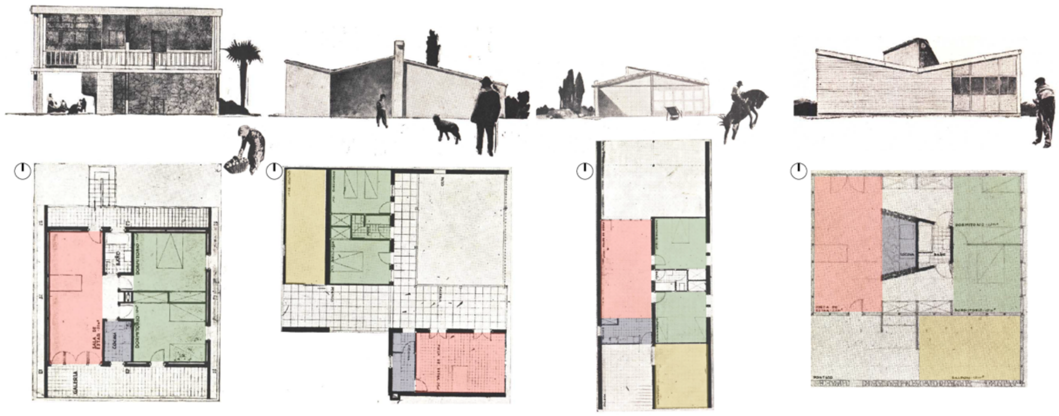


Table 2: Comparative environmental analysis of the 4 houses in their respective climate

	1. WARM	2. TEMPERATE-WARM	3. TEMPERATE-COOL	4. COLD

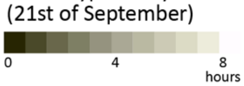
Typology Design

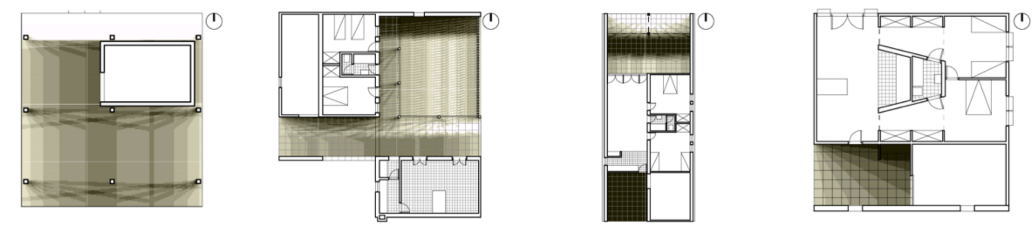




	1. WARM	2. TEMPERATE-WARM	3. TEMPERATE-COOL	4. COLD
Compacity ratio (floor area/exposed envelope)	0.31	0.32	0.48	0.44
Outdoor space (enclosed outdoor/floor area)	1.85	1.8	0.88	0.25

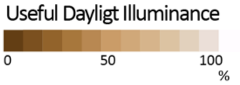
Sun Hours
over a typical day
(21st of September)

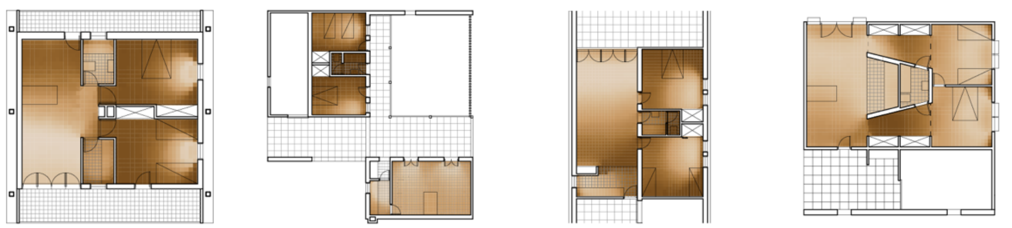




	1. WARM	2. TEMPERATE-WARM	3. TEMPERATE-COOL	4. COLD
W/F ratio	12%	11%	15%	16%

Daylight levels
Useful Dayligt Illuminance

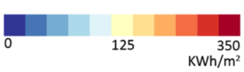




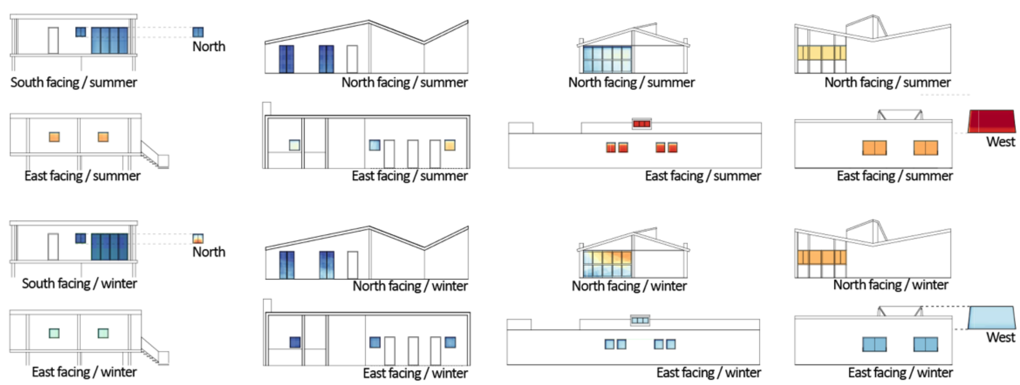
W/W ratio by orientation

	N	S	E	W
1. WARM	2.5%	27.5%	6.2%	0%
2. TEMPERATE-WARM	13.4%	0%	3.5%	4.8%
3. TEMPERATE-COOL	33.6%	0%	10.9%	2.8%
4. COLD	12.5%	0%	17.6%	14.1%

Solar Radiation
falling on windows

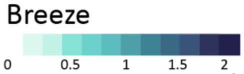


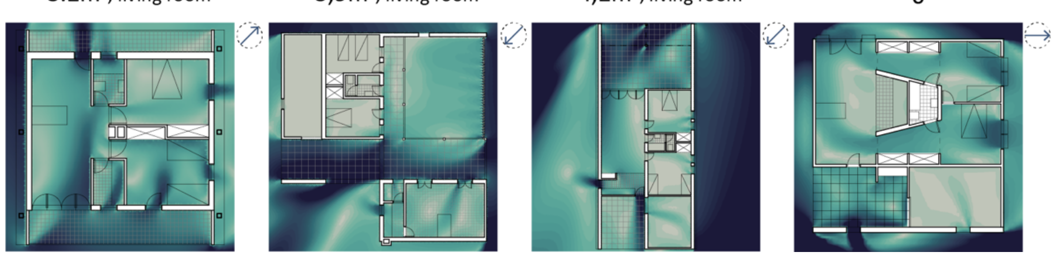
Warm period
Cold period



	1. WARM	2. TEMPERATE-WARM	3. TEMPERATE-COOL	4. COLD
Wind exposure (exposed area to prevailing wind)	3.2m², living room	5,9m², living room	4,2m², living room	0

Breeze





6. COMPARATIVE ANALYSIS

In general, compacity ratios increase gradually as climates become colder. The largest ratio difference lies in between the two designs for the temperate climates owing to the split plan in the warmer one. The area for controlled outdoor spaces increases as climates become warmer, indicating a more intensive use.

Living rooms are located in the most advantageous area of the plan, whilst bedrooms always face east to receive morning sun. The barn and the kitchen are used to protect main rooms from the worst orientations, preventing either from high incident solar radiation or excessive heat loss. In the colder climates, the kitchen is incorporated to the living room to benefit from its heat.

Window-to-floor ratios increase as latitudes increment. Useful Daylight Illuminance calculations show that daylighting patterns are consistent across the different climates, as smaller window-to-floor ratios are compensated with more sky illuminance.

Windows and walls become more shaded as climates become warmer, which is explicit in the original drawings. Solar radiation simulations falling on the windows show a clear gradation, from the ones of the warmest climate that barely receive sun across the year, to the ones of the coldest climate that receive high amounts both in summer and winter. Results prove that the designs were fully thought according to solar considerations, compensating orientation and shading for adequate solar control.

Looking at wind exposure, windows of the living rooms of the 3 warmer climates are facing prevailing winds. Simulations show how breeze easily flows on the living rooms, whereas bedrooms remain protected. Whereas the house of the warmest climate is fully exposed, the 2 temperate are protected by extended walls. The design of the coldest climate has no window at occupant height facing prevailing winds, and breeze barely penetrates, even if winds are much stronger.

7. THERMAL PERFORMANCE

Thermal simulations were performed under free-running conditions and with uniform materials, as specified by Grupo Austral:

- Walls: double layer of bricks. U value: 0.7 W/m^{2}K
- Roof: 20 cm of thatch. U value: 0.8 W/m^{2}K
- Floor: Pine wood elevated with bricks. U= 2.34 W/m^{2}K
- Single glazing. U value= 5.7 W/m^{2}K

All the elements employ air as insulation: in between the layers of exterior walls, separating the floor from the ground through an air chamber, and inside the straws of the thatch roof. Despite the lack of technology, the resulting U values are rather low. An additional iteration was carried out adding layers of insulation to reach nowadays common transmittances (see following section for reference) and to validate the performance of the designs with contemporary standards. The final U-values were as follows:

- Walls of the 3 warmer climates: 0.44 W/m^{2}K
- Walls of the coldest climate: 0.32 W/m^{2}K
- Roofs: 0.29 W/m^{2}K
- Floors: 0.68 W/m^{2}K
- Windows:

warm: single glazing, U=5.7 W/m^{2}K, SHGC= 0.9
temperate: double glazing, U=2.7 W/m^{2}K, SHGC= 0.73
cold: double glazing low-e, U=2.3 W/m^{2}K, SHGC= 0.65

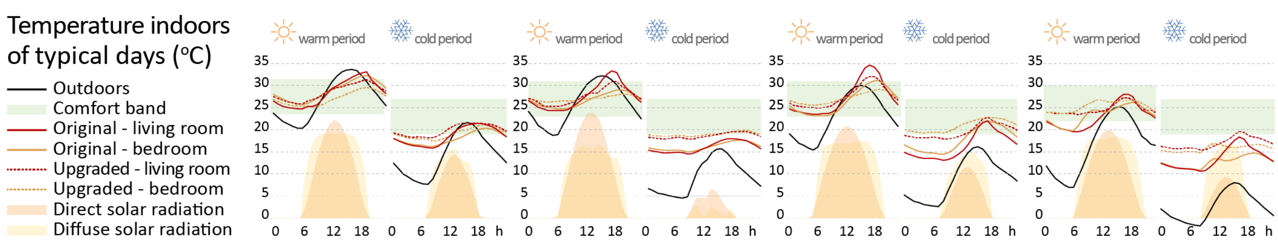
Results of both cases are summarised in Table 3.

The typology of the warmest climate reaches 72.6% of time in comfort, with only 3.2% overheating. During a typical summer day, while outdoor temperatures rise to 33-34ºC from 12pm to 19pm, temperatures inside remain in comfort for most of the time. The thermal mass of the bricks lags and reduces overheating inside to later in the afternoon (3pm, 32 ºC), when the shaded and ventilated area below the house can be enjoyed. It is to be noted also that indoor temperatures never rise above outdoors. Adding insulation brings the number of hours in comfort to 91.4%, an improvement of 26%. On cold

Table 3: Thermal performance of the 4 typologies with the original materials and with added insulation to reach contemporary standards

	1. WARM		2. TEMPERATE-WARM		3. TEMPERATE-COOL		4. COLD	
Time in comfort in comfort / above / below	original	upgraded	original	upgraded	original	upgraded	original	upgraded
	72.6%	91.4%	65.8%	90.5%	61.8%	93.2%	37.6%	66.7%
	3.2% 24.2%	0.4% 8.2%	1.2% 33.0%	0.4% 9.0%	2.8% 35.4%	1.4% 5.4%	0.4% 62.0%	0.2% 33.1%

Temperature indoors of typical days (ºC)



days temperatures stay inside the comfort band, falling below it only at night. Insulation helps to raise indoor temperatures by 1-3ºC.

The houses of the temperate climates achieve similar performances. The temperate-warm reaches 65.8% of time in comfort: the split plan, shading elements, and covering of main rooms from the western sun by service functions help to minimize overheating to 1.2% of time. Temperature patterns during summer days are similar to the warm climate case. During the cold period, the house suffers from a higher-than-expected amount of time underheated (33%), with temperatures falling 1 to 4ºC below the comfort band across the day. Low levels of radiation and abundant solar control prevent the space from raising its temperature naturally. Adding extra insulation brings the house to 90.5% of time in comfort reducing by 2/3 time above and below it. It maintains indoor temperatures of the hottest days in comfort and rises them 1 to 3ºC in the coldest days, touching the lower bound of the comfort band.

The compacity of house in the temperate-cool climate and the adequately controlled sun and wind add up to bring the temperatures of the house in comfort for 61.8% of time. In the warm period, during the 2.8% of time that the house is overheated, occupants can also be outside in the small patio. During the cold period, temperatures are comfortable during daytime, but fall below the comfort band at night. Adding insulation is highly beneficial, making the house attain the best performance overall: 93.2% of time in comfort. Time above comfort is cut by half, whereas time below comfort is reduced by 85%. Additionally, the bedroom seems to be inside comfort even at night, which may almost suppress the need for heating.

The large gap of design intentions in between these two houses is manifested in the small differences of percentage of time underheated, in the higher percentage of time below comfort of the house in the warmer climate (with extra insulation), and in the higher percentage of time overheated of the house in the cooler climate (both with and without insulation).

The house in the coldest climate attains 37.6% of time in comfort, which is relatively high considering the very cold temperatures, little insulation, and single glazing. During the warm period, temperatures during the day remain in comfort, whereas during the night, they fall below as outdoors reach 7ºC. It is clear in all the cases how the morning sun helps the bedrooms rise their temperature before the living-room does. During the coldest period, temperatures fall below the comfort band by 1-8ºC across the house. Nevertheless, the big windows of the living room north and west oriented help to rise the temperature considerably compared to the bedrooms, when outside is only 8ºC. Adding insulation is naturally highly beneficial, doubling the time in comfort, and rising temperature during the coldest period by 1-5ºC.

In general, bedrooms are cooler than living rooms, due to the reduced size of windows. Adding insulation helps in all the cases to attain very high percentages of time in comfort. Thermal performances result solid and flawless, even considering the constraints of the time and exposure to open weather. Passive strategies adopted have proven to be well chosen, properly calibrated and remarkably efficient.

8. COMPARISON WITH CONTEMPORARY HOUSING

Even if similar programs of single rural houses have not been released, the government has constantly built social housing in the city suburbs across the country. The most recent plan dates from 2015. Information was provided by the National Innovation Directory for Sustainable Development (4). The program distinguishes the “regular” prototypes, which were designed by the Housing Provincial Institutes (IPV) and are regularly built in the area; and the “environmental” prototypes, which were ameliorated by environmental consultants. Orientations of the former are generally randomly decided, whereas the latter are oriented according to the most advantageous situation. To carry out the simulations, the most advantageous orientation was always chosen. Plans, thermal properties, simulation results and comparative performance with Grupo Austral are summarised in Table 4.

The designs by Grupo Austral largely outperform the ones proposed by the IPVs. The disparity in between extreme climates is not large whereas the gap in the temperate climates is very wide, with a difference of up to 26.0% of time in comfort, which signals an evident lack of climate capitalisation. Both temperate typologies have a similar percentage of time underheated as the coldest climate -20.1%, 26.1%, and 36.3%-. Taking into consideration how much colder the latter is, this indicates clearly a loss of the sun´s warming benefits.

The performances of Grupo Austral also exceed the ones supervised by environmental consultants, but by a smaller margin. In the 3 warmest climates, all the contemporary designs seem to have too much time above comfort: the minimum attained -1.4%- corresponds to the maximum obtained by Grupo Austral. The excessive overheating results from the lack of suitable shading elements. Overall, recent designs are missing an adequate strategy of solar control.

Considering the leverage of the acquired knowledge in environmental design, progress in scientific research and material quality, and the advantage of pairing the houses, the efficiency of the designs achieved by Grupo Austral is astounding.

9. DISCUSSION

Environmental design concepts for the Regional Plan are remarkably well founded and adapted to their respective climate, even if the science was not yet developed. Layouts are optimised for each situation, passive strategies are adequately chosen, and houses harness optimally sun and wind in all the cases. This translates into sound thermal performances, that become optimal when nowadays common practice insulation is added. Designs of the warm and temperate climates reach very high percentages of time in comfort, ranging from 90.5 to 93.2%, whereas the house in the desert cold climate attains 66.7%. Furthermore, performances of Grupo Austral surpass by 1.1 to 26% all of the contemporary ones analysed, both the traditional typologies built by the government as well as the revised versions by well-known environmental consultants.

10. CONCLUSION

Environmental design in Argentina is nowadays far behind the world´s standards, and there is no build-up of valid references. Housing plans carried out by the government do not rely on vernacular learnings neither on up-to-date simulation tools. It is most relevant to bring back to light projects such as Grupo Austral´s that perform exceptionally well and set precedents. It is most important that these typologies become a flawless starting point of a work tradition that builds up with new solutions, and in which any new project can bank on.

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Table 4: Thermal performance of contemporary typologies built by the government and comparison with Grupo Austral's performance

	1. WARM	2. TEMPERATE-WARM	3. TEMPERATE-COOL	4. COLD
Time in comfort achieved by Grupo Austral in comfort / above / below	91.4% 0.4% 8.2%	90.5% 0.4% 9.0%	93.2% 1.4% 5.4%	66.7% 0.2% 33.1%
Regular prototypes built by the IPVs (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
Time in comfort and efficiency vs. G.A. in comfort / above / below	85.8% 4.6% 9.6% -6.1% -5.6% +4.2% +1.3%	70.5% 3.4% 26.1% -22.1% -20.1% +3.0% +17.1%	67.2% 1.9% 30.9% -27.9% -26.0% +0.5% +25.5%	63.7% 0.1% 36.3% -4.6% -3.1% -0.1% +3.2%
Environmental prototypes designed by the IPVs 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: 0.39 walls: 0.42 glass: 2.3 floor: 0.68
Time in comfort and efficiency vs. G.A. in comfort / above / below	89.8% 3.8% 6.4% -1.7% -1.6% +3.4% -1.8%	89.5% 2.7% 7.9% -1.2% -1.1% +2.2% -1.1%	89.2% 1.4% 9.4% -4.3% -4.0% +0.1% +3.9%	60.6% 0.4% 39.0% -9.1% -6.1% +0.2% +5.9%