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# REGENERATION STRATEGIES ON SOCIAL HOUSING IN CHILE: FROM DEMOLITION TO TRANSFORMATION BETWEEN PAST, PRESENT AND FUTURE.

## ABSTRACT

Recent housing policies in Chile have promoted a massive housing model to reduce its deficit while minimizing construction costs. This model has resulted in the deterioration of their inhabitants' living standards, the buildings and the urban context. The crisis originated by the Type C Blocks led the government to question the current housing policy and to promote new policies to regenerate existing housing. The "Regeneración de Conjuntos Habitacionales" program has established the urgency to reduce these buildings' qualitative deficit using regeneration strategies. The case study is a group of 16 housing blocks at the Marta Brunet complex in Santiago where a prototype proposal will be built to verify the effectiveness of the intervention on a larger scale. The research here presented developed an analysis of the current situation based on literature review, energy performance simulations, field observation and interviews with key informants. Results show existing buildings present low building standards, poor energy performance and living conditions, in some occasions even hazardous for their residents. However, demolition is not the prerogative of the inhabitants, who mainly would prefer to improve living conditions of existing buildings. From the structural point of view, the existing structure is not at risk of collapse, but is incapable to resist any additions or expansions. Based on the results, a regeneration proposal was developed based on an independent structure and a new layout according to users' needs. The proposed building envelope considers an improved energy performance that has been evaluated through dynamic calculations in order to quantify its relevance. Finally, the benefits of the

proposal are discussed with emphasis on energy performance, showing the advantages of the rehabilitation approach and its further possibilities.

**KEYWORDS**: Energy Efficiency, Social Housing Regeneration, Building Envelope Retrofit, Building Energy Simulation.

## 1. INTRODUCTION

In 2019, over 87% of the Chilean population live in cities [1]. This urban population rate reflects a trend towards a continuous sprawl of cities that has been developing since the 1970's, and in that time cities have tripled their population. As a result of this growth, in recent decades strong public housing policies has been fostered to promote the construction of more than 340,000 social housing units in mid-rise buildings [2]. This social housing model has applied the strategy of “more with less”: the search for more quantity, or reduction of the housing deficit, with the lowest possible costs. This situation has caused a drastic deterioration of living standards through the migration of numerous people from small rural informal settlements into new suburban housing developments. Massive construction of mid-rise housing in the 80s and 90s reduced the housing deficit thanks to the rationalization of financial resources and of the land, significantly compromising its housing qualitative standards. The lack of urban facilities and built area of the units, a difficult accessibility, controversial administration, poor thermal and acoustic performance of the building's envelope, obsolescence of the building´s utilities and deterioration of common spaces represent some of the recurring issues of this type of housing [3]. These are housing complexes that generally lack the minimum standards to offer a dignified life, located in vulnerable and abandoned territories where fragmented, unsatisfied, distrustful and disappointed communities live [4]. The emblematic case of this policy is the Type "C" Housing Blocks, a milestone that split the Chilean housing reality into a before and after. An iconic example of the shortcomings of this model was the scandal of the "Copeva" houses in 1997, where brand new units recently delivered suffered serious building damages after a storm. This event synthesizes the various complications that compromised life in social housing and encouraged the dissemination of these issues, resulting in discontent and social mobilizations of neighbors. Eventually, MINVU (“Ministerio de Vivienda Y Urbanismo”: Ministry of housing and urbanism) questioned its housing policy and promoted new policies to solve these issues [5].

## 2. HOUSING COMPLEX REGENERATION PROGRAM

The city continues to grow, and it is estimated that by the year 2050 90% of the nation will live in cities [6]. This implies the need for new homes for a million people, which represent a relevant impact on the life quality of the population and on the environment. Currently, less than 2% of homes comply with minimum thermal comfort standards with energy efficiency and residential buildings contribute to 24% of Greenhouse Gas (GHG) emissions [7]. Presently, the means of social housing endowment rely on the expansion of the city. At the same time, a severe deterioration of existing buildings takes place due to constant demolition and reconstruction. These practices are unsustainable in economic, environmental and social dimensions. In this context, the regeneration of existing housing buildings has strengthened as a sustainable strategy for urban densification.

This is the case with the “Programa de Regeneración de Conjuntos Habitacionales” (Housing Complex Regeneration Program), promoted by MINVU since 2017, which has established the need to reduce the qualitative deficit of social housing buildings. The main objective of this program is the regeneration of buildings and their context, in the most deteriorated examples in the country [8]. The improvement takes place through an interdisciplinary focus based on social, jurisdictional and housing studies. These diagnoses, along with community participation, are the instrument to elaborate a Master Plan that will open the possibility to intervene following three admissible criteria: “the *rehabilitation*, *construction* or *reconstruction* of housing units according to: the quality standards established by the Housing and Urbanism Ministry´s Housing Programmes that are in force; the endowment of community equipment and green areas; the improvement of the urbanization standard; the managing of housing mobility and community organization." [9].

One of the possible regeneration interventions is rehabilitation or retrofitting. These refer to existing built heritage and tend to its *re-valorization* by the introduction of benefits that were not originally present. Retrofitting is not part of the maintenance, since it represents an update, an adaptation of the building, specifically in terms of urban and architectural quality, adaptation to regulatory requirements, social integration, energy efficiency and functions related to the environment and sustainability. Through these strategies, rehabilitation is proposed as a solution for social housing that lacks the minimum conditions to offer a dignified life.

Despite being a relatively new concept in Chile, existing building regeneration is a common and successful practice in Europe. Housing buildings expansion and retrofitting has been promoted, among many others, by French architects Lacaton, Vassal and Druot [10]. In Zug, Switzerland, an analysis concerning regeneration strategies (improvement of envelope, new heating and energy systems) in a post-war building, demonstrated an 80% decrease in energy consumption [11].

Intervention strategies become even more robust and efficient in a public policy context. This is the case with European program Sure-fit and national French program REHA, both thought of with the aim to appraise and share intervention methodologies for rehabilitation. These programs provide exhaustive descriptions of retrofitting methods and techniques, concerning structural integrity, sustainability, energy efficiency and overall urban and architectural quality of the building, involving social themes and its users' needs. The results show that intervening a previously constructed structure is possible, convenient and replicable [12].

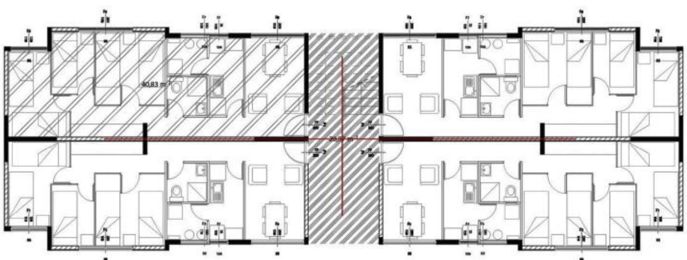
### 2.1. Case study

Within the intervention cases developed by MINVU in the context of the Housing Complex Regeneration Program, the selected case study is the Marta Brunet housing complex, located in the Bajos de Mena sector of the Puente Alto district in Santiago, Chile. This complex was built using a single building model: the aforementioned "Bloque C". The compound covers a rectangular area of just over 11 hectares. Its longer borders are delimited by a continuous wall that marginalizes it from the neighborhood and prevents connection with the context, while three streets located at the short edges act as the only means of access "Figure 1". The residential complex consists of 138 two- or three-story buildings. In total, the project has 1,256 similar departments, divided into two types of construction: "Bloques A" and "B" (subtypes of "Bloque C"). The homogeneity of the social conditions of the inhabitants along with its isolation (physical, social and administrative) have provided the perfect pretext for the transformation of the neighborhood into a "ghetto", with high presence of criminality and low living conditions. Insecurity manifests itself in the perception of the inhabitants, of which 62% feel in danger [13].

Figure 1: Marta Brunet Housing Complex (Source: Stockins 2007).

The Servicio de Vivienda y Urbanización (SERVIU) of the Metropolitan Region is the state agency in charge of the planning and redevelopment intervention of Marta Brunet, as part of the large-scale program “Plan Integral Bajos de Mena”. Its proposal considers starting an experimental project in some buildings to verify the effectiveness of the intervention. The area chosen to carry out this pilot project is the condominium bordered by Quitalmahue, Aguas Abajo and Amasijo streets. Within the chosen area there are four "bars", each consisting of four Bloques A. The buildings are arranged in line, in groups of two "bars", the distance between the two groups is 15 meters, while the distance between the two buildings is 10 meters. A large portion of the apartments have illegal expansions that block public access and increase the criticality and degradation of private homes and common spaces. The four buildings are arranged in the land with an inclination of 22° as to the north of the project, and with a consequent exposure of the long facades to the northeast and northwest, a characteristic that affects the daylighting of the interiors. Approximately 96 families live in this conglomerate of homes, which is equivalent to about 400 people with diverse needs. In addition, the excessive density of the area does not comply with legislation [14], in relation to the maximum gross density allowed (450 inhabitants/ha).

The “Bloques A”, shown in “Figure 2”, present in the complex are defined by a plan with two symmetry axes: transverse and longitudinal. Four identical apartments are composed on the basis of these axes, with an area of approximately 42,3 $m^2$. Two units share the dividing wall, and the stairs are located between one block, open to the outside and located in the center of the floor. External circulation with a central staircase connects the three floors of the building. The interior height of the apartments is only 2,20 m and the mezzanine is structured with an 11 cm reinforced concrete slab. The distribution within the apartments is done through a corridor that connects the different rooms. The original project includes three bedrooms, a kitchen, a bathroom, a loggia, a closet and a dining room. The measly useful area, combined with the composition of the typical nuclear family of the sector, result in 25.8% of overcrowded homes in the complex.



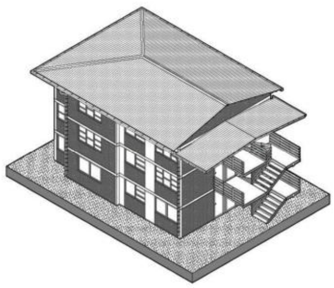


Figure 2: “Bloque A” type, Marta Brunet (Source: prepared by the author).

## 3. OBJECTIVE AND METHODOLOGY

With the objective of consolidating the rehabilitation approach for intervening on mid-rise social housing complexes in Chile, the investigation proposes a method or *modus operandi* -how to do- and a practical suggestion or operational guide -what to do- in order to elaborate a proposal to *re-valorize* what already exists, focusing on energy efficiency, sustainability and social integration.

As previously described, the investigation analyses the case of Marta Brunet, currently under intervention by MINVU's "Programa de Regeneración de Conjuntos Habitacionales", a project proposal for the pilot area and a critical evaluation of the results. Specifically, an analysis and review of the critical elements was conducted to provide guidelines that allow progress towards sustainable design and energy efficient solutions. In this context, with the essential contribution of the IDIEM Research and Development Center [15], the following was carried out: a bibliographic review of the Program's background, documents and reports (i.e. citizen consultation, structural analysis); an on site planimetric survey, observations and assessment of habitability conditions; energy modeling and simulations with particular attention to climate analysis; interviews with key informants of the process. The interpretation of the results informs the guidelines of the project, whose purpose is to reduce or solve problems that range from the urban to the social and energy context.

In order to compare and verify the forecasts with the performance improvements actually achieved a detailed hourly energy simulation has been performed. Information on the heating and cooling systems was collected through interviews and observation of energy bills. Once all the necessary data was gathered, the total energy demand was calculated through the use of the DesignBuilder 2017 software [16].

The interior enclosures of the model were divided according to the different thermal zones, in which different activities are carried out. Five units were defined: bedroom, kitchen, bathroom, living room and hallway. To perform the analysis, the ground floor of the Bloque A with the most unfavorable conditions within the project area was considered. The comfort temperature range was set between 20 and 26 °C [17]. As far as the people density in the apartment is concerned, a family unit was defined as a group of 4 people with a metabolic rate of 100 W/person, and an air renewal rate of n50 = 0.4 ($h^{-1}$) [18] was considered. To define the quality of lighting in the building, the criteria established by the LEED certification method [19] was considered. This method assesses the quality of light according to two directly proportional factors: SDA (Spatial Daylight Autonomy) and ASE (Annual Sunlight Exposition).

## 4. ANALYSIS

The study allowed for the collection of a large amount of information on the operation of the existing building, which is presented in a synthetic and refined manner in order to broadcast the essential points necessary for the understanding of the work. The analysis covers the problem from both a macroscopic perspective, referring to the context of the building, and a microscopic one, referring to the building itself. This categorization is necessary to compare the problems at different scales, knowing that an analysis of what is general, that is to say the factors responsible for the urban scale of the whole complex, is essential to achieve what is specific and face the problems related to the architectural scale.

### 4.1 Climate Analysis

Climate conditions are the starting point to achieve harmony with the landscape one is working with. These are influenced by latitude, altitude and the presence or absence of large bodies of water. In the case of Santiago de Chile, as it can be seen in its temperature chart "Figure 3", quite a low percentage of thermal comfort hours is registered, where only 10% falls within the 20-26°C temperature range [20]. In addition, it can be noted that most hours of the day have a temperature below 20°C. Precipitation is concentrated in the winter period with little rain (444 mm per year) [21], but with a high percentage of cloudiness, about 53% of annual hours. The daily incident solar radiation has an average of 4.1 kWh/$m^2$, with a maximum of 9.5 kWh/$m^2$ in December. The climate of the city of Santiago can be defined as a Mediterranean climate, i.e. warm and temperate.

### 4.2 Citizen Consultation

In the case study it is possible to demonstrate and understand, through the results of Participatory Design Workshops with the community [22], that demolition is not the prerogative of the inhabitants, who mainly desire to: improve the housing complex through new sanitary facilities; expand certain rooms, preferably kitchen and bathroom; improve the acoustic conditions of the enclosures; and, according to 89% of respondents, have accessibility for the disabled. Needs that, therefore, do not necessarily require a demolition and reconstruction intervention, or a new construction, to be answered. On the contrary, such an intervention could modify the reality of a largely socially cohesive community.

### 4.3 Building Survey and Evaluation of Habitability Conditions

The survey, carried out with specific essays and complemented by a visual inspection, a photographic record and interviews with the residents, made it possible to show that the buildings present numerous discrepancies with the original plans, both due to constructive flaws and irregular extensions built by the residents, and that the departments do not meet the minimum surface area of 55 $m^2$ required in DS No. 49 of the current regulatory framework.

The blocks appear in distinctly degraded conditions: various cracks in the walls, evident losses of water with fungal and moisture marks, illegally manipulated electrical systems and without mandatory protection against current dispersion, ventilation and daylighting compromised and often absent due to the enlargements, high thermal transmittance of opaque (3.1 W/ $m^2$K) and transparent (5.8 W/$m^2$K) building envelope components, and an acoustic reduction index in breach of the 45 dB minimum established by legislation. The presence of asbestos on the bathroom walls and on the roof deck should also be emphasized. The only thermally insulated element is the ceiling (35 mm of mineral wool over sky), which currently presents precarious conditions with great deterioration, dirt, water infiltrations and irregularities in the installation.

### 4.4 Structural Analysis

The structural diagnosis has shown that the buildings, structured by confined masonry walls and reinforced concrete masons and slabs, are not at risk of collapse. However, they are unable to withstand additional loads. The various structural elements efficiency and functionality was verified. A reuse and lengthening of their life would allow for a significant reduction of intervention times and to avoid wasting resources.

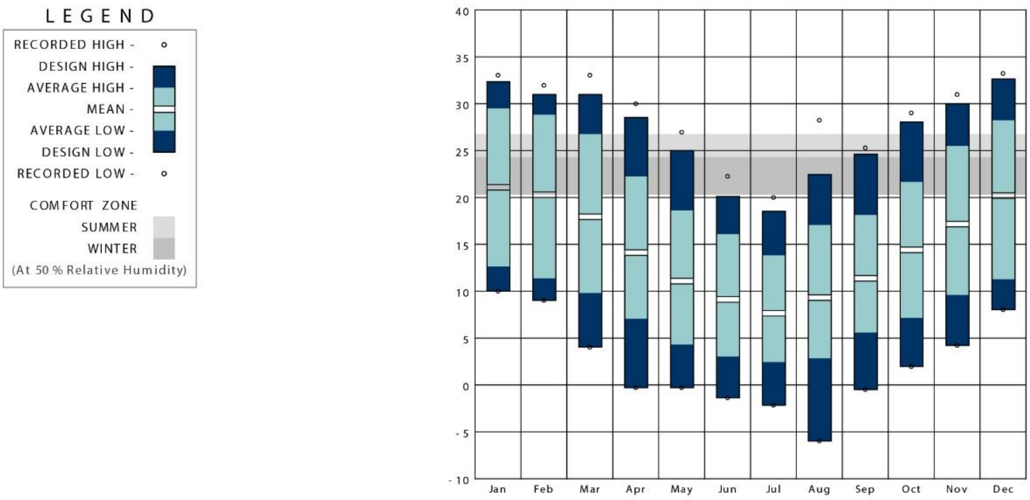



Figure 3: Santiago temperature chart (Source: prepared by the author).

The set of performed analyses demonstrate a series of needs and opportunities. The opportunities appear in the citizen consultation and structural analysis, where the possibility of intervening without the need to demolish is established. On the other hand, the climate analysis and especially the energy analysis (building survey and habitability assessment), reveal the most urgent needs. The precarious conditions of the envelope and other constructive and architectural elements render the buildings unable to provide minimum comfort conditions in the Santiago climate. Moreover, these elements do not comply with current legislation. Hence, energy related improvements become the priority when developing a regeneration project for these type of buildings.

## 5. THE PROPOSAL

The new proposal, among other topics, focuses mainly on the impact of building regeneration strategies and on the energy efficiency of the envelope, introducing solutions that focus on incorporating precautions sensitive to the basic concepts of passive house standards [23]. For this reason, the first step was to take advantage of the benefits that the local climate offers, placing the "night" zone on the southwest (darker) side and the "day" zone on the north-east (brighter) side.

These characteristics allow for the generation of new distributions within the apartments, in order to offer the best living conditions to their future users and meet the minimum requirements of space and habitability. Two solutions are then proposed, one of 83 $m^2$ and another of 62 $m^2$, due to the need to respond to specific requirements. The 62 $m^2$ apartments are born from the fusion of two "bloques" and the circulation space between them. In contrast, the 83 $m^2$ apartments "figure 4" are given by the merger of two apartments of a single block. What follows is the elimination of old and unstable stairs and the design of a new distribution system, mostly central and in the courtyard.

Due to the characteristics of the pre-existence of not being able to withstand additional loads, a new prefabricated and fast-execution structure was developed, with a properly spaced and calculated portal frame that functions as a "box" that encloses the original building without touching it [24]. The new structure is characterized by the addition of balconies on the northeast side, which have a double function: as circulation, for access to the apartments, and as eaves, shading the facade in the summer periods, which considerably decreases solar radiation thermal gains. The new frame allows for the placement of all the installations outside, and in this way, avoids drilling the reinforced concrete floor and any change or subsequent adaptation of the house will be easier.

All new apartments have double exposure and double ventilation (east-west). Regarding the energy efficiency of the building, the envelope of the pre-existence (inner box) is insulated with 10 cm of EPS, avoiding thermal bridges and improving the current heat transmission values. Specifically, the transmittance goes from 3.1 W/ $m^2K$ to less than 0.6 W/ $m^2K$. Referring to the windows, the existing ones are replaced by new floor-to-ceiling windows that allow better interior lighting and ensure greater heating of the slab in the apartment, thus taking advantage of the high thermal inertia of reinforced concrete. A product with 4 mm double glass and a 16 mm air gap with 100% air inside is chosen, decreasing the thermal transmittance of windows from 5.8 $W/m^2K$ to 1.8 $W/m^2K$ .

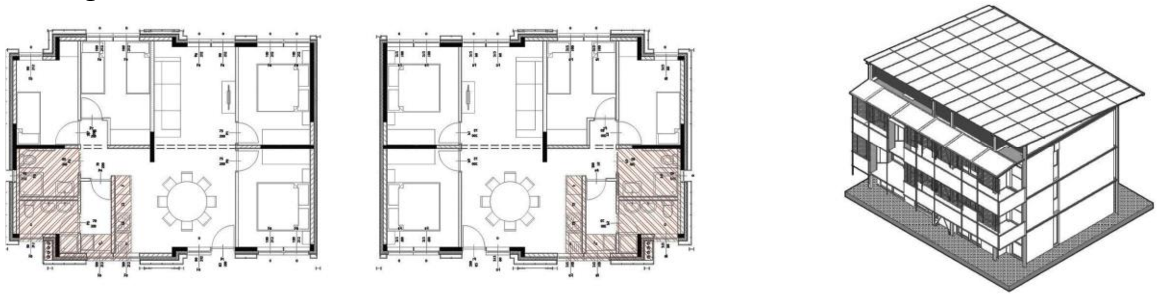


Figure 4: “Bloque A” type, intervention proposal (Source: prepared by the author).

## 6. RESULTS AND DISCUSSION

Through the study carried out and the results obtained, the effectiveness of the proposal can be demonstrated. The graphics shown in “Figure 5-6” are the results of the dynamic energy simulation of the existing building (on the left) and the new project (on the right). These diagrams represent both the thermal comfort (by way of a monthly hours percentage) and the energy demand of the apartment (in $kWh/m^2a$).

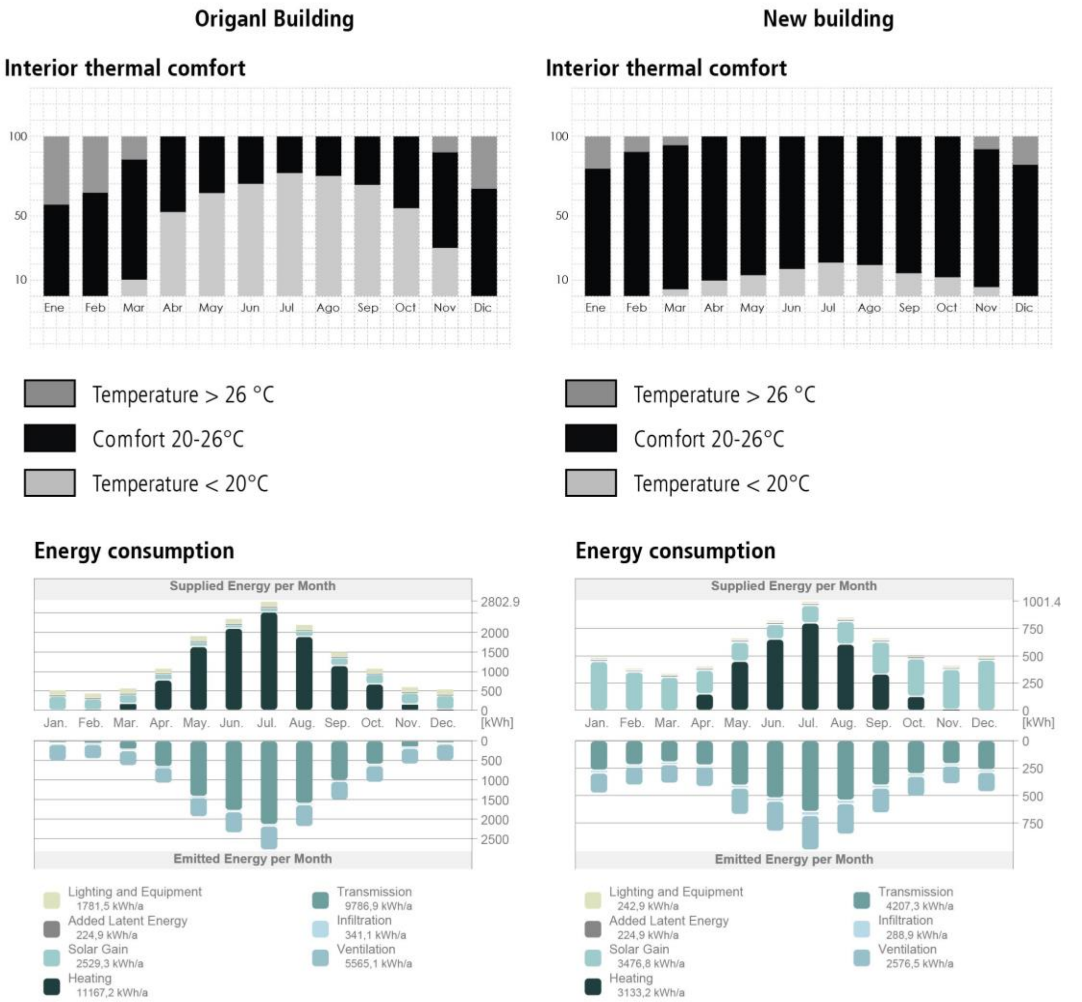



Figure 5: Internal thermal comfort and energy demand comparison (Source: prepared by the author).

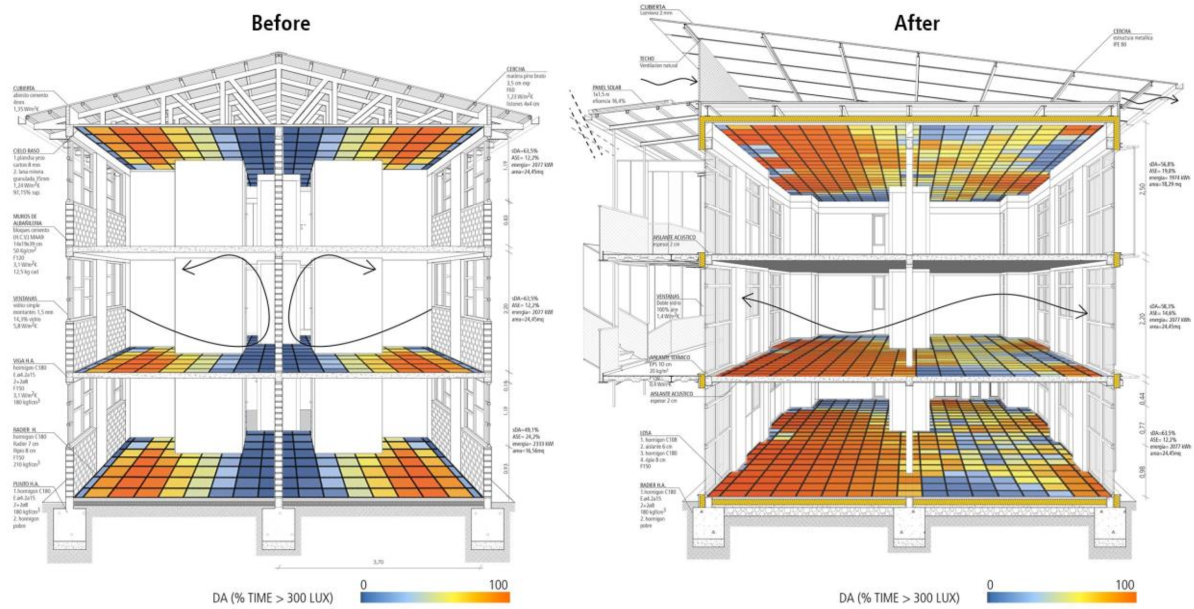



Figure 6: Original building vs. proposal performance (Source: prepared by the author).

The temperature inside the original building shows considerable oscillations during the year, with a significant decrease in winter and a consequent perception of discomfort by the user. Comfort hours during a calendar year represent only 26% of the total. This situation of discomfort translates into a very high energy demand to heat and illuminate the rooms, reaching 186.07 kWh/$m^2$a.

As far as the new proposal is concerned, the addition of insulation and the new cross ventilation strategy produce an improvement in comfort hours of almost 80%, and a decrease in annual energy demand, which drops to 38.44 kWh/ $m^2$a . The obtained result is possible thanks to the integration of new light regulation systems (balconies, eaves and lattices) that lower the maximum indoor temperature in summer from 38 to 30°C. With respect to the interior daylighting, the change of windows allows the compliance of the SDA and ASE factors with percentages equal to 63.5% and 12.2% respectively. SDA (Spatial Daylight Autonomy 300/50%) represents the amount of hours the surface has an equivalent illumination of 300 lux; and the value to be considered positive must be greater than 55%; while ASE (Annual Sunlight Exposition 1000/250) represents the amount of surface that exceeds 1000 lux for more than 250 hours a year. An acceptable range for the ASE coefficient is between 10 and 20%.

Through the results obtained, it is possible to visualize the benefits of the project, which acquire greater power being a rehabilitation proposal that does not waste resources. Saving and reducing resources should not necessarily be understood as a subtraction to the quality of the project, but as an opportunity to give new value to existing assets.

## 7. CONCLUSION

The results demonstrate the numerous benefits related to energy performance and indoor environmental quality that rehabilitation strategies may have as an alternative to demolition. Tangible benefits that are evidenced in an increase in comfort hours, reduction of the thermal transmittance of the envelope (including double glazed windows), improvements in daylighting, and more hygienic and controlled air conditions through cross ventilation. These results translate into a reduction in energy demand for heating. The drop in operational energy consumption leads to significant savings for the low-income families that inhabit these housing complexes, and also represent a substantial decrease in energy demand, and carbon and particulate matter emissions at a national level. Thus, the regeneration of existing buildings is a practice that proves to be energy efficient, structurally viable, economically convenient and socially responsible, reaching quality levels (urban, architectural, energetic, light, thermal, etc.) of new constructions.

Further work to extend this research foresees evaluating the possibility of a sustainable and prefabricated design, adaptable and replicable in other case studies with different characteristics. These new solutions would call for an analysis of the costs, an investigation of the life cycle of the materials and a calculation of the period of economic and energy return. In this way, it becomes possible to evaluate the actual feasibility and convenience of interventions, and lends to possible readjustments of the project.

## 8. ACKNOWLEDGMENTS

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