Retrofitting of The Former Built Environment, Tirana Case

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Abstract

The awareness about the climate change brings the attention of the society toward the sustainable development. Taking in consideration the implementation of the Energy performance of buildings directive and the energy consumption of the building sector it is necessary to undertake urgent actions, and especially to the large amount of the building stock. The residential building stock need urgent retrofitting intervention, actions of deep renovation, dictated by the Directives. Good interventions of retrofitting intervention to the building stock, in order to upgrade their energy efficiency, can reach up to 60% of savings to the current energy demand, so a good ecological and economic solution. The residential building stock need retrofitting interventions, with clear strategies and integrated design of the whole building organism with its surrounding. For these reasons, it is important to focus on this research on certain physical problematics, the ones close related to the morphology, materials, context, indoor environmental quality and the inhabitants' behaviour of the residential multi-storey blocks, which are a good part of the building stock in Albania. The residential building blocks have faced different interventions dictated by many factors. The choice of the case study is based on an empirical and observational research on the territory, but although on the descriptive research done to the existing literature, that evidences building typologies spread in the territory. This research aims to present retrofitting strategies for a chosen case study.

Keywords: retrofitting, sustainability, environmental design, energy building performance

1. Introduction

The development of our society is based on the energy consumption which is strongly connected with the depletion of fossil fuels and climate change. The European Council aiming the reduction of the CO_2 emission has made a long-term commitment with the target of an 88 to 91% cuts in emissions by 2050 to EU and other industrialized countries (European Commission, 2010).

Table 1: Final energy consumption by sector, EU, 2020 (% of total, based on terajoules)

Categories	Final end use of energy in the EU
Agriculture and forestry	3.2 %
Transport	28.4 %
Industry	26.1 %
Households	28 %
Services	13.7 %
Other	0.6 %

Source: Eurostat (nrg_bal_s)

Households and services buildings, responsible for 41.7% of energy use, are the target of many polices evidencing the considerable potential for energy conservation, as evidenced in Table 1. The residential building has a larger energy saving potential and benefit than other sectors. For this great potential that the building sector has, it was developed in 2002 the European Directive on the Energy Performance of Buildings (EPBD). According to this Directive each building should provide an energy performance certificate. The main objective of the EPBD is to 'promote the improvement of the energy performance of buildings within the community taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness'. Aiming the energy performance of buildings, the EU has established a legislative framework that includes the Energy Performance of Buildings Directive 2010/31/EU and the Energy Efficiency Directive 2012/27/EU, to promote policies that will help to: achieve a highly energy efficient and decarbonised building stock by 2050; create a stable environment for investment decisions; enable consumers and businesses to make more informed choices to save energy and money (Harris, 2016).

1.1 Problematics

Considering the fact that under examination are the existing residential building stock, the list of possible problems is really various, from the structural ones, the degrade of the materials and so on, but all interconnected as an organism. Talking about building of a certain age it is important the Life Cycle Assessment (Simonen, 2014). With the retrofitting guidelines the intent is to extend the use and life of each component, or the appropriate substitution if needed and justified.

Some of the problems that are related to the Energy consumption[1] are such as: the thermal performance of the building envelope - which is caused from different aspects, different standards of construction, no use of insulation, not appropriate design and technology – that can create high energy consumption; air tightness of the building – which is directly affected by the inappropriate design and technology used for the openings creating discomfort and high energy consumption; thermal bridges – caused by inadequate design and aggregation of materials in absence of insulation, without use of plaster and so on causing high energy consumption and the possibility of internal condensation, mould and humidity; antiquated installations – with the development of the technology and the new standards the old installations can create different problems from the technical ones to the high energy consumption (Hensen & Lamberts, 2019).

1.2 Retrofitting definition

Retrofitting in terms of building interventions include a lot of techniques, tools and procedures, that can be applied in the existing constructions from some small interventions to the total reconstruction of the building. Referring to different sources there are some small differences in the terminology used about these kinds of intervention in the existing buildings. The terms renovation, refurbishment and retrofit are often taken to mean the same thing, or used as if they are interchangeable. However, they have different specific meanings:

Retrofitting - providing something with a component or feature not fitted during manufacture or adding something that it did not have when first constructed (Eames, Dixon, & Lannon, 2014)[2]. It is often used in relation to the installation of new building systems, such as heating systems, but it might also refer to the fabric of a building, for example, retrofitting insulation or double glazing. The terminology used for minimum necessities to the energy performance applied in the existing residential blocks, is "major renovation", and for the member states it goes for renovation applied with a cost 25 % higher of the building value (DIRECTIVE, 2010/31/EU).

1 When used apprpriately, building performance simulation has the potential to reduce the environment impact of the built environmentm to improve indoor quality and productivity, and energy consumtion.

2 What does 'Retrofit' mean? To retrofit literally implies providing something with a component or feature not fitted during manufacture or adding something that it did not have when first constructed. The term has been used in the built environment to describe substantial physical changes at building level and has often been used interchangeably with terms such as 'refurbishment', 'conversion' or 'refit'. But at an urban or city scale retrofit means something much larger and more comprehensive, more integrated; underpinned by sustainable financing and with a clearly defined set of goals and metrics.

1.3 Why retrofitting

Interventions of retrofitting has to be applied on the building stock with low energy performance and to reduce the green-house gasses. Even though the energy consumption is e key factor it is not the only aspect to activate the retrofitting interventions, it comes from several needs and motivations from the owner, in parallel with the technical and operational upgrade there are also the financial and social-cultural aspects. Financing in energy efficiency has a direct impact translated in money saved like less energy consumption and more valuable properties. Aging effect cannot decrease the value of a property if it was upgrade (Power, 2008)[3].These renovation methods can be part of a procedure to increase the value and also the prices for rent of a specific dwelling. Social reasons for retrofitting can also be used as a tool to create a new image for buildings, redevelop problematic areas and of course improve the individual's accommodation and indoor environmental quality (Battisti, 2014).

2 Albanian context

Albania is a small country but with a long history. The development of the country faced a lot of political, economic and socio-cultural aspects that influence its course. The management of the country, during the totalitarian communism regime[4], by the central government brought a very organized and controlled development, but the enclosure (isolation) of the country didn't allowed the technology end the experts to be in line with the other countries (Kolevica, 2004).

2.1 Residential buildings stock

Albanian building stock is relatively new in age, 66% of the building stock (up to 2001) belongs to the period 1945 – 1990, presents standard characteristics with a low building profile, very low level of services. 25% of the building stock belong to the late decades, signing so the visible growth of the urban areas. The records of the registration of the population and buildings done in 2001 gives more information regarding the typology of residential buildings, collective or individual ones, multi-storey residential building by number of floors and numbers of apartments per building, and distributed in years.

[3] The environmental benefits of refurbishment are shown, based on work by the Empty Homes Agency, evidence from English Heritage, the Building Research Establishment and the Prince's Foundation. Work on refurbishment shows that existing homes, often in brick-built terraces, are relatively easy to upgrade and, with careful reinvestment in the existing buildings, can achieve as high environmental efficiency standards as current new build.

[4] Ismail Kadare: "It is well known that in the Communist countries, and especially in my own, Albania, readers were often called upon to demonstrate their vigilance by detecting and denouncing the 'errors' of authors."

The residential building blocks started to be constructed after 1960 (Bërxholi, 2000). Regarding the old stock of residential buildings, 44% of them are constructed during 1960 – 1980. Other data to this Report is given about the numbers of floors, and it is easily visible that the numbers of floor has been increasing abundantly after 1990, and this is strongly related to the market-economy and the will of the developer for the maximum profit (Velo, 1998).

Table 2: Buildings typology by construction period, 2001, credits: INSTAT

	Numbers			**%**		
Periods	**Total**	**Collective**	**Individual**	**Total**	**Collective**	**Individual**
Total	507180	16699	490481	100	3,3	96,7
… - 1945	40438	886	39552	100	2,2	97,8
1945 - 1960	68468	2316	66152	100	3,4	96,6
1961 - 1980	154701	7279	147422	100	4,7	95,3
1981 - 1990	115727	4328	111399	100	3,7	96,3
1991 - 1995	52880	796	52087	100	1,5	98,5
1996 - 2001	74966	1097	73869	100	1,5	98,5

Source: REPOBA

The total amount of the residential buildings stock is characterized by a reduced number of dwellings, mainly built in rural areas and small cities, big cities present a different picture. The number of the dwellings in the same building changes a lot during years, depending on many factors. The residential building blocks are not the majority of the building stock in Albania (17%), even though their maintenance illustrate one of the main problems of housing (Faja & Alimehmeti, 1983). Their main part, 14.000 residential blocks were built during 1945 – 1990 as shown on Table 2, which are characterized by insufficient surface per inhabitants, and almost with no common services at all (Misja & Misja, 2004). The quantity of buildings related to the main material used in it is evidenced in the Table 3.

Table 3: Quantity of buildings related to the main material used on it, 2001, credits: INSTAT

	Total	**Prefabricated %**	**Brick / Stone %**	**Wood %**	**Other %**
Total	100	4,5	88,3	1,3	5,9
... - 1945	100	-	92,5	1,2	6,3
1945 - 1960	100	-	93,3	1,8	4,9
1961 - 1980	100	3,0	91,3	1,2	4,5
198 1 - 1990	100	5,2	88,3	1,1	5,4
1991 - 1995	100	8,7	81,9	1,4	8,0
1996 - 2001	100	10,4	79,8	1,6	8,2

Source: REPOBA

After the political changes of 1991, with the intervention of the private companies in the building sector, is noticeable that the number of the plastered building increased. Meanwhile, the non-plastered multi-dwelling buildings, built during communism period, seems to remain in the same conditions due to the mixed ownership of them, without finding a common decision to intervene in the building stock (Bego, 2009).

2.2 Typologies of the residential building blocks in Tirana

In order to investigate and better understand the typological, constructive and technological characteristics of the residential building block during the communism period 1945-1990, there are different typologies. The construction residential sector was operating with types and any of them, with small changes, was "distributed" and built around all the Albanian territory, with a high concentration in the urban areas (cities).

3 Retrofitting case study: Tirana

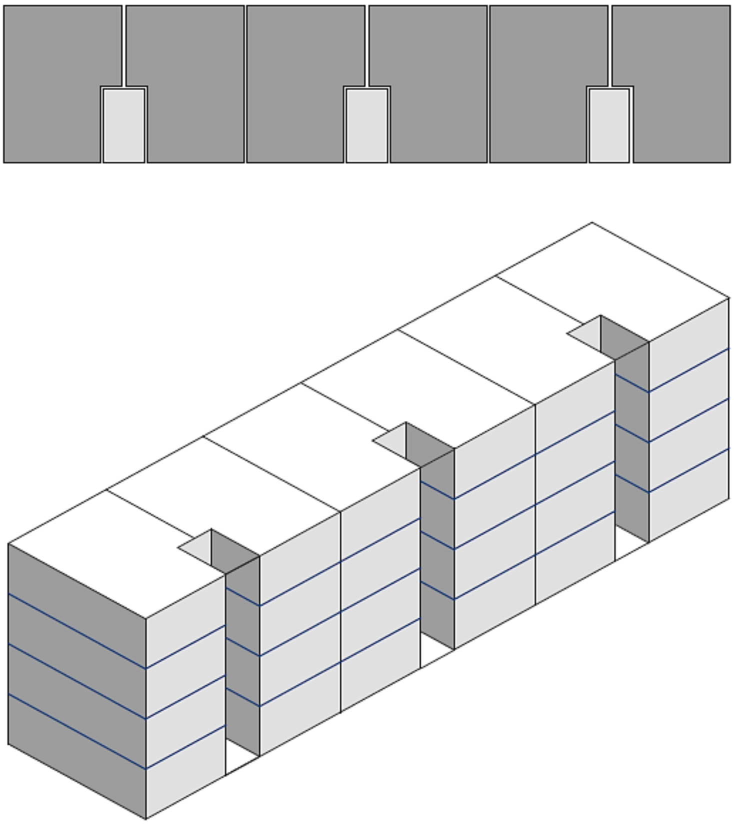
For the best strategies on the retrofitting interventions, it needs to be developed a deep analyses of the residential building and its context, to have a clear picture for the overall strategies for environmental regeneration, architectural and energy retrofitting of residential buildings blocks. The typology of the building chosen will be Type 59-1, to demonstrate the analyses and strategies[5] of retrofitting (Hensen & Lamberts, 2019). The choice is done mainly by the difference of the morphology, compact and articulated architecture.

3.1 Analyse of the residential building typology 59-1

These residential building block, situated in the close centre of the city are designed and built in 1959. There are five residential blocks distributed one parallel to the other, in a row, built with the same typology. The former destination of use was only residential. This typology is a five-storey building, composed of three identical sections, with a total of 30 apartments, as evidenced on Figure 1.

[5] Building performance covers a wide variety of aspects, with attention to energy efficiency of building and communities.

Figure 1: Compositional Scheme



Source: Design by the author JV

Table 4: Compositional Scheme data

Compositional Section		**Linear distribution**	
Gross floor area	143 m^2	Gross floor area	423 m^2
Length	14,28 m	Length	42,34 m
Width	9,98 m	Width	9,98 m
Perimeter	48,52 m	Perimeter	104,64 m
Surface	866 m^2	Surface	2.070 m^2
Volume	1.760 m^3	Volume	5.280 m^3
S/V Ratio	0,49	S/V Ratio	0,39

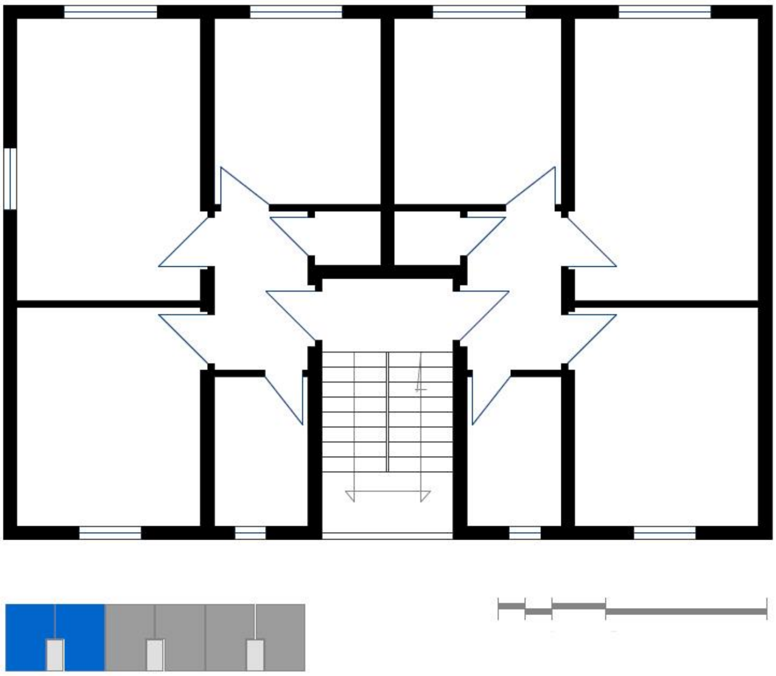
Source: the author JV

Based on the compositional data shown on Table 4, in specific noticing S/V ratio = 0,39 (0.2 < S/V <0.9) it is notable that the building has a compact shape (Cangelli, 2008).

Compositional Section – Plan

Each residential section has one staircase and 2 apartments per floor. The ground floor is detached from the terrain. There is present only one typology of dwelling unit, which is mirrored for the second apartment, not offering any variety of apartment in this residential block, as can be seen in Figure 2. The dwelling unit offers: 1 living room which includes even the kitchen 10,80 m^2; 2 bedrooms, one of them was designed to offer even the studio within it 18 m^2 and the other 14 m^2; 1 bathroom 4,90m^2; 1 corridor 5m^2; 1 utility room 1,20 m^2. Those are the first examples that propose the utility room in their compositional scheme, shown on Figure 3.

Figure 2: Unit floor plan design

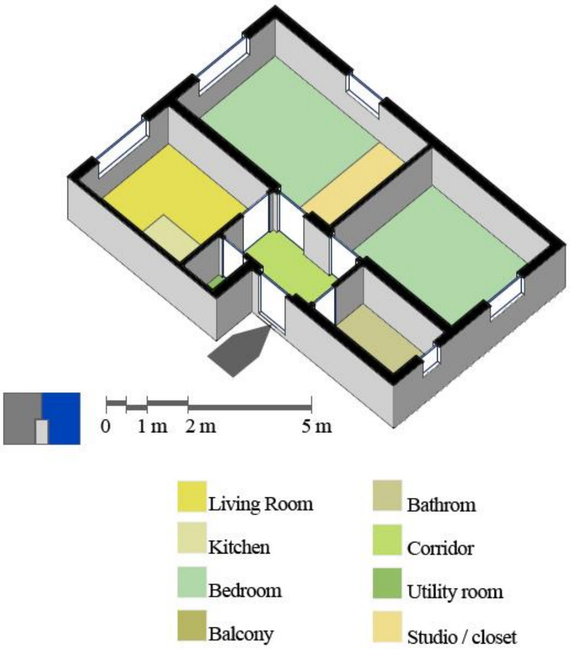


Source: Design by the author JV

Dwelling Unit

The dwelling unit face the two longitudinal façades of the building, offering so to all the apartments the possibility to have openings for all the rooms. The windows positioned on two opposed façades enable the cross ventilation for the apartments.

Figure 3: Dwelling functional scheme



Source: Design by the author JV

Façade components

The former façades of these residential blocks were built with brick-faced, as can be seen in Figure 4. For the external walls were used solid clay bricks, and notable for the red colour. Those residential blocks were positioned in the inner part of the residential complex, this (money saving) was one of the reason for the lack of the plaster in the outside part of the external walls. The staircase is an open space and in the past was a common space where people and children were sharing experiences.

Figure 4: Picture of the existing façade

Source: picture by the author JV

Openings

The openings of these residential buildings are the external door and the windows of the dwelling unit. The former doors were prepared on wood material, in a very simple design and without any insulation or other properties. The windows were in single-pane and with wood frame, without any protection from the heat loss. Other façade components like balconies or shading devices were integrated with the façade offering a plate façade, there were no shading device, despite the internal tends. The balconies were not present for all the units, and where present are present in the shape of loggias.

Figure 5: Axonometric view

Source: Design by the author JV

Building morphology

This typology of the residential building block is formed by the linear attachment of the compositional section offering so a linear distribution of the building, this linearity can be noticed on Figure 5. The repetition of the compositional section depends on site and the possibility it offers; in this example we have a triple compositional section.

Construction structure

These buildings are characterized with thick bearing walls constructed with solid bricks. Because of wall thickness, these buildings consist of mostly 4-5 floors. Wall thickness is different in each floor, with thicker in lower floors. The vertical divisions are enabled by the use of used reinforced ceramic slabs. It is necessary to study and analyse the original construction structure of this typology for any retrofitting intervention.

Materials

The main material that better characterize this building is the clay brick, present in two different shapes: solid and perforated clay brick. All the external and internal divisor walls are built in brick. The divisor walls use the perforated clay bricks and plastered. The external walls for their double role, divisor interior / exterior and structural element uses the solid clay bricks. The foundations are in stone. The vertical divisions are enabled by the use of used reinforced ceramic slabs. The wood material is used for the timber door and its frame.

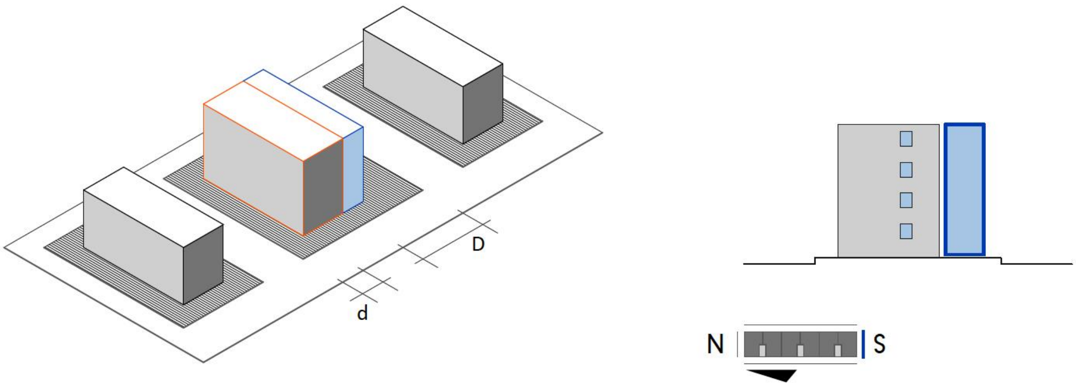
Roof

This residential building is covered by horizontal roof, in reinforced ceramic slab. The roof had only a thin layer of bitumen hydro-isolation. The roof had a limited access of the residents in it, only for the service of the TV antennas. Nowadays the roof offers other services like antennas and satellite for the TVs; water tank (due to the problems with water supply) making use of gravity, although the electrical cables and the ones for internet services, etc.

3.2 Environmental regeneration, architectural and energy retrofitting

Hereinafter will be explained the retrofitting programme and phasing, in order to have a clear operational frame for a better coordination of the work. After the deep analyses of the residential building and its context as it can be seen on Figure 6, to have a clear picture of the overall strategies for environmental regeneration, architectural and energy retrofitting of residential buildings blocks (Bergman, 2012).

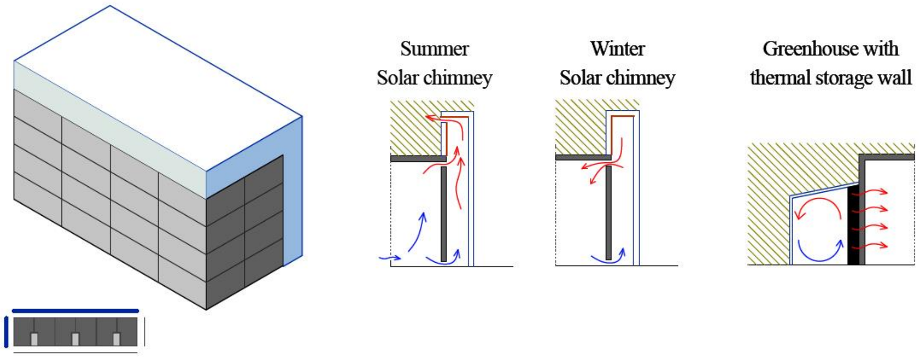
Figure 6: Contextual axonometric view



Source: Design by the author JV

Context - the residential building has only one side space, green (grass) parcel, so for the two longitudinal facades. In this case, with medium distances, there can be done only few additions, but not exceeding in distances. This aspect influence directly the solution finding where can be proposed additions (in reduced dimensions – intending buffer spaces) of Double facades and glazed balconies and sun spaces (greenhouses) and although insulation of the opaque surfaces and substituting the windows frame.

Figure 7: Extension to the existing building



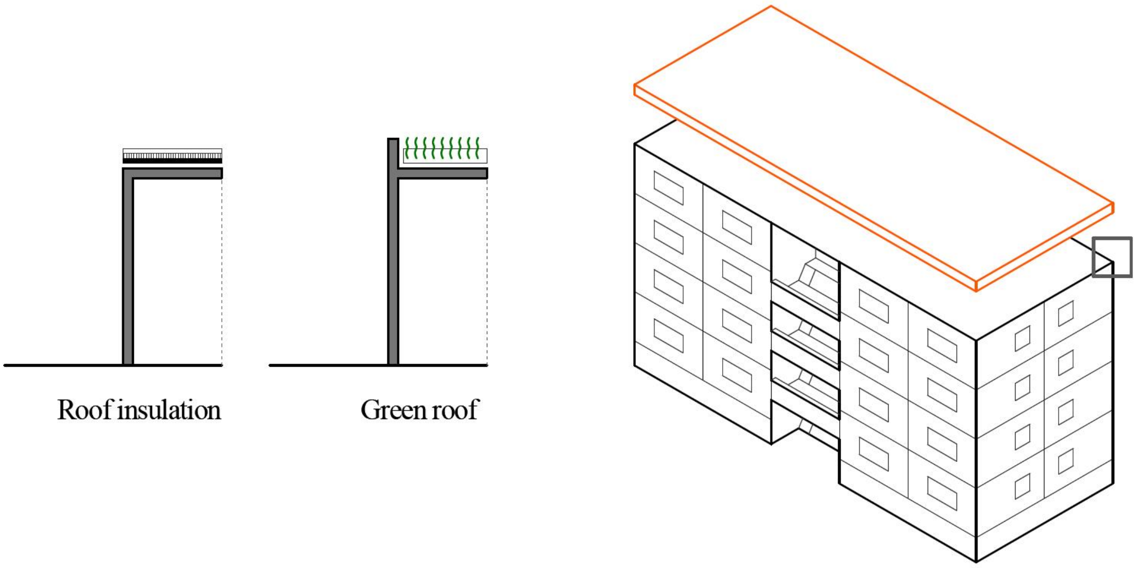
Source: Design by the author JV

The possible extensions Top and East side - vertical additions of a side elevation block to the whole front, with the function of heat gain in winter the possibility to control the natural ventilation in summer, as can be noticed on the scheme of the Figure 7. The extension should be designed to take advantage of: Winter Solar Chimney; Summer Solar Chimney; Greenhouse. Operations of addition of volumes to the existing one, that alter the side elevation or the cover of the building with the intent to improve the solar exposure and receiving more sunlight and to get ride to the prevailing winds for the natural ventilation or protection.

Roof - thermal Insulation

In order to improve the indoor environment quality, it is necessary to intervene on the treatment of the roof, with all the benefits the different solutions bring, as shown on Figure 8.

Figure 8: Roof insulation scheme



Source: Design by the author JV

Access to the roof, common space for the residents,

Green roof / that can be combined or dictated by the use of the spaces.

Windows - windows double pane; Vertical opening;

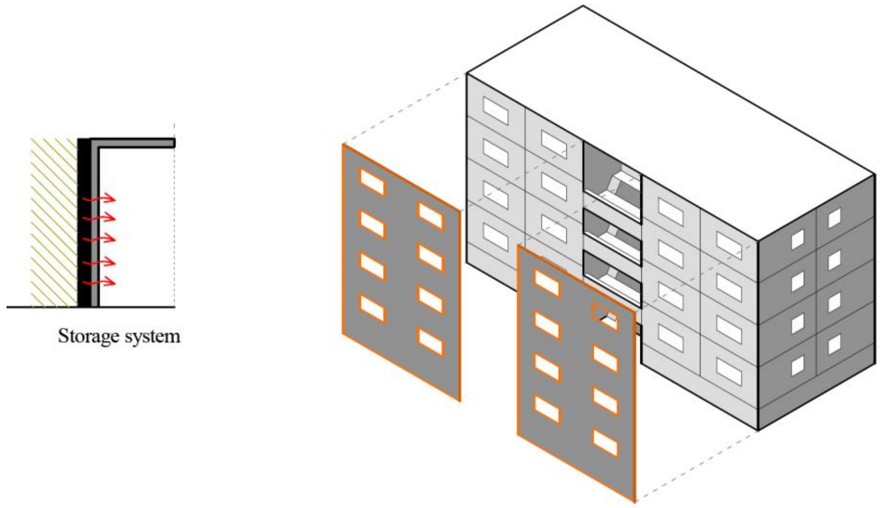
External shading devices – Flexible

Side Elevation - thermal Insulation with the integration of Storage systems

Addition of functional vertical volumes. The extension should be deigned Should be designed to take advantage of: Winter Solar Chimney; Summer Solar Chimney. Addition of elements with high heat capacity for the accumulation of heat known as Trombe-wall. is built on the winter sun side of a building with a glass external layer and a high heat capacity internal layer separated by a layer of air.

The state of preservation of facades differs depending on the type of coating; the plaster is undoubtedly the one that has the worst state of conservation, especially for the poor maintenance, but although, in the residential buildings under study comes out the big presence of the buildings having solid clay face brick and calcium-silicate face brick, with very poor maintenance too. Those façades can be insulated as evidenced on Figure 9.

Figure 9: Façade insulation

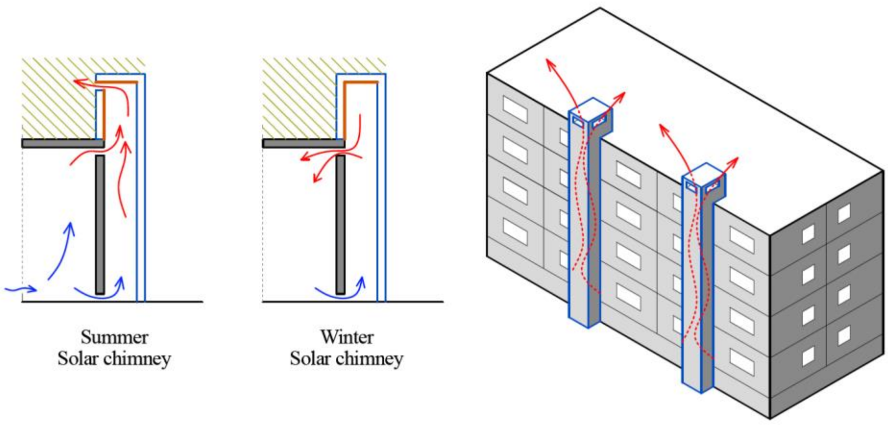


Source: Design by the author JV

Staircase closure

Addition of functional vertical volumes, playing the role of solar chimney too, a way of improving the natural ventilation of buildings by using convection of air heated by passive solar energy, like in Figure 10.

Figure 10: Staircase closure



Source: Design by the author JV

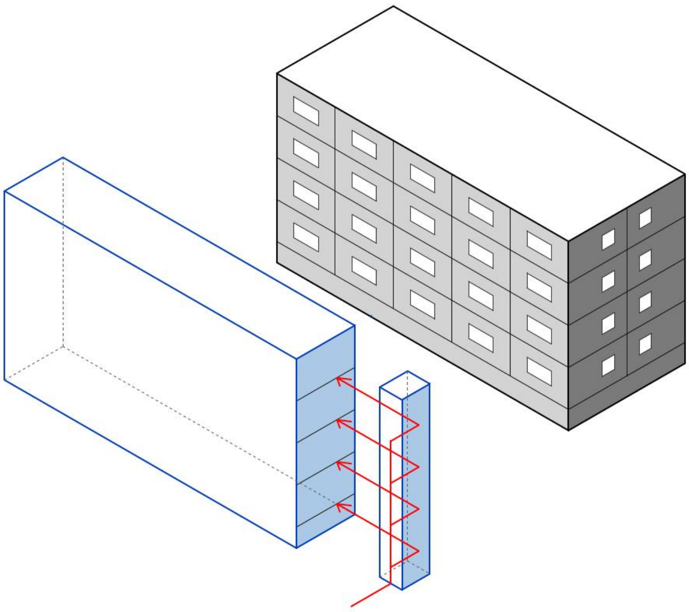
Additions and Elevator

Vertical Addition, East side DL – Addition balcony/room – the system of opening/glazing

Vertical additions of a side elevation block to the whole front, with the function of heat gain in winter the possibility to control the natural ventilation in summer, like in Figure 11.

One technological achievement that influenced the design of the residential blocks is the elevator. During the socialist period in none of any residential blocks the elevator was present. Here is schematically described where the possible elevator might be implement, in the case it is possible.

Figure 11: Additions and Elevator



Source: Design by the author JV

4 Findings

This research aimed to evidence and motivate how the retrofitting interventions are of vital importance to the residential building stock, and building up an approach with the intent to integrate the retrofitting strategies into the design process for a successful upgrade of the energy performance. This research started from the concern and the need for the energy retrofitting of the buildings stock in order to reduce the energy demand, as this sectors is one of the main consumers of it. Regarding the control of energy consumption there are different directives which are putting ambitious targets, for 2020 and 2050, for the building to achieve in order to reduce the CO_2 emissions, one of the main component of the greenhouse gases.

In these regards retrofitting interventions should be both quantitative and qualitative, for ensuring deep upgrading and enhancing the comfort and the energy performance of the residential buildings (Williamson & Dunham-Jones, 2021). Achieving this goal means different instruments and policies, funds and incentives, but the fundamental step of this is the design process where to identify and build the right and most cost-effective retrofitting strategies. These aspects determined the direction of the research, the task of informing and facilitating the best passive strategies at the very beginning, for helping on building up the best retrofitting design strategies. The sustainable design and intervention should combine different aspect to aim the best solution, this mean passive and active techniques, without underestimating the renewable energy sources and the goal achievement is ensured by an integrative design process.

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