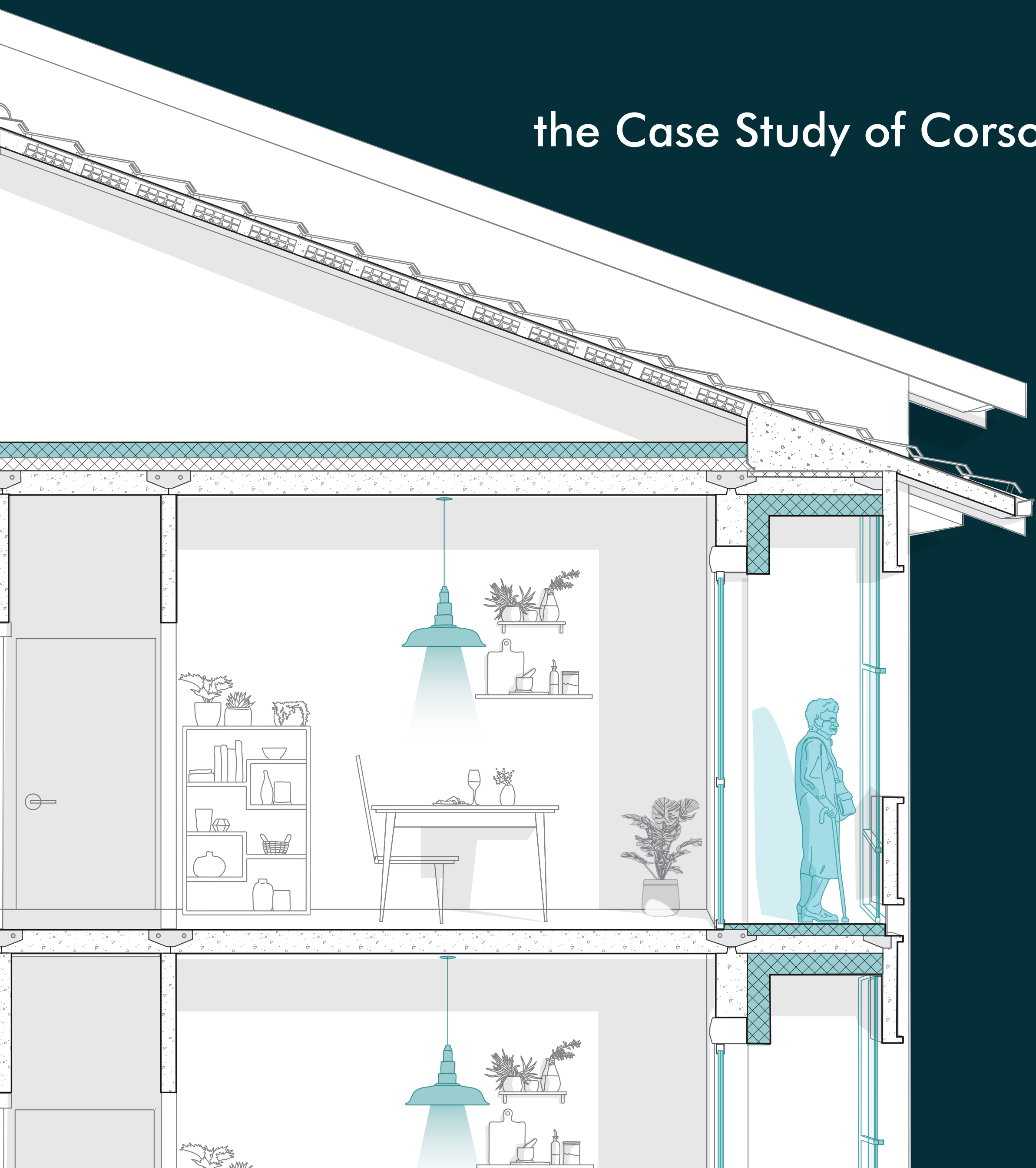
BEYOND FAST

Refurbishment Strategies to Respond to Socio-economic Burdens in Social Housing

the Case Study of Corso Taranto, Torino



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Beyond Fast

Refurbishment strategies to respond to socio-economic burdens in social housing: the case study of Corso Taranto, Torino

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ABSTRACT

IPCC has announced that temperatures have already passed the critical state with climate change. Every new opening in the oil and gas field has an impact, and we have already passed the limit given by the Paris Agreement. Fuel usage increases as the fuel needs to counter the effects, eventually changing the climate and creating an inevitable cycle of cause and effect. Thus, energy consumption is increasing while the energy costs rapidly rise in contrast to the planned reserve openings. The families' income cannot keep up with the pace of energy prices. Energy bills are rising, as well as consumption, while families spend more than 10% of their incomes on energy bills, accounting for energy poverty. The residential sector creates more than half of the CO2 production while the prices increase, and residents must choose their needs to keep up with the prices. Inadequacy in reaching energy prices highly affects low-income groups, especially those residing in social housing blocks, wherein for each new resident, residualisation decreases income and purchasing power. The construction of social housing block stock for lower income groups was rising, especially in Europe after WW2, with the economic boom requiring work power. In the case of Italy, the effect of the boom was that many factories, specifically in Turin, the FIAT factories, emerged, and to respond to the housing needs, new neighborhoods were born. These failed to respond to the needs of the people, where they demanded different social and economic needs, which currently need to be improved to cope with energy poverty. In light of the criticality of energy poverty in today's situation, the thesis focuses on explicitly co-housing units owned by a public body, such as a local government or a housing authority. The reason is to have holistic design options and to satisfy multifamily needs with different needs and occupancy ratios while establishing multiscale regeneration strategies to respond to the least lower-income people. The research explores Turin's public housing neighborhoods, specifically focusing on a case study of Corso Taranto. This examination aims to assess the viability of various methods and actions in this context, drawing comparisons with similar case studies. Initially, the study defines the existing problems through a thorough literature review and historical analysis of the case study. Then, the research looked for examples of transformations with various goals in co-housing blocks. The transformations are evaluated through their achievement in economic viability and socio-demographic effects, and then later examples are used to define the range of refurbishment costs parametrically. The applications are divided into two categories with two different scales of intervention and defined on the case study of Corso Taranto. The economic viability and socio-demographic effects are evaluated together with energy consumption simulations. Energy simulations are used to define various groups of income residents that are subjected to energy poverty. These regeneration strategies are then grouped for five future scenarios depending on their actors and viability. The study shows that a regeneration strategy supported by resident and public actors can significantly reduce energy poverty in social housing while enhancing overall building performance. Compared to that, the best result is achieved with high funds from public bodies to respond to the energy poverty and socio-demographic needs to meet the urgent housing needs.

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CHAPTER 0

Housing as a Crisis Source and as a Possible Solution

"Public housing should not be seen as a number but as a social effect that impacts the residents. Affordable housing needs to be socially environmentally and ecologically sustainable and "responsive" to demographic projections, accessibility/affordability to energy and climatic change."
(Günther,2023)

0

The research is centered on Corso Taranto, a distinctive area located in the Regio Parco region northeast of Turin. This site stands out due to its unique local values and resident actions, making it a key example of the social housing situation and the socio-economic and socio-cultural issues it faces. It is one of the neighborhoods built in Turin after the economic boom in the 1960s. To fully grasp its significance and the selection, several factors need to be considered explained in this chapter.

The burden of the energy poverty in the context of social housing

Refurbishment and retrofit have challenges and barriers that are hard to deal with when considering collective housing. In privately owned co-housing buildings, there are many difficulties in forming decision mechanisms and gathering money from the individual parties who are the owners of the different dwellings in the same building. In the case of Corso Taranto, it can be observed that it is a public rental social housing, which means a public entity owns it. It has been said that they are in possession of the building even though occupants are in charge of managing communal decision-making. The disadvantage of this is that there is no specific feedback and action connection against the needs (for example, if a tenant requests a repair or improvement, there is no direct process mechanism for how this request is addressed, and there should be a certain percentage of user feedback to ATC to something to be done only by some various actions. Community meetings for discussion of the issues.

Nearly in all ATC neighborhoods, tenants are dissatisfied with the buildings being cold and still cannot keep up with the energy prices.

Therefore, we should turn our scope to the residents' needs. In the case where the user - that is, the occupant- is the subject, it follows that not only renovation and retrofit expenses are sufficient to determine energy poverty, but also social needs and spatial organization taken into account.

"The cost of district heating has practically doubled, don't trust it, in the past years we were told to switch to district heating that we would save money. Then we Turin people are diligent, if there is to save and respect the environment...."

0.1 Housing in the Crisis

The rapid urban development that accompanied the Industrial Revolution marked the beginning of a profound transformation in collective living, profoundly impacting social structures. This shift in social dynamics prompted architects to move away from small multifamily houses towards large housing complexes, influenced by the emerging Utopian urban philosophies. However, it was the early Utopian socialist ideas of the mid-1800s such as Charles Fourier's ideas (Mumford, 2018), advocating shared land ownership and collective living, that played a pivotal role in shaping these new housing models. Expressed through sketches, drafts, and realized in large-scale neighborhoods, these ideas placed collective housing models at the forefront of social discourse, leaving an indelible mark on contemporary ways of living. These new housing models rapidly adapted to the economic boom and need for housing, significantly shaped Europe after the Second World War.(Fig 0.1 and Fig 0.2)

These housing typologies then formed the new worker housing quarters and divided the social roles of those who were accommodated in the housing complexes. The relation of income and collective living is integrated and leading to social separation in today's world with residualisation and gentrification. Not long after, these approaches to future cities and mass housing did not plan for change of the energy consumption, and energy problems emerged. These mass housing blocks are sometimes no longer in good condition due to insufficient funds or a lack of maintenance schedule. They're insufficient to satisfy the existing residents' needs, and they are insufficient to satisfy the demand for housing requested by the general public. They are also not responsive to several future scenarios that can be present in the future.

Figure 0.1: Robin Hood Gardens in London (built in 1972 and demolished in 2017)[1]

Figure 0.2: Vele di Scampia in Naples (built in 1962 and demolished between 1997 and 2003)[1]

0.1.1 Cause, Action & Effect in Housing

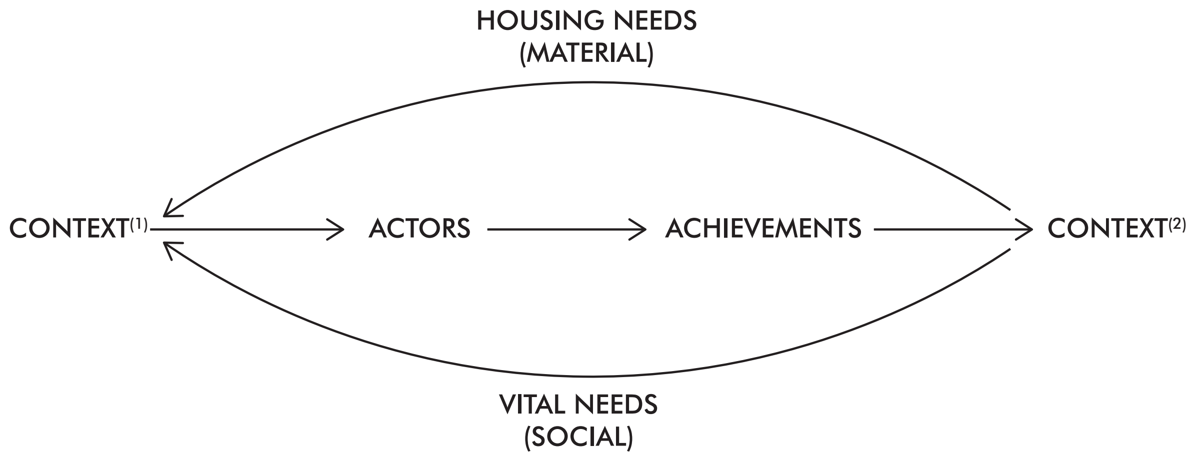
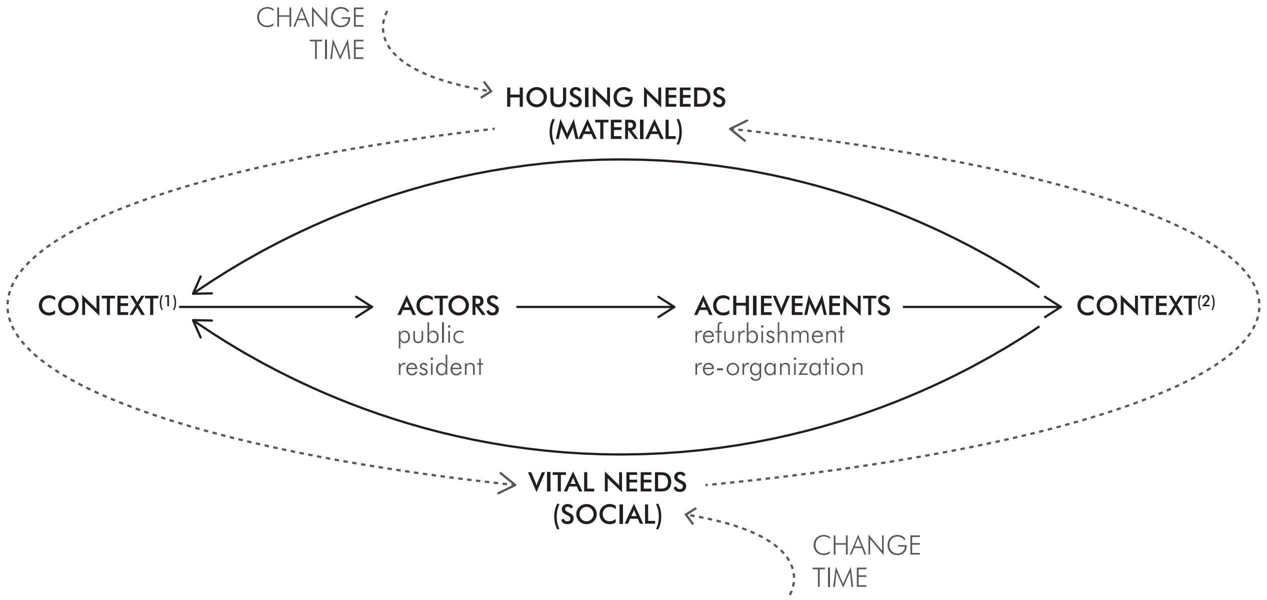


Figure 0.3: Simple systems definition of the housing according to the Turner (1972)

In the book of Turner and Fichter (1972), housing is mentioned to be evaluated as an action. It is illustrated as a simple general definition of the housing action starting from the first *context*. Then, it depicts the actors and the decision makers' influence on the achievements depending on the influence of profit, political power, and personal use depending on the actor (public or private). The achievements could be construction of the whole house as well as the refurbishment. Housing achievements do not just consist of materials and environments but also the way they are designed, funded, organized, and maintained. The achievements completed defines the secondary context which is the situation after the action. Before this action is complete, the author of the book proposed there is a feedback mechanism from the related bodies.

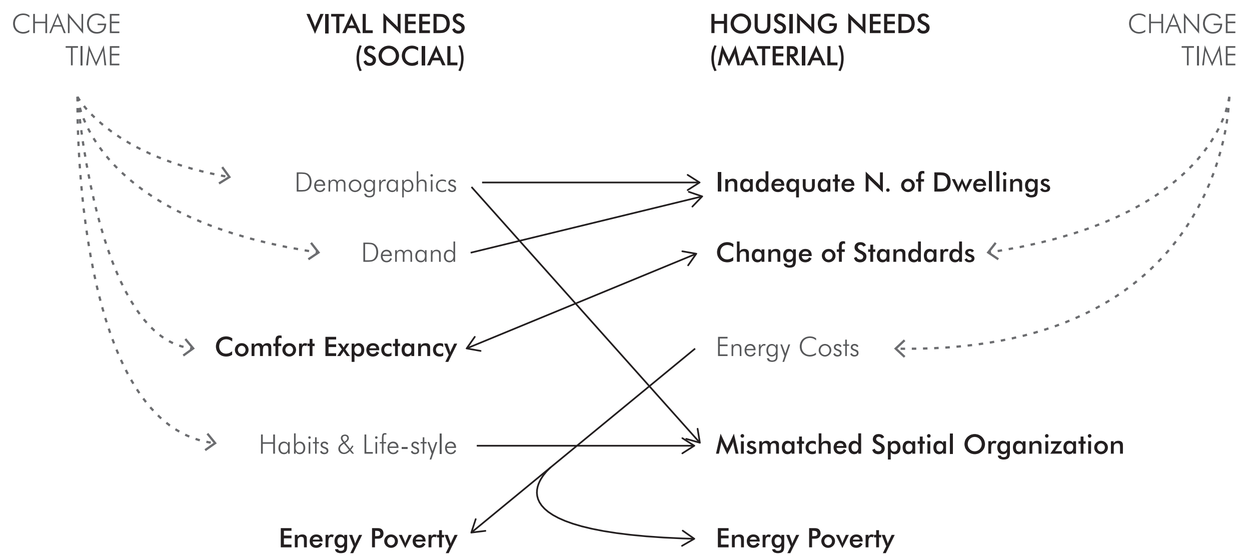
They define the feedbacks as needs which are advised to consider before the action considered finished. It is discussed that feedback is crucial to complete the housing action holistically. The authors split this feedback process into two for a comprehensive perspective on the needs by splitting them into intangible and tangible aspects. Housing needs are defined as materialistic needs that are tangible. However, in the case of housing, intangible aspects that are not materialistically computable but necessary for living are described as vital needs.

To extend this to the current problems of existing buildings, we should add the *change* component, which refers to the evolving societal, economic, and environmental factors that affect specific needs over time. These changes form the basic needs and problems social housing blocks are currently facing, highlighting the dynamic and depended nature of housing issues.



(diagram redrawn by Author)

The main changes are done in the diagram is addition of the change to redefine the vital and housing needs. Even though its exploded as a two feedback action they are effecting and controlled by each other. To understand holistically, the needs are exploded with merging with the change factors illustrated below. The needs connected to the newly defined keywords and objectives that are used in this thesis.



Changes by time could be affected by the changes in demographics, politics, social structure, habits, climate and costs. These are creating new factors and parameters due to buildings stability in changing context. The change in the current situation is inevitable, therefore design should be following a certain flexibility to overcome or predict possible future scenarios.

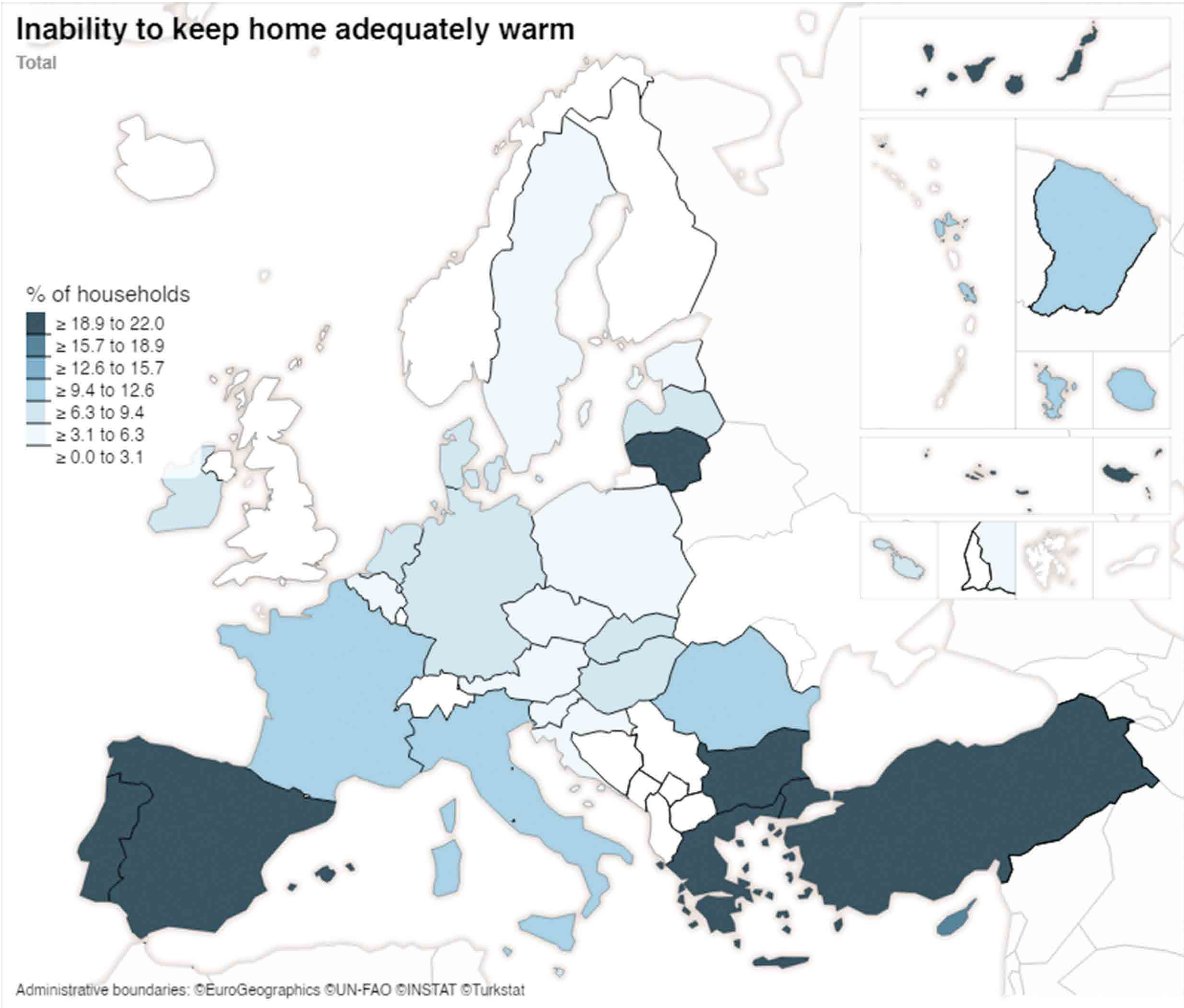


Figure 0.4: % of the total population who are unable to keep their home adequately warm (Eurostat,2021)

0.1.2 Housing Crisis

Access to housing remains a significant challenge for many European countries. The economic crisis seen in the current decade affected the housing sector, where social inequalities have been growing for the last twenty years. (Maloutas et al., 2020). Calls for affordable housing have reached a scale large enough to prompt European-wide policies demanding more accessible housing options. This is also highly affected by increasing construction and maintenance spending on residential buildings, influencing the housing market's rise. The critical role of the residential building sector is evident in CO_2 emissions, with construction and operations accounting for 38% of global CO_2 emissions related to energy in 2015 (United Nations Environment Programme, 2021). To address emissions in the building sector, the Energy Performance of Buildings Directive (EPBD) has established mandatory regulations for both new and refurbished buildings (European Parliament, 2018). It is crucial to incorporate sustainable energy practices, especially since they are closely linked to the socio-economic dimensions of housing affordability.

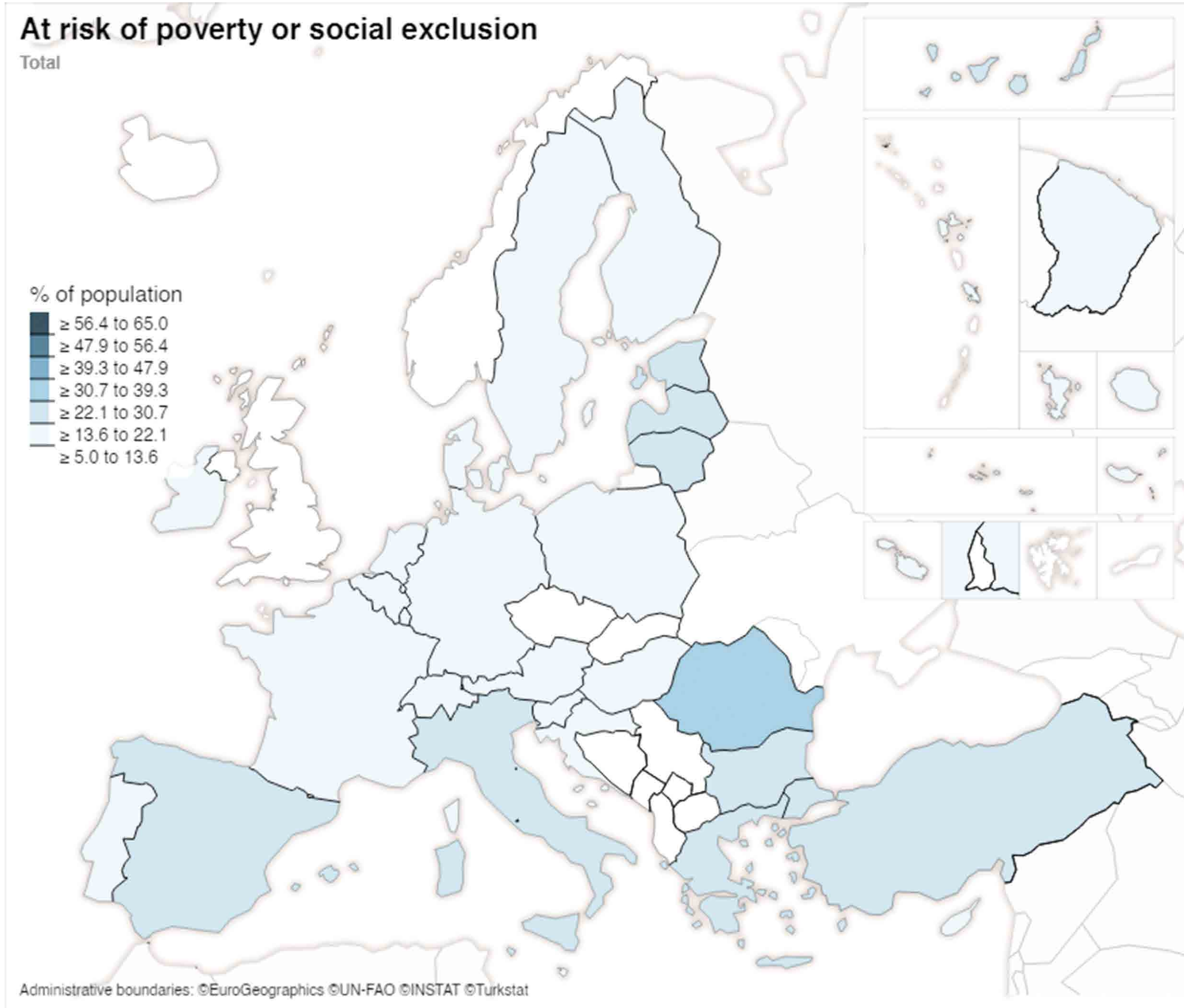


Figure 0.5: % of the total population who are at risk of poverty and social segregation (Eurostat,2021)

The increasing demand for housing and the necessity for sustainable energy measures underscores the broader intersection of housing and climate objectives across various countries. This has prompted the development of new policies and legislation primarily addressing energy poverty, a term that has gained prominence in recent years.

0.2 Social Housing in the Crisis

0.2.1 Poverty to energy poverty

Figure 0.6: Sustainable Development Goals that are directly related to the mentioned issues.

The energy poverty issue is inseparable from the energy efficiency term in housing stock, which should be addressed together. As a description, a household is classified as experiencing energy poverty if it must spend more than 10% of its income on fuel to maintain adequate warmth (Thomson et al., 2016). In 2023, 10.6% of households were burdened by energy costs that exceeded 10% of their income, a situation that worsened over the years. Energy poverty has risen by nearly 4% percent from 2021 to 2023 in Europe (Eurostat,2024). This results from the high energy demands and inefficiencies in many social housing units, where older buildings often lack sufficient insulation or efficient heating systems while trying to keep up with the new consumption increase and costs due to climate change and political effects. While affordable housing is crucial, the issue also encompasses the need for energy-efficient and healthy living environments that do not financially strain residents or contribute to energy poverty.

The recent energy crisis and escalating energy costs have further highlighted the urgency of addressing energy poverty and housing crisis. In response to these current challenges, new European social housing policies were mentioned and added as a guideline in Housing 2030, Horizon 2020, UN-Habitat, Housing Europe, and Sustainable Development Goals. Although each Member State has its methods for tackling this issue, the European Commission has increasingly prioritized energy poverty within its broader policies on energy efficiency, decarbonization, and the transition to clean energy. (EPRS BRI, 2022)

Traditional energy efficiency measures often overlook the crucial link between residents' energy habits and their use of efficiency technologies. Neglecting this behavioral aspect can inadvertently lead to inefficiencies in a building's lifetime, reducing the effectiveness of energy-saving measures and perpetuating the issue of energy poverty. Therefore, adopting a holistic approach that considers both the technical and behavioral aspects of energy efficiency is essential.

Social collective living, with its potential to surpass individually owned dwellings, offers a promising solution to the urgent and pressing housing crisis. Residents' willingness to pay is another keyword that needs to be included in this aspect. Awareness of the problems is the key to resolving the issues coming with the housing crisis. Residents are solely the users in residential housing who experience inadequacy in the buildings. The advantages and the potential of co-housing communities and neighborhoods are important for this aspect. Organizations have already been formed, and collaborations have been formed in the communities to discuss issues, including energy concerns (Hagbert, 2019). Therefore, they are seen as the co-actors rather than the consumers and costumers of the housing sector, so in co-living communities, residents can be counted as co-actors in Turner's diagram.

0.2.2 Residualisation

In the current situation throughout Europe, social housing bodies are targeting and allocating the lower income residents. The tenants' income, the lower the rents that can be charged, and the higher the risk of poverty. This is called residualisation, which has contributed to rising socio-spatial segregation, mainly as much of the remaining social housing stock is now concentrated in peripheral city areas. It is a phenomenon seen in many different countries, and they have separate responses due to differences in their existing housing stock and policy structure. For example, public housing is often clustered in particular city zones in Milan, Italy, where housing quality may be low and segregation dynamics pronounced. (Cavicchia et al., 2023). The housing system shows a stronger orientation toward social needs because it is built organizationally as neighborhoods with connected infrastructures rather than the individual social housing constructions seen in northern parts of Europe. However, in any case, spatial and social divisions are increasing between different hierarchy income groups due to the residualisation phenomenon.

Thus, the inequality and inadequacy of affording housing cost become more challenging for the new generation of residents. In Tammaru (et al. 2016) evaluation, capital cities show signs of desegregation due to new demographics. The gap between high-income and low-income groups is increasing without exceptions around Europe.

0.2.3 Refurbishment Difficulty

While improving the existing building stock is a fundamental approach to tackling the housing crisis and energy poverty, it is not without its challenges. Economic, legislative, social, and technical barriers often hinder the renovation of buildings, especially those in the public housing stock. These barriers, which range from financial constraints to legal and technical limitations, underscore the sheer complexity of the task at hand. Additionally these financial constrains are inline with the refurbishment actions that differ to various actions taken that are differentiated with the several building layers. These are needs to be considered as a whole but not the same.

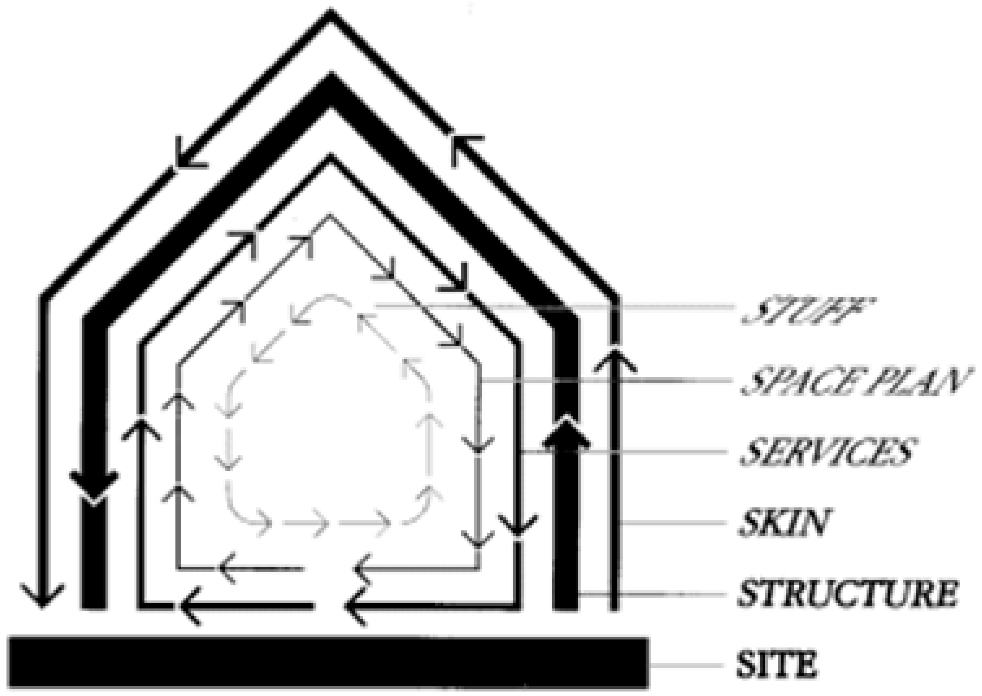


Figure 0.7: Layers of the building according to their life cycle (Brand, 1994)

Brand (1994) explains this concept through the 'Shearing Layers of Change' framework presented in "How Buildings Learn," which divides buildings into six distinct layers, each evolving at different rates and reflecting varying capacities for adaptation. The framework identifies the Site and Structure, which are the foundational location and load-bearing elements, as the most enduring components, with lifespans ranging from centuries to several decades. In contrast, the Skin (exterior) and Services (such as plumbing and HVAC systems) necessitate periodic updates in response to aesthetic, environmental, or technological advancements. The Space Plan, concerning interior layouts, tends to adapt more frequently to functional shifts, while the Stuff, referring to furniture and personal items, exhibits high flexibility, shifting following the occupants' needs.

Brand's model underscores the importance of designing buildings for adaptability specific to each layer, fostering sustainable and incremental change while giving different life expectancies for each layer. This approach not only enhances the longevity and functionality of building structures but also addresses the socioeconomic challenges associated with high initial costs in social housing.

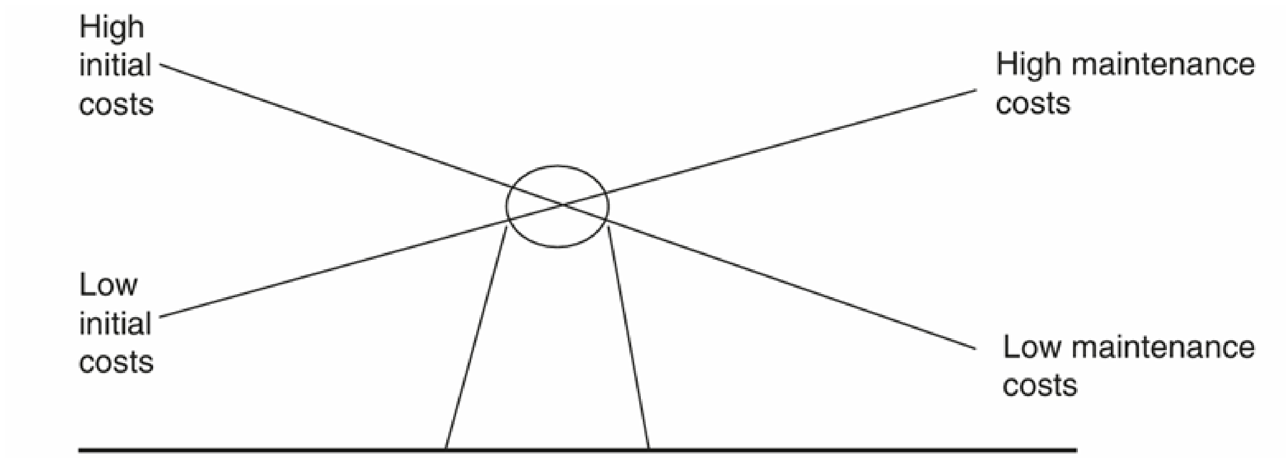


Figure 0.8: The maintenance seesaw hypothesis (Douglas, 2006).

The differentiation of the life expectancy of the layers and their differences in the role of the building, main challenge remains as the capital. The main concern of the initial capital and life cycle costs are in opposite relation in the building sector.

Residential buildings, especially social housing buildings, have a high life expectancy with few major refurbishments and interventions in their life. Commercial buildings have shorter design lives, so they are adapted more frequently than residential buildings (Douglas, 2006). This makes it harder for social housing blocks because they have already been built with a high initial cost. It is crucial to adopt a more holistic approach to building design, one that takes into account their historical, temporal, and physical contexts. Building adaptation, the process by which buildings are made to respond to these influences, is key.

Therefore, their maintenance or intervention costs are expected to be lower. However, in the current situation, even though the interventions have been done in 10 years, tangible and intangible needs are already not satisfied due to rapid external factors change in the case study Corso Taranto, the case study will be explained in Chapter 1. However, improvements need investment and expect a return of investment as profit; the concern is that current policies targeting green growth agendas enforce the refurbishment goals to be profitable, thus upgrading neighborhoods by increasing socio-spatial inequalities rather than reducing them.

0.3 Research Goals

In response to these challenges, it is essential to implement actions that improve the energy efficiency of the building stock to decrease energy poverty and address the housing crisis. Thoughtful design in housing that responds to various future scenarios is necessary to prevent rising housing prices, social segregation, and inequalities resulting from residualisation. UN-Habitat estimates that energy consumption in residential buildings could be reduced by approximately 30–50% globally through simple retrofitting (UN-Habitat, 2015). However, identifying the critical actors involved in retrofitting is crucial. Future scenarios must consider different stakeholders based on available funding. In any scenario, involving residents in the decision-making process as co-actors is vital to ensure effective housing solutions.

For this reason, research focuses on understanding how socio-economic conditions, energy poverty, and refurbishment processes intersect in public social housing. Using the case study of Corso Taranto, the thesis will explore the factors influencing refurbishment decisions, and how to balance the costs of retrofits with the need to improve energy efficiency and living standards with considering changing demographics and social housing demand. To address these areas, the following key research questions will be covered in the thesis scope:

1_What are the socio-economic challenges faced by residents in public social housing, and how do these contribute to energy poverty?

2_What type of refurbishment process taking place in public social housing, particularly in terms of economic resources, response to diverse resident needs, and energy performance?

3_How can a balance be achieved between cost-effective refurbishment strategies and addressing energy poverty in public social housing, considering the need for long-term sustainability, reduced energy consumption, and improved living conditions for diverse socio-demographic groups?

0.4 Metholodology

From the research questions asked related to the socio-economical burdens in the social housing buildings are answered throughout the thesis with the methodology as follows.

1

Brief history from the Italian of the "fast" to an emergence of contemporary problems in Corso Taranto

Firstly, the research searches the current problems in the neighborhood of Corso Taranto. To identify the problems, a historical research from a broader perspective of Italy is described to respond why these current problems of the energy and infrastructural insufficiencies are present.

2

Case outlook on the multi-scale regeneration strategies and reframing of the costs

Secondly, a case study research is taking part in the thesis for to observe various responses to the problems that are present in Corso Taranto. these are evaluated from 4 different aspects that is defined previously.

3

Defining the Energy Poverty of Today

Thirdly, a simulation is created to define the energy consumption of the room types. These later defined which residents are in the burden of the energy poverty.

4

Social & Economic Goals Across Multiple Scales

Fourthly, design transformations are defined by the two main scales; building scale and dwelling scale. The scope of the interventions are crucial to define the cost and the actor of the buildings. The effects of the transformations is represented by the living-sections and they are simulated if applicable.

5

Looking Ahead on Future Scenarios and Possibilities

Lastly, the strategies defined previously used for transforming the buildings in different possible scenarios that are responsive to the cost of the interventions and the actors. The scenarios are categorized by their funding amount being high or low cost and categorized as either resident as actor, public as actor or colaboration from both. In the end, the cost is not relative to the energy poverty and the efficiency but rather multiple factors indicates that the most cost efficient solution is the collaboration of the multiple actors.

CHAPTER 1

Brief history from the Italian of the “fast” to an emergence of contemporary problems in Corso Taranto

1

In the case of the public housing initiatives in Italy, they have had various issues. Ina-Casa's plan in Italy after the Second World War aimed to provide employment in the building industry and respond to the housing shortages. Later on, the Gestione case per i lavoratori (Gescal) was established in 1963 following the Ina-Casa plan. It was financed through a compulsory contribution system for the firm and its workers. (Poggio & Boreiko, 2017) The lack of constant resources to upkeep and refurbish the existing stock and cuts in public investments created the maintenance and lack of attendance on the public body side, which was the only actor at the time. The system of the Italian ERP(edilizia residenziale pubblica) the public housing organization) They have had a traditional rent-setting model, which is financially faulty in terms of the sustainability of the system. It benefits low-income residents by lowering the rent in relation to income; however, it needs a constant resource supply for maintenance and future refurbishment investments. Or, for another scenario, public bodies increase the investment/refurbishment costs to the rent of the low-income households already struggling to meet their ends.(Cucca & Friesenecker, 2021) In the end, higher intervention is needed to improve the housing conditions to keep up with the existing problems.

1.1 "Fast" in Italy

1.1.1 *Fast* neighborhoods - Law 167

In the building sector in Italy, various legislations in the first half of the 20th century were established to construct workers at reasonable prices to meet the demand for the industry's employment requirements. These were incorporated into law for low-cost housing for the post-war period. Therefore, a new law was established on 18/4/1962, no 167, translated as "Provisions to encourage the acquisition of building areas for low-cost and mass housing," was dictated. Law 167 of 1962 called upon municipalities to make heavy commitments from both a political-administrative and economic point of view. It was a valuable tool for setting up impossible urban interventions with the previous legislation. However, the application of Law 167 was very troubling.
According to Law 167, provisions are made to promote the establishment of the sites for creating affordable and public housing zones, which was approved by the Ministry of Public Works (current Ministry of Infrastructure and Transport). This law, significant for the development of Italian cities until the 1980s, led to massive construction of the grand districts of mass public housing neighborhoods with zones of PEEP (Plans for Affordable and Public Housing), which are integrated within the general municipal master plans. Popular examples of grand mass housing districts are Corviale in Rome, the Vele in Naples(Fig 1.4), and Zen in Palermo. Their problems were soon to emerge as physical and social consequences. These areas symbolized Law 167's problematic policies that lack social integration.

Table 1: The Italian housing system and policy: selected indicators by year (1995-2014)

	Year									
	1995	1998	2000	2002	2004	2006	2008	2010	2012	2014
Housing tenure										
All households										
Private rent	19.4	18.9	17.4	16.4	16.8	16.6	17.6	16.9	17.3	15.5
Public/social rent	4.3	3.8	3.5	4.5	4.9	4.3	3.8	4.2	4.5	5.2
Homeownership	65.5	66.5	69.0	69.0	68.1	69.1	69.3	68.7	67.4	68.2
Rent-free, usufruct	10.8	10.8	10.1	10.1	10.2	10.0	9.3	10.2	10.8	11.1
All tenures	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
(n)	(8,135)	(7,147)	(8,001)	(8,011)	(8,012)	(7,768)	(7,977)	(7,951)	(8,151)	(8,156)
Low-income households (1)										
Private rent	32.2	30.5	27.9	28.6	27.4	31.1	37.2	39.6	39.7	34.4
Public/social rent	10.3	9.5	9.6	13.2	15.5	12.6	12.4	13.2	13.3	18.2
Homeownership	45.3	46.5	51.7	47.4	44.0	47.1	41.0	35.1	34.8	33.6
Rent-free, usufruct	12.2	13.5	10.8	10.8	13.1	9.2	9.4	12.1	12.2	13.8
All tenures	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
(n)	(1,439)	(1,248)	(1,422)	(1,355)	(1,273)	(1,248)	(1,229)	(1,225)	(1,220)	(1,203)
Low-income households (1)										
Unaffordability index (2)										
Among private renters	37.0	44.1	49.2	56.0	58.5	61.5	64.5	70.6	73.8	73.7
Among social tenants	10.0	21.9	13.6	15.4	12.8	8.4	17.4	19.5	21.3	20.0
Degree of targeting (3)	43.7	45.6	49.3	52.0	52.8	50.5	54.6	52.3	48.6	57.9

Figure1.1: Placement of low-income individuals in the housing stock (Poggio,2017)

This law aimed to solve urban development issues related to the rapid construction of mass housing. It included new planning tools to establish new neighborhoods with better infrastructural relations to the city. The dwellings were low-cost compared to surrounding options, making them desirable for people who wanted shelter in the new city where they came to work.

However, once the law on affordable and popular housing was passed, even though it was mutilated by financial support, a clash opened up in the individual cities over the criteria for its application. New restrictions were established for each state because they were applied differently in each city. From the plans adopted, it was then seen that the municipalities had restricted areas to build low-cost housing to control the new district plans. These areas are selected as the periphery of the cities. These restrictions were higher in priority than the quality of the housing. This led to so-called "ghetto" districts later due to problems related to connection to existing infrastructural networks.

Since the 1990s, all policy-related responsibilities were transferred from the provinces to local authorities, leading to the abolition of the central fund for public housing, the GESCAL. From that point on, few aspects changed; however, the 2008 National Housing Plan recognized the essential role of private capital in increasing affordable housing supply, thereby contributing to the creation of housing in Italy and involving new stakeholders, such as banking foundations and the establishment of a national financing platform, the Integrated Fund System (SIF). However, these social housing interventions aimed at low- to middle-income groups and rental support do not address the needs of the lowest-income segments, which remain relegated to the Public Residential Housing (ERP) sector. Since its inception in 2009, SIF's goal has been to develop over 250 projects and create more than 18,500 housing units by 2020. (Bardelli, Capomolla, & Vittorini, 2003)

In recent decades, housing difficulties have worsened, now also affecting segments of the middle class that struggle to access the housing market. The policies implemented to address this issue have proven insufficient, as has the public housing stock, which continues to play a marginal role and is wholly inadequate for addressing current challenges. This situation calls for immediate attention and action.

The ATC's approach has also shifted, focusing more on rehabilitating and restoring existing properties rather than planning new social housing districts. However, managing public housing stock by the former public housing entities faces the dual challenges of limited financial resources and complicated regional administration.

"Fast" Fall Example

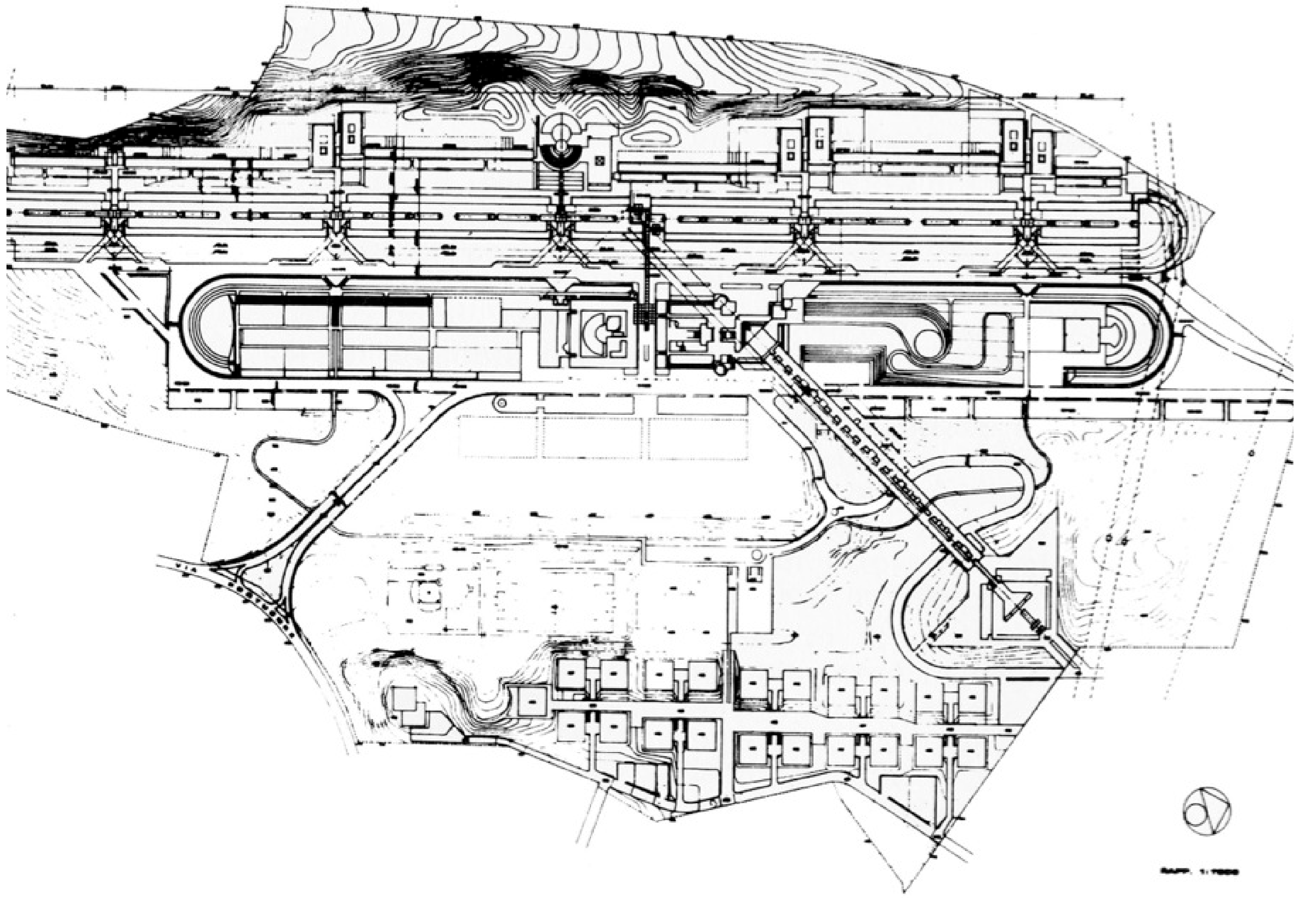


Figure 1.2: Corviale [2]

A bold and ambitious project, almost a kilometer long, located in the countryside on the edge of the suburbs to block urban sprawl, architecture proposed as a peremptory idea if only for its size and function and superimposed on a landscape that is not yet urbanized and which, with experimental funding from Gescal, creates houses and services together.

The project, with its Le Corbusian development, was a bold experiment. However, it was a leap of faith that did not fully consider the historical limits of Italian public intervention, bureaucratic obstacles, institutional expertise, and the cultural understanding of the recipients.

Failing to follow original intentions and the lack of management of the spaces degraded the complex, which became one of the key examples of the fall of the mass housing policies mentioned.

Figure 1.3: Corviale [2]

Figure 1.4: Corviale[2]

1.1.2 Fast Building Techniques

The ‘INA-Casa plan’ was a significant housing initiative characterized technologically by its choice to prioritize traditional construction methods in building new public housing developments. This choice was made to ensure maximum employment on construction sites. The plan, which succeeded INA-Casa in 1963 to meet the significant demand for new housing, opened up to innovative construction systems in its technical regulations. This decision came amid a shortage of available labor, which was increasingly absorbed by the rapidly growing manufacturing industry.

This choice marked a turning point in the national construction sector, which was centrally directed toward the gradual industrialization of the construction process. The large scale of the intervention, enabled by state initiative and supported by the 1962 law 167—establishing regulatory foundations for municipal administrations to allocate land for low-cost housing and enabling both public and private entities to promote zoning plans—made serial industrialized production of building elements economically advantageous, addressing the need to reduce construction time and costs. To meet tight deadlines and budget constraints while securing substantial contracts, companies adopted a bottom-up approach to streamline the construction process, integrating industrialized organizational and technical construction procedures, becoming national licensees of these methods. This led to the emergence of fast construction systems.
The rapid importation of heavy prefabrication patents, already in use across Europe and often considered outdated in their origin countries, marked the beginning of Italy’s path to industrialization. In its mature phase, this would shift toward mechanized concrete pouring procedures. The spread of industrialized patents and construction methods inevitably impacted design, construction sites, and construction firms.

The structural-concept imbalance often observed in these projects created the basis of the architectural spaces and form that restricts the spaces inside the construction. Therefore, the dwellings’ variety and spatial layouts were limited and repeated. This will also make refurbishment harder if the space organization is changed. The plans were not flexible in layout and could not be due to “fast” construction problems, as the constructional elements are indestructible due to the widespread use of wall and slab elements exactly in room dimensions designed at the time.

The site became a place to assemble prefabricated building components, either made off-site or assembled on-site. Site organization was influenced by production, handling, and panel assembly routes, which varied according to the patent type used, along with specific areas like storage zones or concrete mixing stations.

1.2 Torino in "Fast"

These were the years when Turin was dealing with the consequences of the economic boom and the housing emergency. Industrialization had brought many families from the southern regions and impoverished areas of central-northern Italy to move to the industrial triangle of the north-west. The demographic trends of those years, along with the associated aspects of urbanization, were radically transforming the urban layout of Turin and the social composition of its inhabitants. "The city grew from 719,300 inhabitants in 1951 to 1,124,714 in 1967."

At a time when Turin was expanding its perimeter and almost doubling its population due to the growing migration, the Istituto Autonomo Case Popolari and GESCAL districts were established in the province.

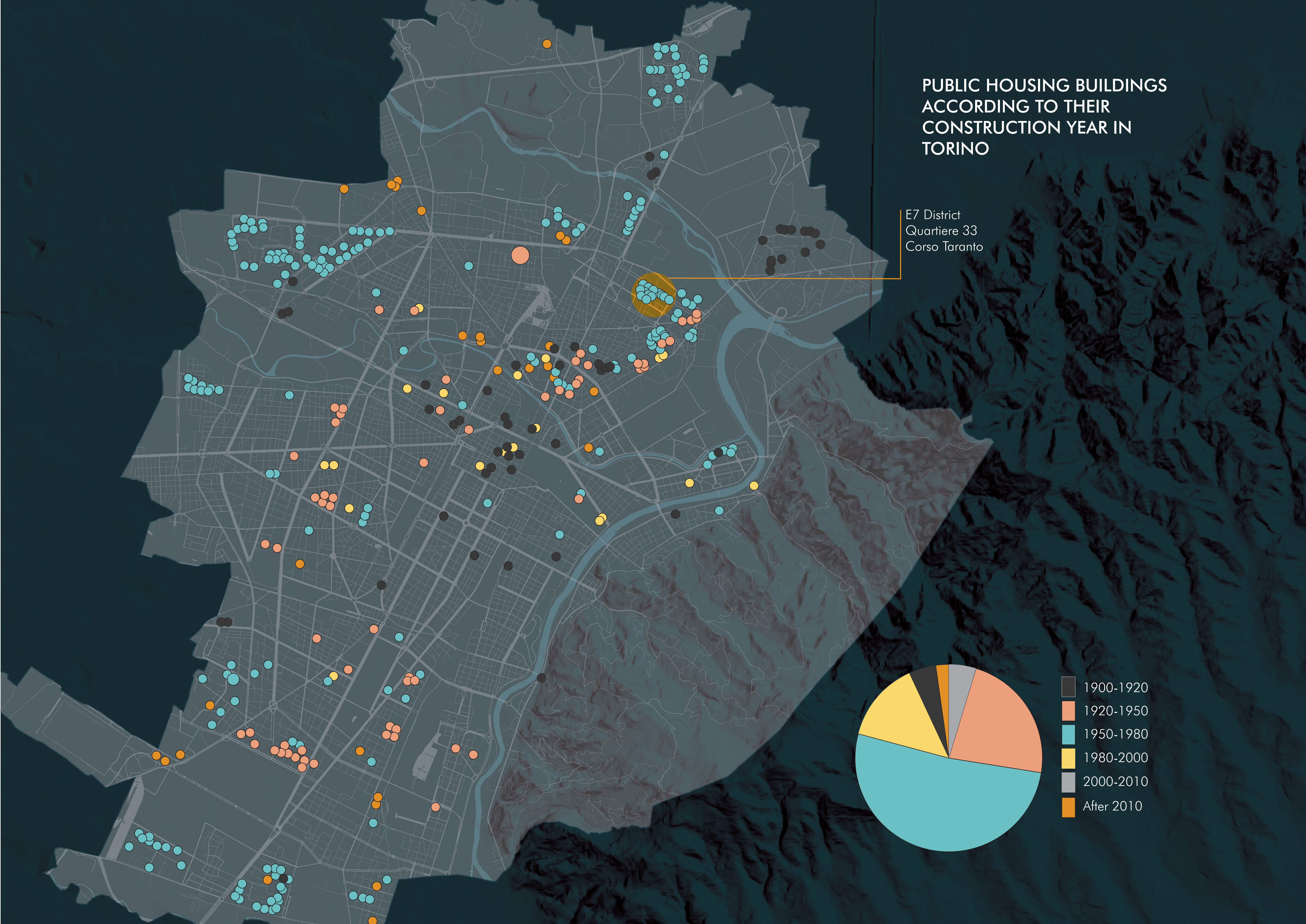
In partial application of the provisions of law 167, the Municipal Council of Turin identified 24 areas to be designated for public housing developments. In particular, between 1941 and 1967, 51 buildings, 979 dwellings, and 4974 rooms were built on behalf of the IACP; on behalf of the state, 47 buildings, 395 dwellings, and 1769 rooms; on behalf of GESCAL, 185 buildings, 690 dwellings, and 3650 rooms. The neighborhood, the subject of this study, was built on one of these, the E7 district.

During the economic boom of the 1950s and 1960s in the northern part of Italy, Turin was one of the northern cities that was fully industrialized. For this reason, it attracted hundreds of people from the surrounding areas and from Italy's economically poorer cities.

"In Turin, every day, hundreds of people arrive at Porta Nuova station on board the Treno del Sole. They were the "Trains of Hope" full of people looking for a better future."
(Corso Taranto: trent'anni di vita, speranze, progetti)

Most of the immigrants came from countryside areas, with a completely different pace of life compared to that of a factory city like Turin, where instead time was marked by the rhythms of industrial work, in those thousands of workers coming for the, mainly from the South.

Turin's social housing industrialization process mirrored trends in other major Italian cities, transitioning from fully pre-fabricated systems using planar elements—such as the Barets, Co.Im.Pre.-Skarne, Costamagna, Estiot, and Tracoba I systems—in its first phase from 1963 to 1973, to methods of concrete pouring industrialization in the second phase from 1974 to 1980, beginning with the introduction of the coffrage-tunnel. The following three construction case studies provide a concise, integrated analysis of the substantial impact these widely adopted patents had on the formal qualities, spatial configurations, and operational methods in Turin's public housing projects, all within the context of the political, economic, professional, and technical landscape of the time. (Garda & Mele, 2016)


PUBLIC HOUSING BUILDINGS ACCORDING TO THEIR CONSTRUCTION YEAR IN TORINO
E7 District
Quartiere 33
Corso Taranto
1900-1920
1920-1950
1950-1980
1980-2000
2000-2010
After 2010

1.3 Corso Taranto- From past

The actions of its residents have primarily shaped the history of the neighborhood. Through small gestures, a sense of belonging and a desire to contribute to the neighborhood's well-being has been fostered from social consciousness and solidarity. This chapter delves into the social relationships and historical events that have taken place in Corso Taranto. Ultimately, it becomes clear that the current needs are not significantly different from the past needs and habits, including discussions of community problems, demographic diversity in the neighborhood, and energy issues. This section will explore these aspects in the past with documentations, pictures from that period.

1.3.1 The Beginning of IACP Quartiere 33

With the funds of Law 167, the Corso Taranto district was established in 1969. The zone was called PEEP (Piani di Edilizia Economica Popolare (Plans for Affordable and Public Housing)),district E7 and 33th Neighborhood by IACP (Istituto autonomo per le case popolari) in a part of the Regio Parco district between via Pergolesi, via Mercadante, Corso Taranto, and via Corelli. Corso Taranto, was an area that had only hosted farmhouses and fields until recently, became a new distinct neighborhood of the city.

The approved plan foresees accommodating 6.300 people on 32 lots around the district. However, it was later seen that even though 23 buildings were complete by June 1968, the number of inhabitants had already reached up to nearly 6.700 people. The initial plan was to fill the need to accommodate the immigrants from outside and inside of Italy as all the neighborhoods established in Torino in these years. The plan of Corso Taranto, built by IACP, was composed of 16 publicly owned social housing buildings to accommodate 652 separate dwellings. The buildings consisted of ten 10-story buildings and six 7-story buildings. These were produced in such a rapid time with prefabric concrete panels of 16.300 within a 10-month timeline that it was quoted as a "mushroom district" by the newspapers in 1965.(Fig. 1.6)

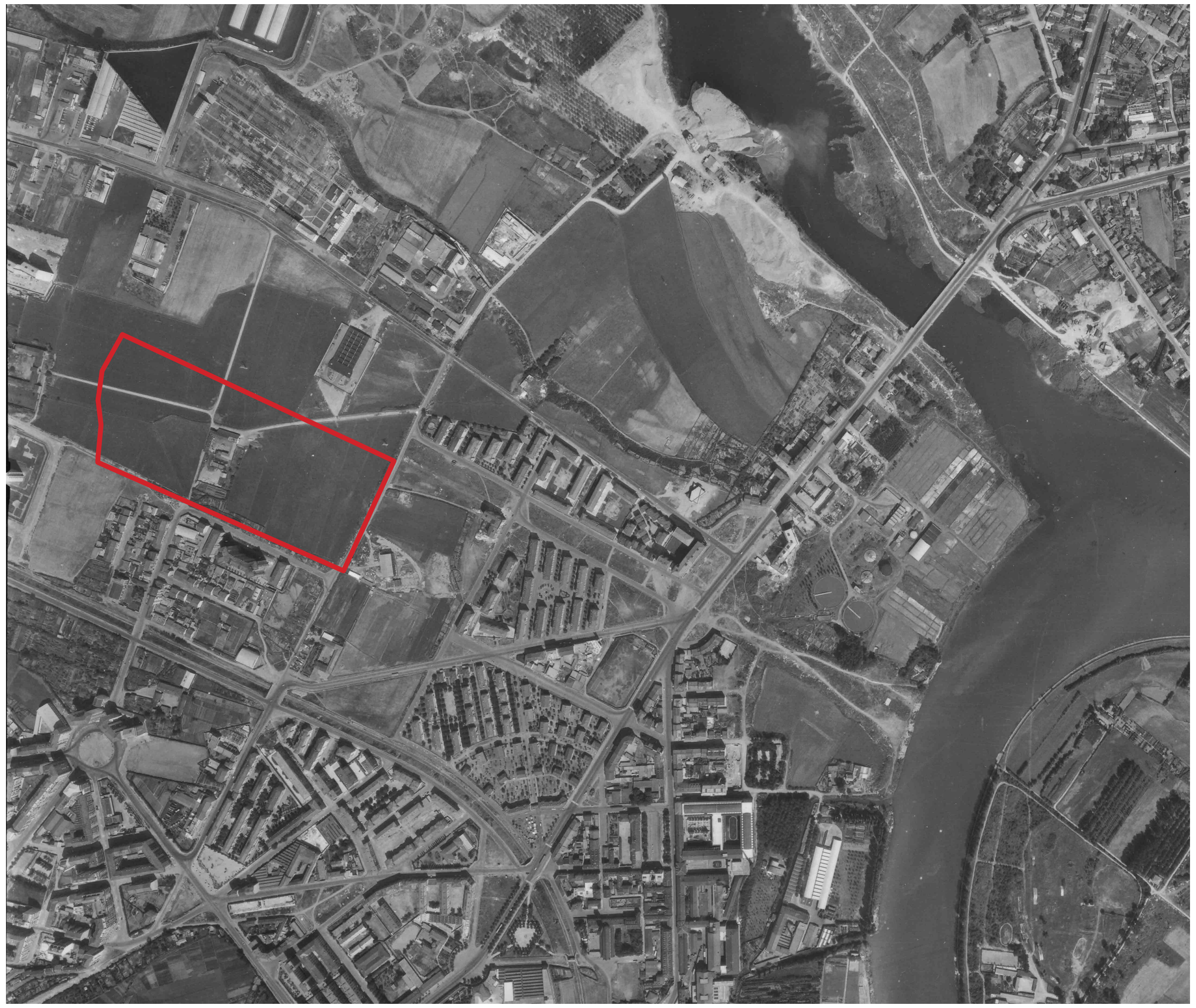


Figure 1.5: Map of the neighborhood 1962 (Archive of the City of Turin)

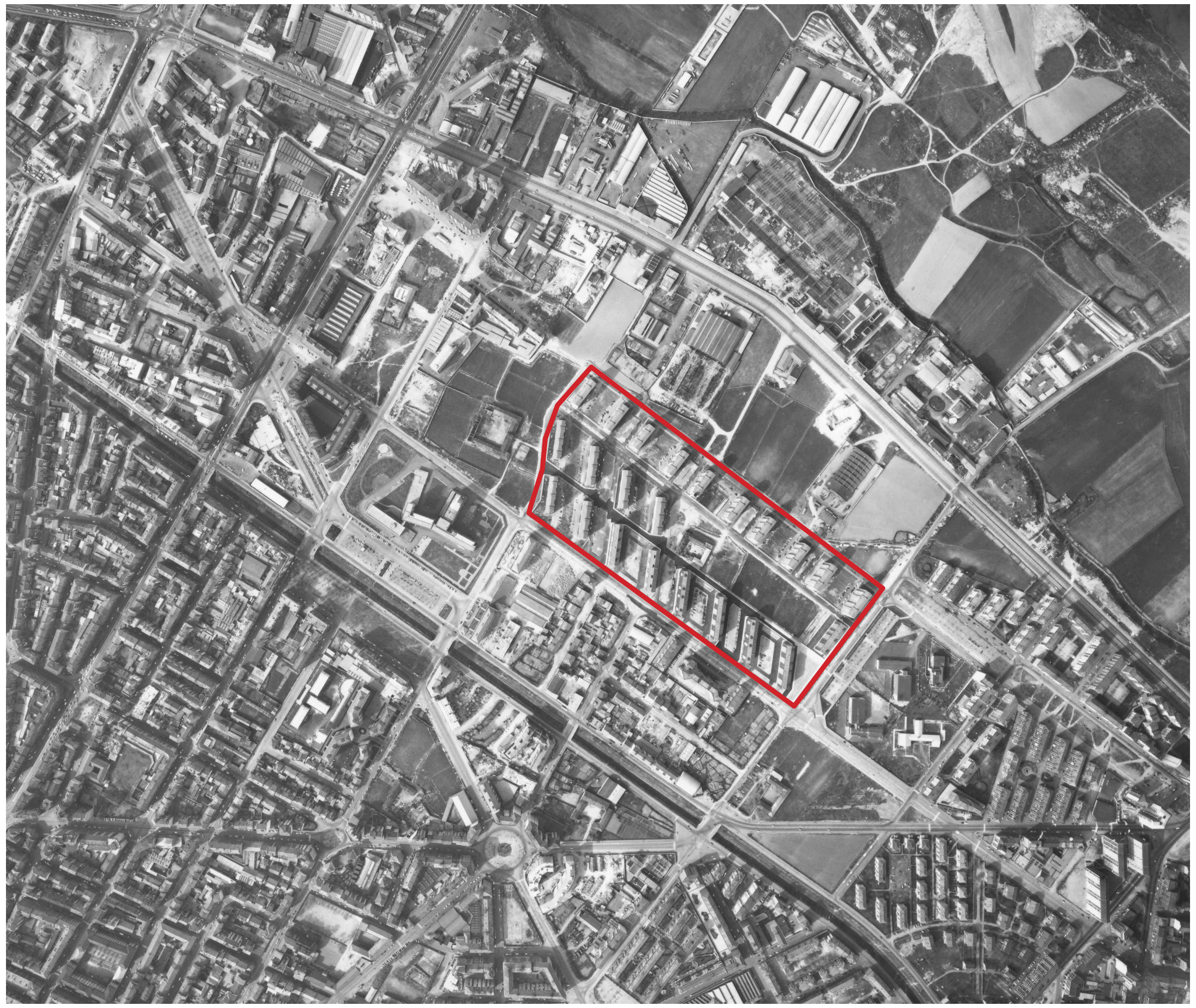


Figure 1.6: Map of the neighborhood 1968 (Archive of the City of Turin)

2 Venerdì 15 - Sabato 16 Ottobre 1965 STAMPA SERA Anno 97 Numero 243

CRONACA CITTADINA

Una selva di torrioni di 7 e 10 piani domina già corso Taranto

Nasce un «quartiere fungo»

La costruzione, con elementi prefabbricati, a tempo di record - I palazzi sono 16 e sorgono a strati: in soli 4 giorni pronte le strutture di un intero piano, quindi ciclopiche gru issano le pareti e si istallano gli impianti - Il nuovo villaggio (652 alloggi con 3561 vani) sarà autosufficiente - L'iniziativa è dell'Istituto Case Popolari: spesa, oltre tre miliardi e mezzo

Il siciliano condannato all'ergastolo davanti ai giudici d'Appello

Si gettò sulla "sposa bambina„ e l'assassinò con 12 coltellate

Ore 13,30: riconfermato dalla Corte il carcere a vita

Giuseppe Randazzo: la gelosia l'ha fatto impazzire?

Valle Susa: dal ministro la proposta delle banche

Oggi il curatore si incontra con l'on. Lami Starnuti (Industria) Lunedì la pubblicazione ufficiale della sentenza di fallimento

Anche in carcere la giovane si proclama innocente

Chi ha spinto la contabile nel carosello dei milioni?

Si cerca l'alloggio dove ogni sera avveniva la straordinaria trasformazione da modesta impiegata in ricca «ragazza di classe» - Non si esclude che le indagini portino a qualche colpo di scena

Figure 1.7: A newspaper from “Cronaca Cittadina” on 16 October 1965

“A “long neighborhood” is being built on the outskirts of Turin. The new neighborhood, built by the Istituto Autonomo Case Popolari, extends over a surface area of approximately 66 thousand square meters and is included in the “E-7” area of the urbanization plan; finished in the space of a week. Two enormous cranes that lift the prefabricated walls like twigs up to 15 meters in height help speed up the work. “This neighborhood,” declared the president of the Istituto Autonomo Case Popolari, lawyer Dezani, “will be self-sufficient because it will have shops, public services and security that will allow it to have a life of its own...” It will consist of 10 buildings with seven and nine floors, for a total of 540 apartments and 1988 rooms. Its cost is just over 13 billion and it will also be habitable in the spring of 1967.”

Corso Taranto was one of the seven neighborhoods that were produced with a technology adapted from French prefabrication patents of a heavy industrialization system that was new to the building sector. The speed of the process was truly impressive-prefabricated panels were swiftly lifted with cranes and laid on rails to install the cores of the buildings. Simultaneously, different phases of each building were installed, with one team working on the upper floors while another installed the heating and plumbing services on the completed floors. This simultaneous approach ensured that the apartments were finished in a remarkably short time.

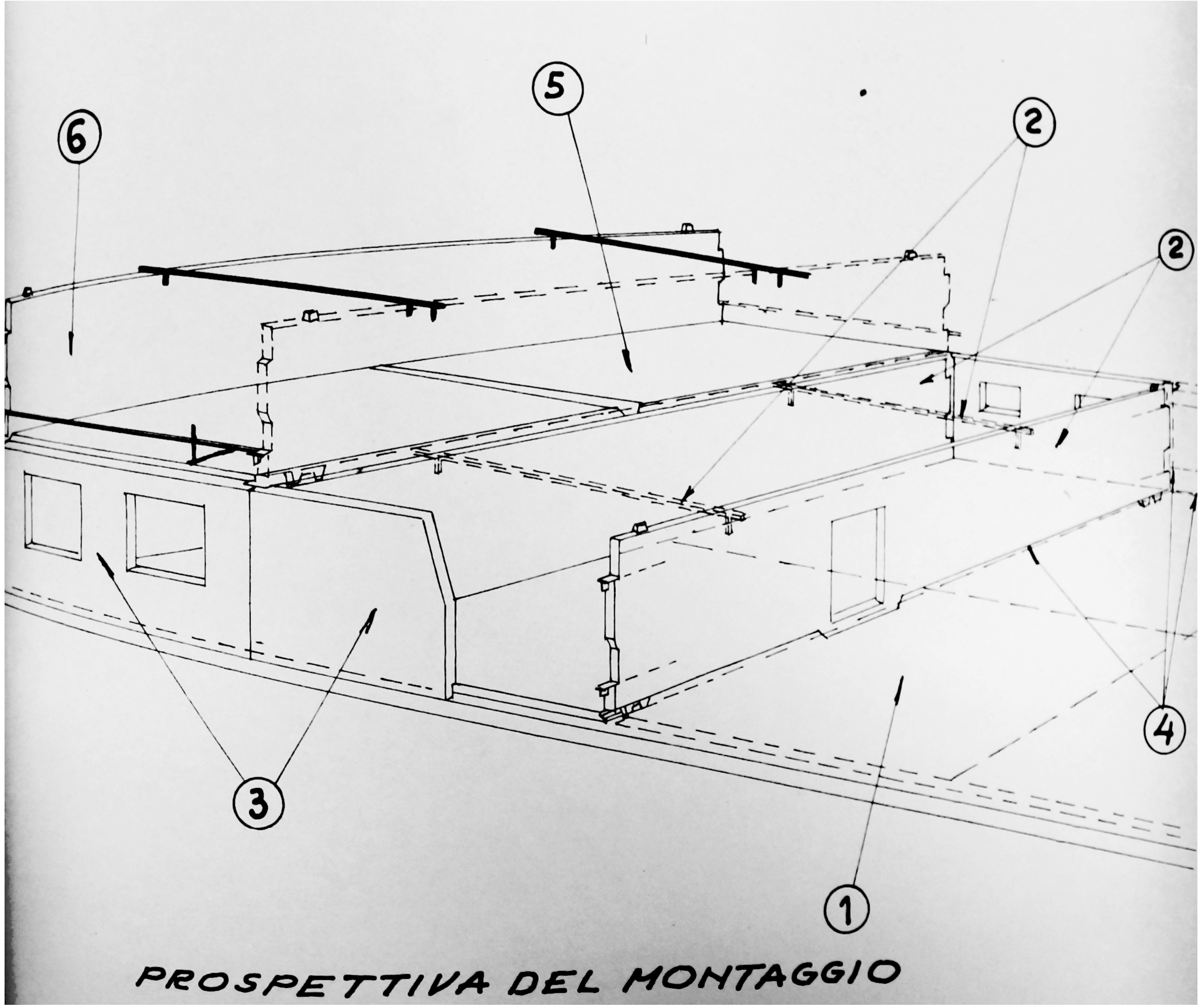
Photo showing installation and construction process, taken from ATC archive.

(from ATC archive)

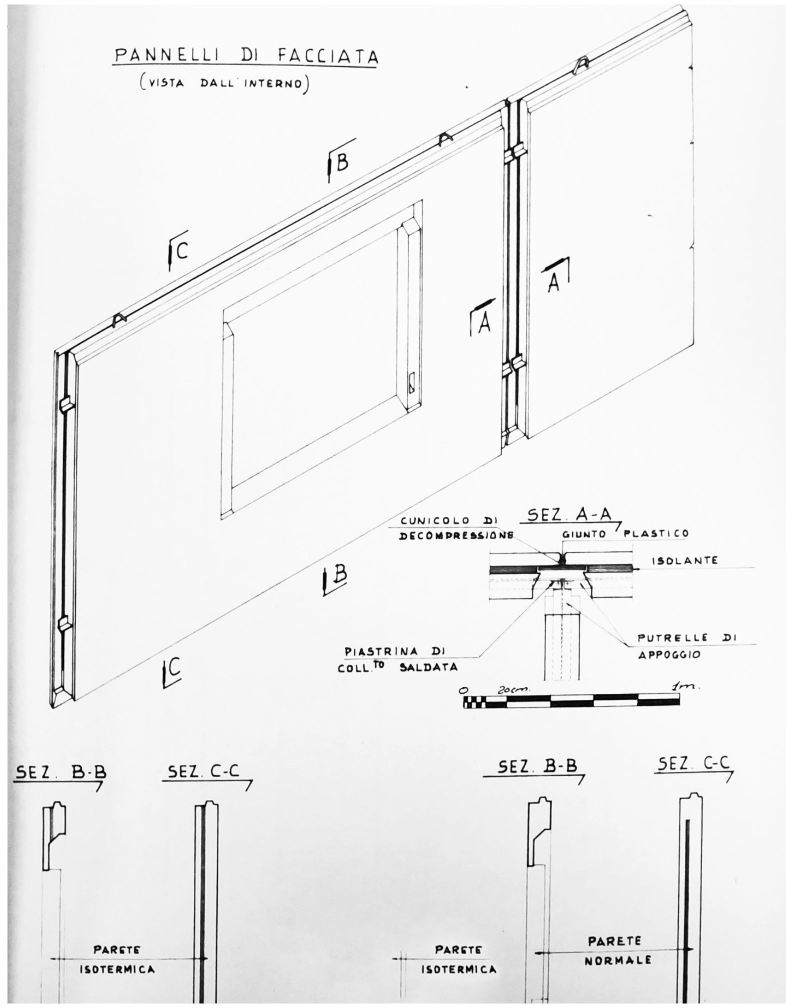
(from ATC archive)

(from ATC archive)

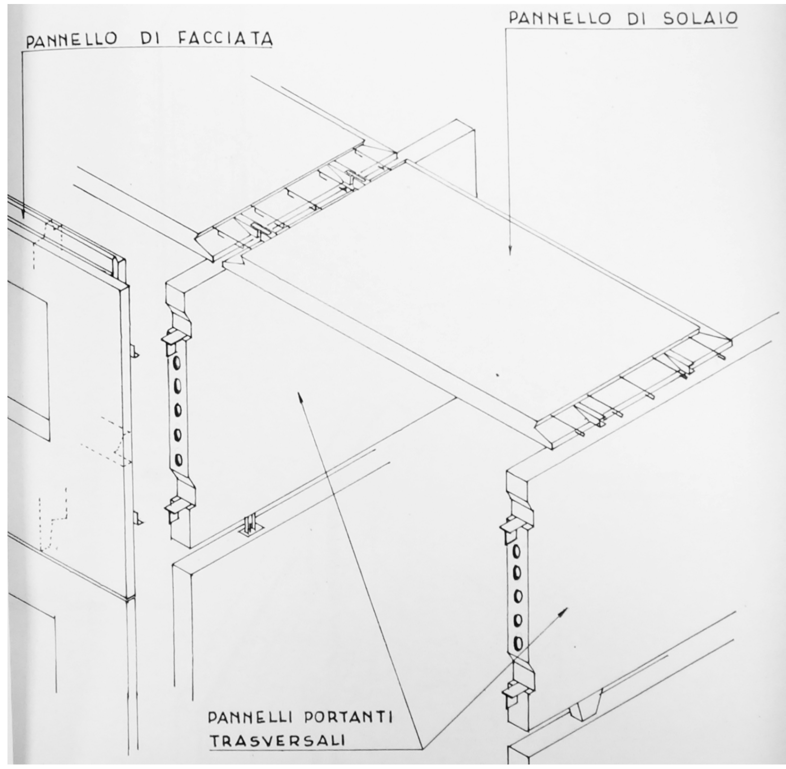
(from ATC archive)



Perspective drawing of the prefabric panel assembly (from ATC Archive)

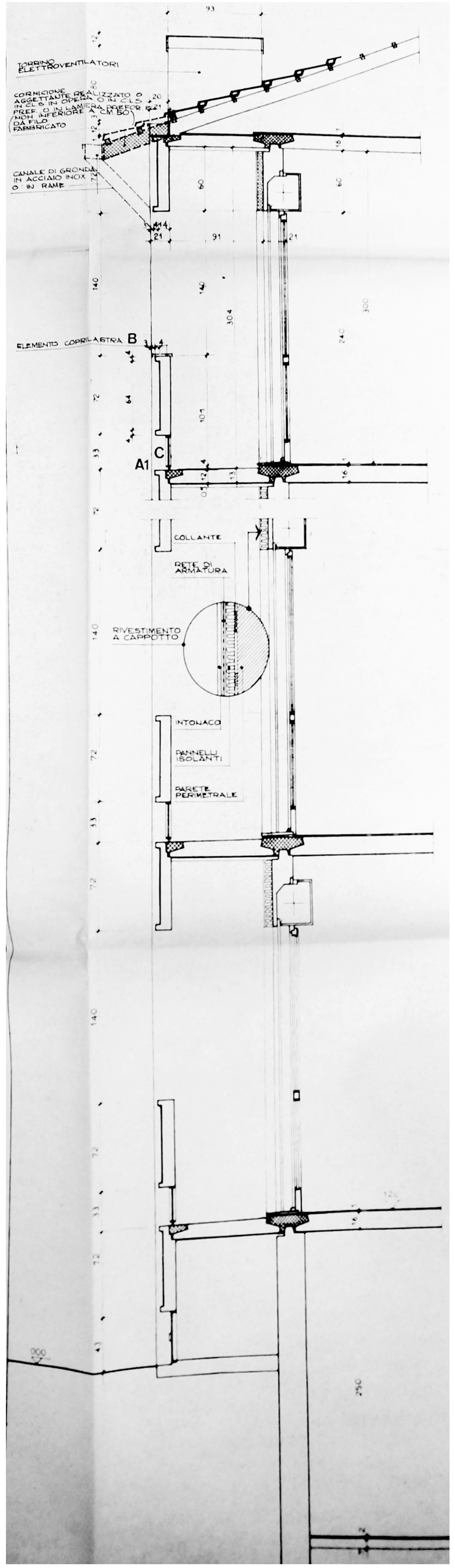


Isolated assembly of the insulated façade panels (from ATC Archive)



Isometric drawing of the prefabric façade and ceiling panel assembly (from ATC Archive)

Front Façade Drawing of the building Type-D on March 1964 (from ATC Archive)



Whole Building Detail Section Drawing on July 1985 (from ATC Archive)

1.3.2 “Fast” But Cramped

These houses were promised to deliver improvements for families who mostly come from very disadvantaged situations. The residents of the neighborhood were from families of Calabrian, Sicilian, Lucanian, Campanian, Venetian, Piedmontese, Apulian, Molisan, Abruzzese, Sardinian, and Tunisian origins.(Angeli, Castrovilli, & Seminara, 1998)

Areas of Birth by Region	Values by Percentage (%)
Abroad	7.85%
Northern Italy	29,17%
Central Italy	1,54%
Southern Italy	61,84%

Table 1.8: Population of Corso Taranto above 21 years old by birth locations (Angeli, Castrovilli, & Seminara, 1998)

Regions of Origin	Values by Percentage (%)
Puglia	27.47%
Sicilia	11.91%
Calabria	10.22%
Basilicata	5.48%
Veneto	5.35%

Table 1.9: Population of Corso Taranto above 21 years old by regions of Italy (Angeli, Castrovilli, & Seminara, 1998)

As mentioned before, the number of inhabitants exceeded the number of provisions. This led to an increase in the ratio between inhabitants and infrastructure services planned, resulting in worsening living conditions that were already inadequate. With the birth of the neighborhood, people who came from different regions learned to live in an urban agglomeration built to respond to the housing emergency. They soon had to face the lack of many services.

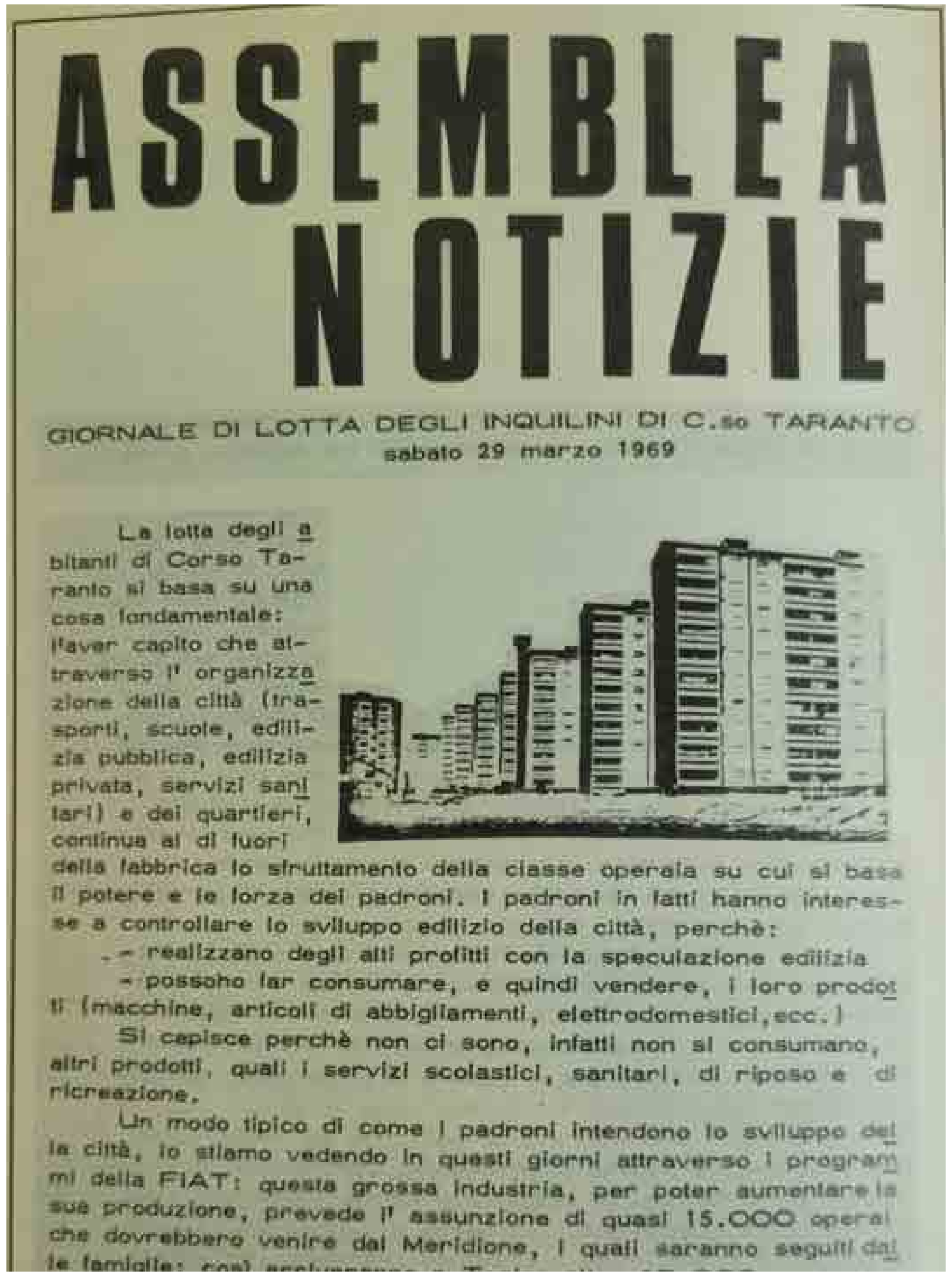
Number of individuals	Amount	Percentage (%)
0	1	0.10%
1	2	0.20%
2	21	2.09%
3	102	10.14%
4	226	22.47%
5	253	25.15%
6	170	16.90%
7	121	12.03%
8	58	5.77%
9	31	3.08%
10	10	0.99%
11	7	0.70%
12	1	0.10%
13	2	0.20%
14	1	0.10%
TOTAL	1006	100.00%

Table 1.10: Family units by number of individuals of Corso Taranto District in 1971 (Angeli, Castrovilli, & Seminara, 1998)

According to the table 1.3.4, the average value of the nuclei seems to be 4 to 6 people, which even reaches out to 14 people in one family. Authors discuss that the number of larger families would be higher considering the transparency of responses. If the dwelling typologies thought, the maximum room number for dwellings is three rooms (2 single rooms with one master bedroom), number of individuals in a family is a lot more than the limit of the dwellings.

The crowding index is not one inhabitant per room but larger, and the meter square greenery ratio, which should ideally be in line with what law 167 foresees, is less than the expected standard. Despite the IACP collecting a significant amount of 350.000 lira per month from the residents for public space maintenance and gardens, these areas are left to deteriorate, placing a financial burden on the residents without receiving a service.

1.3.3 Inadequate Infrastructure



ASSEMBLEA NOTIZIE

GIORNALE DI LOTTA DEGLI INQUILINI DI C.so TARANTO
sabato 29 marzo 1969

La lotta degli abitanti di Corso Taranto si basa su una cosa fondamentale: l'aver capito che attraverso l' organizzazione della città (trasporti, scuole, edilizia pubblica, edilizia privata, servizi sanitari) e dei quartieri, continua al di fuori della fabbrica lo sfruttamento della classe operaia su cui si basa il potere e la forza dei padroni. I padroni in fatti hanno interesse a controllare lo sviluppo edilizio della città, perchè:
- realizzano degli alti profitti con la speculazione edilizia
- possono far consumare, e quindi vendere, i loro prodotti (macchine, articoli di abbigliamenti, elettrodomestici,ecc.)

Si capisce perchè non ci sono, infatti non si consumano, altri prodotti, quali i servizi scolastici, sanitari, di riposo e di ricreazione.

Un modo tipico di come i padroni intendono lo sviluppo della città, lo stiamo vedendo in questi giorni attraverso i programmi della FIAT: questa grossa industria, per poter aumentare la sua produzione, prevede l' assunzione di quasi 15.000 operai che dovrebbero venire dal Meridione, i quali saranno seguiti dalle famiglie: ...

Figure 1.11: Copy of "Assemblea Notizie" newspaper edited by the tenants comitee and published in 29 March 1969 (Angeli, Castrovilli, & Seminara, 1998)

" Almost three and a half years have passed since we came to live in the Taranto neighborhood, we left behind some unpleasant situations and arrived in this new neighborhood, with the hope of improving our condition.

A disappointed hope, since the accommodations, although better than those we came from, did not meet and still do not meet the needs we have. "

Residents soon brought up the lack of services (Fig 1.12), complaining about the exploitation of the workers by the company they were working for. Specifically, FIAT was earning significantly a lot and thinking of increasing its workforce by thousands of people and expecting more without changing the existing workers' life standards.

In the early years of the neighborhood, between the '60s and '70s, Fiat provided employment to most of the local workforce, attracting more people from other regions of the country. However, this led to the need to ensure various services, including those that may seem less important but were essential for urbanization and the proper organization of the workforce. In the end, workers were not just numbers but were people with families and needs. Surprisingly, the inadequacy of the infrastructure was not new in the neighborhoods that are built as 'ghetto' districts that are built by Law 167. Neighborhoods were seen as needing to shelter the people coming from the South as fast as possible, but architecture and quality of life were ignored. Infrastructure was missing, and neither the interior nor the furnishing was sufficient. Even after the construction, there were already complaints related to the prefabricated construction. Residents complained about the walls' swelling and dampness, which led to the external layers falling to the floors (Garda & Mele, 2016).

Additionally, many other problems were increasingly felt, such as the lack of school services and transport, the inadequacy of areas equipped for children, and the lack of a shopping center, sports centers, and meeting places for young people and adults. Since the birth of the neighborhood, all this coagulated the protest and the demands of the inhabitants. There were no services such as shops, doctor, meeting or recreation facilities like sports fields, bus services, or schools.

" *Finally, around 1969 or 1970, we managed to get a small market in via Mascagni, between via Cilea and via Tartini."*

"The doctor arrived between 1968 and 1969 on via Pergolesi," Marino recounts, "and little by little, families started going to the doctor, who was soon forced to keep his practice open until midnight, with a line stretching along the sidewalk. "

★ TORINO SETTE GIORNI ★

Importante piano di ampliamento della rete urbana

Finalmente tutta la periferia sarà servita dalle linee ATM

Interessate le zone all'estremo sud, a sud-ovest, e a nord-ovest - L'Azienda Tramvie ha avuto la collaborazione dei «Consigli di quartiere» - Sono otto i provvedimenti più importanti - Una linea attorno a tutto il Cimitero generale

Una giornata regionale per il clero

I problemi dell'ecumenismo

Sarà resa libera l'attuale area di corso Inghilterra

A marzo il mattatoio nuovo

L'importante complesso sorge nei pressi di Venaria - Si articola su 180 mila metri quadrati - L'opera è costata 4 miliardi - Dal mercato bestiame alla lavorazione completa - Sarà possibile anche svolgere un'azione calmieratrice dei prezzi

Problemi della periferia sottoposti alle autorità responsabili

Contestano un nuovo caseggiato per poter salvare un poco di verde

L'episodio riguarda la «zona 33» di corso Taranto - Incontro tra pubblici amministratori e i membri del «Consiglio di quartiere» - Un'esperienza democratica che va incoraggiata

Incontro zonale con l'Arcivescovo in Duomo

Notiziario A. C.

Ingresso parrocchiale a Maria Ausiliatrice

Figure 1.12: Torino Sette Giorni newspaper published in 18 December 1968 voicing the comitee's critiques about limited acessible green area of the neighborhood if the provisioned extra building would be built.

A resident mentioned in the Fedele & Darchini(2016) published by the ATC, talked about the services that arrive later after they reside:
Faced with these challenges, a tenants committee was formed to represent the residents' concerns to the relevant authorities. The committee wasted no time and immediately began addressing the most pressing issues: transportation, housing quality, and the need for a nursery school for workers' children. They organized public meetings, distributed leaflets, and sent letters to the mayor, political parties, newspapers, and the IACP, demonstrating their commitment to improving the neighborhood. As an example, one of the issues was that it was planned to add a new 7-story high building to occupy more people, which was currently a green area (which was already inadequate compared to the square meters per person).

The committee's actions resulted in the road being paved, public lighting being improved, a shopping center being built on Via Tartini, and a community center being created at Via Mascagni 20. The residents of Corso Taranto's actions in these areas likely helped keep the neighborhood alive and showed their commitment to implementing projects at their 'homes.'

1.3.3.1 The Heating Problem

In 1979, some residents began to install wall-mounted boilers illegally. The reasons why residents were using illegal boilers were the same as today's reasons. They could not keep up with the prices of the gas. Residents who were using the central heating without the illegal boilers were also questioning the service quality since the prices were increasing. Residents even checked the tunnels where the central heating pipes were located to make sure the insulations were well made.

Nevertheless, the problem was mostly in line with the type of "fast" construction that was done in 1969. Since buildings were made of prefabricated concrete panels, thermal dispersion was inevitable due to the lack of cladding as well as insulation. In 1985 detail sections documented from ATC archive (Fig. 1.13, Fig. 1.14), we can observe that ATC conducted extraordinary maintenance work that consisted of cladding and insulation of the façade, restoration of the panels and joints, as well as the roof section alteration due to leakage problems.

1.3.3.2 Changes after 2000's

Among these changes, we must note the lowering of income compared to rising prices, inflation, and job insecurity that have occurred for families who have recently been assigned public housing by the Municipality. This meant that the priority for these families was naturally aimed at finding a way to make ends meet. As a result, the attention and perception of the problems have changed, and this set of circumstances implies the difficulty in embracing broader issues relating to the neighborhood's services, even if the attention to the immediate maintenance needs remained. In the 2000s, there was naturally an upkeep challenge for buildings since they were more than thirty years old.

The funding for the renovation of the old buildings was provided by the Piedmont Region with the Regional Operational Program "Competitiveness and Employment" of the European Regional Development Fund for the period 2007/2013. In this fund, the Piedmont Region identified "Sustainability and Energy Efficiency," targeting "Energy re-qualification of public buildings managed by ATC (Social Housing)." In 2010, the Region issued a call for proposals.

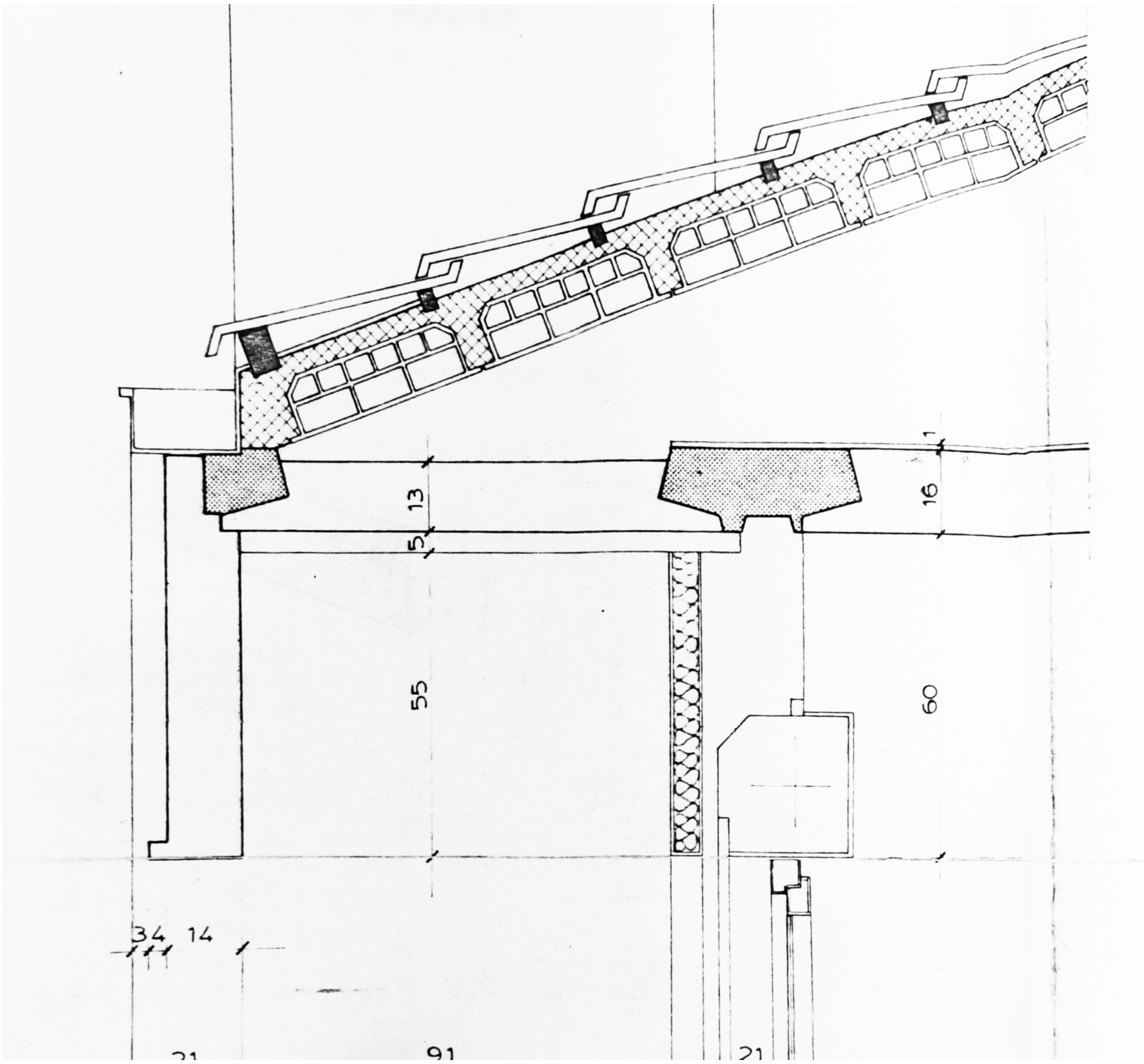


Figure 1.13: Detail Section of the roof before the extraordinary maintenance on 1985 (from ATC Archive)

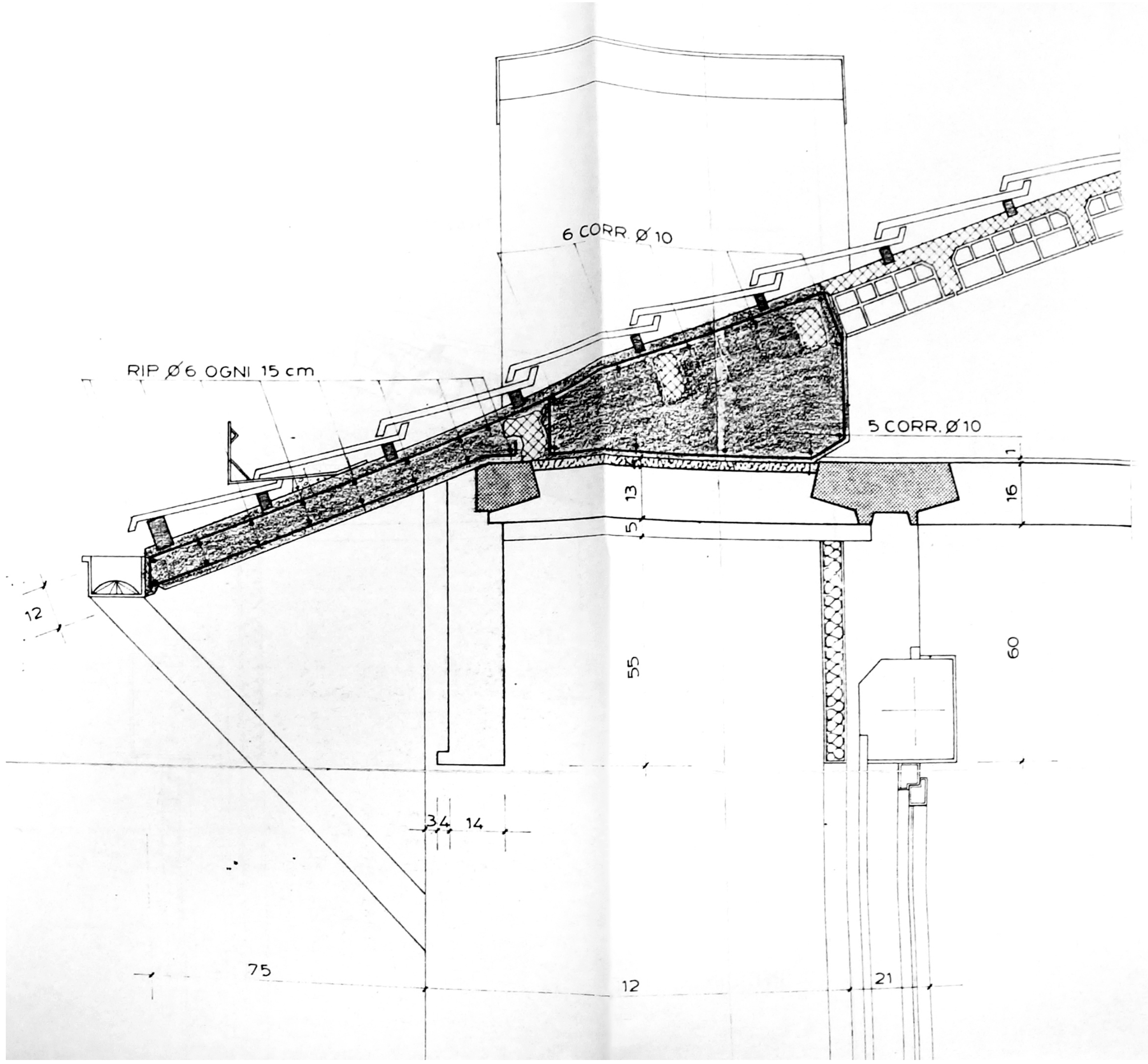


Figure 1.14: Detail Section of the roof after the extraordinary maintenance on 1985 (from ATC Archive)

In Corso Taranto, the project allowed for interventions on window fittings, insulation, and heating, as well as the establishment of a thermal power station and a district heating network. ATC refurbished the windows of the 16 buildings in the neighborhood and re-insulated the end walls of the north and south facades of the ten-story buildings along Corso Taranto. Before the work on the windows and insulation was finished, 2013 construction began on the district heating system. Financed by ATC, along with private funding, a co-generation heat production plant, a "neighborhood" district heating network, and solar thermal panels for producing domestic hot water were established. All work was completed by December 2013.

1.4 Corso Taranto - To Present

This chapter will show that current requirements closely resemble past needs and habits. This part will explore these aspects more thoroughly, extend the current picture into a larger concept that compass tangible and intangible sides such as various community issues, the diverse demographics within the neighborhood, and pressing matters related to energy consumption.

These points will create the main basis of the design strategy selection decisions and evaluations will be mentioned in the Chapter 2.

1.4.1 Flexibility (F)-*Sociodemographic Needs*

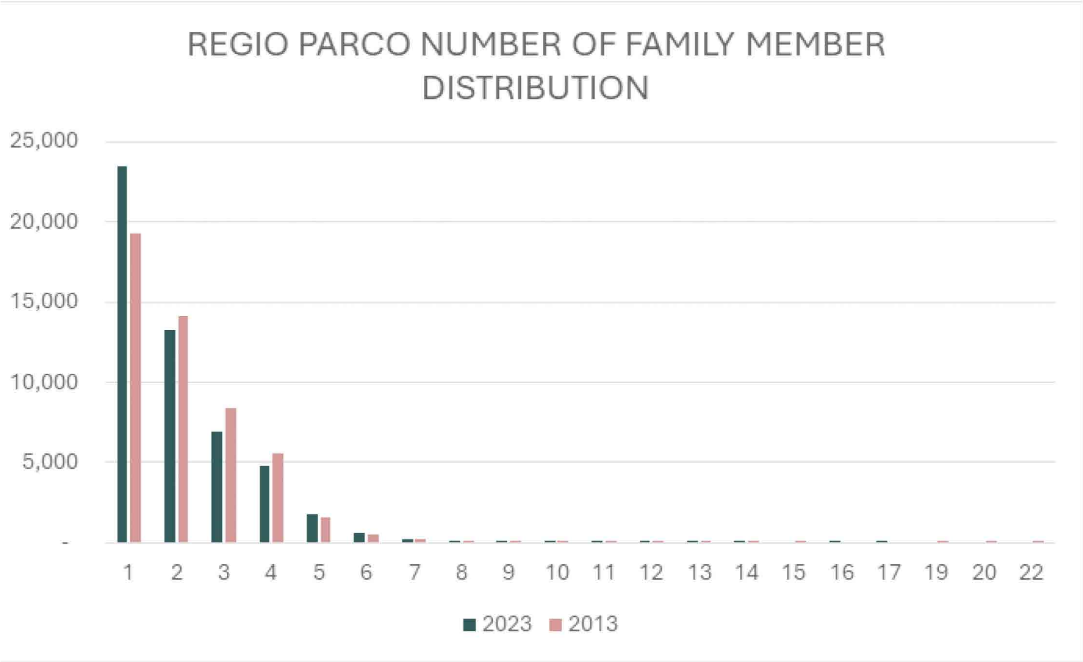


Figure 1.15: Family unit change in 2013 and 2023 (Istat)

There is an increasing need for social housing in the Piemonte region, especially in Torino.(Fig. 1.16) However, the number of assignations to houses is not enough compared to the need for housing. There is still a need for social housing, and according to the observatory in Torino, it is increasing by year. There is an urgent need for additional accommodation units in existing publicly owned social housing neighborhoods to close the gap between them.

Thus, the first design action should not disregard the dwelling structure combined with current demographics. Specifically, for the Corso Taranto case, as previously mentioned, the number of 'nuclei' (families or households) members was around 4 to 6 people. So, the dwelling units were built according to large family structure. However, in the current situation, according to the data from the Commune of Torino, we can observe that most of the nuclei consist of 1 or 2 people, and the percentage keeps increasing. For example, the living rooms with large dining tables created for large families in the past now need a changeable arrangement and flexible program when considered as shared flats rather than tables in line with the demands of common areas. As the number of people in need of social housing increases, instead of 2- and 3-room houses, it is an inevitable solution to think about 1-room or studio flats and shared house plans. Thus, the dwelling should respond to the needs of the people through the years. This leads to the first consideration of social housing: flexibility. However, a design cannot foresee every aspect of the use. Therefore, the action that needs to be taken should also be spatially flexible to leave space for multiple scenarios.

Province	N. of People
Alessandria	805
Asti	614
Biella	431
Cuneo	1463
Novara	1101
Torino	8721
Verbania	607
Vercelli	262

Figure 1.16: Unsatisfied demands for social housing in 2023 per province (L'Osservatorio Abitativo Sociale della Città metropolitana di Torino,2023)

	2012	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*
Domande insoddisfatte di casa popolare	21.522	22.947	22.532	22.731	25.584	26.037	24.332	22.983	15.593	13.900	13.738	14.004
Assegnazioni annuali	1.689	1.972	1.674	1.723	1.550	1.580	1.595	1.257	927	1.443	1.309	1.040
Grado di soddisfacimento annuale	**7,8%**	**8,6%**	**7,4%**	**7,6%**	**6,1%**	**6,1%**	**6,6%**	**5,5%**	**5,9%**	**10,4%**	**9,5%**	**7,4%**

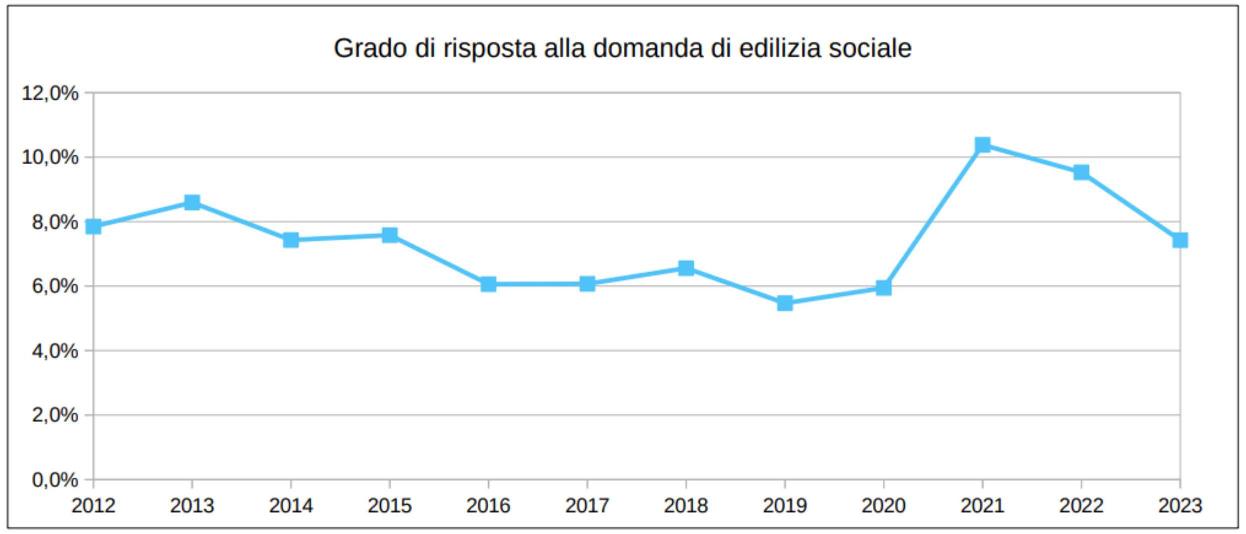


Figure 1.17: Unsatisfied demands for social housing from 2012 to 2023 in Piemonte region (Report of Osservatorio regionale condizione abitativa)

1.4.2 *Communal (C) Needs*

Community activities are still active and present in today's neighborhood. There are many various activities planned in the community center.

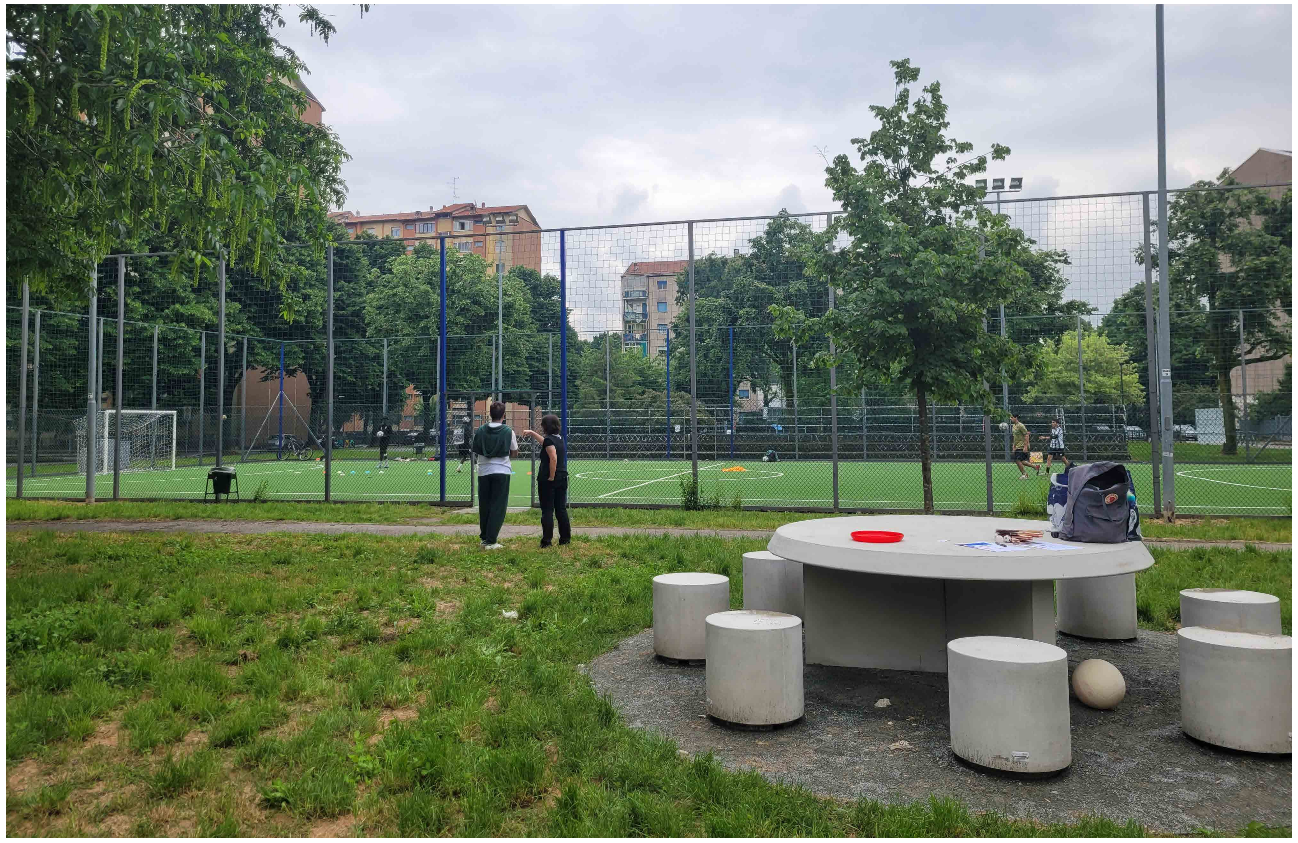
There are various courses for different user groups.
The neighborhood is still a multicultural zone. Therefore, in the community center, many cultural activities are held, especially for foreigners. A few examples: Arabic course mainly for minors to teach Italian, Piedmontese dialect theater, folk dances, country, hip hop, aerobics, Latin American dance, enjoy dance, Zumba fitness, women's group dances, martial arts courses…

The community center is not just for foreigners; we also see that as the population ages, there is a need for communal semi-close or indoor spaces to be introduced for older people. Today, older people's need for indoor spaces where they can spend their time and socialize is met only by the community center.

" In the neighborhood, the community center is the only reference point for the elderly. Here, they can meet to play cards and chat in friendship, and over the years, outings have also been organized. When the center was established, there was also a polyclinic with nurses providing basic care, while more recently, we hosted a tax assistance service to allow the elderly to have an additional service nearby and avoid traveling too far. We also offer a gym class for the elderly. "
-one of the tenants and committee member
(Fedele & Darchini 2016)

(Photo taken by Author)


(Photo taken by Author)



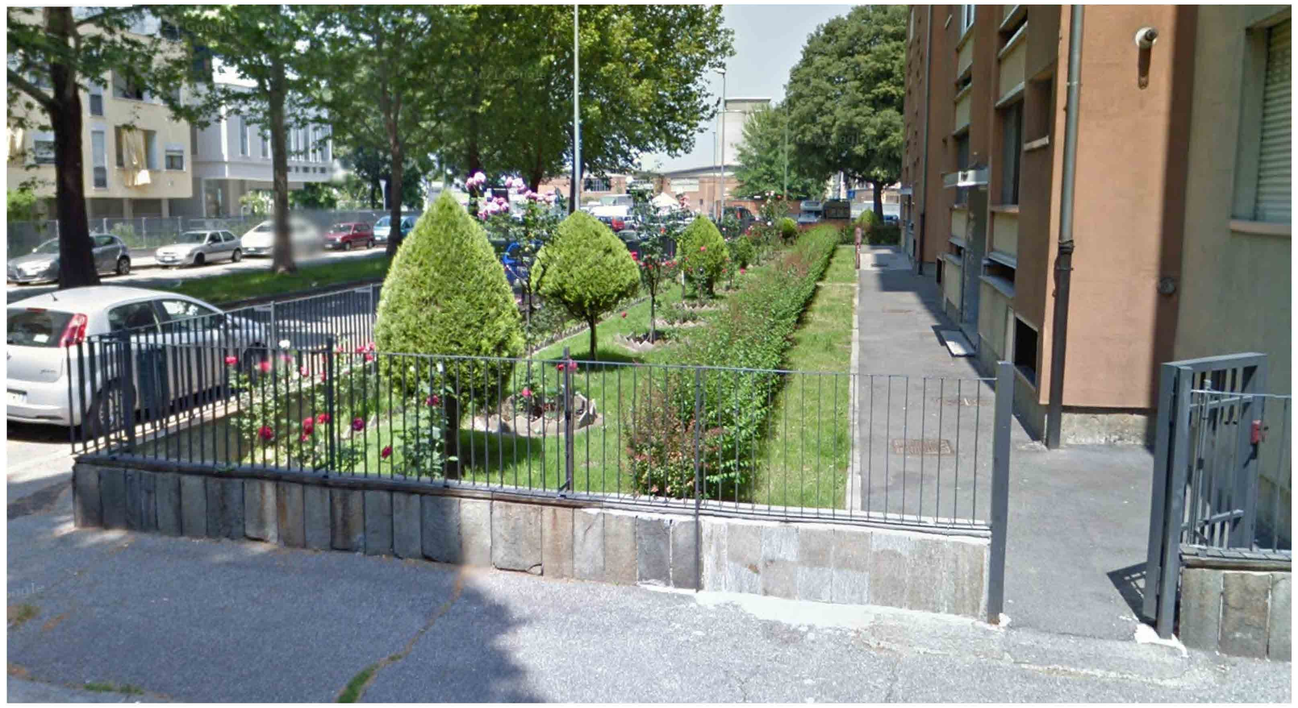
(taken by the *Author*)

(taken by the *Author*)

(taken by the *Author*)

This community consciousness is not only visible in the community center. When we walk through Corso Taranto, we can observe a tendency to alter various spaces privately and publicly to shape their homes according to their needs.

People in the neighborhood created their own community gardens and parks to enjoy. Together with these observations, we could conclude that the neighborhood actively uses and needs communal zones.



(from Google Maps,2024)

1.4.3 Energy Poverty (E) in Corso Taranto

Neighborhoods and especially social housing blocks are exposed tc risks of climate change. The less opulent the neighborhood, the r they are fragile towards changing and increasing energy prices. Fur more, we cannot deny the fact that the Corso Taranto neighborhoc located in one of the poorest districts of Torino.(Fig. 1.20)

As can be observed from the protests in front of the ATC on the news nearly in all ATC neighborhoods, tenants are dissatisfied with the b ings being cold and still cannot keep up with the energy prices. Th not surprising considering that the data, according to their bilanco, is habituating half of the residents who earn less than 6000 euros year, which is highly below the average income.(Fig. 1.19)

ANZIANITÀ DI ASSEGNAZIONE

più di 30 anni = **26%**
da 10 a 30 anni =**47%**
meno di 10 anni =**27%**

NUCLEI con ISEE < 6000 EURO = 53%
NUCLEI con ISEE da 6000 a 10.000 EURO = 20%
NUCLEI con ISEE da 10.000 a 14.000 EURO = 12%
NUCLEI con ISEE > a 14.000 = 15%
NUCLEI composti esclusivamente da over 65 = 30%
NUCLEI composti esclusivamente da under 40 = 6%

IN TOTALE NELLE CASE IN GESTIONE AD ATC NELLA SOLA CITTÀ DI TORINO RISIEDONO 37.483 PERSONE

Figure 1.19: Assignation to ATC (Bilanco sociale,2017)

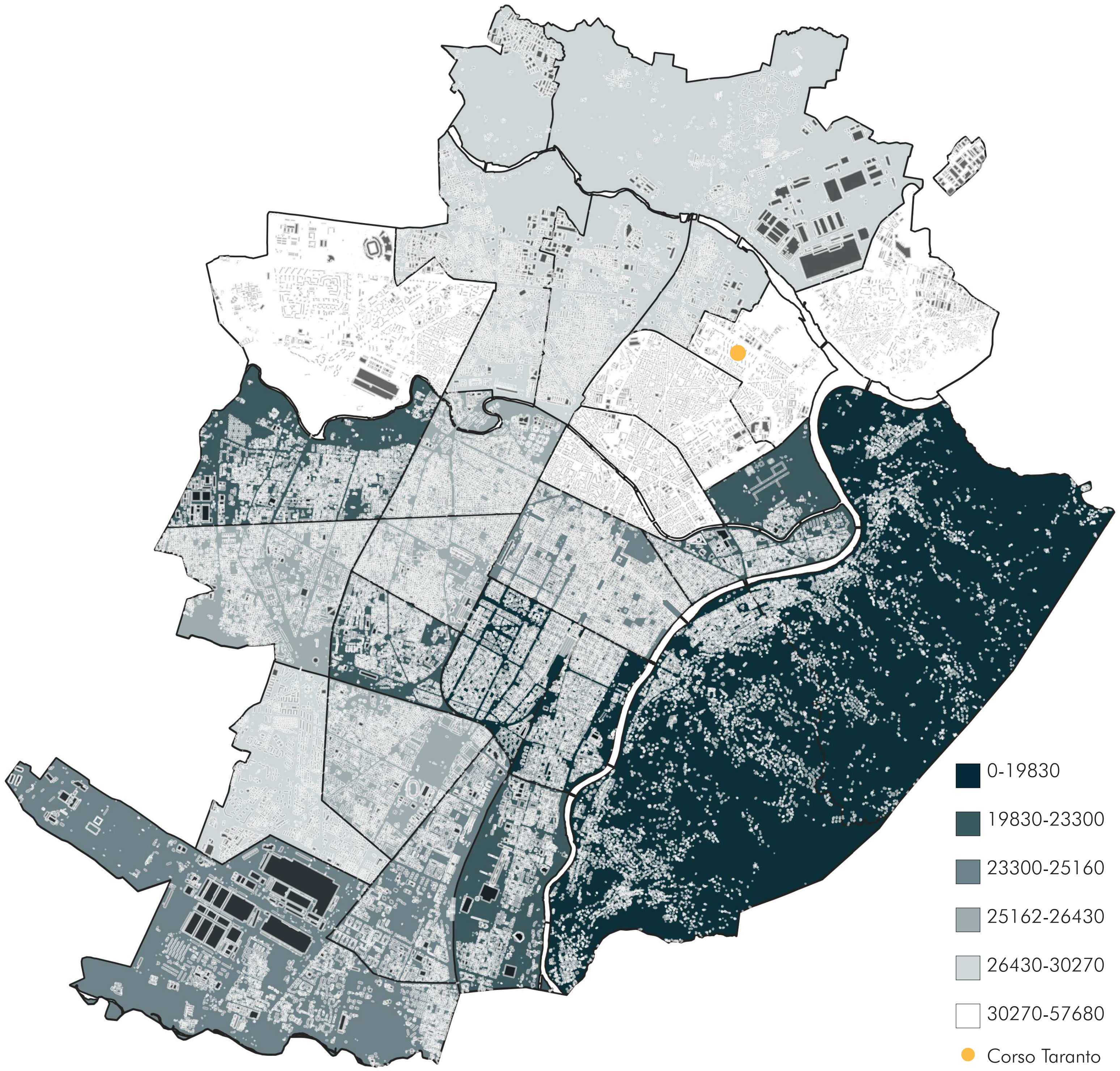


Figure 1.20: Median Income Per Year by Quartiere (francomostacci referenced from Dipartimento delle Finanze,declaration of income 2021)

Figure 1.21: A recent protest on 24 January 2024 related to heating bills was participated in by three different ATC neighborhoods complaining about the huge leap in heating energy prices compared to previous years. (Torino Cronaca,25 Jan 2024)

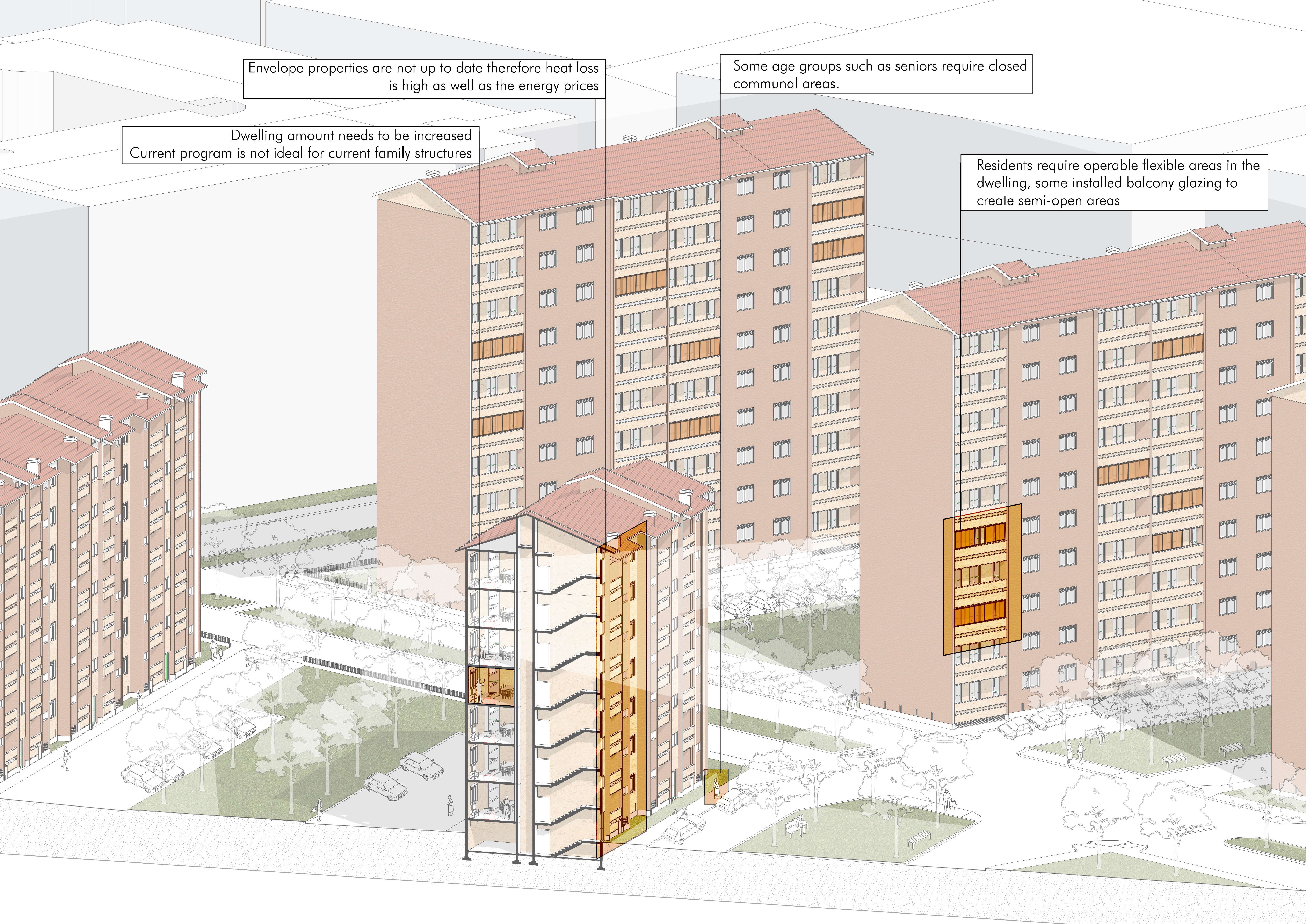
(taken by the *Author*)

There is also a perceivable need to transform balconies into semi-open flexible areas that add up to the spaces that can be usable in the wintertime. Residents could be taken as a reference for a design strategy. We can also think of these spaces as a buffer zone between the outside environment and use them as one of the solutions and benefits from its energy saving feature as well as respond to energy poverty.

1.4.4 Scalability (S)- *Spatial and Economical Feasibility*

All these syntheses should be taken into account together with the residents' perspective. Therefore, the solutions should be economically and spatially reasonable to the bodies vitalizing the regeneration actions (both public and private funding).

Another aspect while renovating the social housing buildings is baring in mind to avoid major interventions that would not drastically disturb residents that are already accommodating in the neighborhood. Therefore in the next chapter, selected case studies also taking into account of the residents while the interventions are conducted. This approach not only ensures the feasibility of the proposed changes but also demonstrates our understanding and empathy towards the residents' needs and concerns.


Envelope properties are not up to date therefore heat loss is high as well as the energy prices
Some age groups such as seniors require closed communal areas.
Dwelling amount needs to be increased
Current program is not ideal for current family structures
Residents require operable flexible areas in the dwelling, some installed balcony glazing to create semi-open areas

CHAPTER 2

Case outlook on the multi-scale regeneration strategies and reframing of the costs

The chapter is divided into two main chapters.

First one is analyzing the interventions done to residential blocks which are similar to the Corso Taranto by means of construction year and system. These are evaluated by means of architectural and socio-economical values.

Second sub-chapter delves into the cost and cost optimality to give a reference for the design strategy inteventions that could possibly applied in the thesis case study. The conclusion is gathered from the existing constructed renovations are from the academic papers to have comprensive idea of the cost-optimality in Italy and Europe.

Cases of 2.1
1_Refurbishment of Block G, H, I
2_Kleiburg - DeFlat
3_Du Lignon
4_Moerbosch
5_HBIM APUR
6_Woodside Multi Storey Flats
7_Croydon retrofit

2.1 Transformations through Architectural Focus

Methodology of the Selection and comparison

In order to develop a strategy for reducing energy expenses and meeting social needs, it is essential to examine various case studies. For this reason, seven distinct case studies have been chosen based on their unique solutions that may be applied to the Corso Taranto case. These examples are selected by means of their structural similarity, closeness in construction year, and mass typology. Then, since the design methodology is to create solutions that can be applied to 16 ATC buildings sharing two different dwelling typologies, examples are compared based on four different features that are later targeted at the end of the design process.

These are :
Flexibility(F): Consideration of changes in demographics or needs of the residents

Communal Versatility(C): Implementing communal areas and creating a community concept between social housing residents.

Energetic Sensitivity(E): Taking energy performance and energy costs into consideration

Scalability & Applicability(S): The feasibility of intervention depending on the economic funds and consideration of existing residents, and capability to adapt the solution to various scenarios or climate conditions.

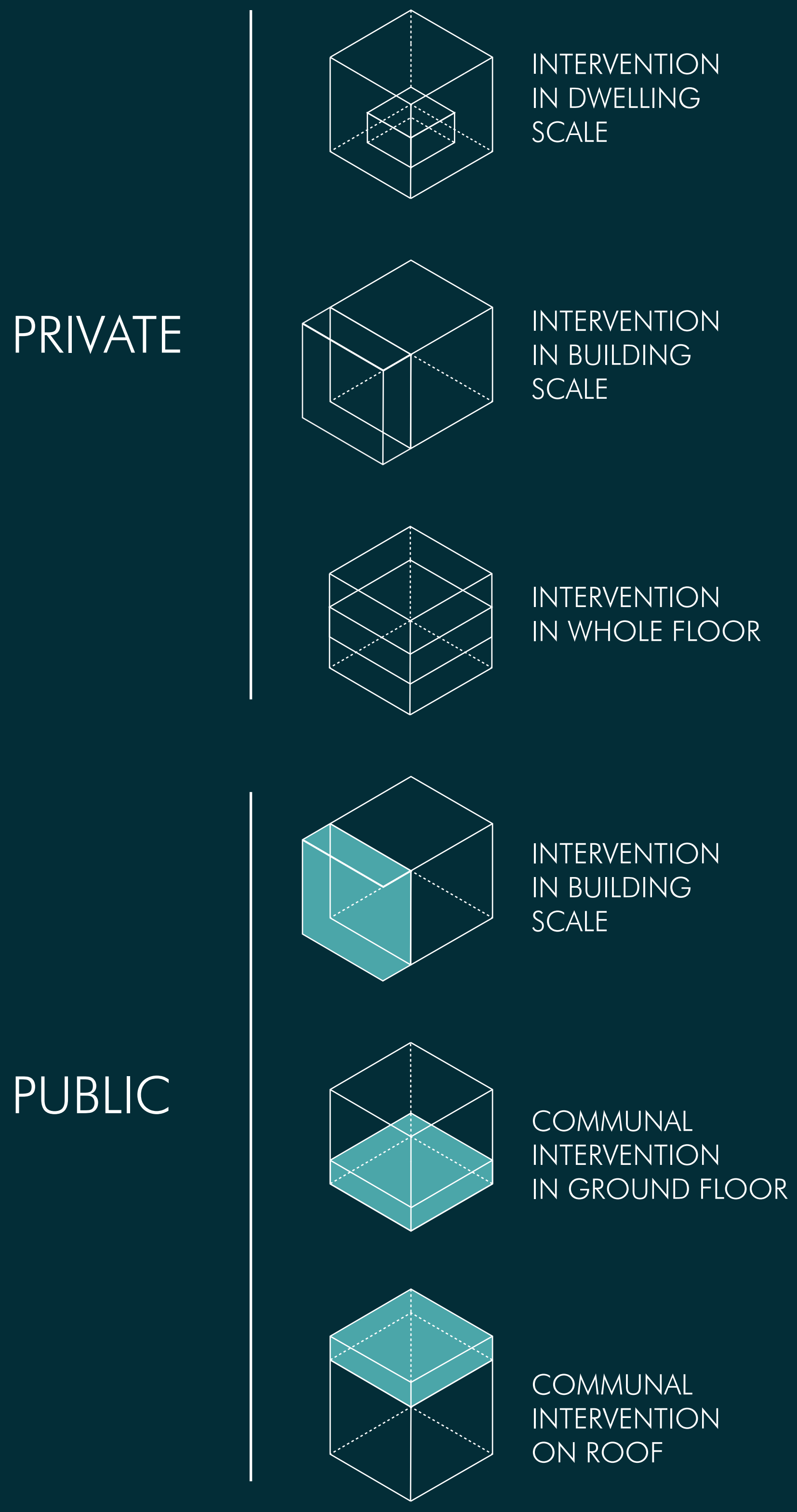
To compare the case studies, following charts are used for reference:

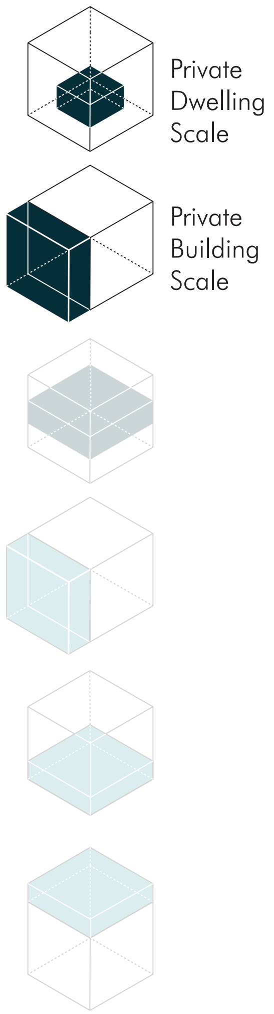
	F
0	not considered
2	considered

	C & E & S
0	not considered
1	considered
2	successfully implement-ed

F	Adaptive to various user groups Adaptive to future improvement
C	Communal Area Communal Dwelling
E	Enegy Saving & Performance Improvement
S	Residents remained Applicable to various sites Cost Funding

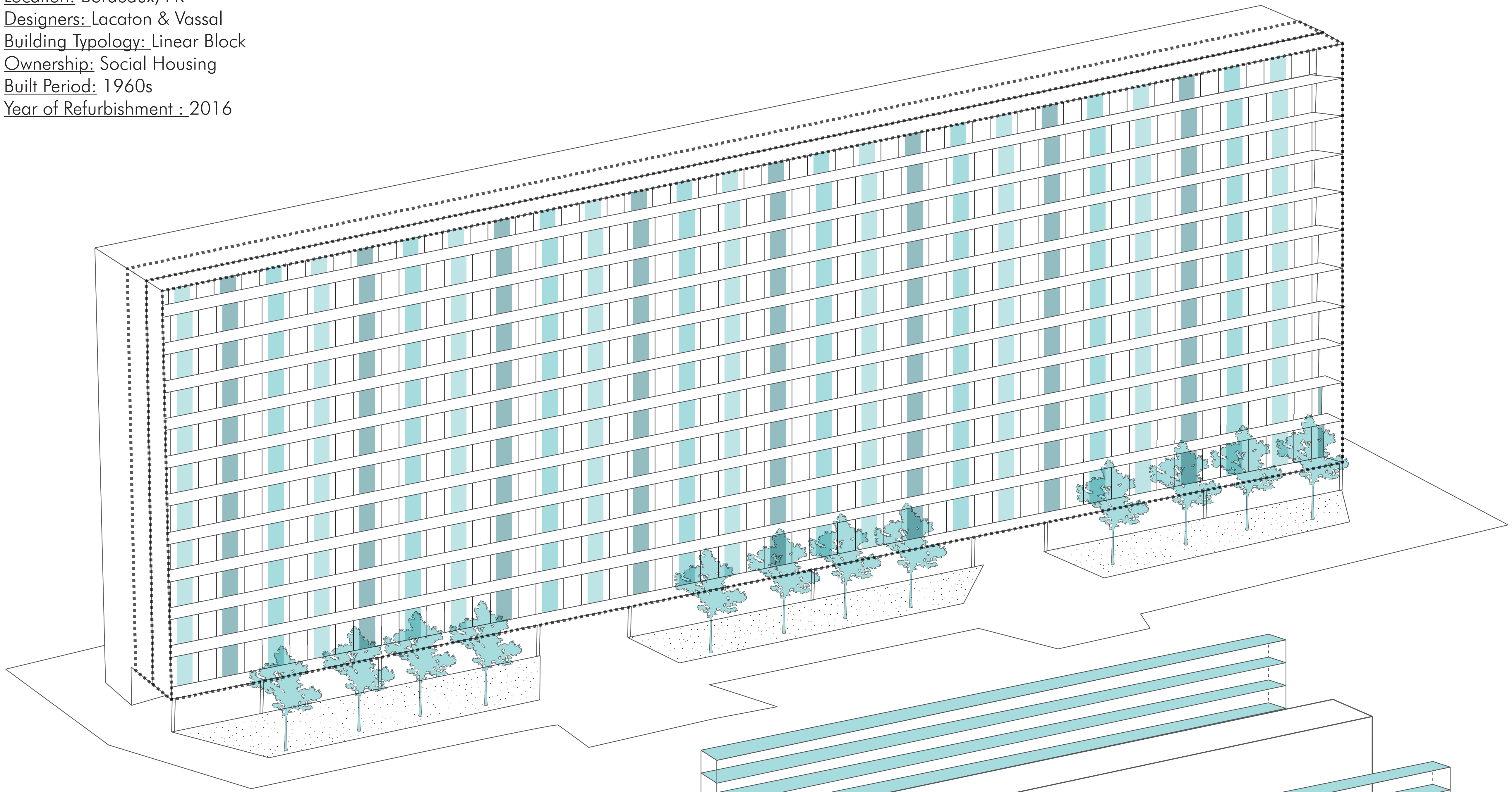
INTERVENTION CLASSIFICATION
ICON INDEX

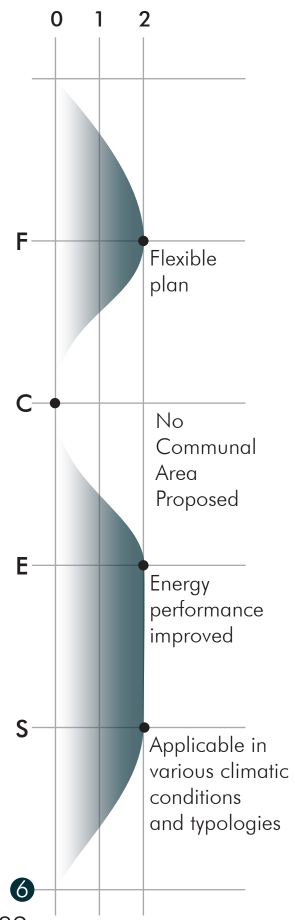




2.1.1_Refurbishment of Block G, H, I

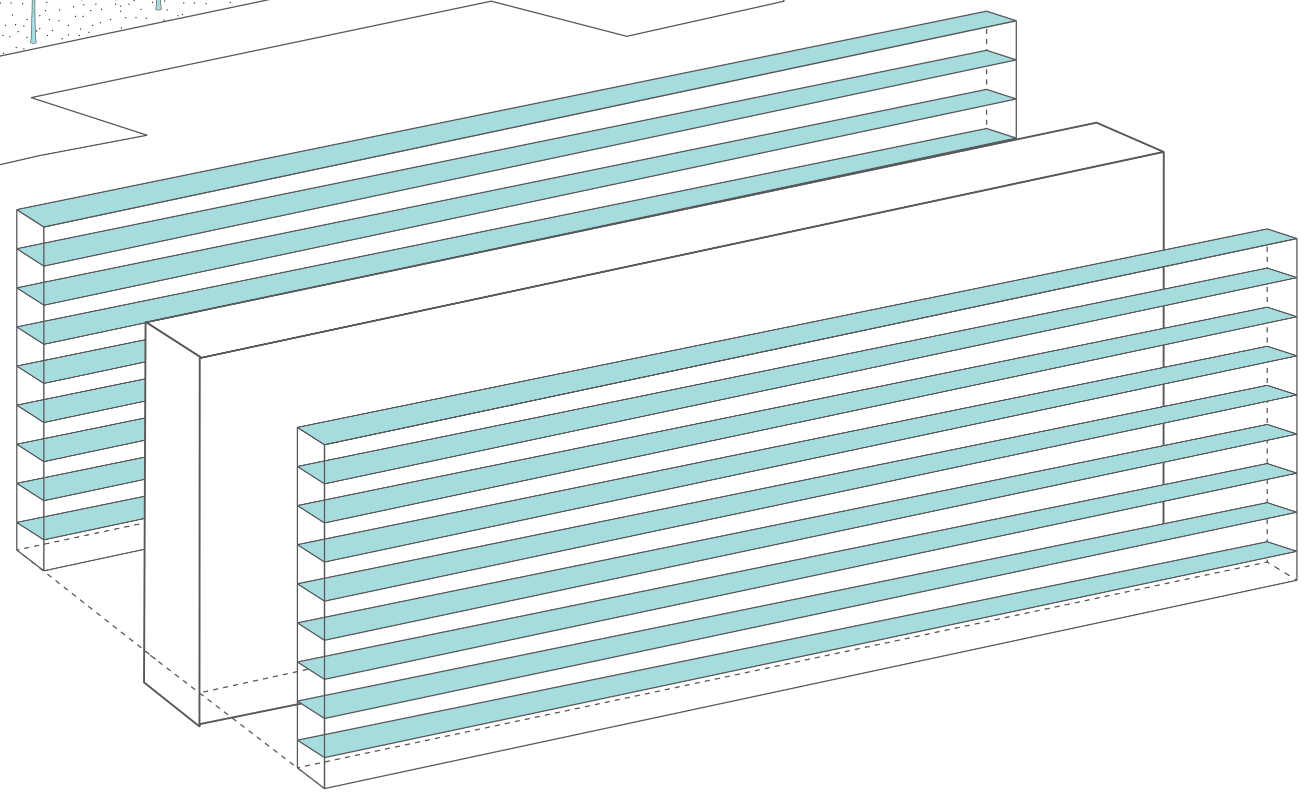
Location: Bordeaux, FR
Designers: Lacaton & Vassal
Building Typology: Linear Block
Ownership: Social Housing
Built Period: 1960s
Year of Refurbishment : 2016





Winter gardens & Façade enhancements

Addition of winter gardens and balconies to improve spatial quality, natural light access, and flexibility. Movable walls added to create adaptable, multi-purpose spaces. Increased dwelling quality and adaptability for future needs. Iconic exterior design enhancing the buildings' identity. Better comfort and utility for residents.



General Scope of the Refurbishment

The project focuses on the refurbishment of three social housing buildings, which are included in the first phase of a renovation program called 'Cité du Grand Parc' in Bordeaux. The buildings were constructed in the early '60s, and they have accumulated more than 4000 dwellings. The buildings named G, H, and I are 10 to 15 floors in height. The project focused on improving building and dwelling quality and comfort.

The design solution was to add a winter garden and balcony space on the exterior walls to create a better spatial quality of the dwellings by integrating natural light and flexibility in the plans. This solution also considers the conservation of the existing building without making significant interventions on the structure, existing floors, or the vertical circulation elements.The approach to the economic aspects of the interventions and the flexibility enhanced the effects of the new design for future decades and made room for the change in the following weather conditions.

From a detailed perspective, winter gardens and balconies created an adaptive semi-open space large enough to create a room for different purposes due to its dimension in width by 3.8 meters (Fig 2.1).For the building typology H and I, the design is used only in one direction and for the G building it is used for two opposite façades.

The renovation took place in the interior space and outside of the buildings. Bathroms are reconstructed and landscape next to the buildings are improved also by making it accessible. At the end buildings gained it own characteristic form on the exterior with providing a better quality in social housing dwellings.

Figure 2.1: Previous condition of the façade & after the new space extention[1]

Figure 2.2: Built living space extention types by the uses [1]

(F) Responsivenes and adaptibility to future scenarios

Refurbishment included movable walls. By this, dwellings are enlarged. Without a structural element separating, these spaces are used with different purposes by the residents depending on their needs. This enabled for different programs in the same addition. The introduced space also worked as a semi-open area for sedients to use.(Fig. 2.2)

(C) Consideration of different co-living & user group needs

The intervention is not considered any communal living units or areas for different demographic groups.

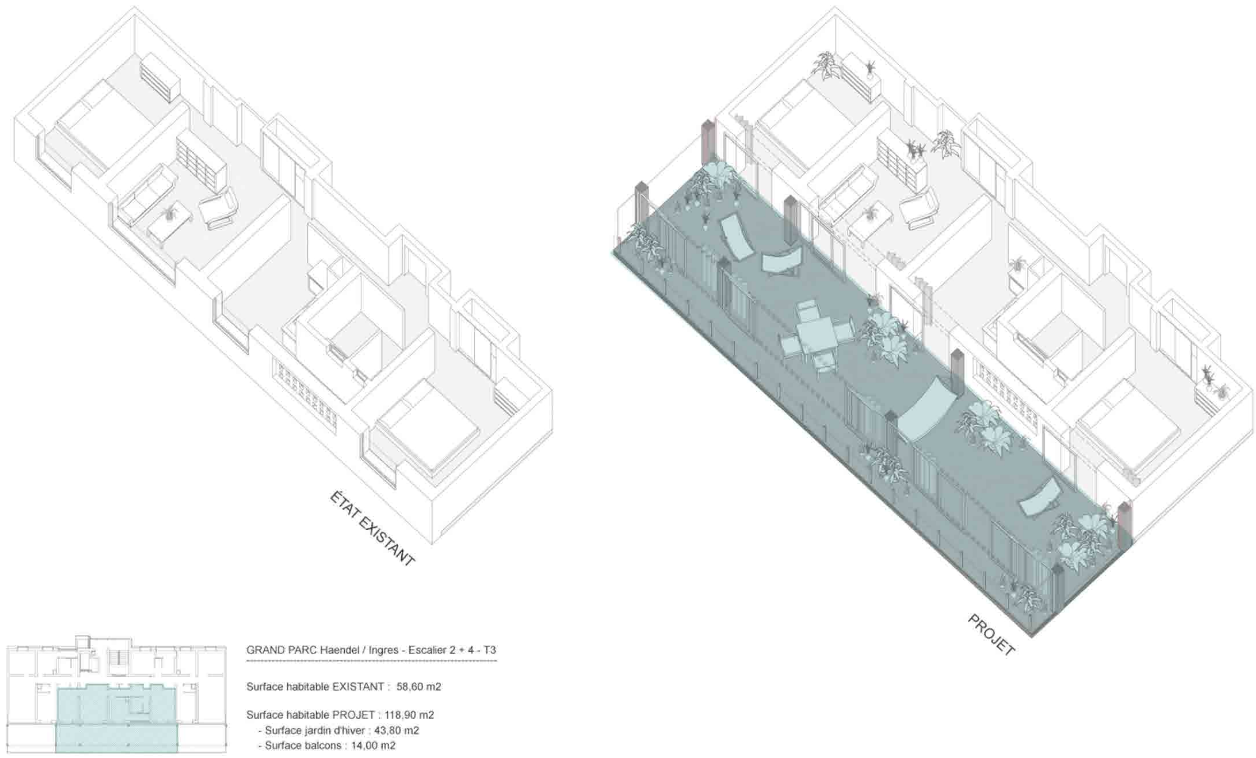


Figure 2.3: The intervention of the dwellings in the isometric view. [2]

(E)Energy sensitivity and performance improvement

Northern façade of the building is insulated and improved as performance according to the refurbishment year regulations. High performance glazings are also mounted to this façade. For the façade that had intervention of the balconies did not had additional insulation. Buffer area acted as a passive design improvement for the energy. In this façade, existing walls are not insulated but repainted as an interior wall. Glazing looking at the added space are did not renovated but left as it is for the visual connection.

(S) The economic feasibility & viability of the intervention and consideration of existing residents

During the transformation, management of the implementations were well planned. Firstly, exterior addition is constructed. The structure façade is constructed before dismounting existing glazing units and demolishing the walls that later create sliding openings.(Fig.2.4) Thus, accomodating residents did not need to move during the improvement. In the interior part bathrooms and walls are cladded and repainted but this process thought meticulously for not disturbing the residents everyday lives.
The project was funded by the Aquitanis O.P.H. of the Urban Community of Bordeaux (CUB) with total spending of 28,4 million Euros (27,2 Million € transformation+ 1,2 Million € new dwellings on site)

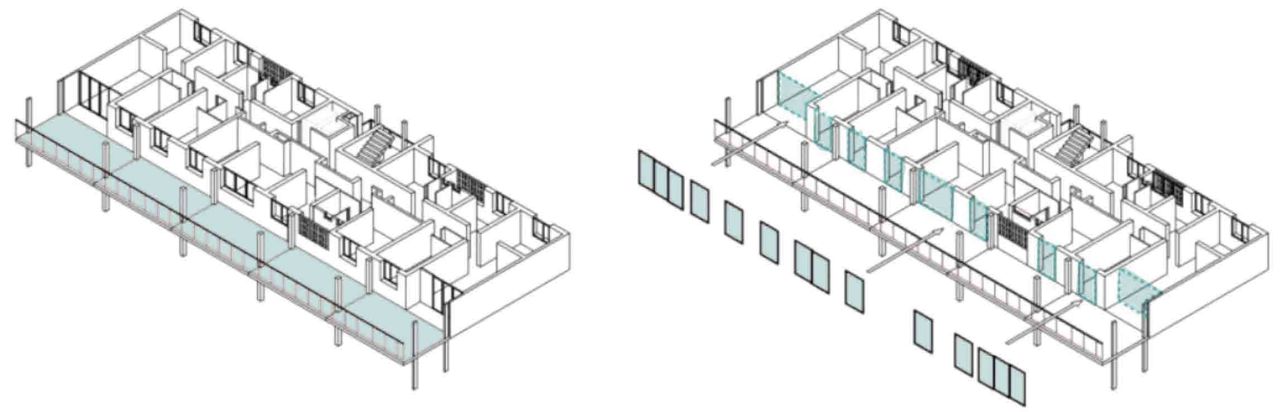
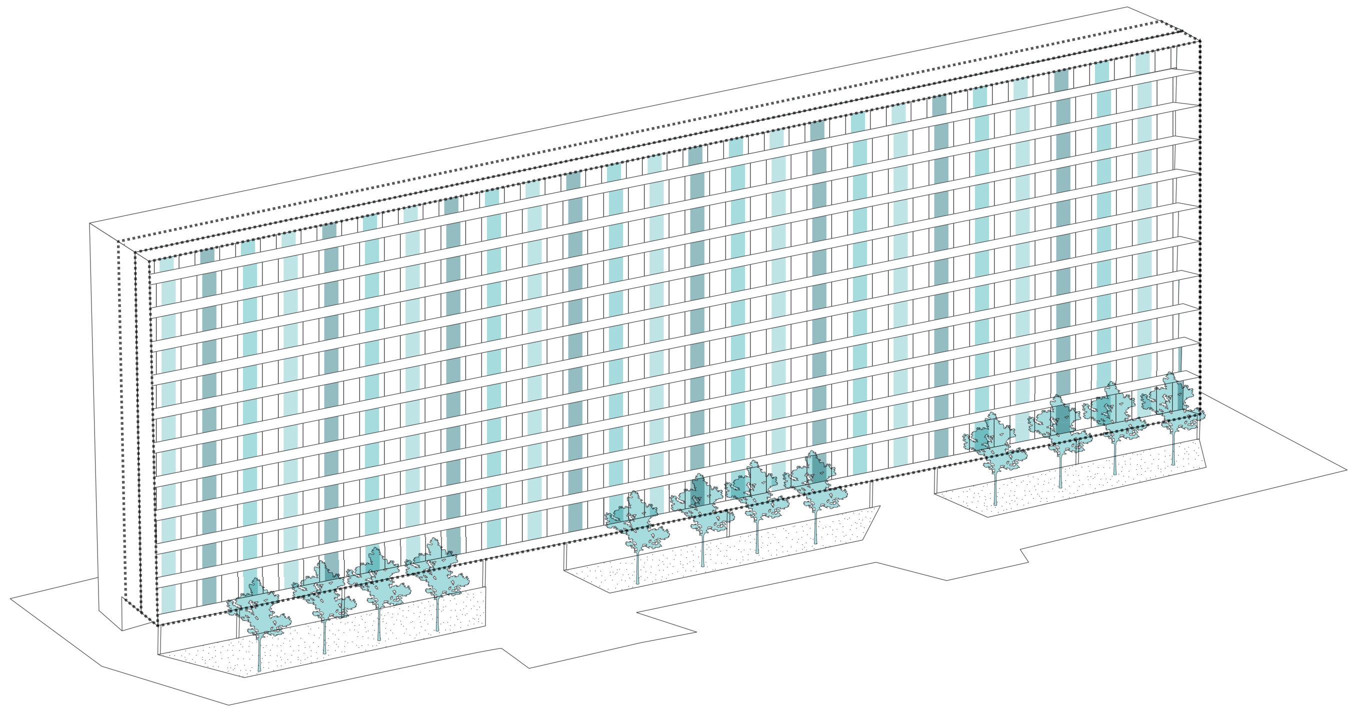


Figure 2.4: The extension structure implementation before demolishing the walls and demounting the windows. [2]

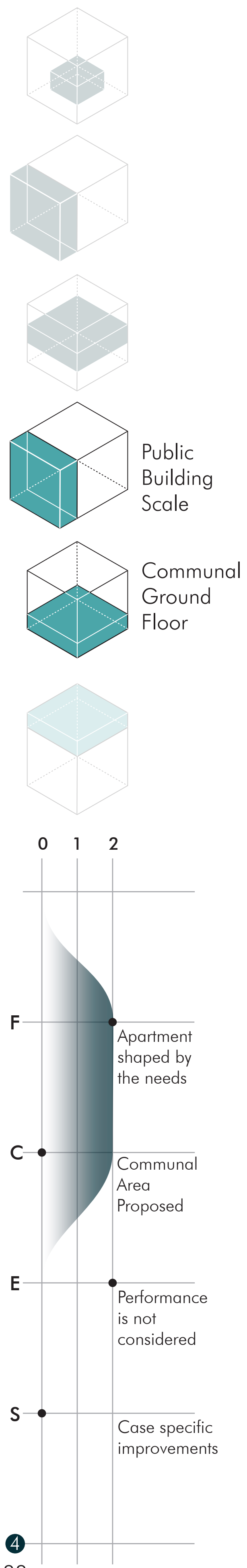


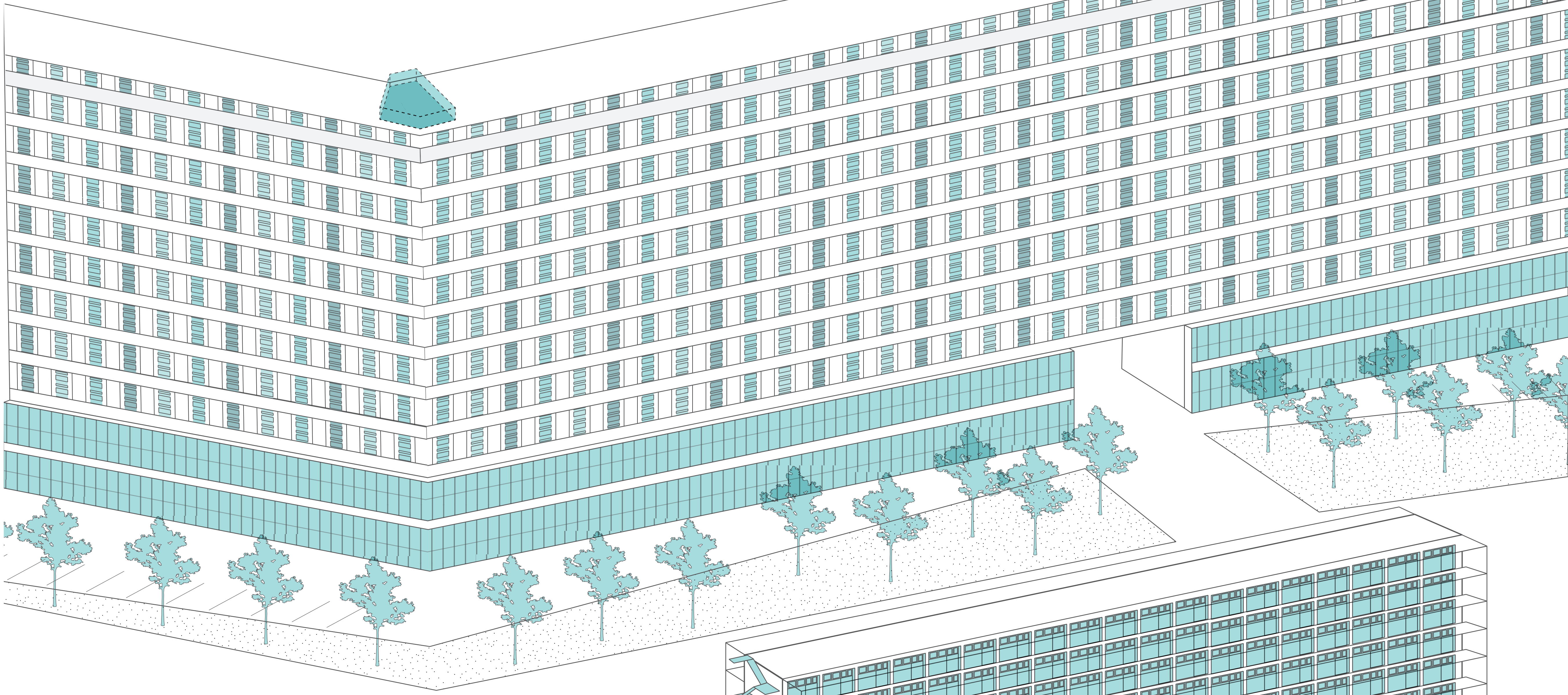
Overall the intervention enhanced the user lives while introducing increased energy performance façades. The space addition is added externally, the relocation of the residents did not be necessary. It can be said that it is succesfully implemented. However there is not a communal living proposal or it is not adaptable to variable nucleic families since the dwellings are in fixed types.

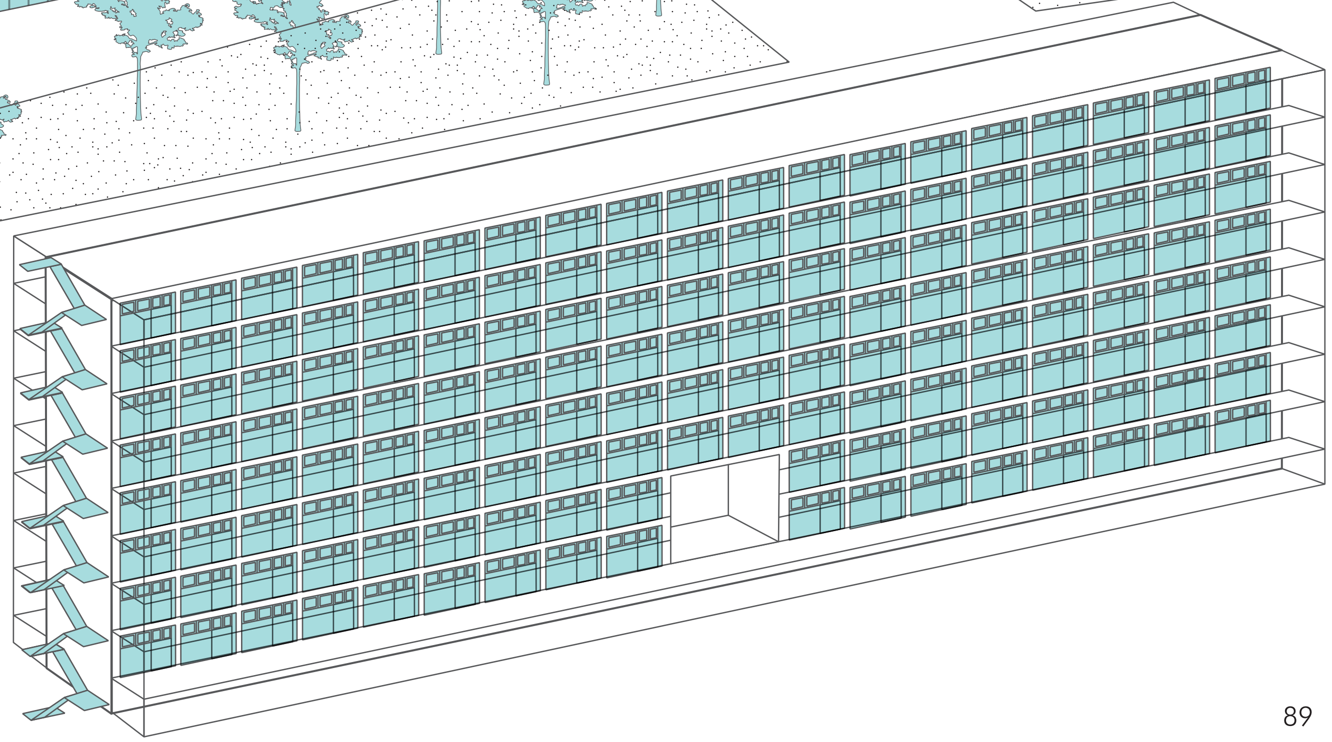
F	Adaptive to various user groups	No
	Adaptive to future improvement	Yes
C	Communal Area	No
	Communal Dwelling	No
E	Enegy Saving & Performance Improvement	Yes
S	Residents remained	Yes
	Applicable to various sites	Yes
	Cost	27,2M €
	Funding	Public

2.1.2_Kleiburg - DeFlat

Location: Amsterdam, NL
Designers: NL Architects & XVW architectuur
Building Typology: Linear Block
Ownership: Social Housing
Built Period: 1960s
Year of Refurbishment : 2016
Structure: Prefabric concrete structure -11 Floors
Residents: 100.000







Façade interventions & Ground Floor Interventions & Circulation Improvement
The design idea benefited from the vacant building and low cost solutions by creating DIY rooms to keep the resident interest in the building to stop the building from the destruction. The design moved the vertical circulation in interior, created outdoor passages from the building, and façade improvement.

General Scope of the Refurbishment

Kleiburg is one of the most iconic and last examples of the honeycomb building type from the 60s movement in Amsterdam. It is designed by the Dutch architect Fop Ottenhof, referencing the masterplan of the enormous urban extension in the southeast of Amsterdam. It is one of the examples of the 20th-century Modernism movement.

Due to neglect and lack of maintenance, it almost reached the risk of demolition. However, later on, an architectural competition was planned, and the winning project, 'De Flat,' focused on solving the current problems and targeting a new affordable co-housing model with a DIY concept for residents to participate in renovating their homes.

In 2017, the design won the Mies van der Rohe Award for its modest refurbishment techniques.

Figure 2.5: Refurbished building with the designed communal areas. [5]

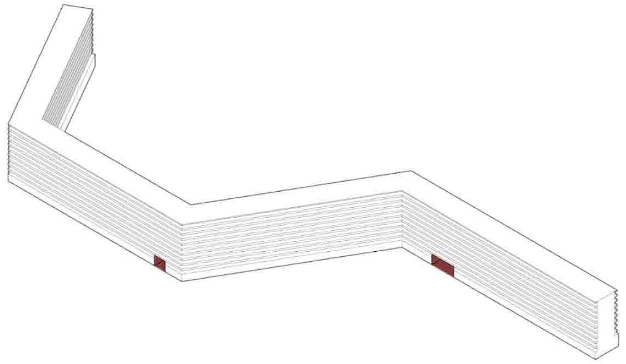


Figure 2.6: Introduced larger passages. [4]

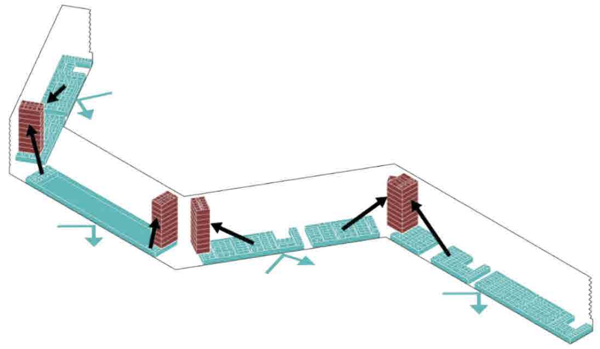


Figure 2.7: Relocating the service cores for freeing ground floor to communal zones. [4]

(F) Responsivenes and adaptibility to future scenarios

One of the design aim was to connect various dwellings horizontally and vertically by creating multilevel plans for the individual apartments. The structure of the building and the original plans of the dwellings are respected while refurbishing the building. In addition to that, residents are given various catalogues of façade and dwelling types to choose for their liking. By this way, even though the buildings original repetitive nature is kept, galleries could have variety depending on the user requests.

(C) Consideration of different co-living & user group needs

The ground floor level was repurposed by moving mechanical equipments and adding local businesses or entrance passages. The design also allowed some new purposes such as daycare, workspaces or apartments. Vertical circulation elements are also integrated into the building mass also connection with the intervention of interior "street" for residents to serve as a communal ground.(Fig.2.8)

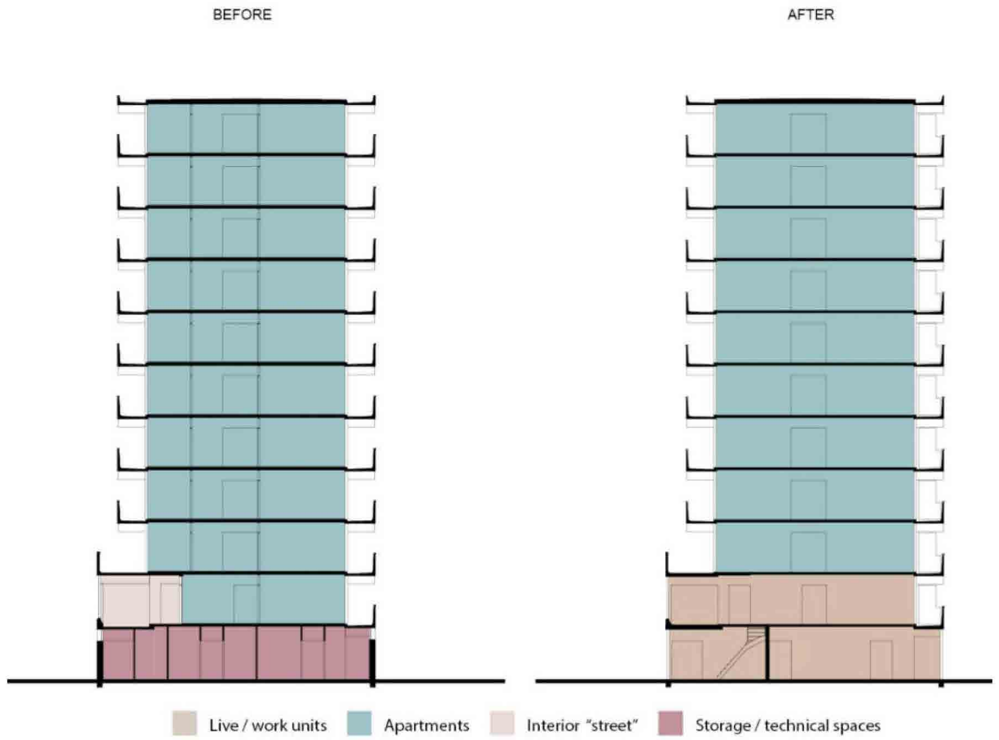


Figure 2.8: Change of the space organization before and after [4]

(E)Energy sensitivity and performance improvement

Energy performance is not considered in the intervention. Opaque panels of the building was replaced with double glazing panels.

(S) The economic feasibility & viability of the intervention and consideration of existing residents

The concept involved refurbishing the main building features, such as elevators, galleries, and installations, while intentionally leaving the apartments unfinished without furnishings. There were no rooms or fixtures in the apartments. This approach omitted kitchens, showers, heating, and designated rooms, thereby reducing initial investments and introducing a economically viable housing model in the Netherlands called DIY concept.

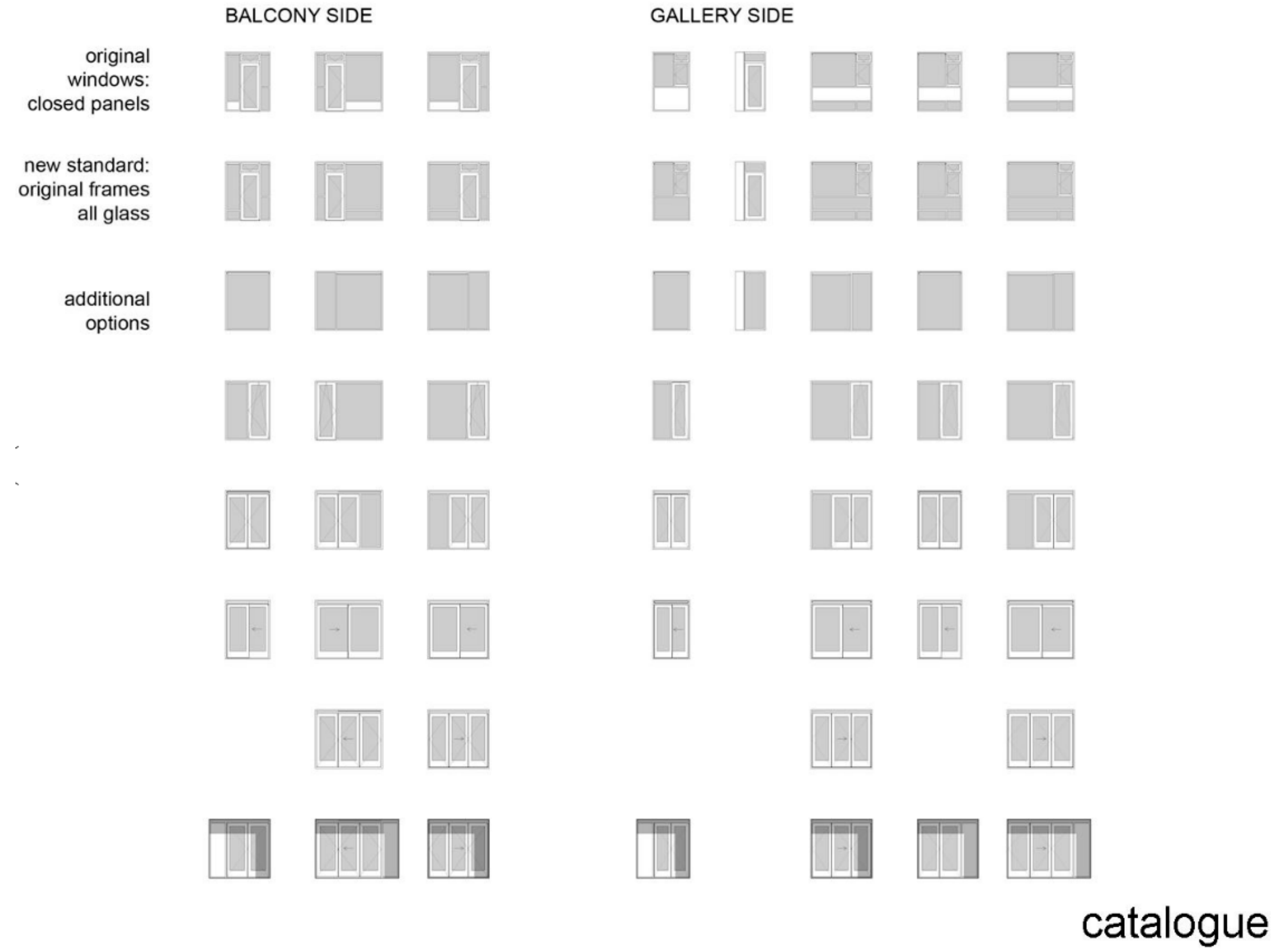
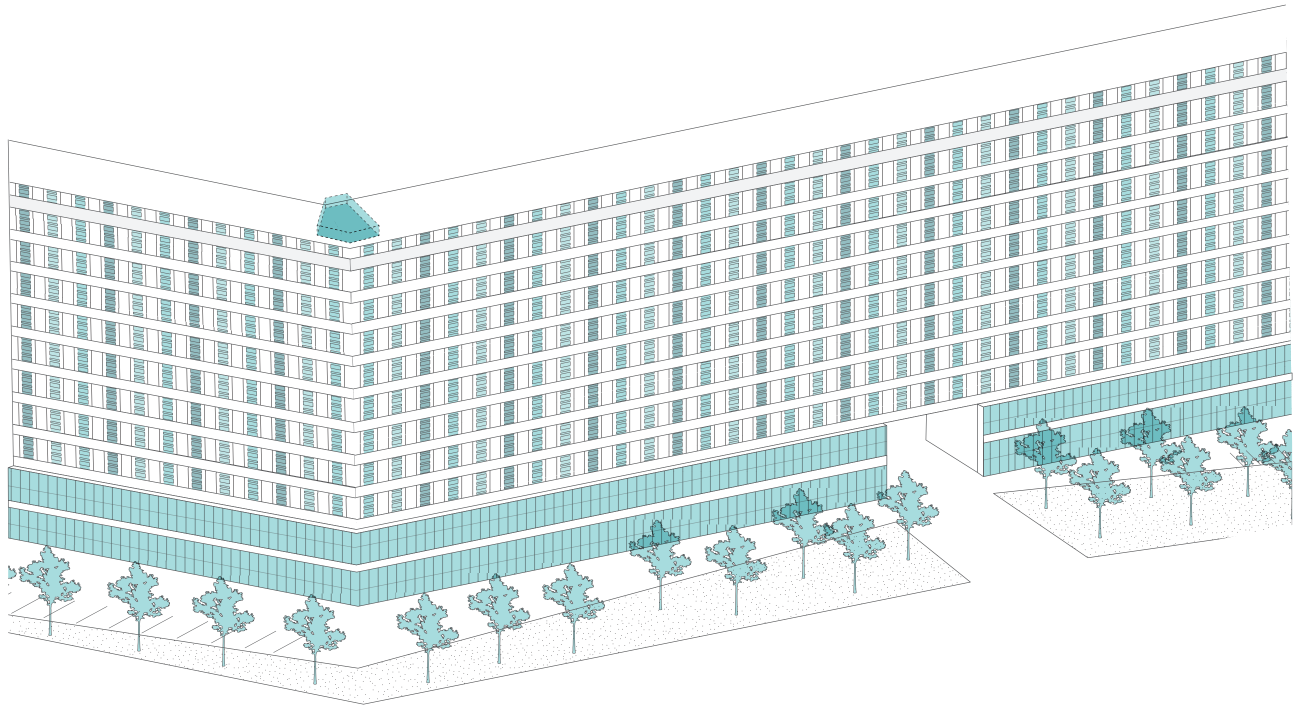
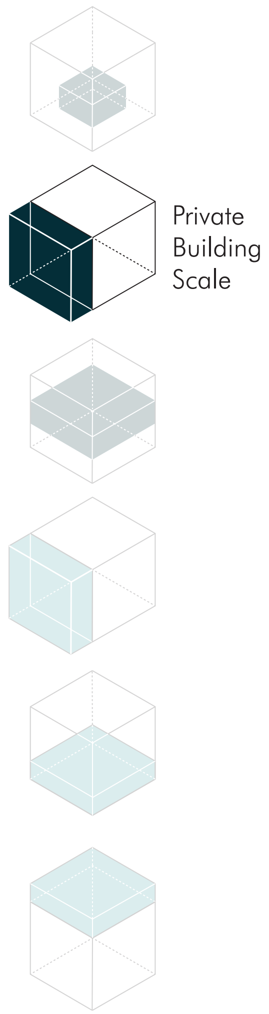


Figure 2.9: Façade catalogue given to residents to decide on their apartments façade. [4]



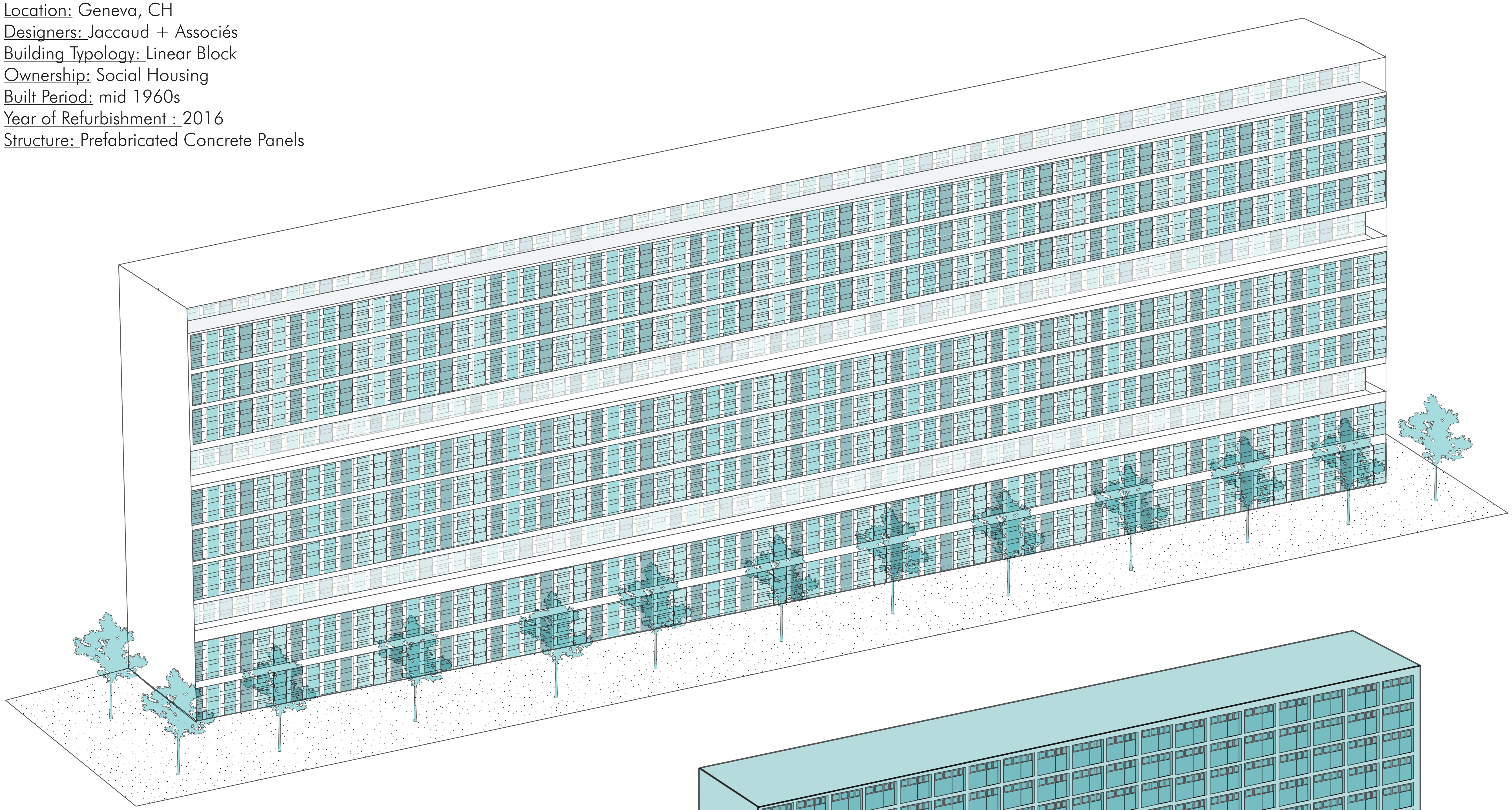
The importance of the design is the DIY concept that kept the cost minimal as possible. While with the main infrastructural changes and addition of the communal ground floor centers that can be also used as work-homes ables for different user groups to be satisfied with their spatial needs.

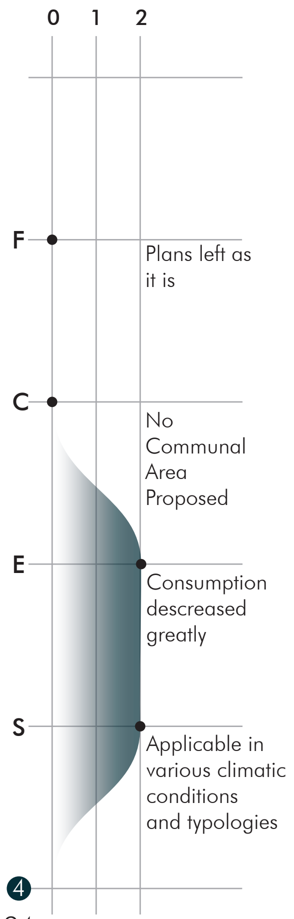
F	Adaptive to various user groups	Yes
	Adaptive to future improvement	Yes
C	Communal Area	Yes
	Communal Dwelling	Yes
E	Enegy Saving & Performance Improvement	No
S	Residents remained	No
	Applicable to various sites	Yes
	Cost	/
	Funding	Private



2.1.3_Du Lignon

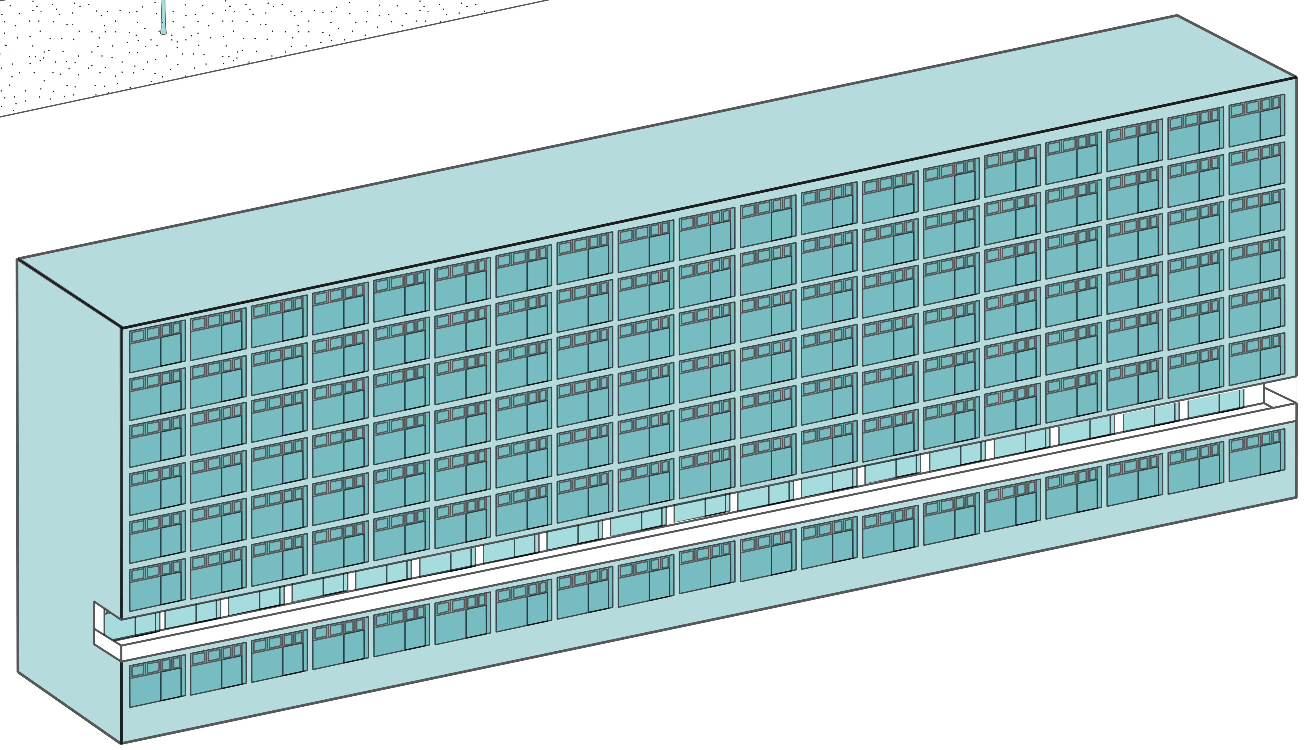
Location: Geneva, CH
Designers: Jaccaud + Associés
Building Typology: Linear Block
Ownership: Social Housing
Built Period: mid 1960s
Year of Refurbishment : 2016
Structure: Prefabricated Concrete Panels





Façade intervention

The design intervention increased the energy performance by improving the existing façade construction and reinstalling the dwelling façade panels that are respectfully implemented to its historic design.



General Scope of the Refurbishment

The building, constructed between 1962 and 1971 by architects Georges Addor, Louis Pavot, and Dominique Julliard, is situated on the outskirts of Vernier and is one of the largest residential complexes in Switzerland. It encompasses 2,780 dwellings along with various infrastructure such as a school, shopping center, medical center, church, and urban farm. Originally developed to satisfy the housing shortage in the 1960s, the complex now houses nearly 7,000 residents.

Le Lignon, characterized by its linear block type of construction, spans 1.1 km and stands 26 to 30 floors tall. Retrofitting the building presented significant architectural challenges due to its original lack of flexibility and the use of prefabricated concrete panels in its construction. Another complexity was the ownership structure, with most dwellings owned by residents and a portion designated as public social housing.

Despite changes in the materials and spatial changes, the characteristic look of the building was still there, and the change was indistinguishable from the previous design. The architects proposed this solution as an 'invisible cloak' for the building, and the biggest compliment they received was that 'there was no refurbishment clue at all.'

Figure 2.10: Retrofitted façade of the Du Lignon [7]

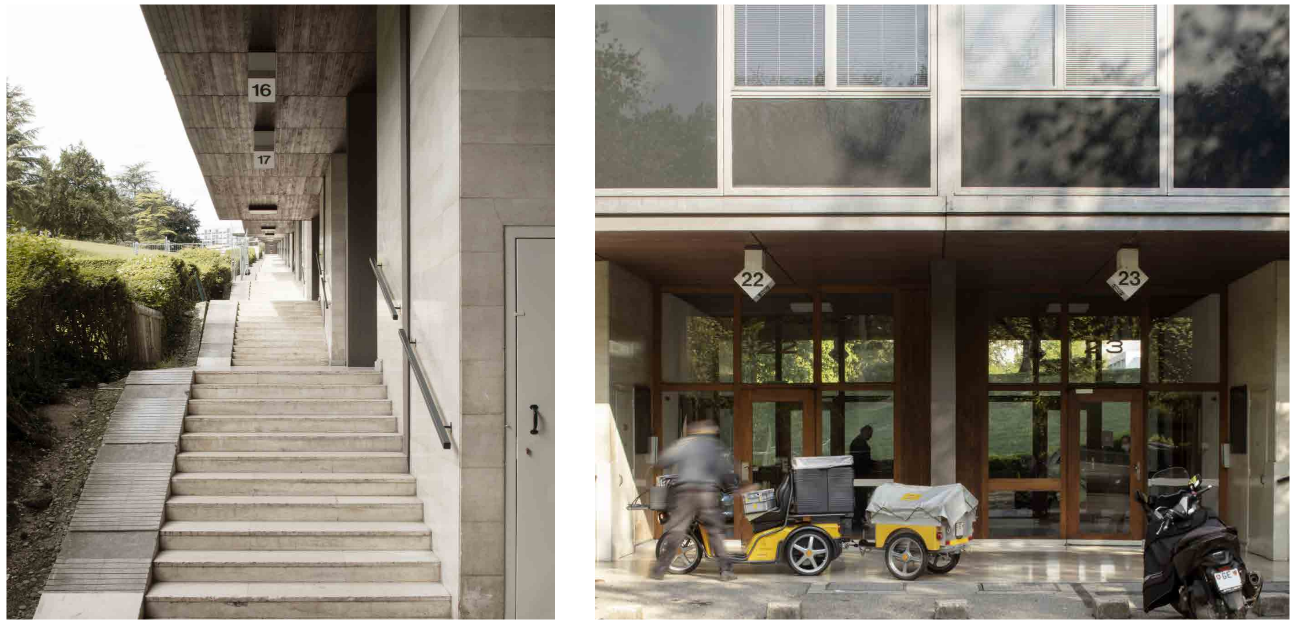


Figure 2.11: Street of ground floor [7]

(F) Responsivenes and adaptibility to future scenarios

Dwellings were renovated minimally for the maintenance purposes to keep the cost as much us lower.

(C) Consideration of different co-living & user group needs

Communal streets and corridors are created and renovated. Relation to neighborhood is preserved.(Fig.2.11)

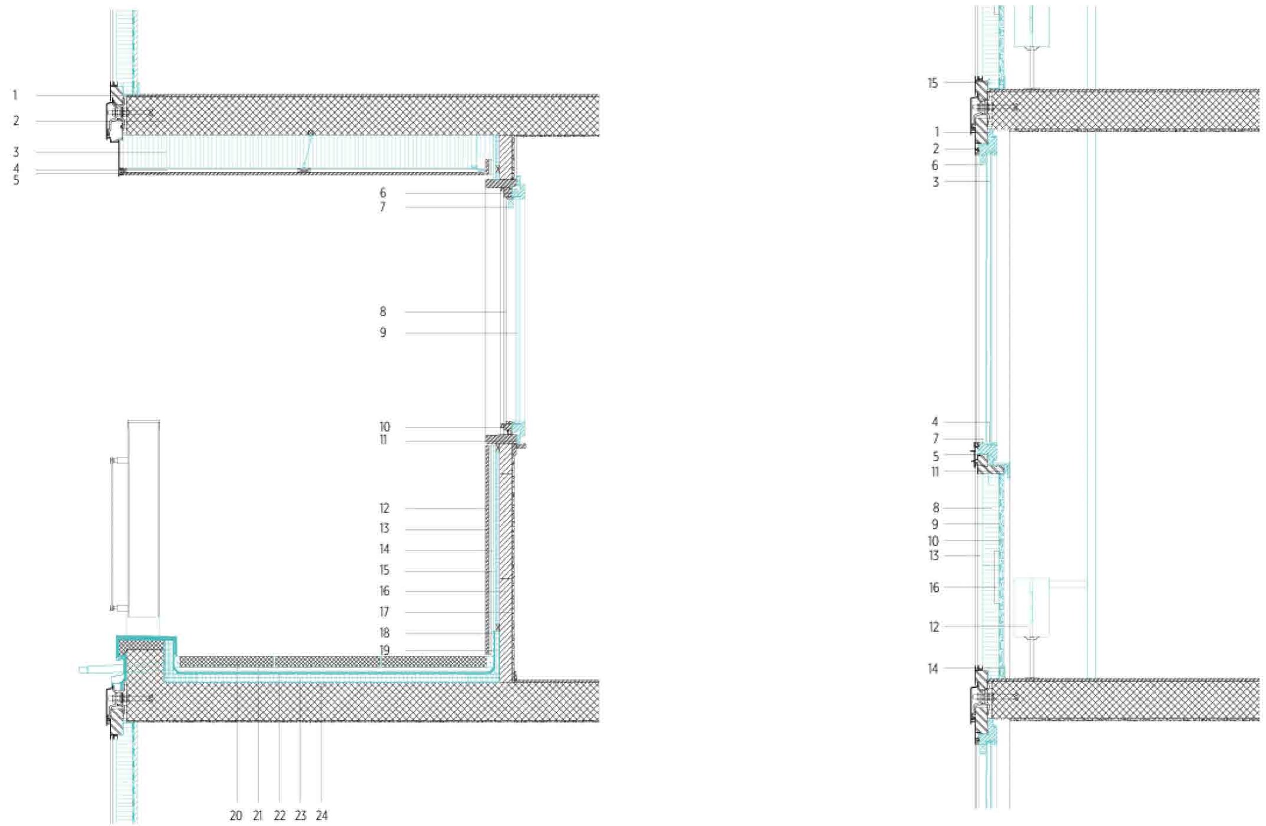


Figure 2.12: Retrofitted detail section from communal corridor and from regular floor plan [6]

(E)Energy sensitivity and performance improvement

The new thermal building regulations in the envelope are considered while renovating the façade of the building to improve its building performance by testing the renovating façade with a prototype. Then, architects designed new materials for the façade, replaced the timber façade, and added double-glazed windows to the apartments.
The inner porch door was also added to create a new thermal boundary, and the old radiators were changed.

(S) The economic feasibility & viability of the intervention and consideration of existing residents

The most significant socially responsible action was that the residents remained in their homes. At the same time, the building was renovated, and without a change in rent, they could quickly notice the change in maintenance costs and energy savings on the bills, which are supplied by the central heating district system.

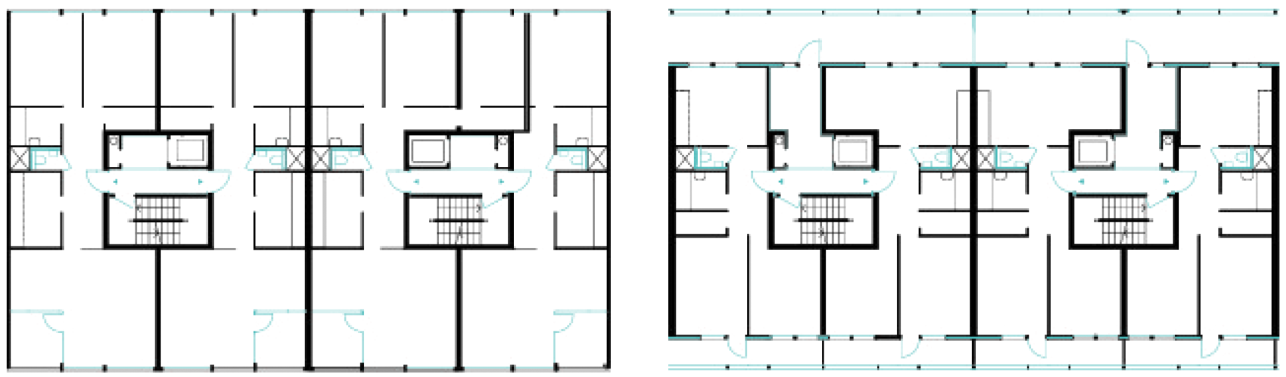
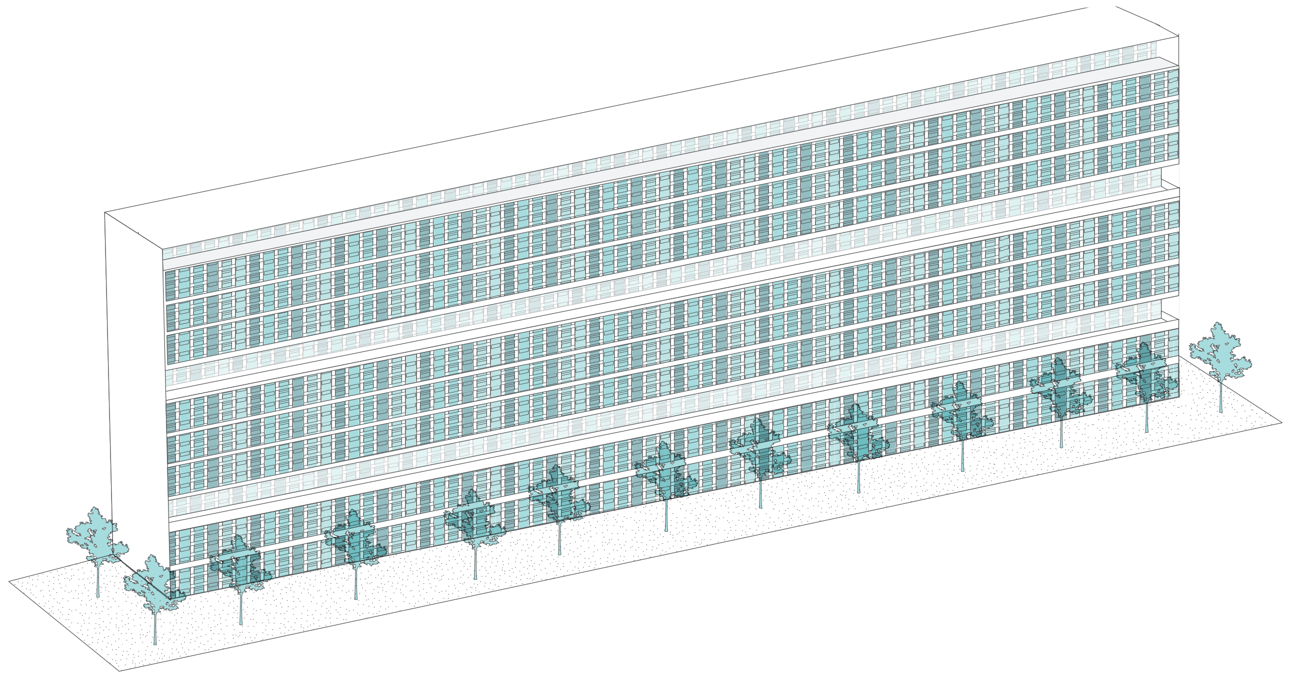


Figure 2.13: Change in floor plans highlighted in blue in regular floor plan and communal corridor floor plan [6]

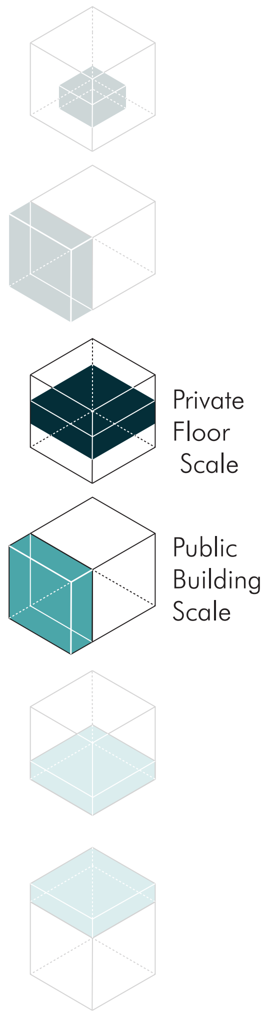


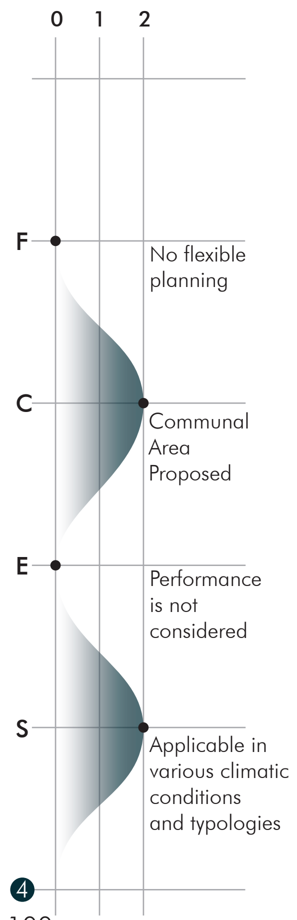
The design is respectful towards to the previous identity. There is no change in the interior plans greatly that will change the dwelling layout for different families that consist of different number of members. The design respected to the residents and residents are remained in the building throughout the intervention.

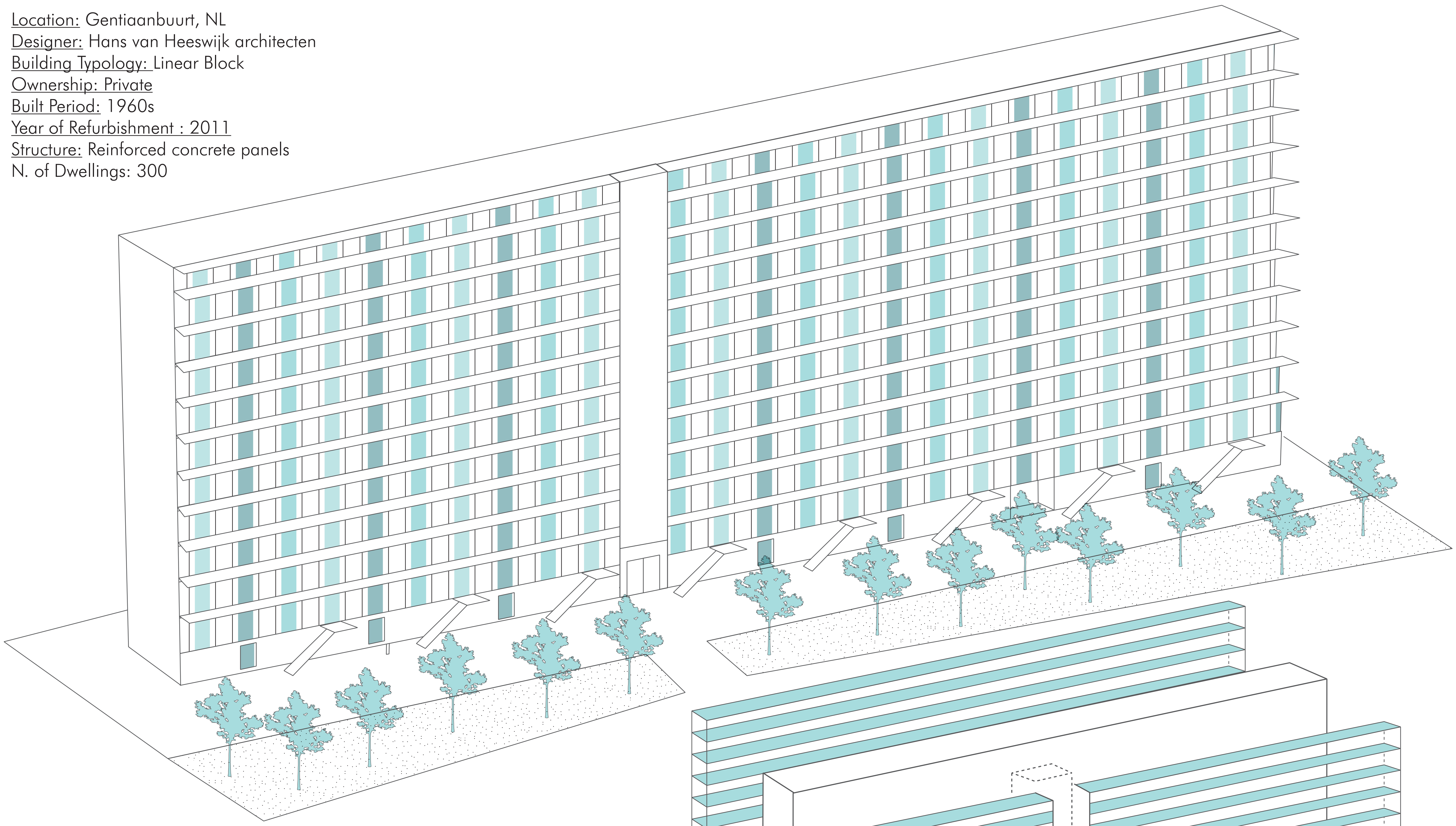
F	Adaptive to various user groups	No
	Adaptive to future improvement	No
C	Communal Area	Yes
	Communal Dwelling	No
E	Enegy Saving & Performance Improvement	Yes
S	Residents remained	Yes
	Applicable to various sites	Yes
	Cost	€90,1M
	Funding	Private

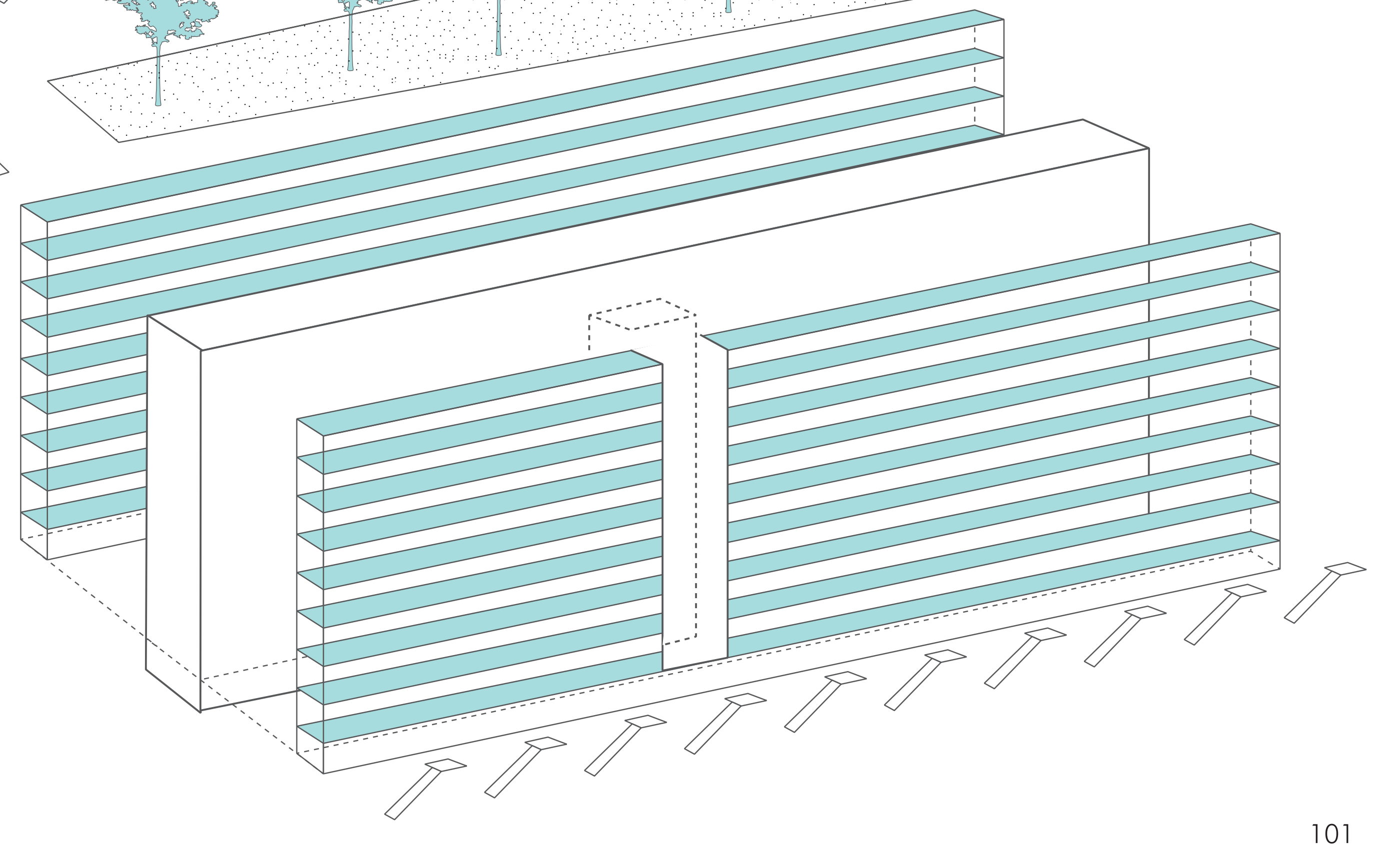
2.1.4_Moerbosch

Location: Gentiaanbuurt, NL
Designer: Hans van Heeswijk architecten
Building Typology: Linear Block
Ownership: Private
Built Period: 1960s
Year of Refurbishment : 2011
Structure: Reinforced concrete panels
N. of Dwellings: 300









Addition of Communal Corridors & Diverse Entrance Point Design

The design strategy was to add another spatial structure to the façade of the building and fixing the vertical circulation. Residents are easy to encounter to each other for the social interactions.

General Scope of the Refurbishment

The building lacked maintenance and had an introverted design. The architects aimed to give it a contemporary and extroverted facade. They implemented various solutions, such as connecting every three flats to create communal areas while maintaining their privacy. The addition of corridors gave the building two front sides, blending it seamlessly with its surroundings.

The original design provided a practical and stable foundation, so the architects did not alter the structure. As a result, the design proved to be successful, allowing the building to function more effectively as a cohesive unit while enhancing comfort and refinement.

Figure 2.14: Northern Façade with the implementation of new stairs and transparent vertical circulation core [8]

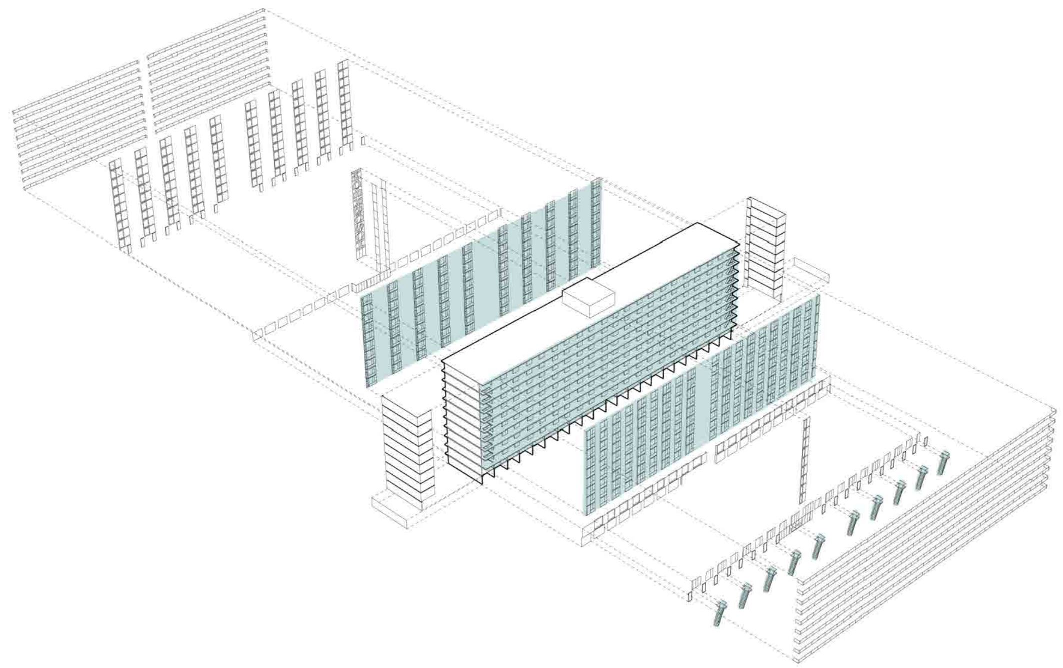


Figure 2.15: Exploded view of the interventions [8]

(F) Responsivenes and adaptibility to future scenarios

Only one type of dwelling is realized. Thereofre, there is no consideration of various user groups or flexibilty in different scenarios of living.

(C) Consideration of different co-living & user group needs

The design aimed for transparent circulation, which was achieved through the use of transparent surfaces along the main stairs and elevator. This transparency highlighted the difference between public and private spaces, especially at night when the building was illuminated. Additionally, ten stairs were added to the ground floor to eliminate the perception of a closed entrance on the north side. In the ground floor, elevated floors are individually assigned to one stair for access.

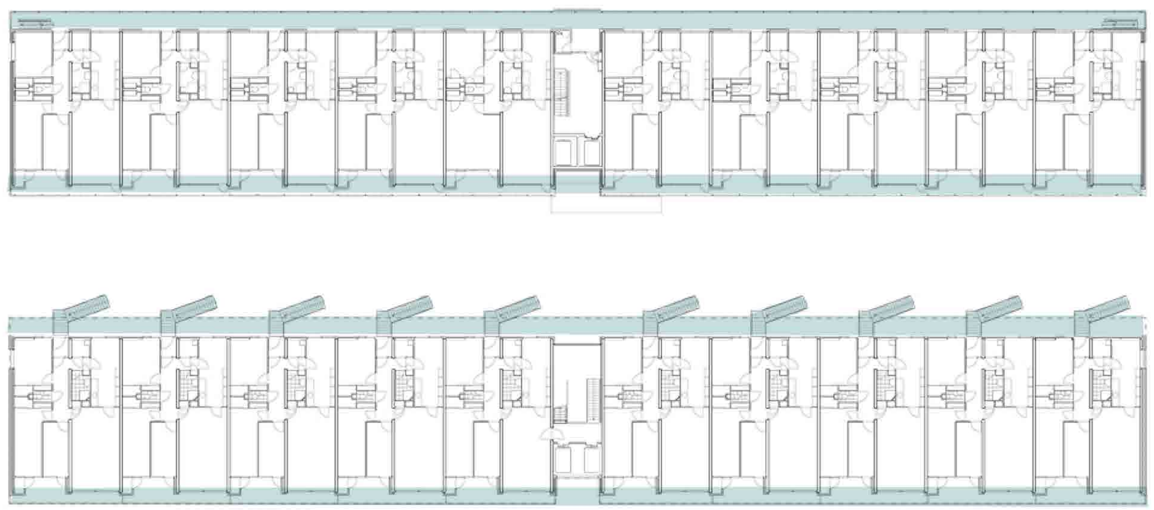


Figure 2.16: Previous and current ground floor plan. As can be seen, on the northern side platform is removed to improve feeling of the security. [8]

(E)Energy sensitivity and performance improvement

Building is renovated but there was no energy consideration or improvement of energy performance.

(S) The economic feasibility & viability of the intervention and consideration of existing residents

The building was mostly renovated through its communal vertical core and façade. Thus, throughout the renovation process, residents were able to stay in their homes.

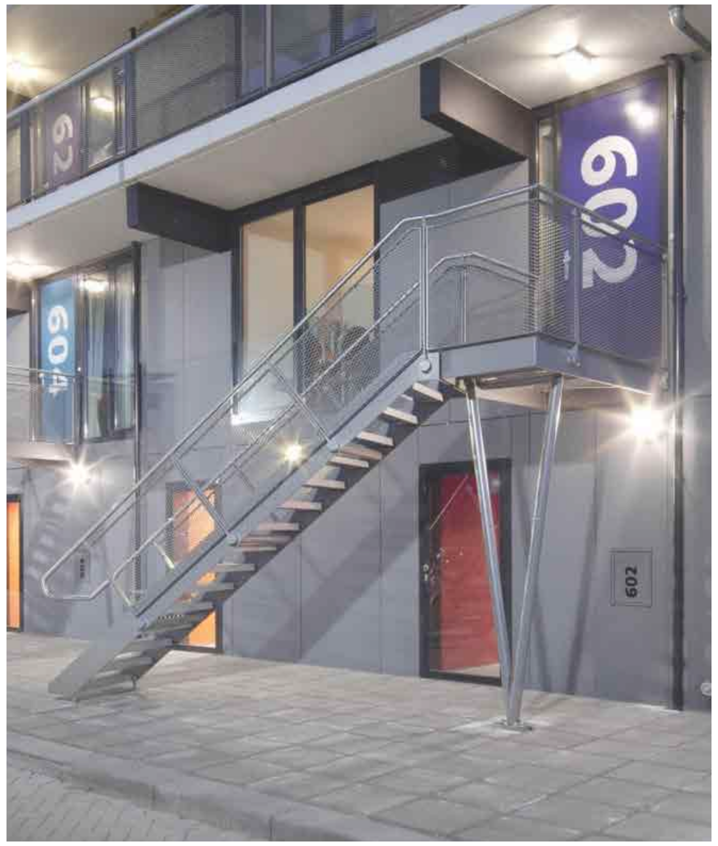


Figure 2.17: Northern Façade (8)

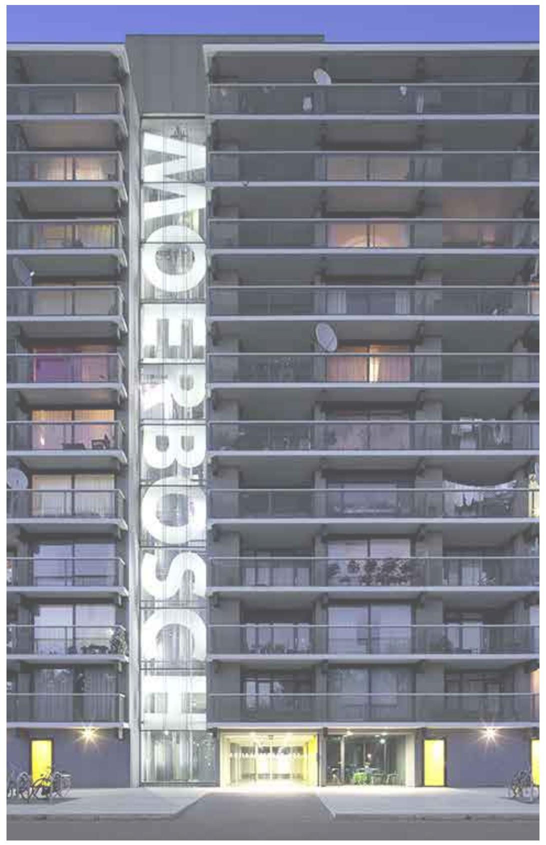
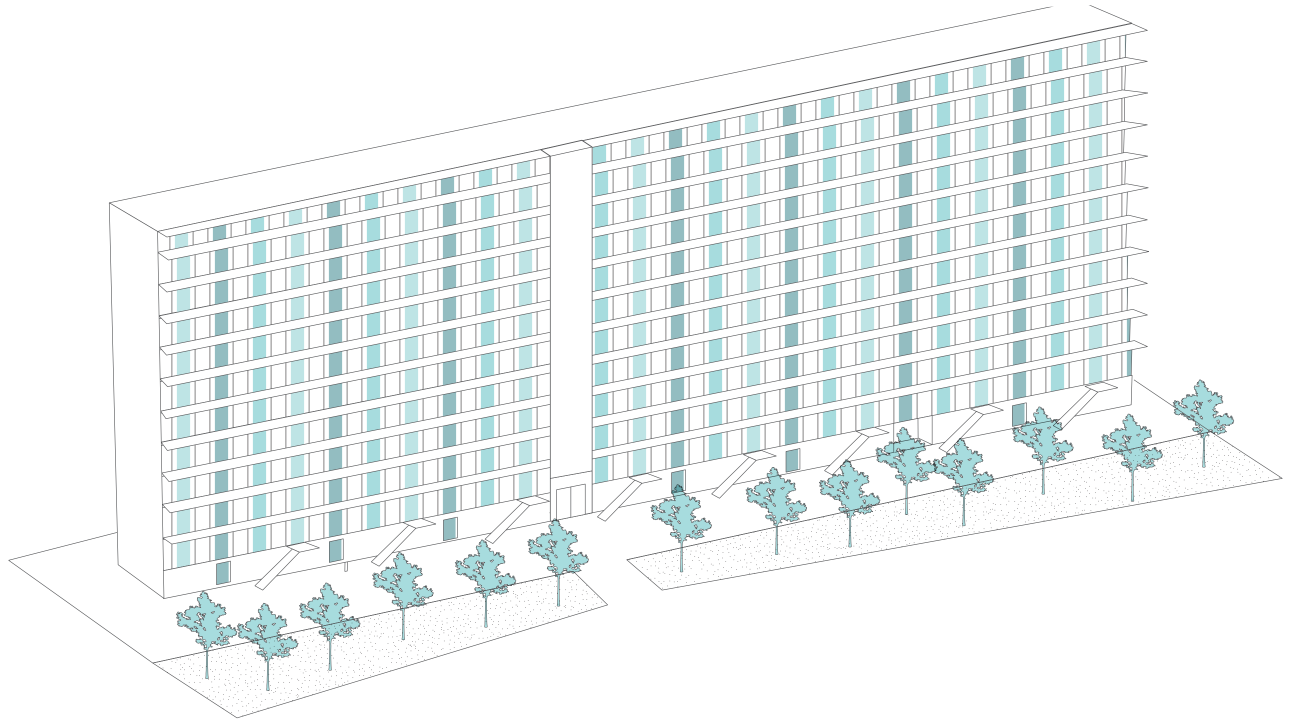


Figure 2.18: Southern Façade (8)

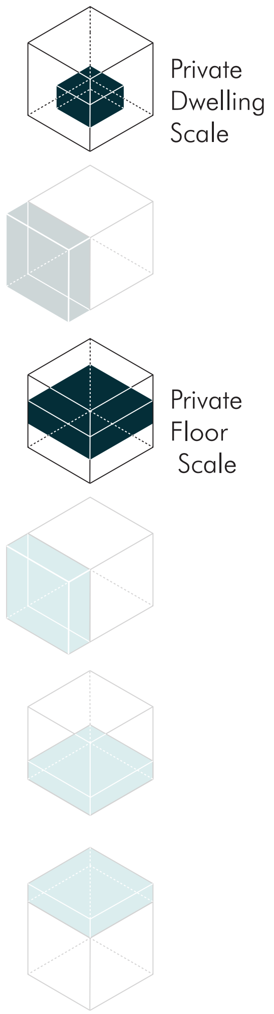


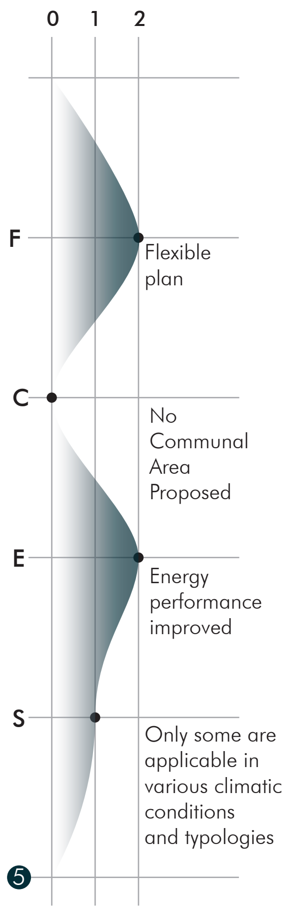
The design succesfully implemented communal area while creating a different access levels for the different residents. These are highlighet with the design articulations and the materials to creaste an architectural identity. The energy performance was not a key factor in the design.

F	Adaptive to various user groups	No
	Adaptive to future improvement	No
C	Communal Area	Yes
	Communal Dwelling	No
E	Enegy Saving & Performance Improvement	No
S	Residents remained	Yes
	Applicable to various sites	Yes
	Cost	/
	Funding	Public

2.1.5_HBIM APUR

Location: Paris, FRA
Executer: APUR
Building Typology: L shaped, Linear Blocks
Ownership: Public & Private
Built Period: Multiple, Post-war I & II
Year of Refurbishment : 2007-present
Construction: Various
N. of Dwellings: 27.000





General Scope of the Refurbishment

In 2007, the City of Paris adopted a Climate Plan with the ambition of reducing greenhouse gas emissions by 75% in 2050 compared to 2004. This Plan, revised in 2012 and 2017, sets out quantified reduction targets by sector: buildings, transport, consumption and waste, industry. The housing sector represents a major challenge for Paris since 1.3 million Parisian homes represent 35% of the overall energy bill, or an expenditure of 1 billion euros every year .

The New National Program for Urban Renewal (NPNRU) discusses the rehabilitation of Habitations à Bon Marché (HBM) in Paris towards a socially and environmentally sustainable initiative.

The collaboration of Apur and the city of Paris targeted a consumption objective and a reduction of energy consumption in low-cost housing in Paris. It is a comprehensive urban renewal strategy with different design approaches from different firms. Neighborhoods consisted of buildings built from the 1920s to 1970s.

It can be observed that there are three significant architectural approaches to refurbishing this large housing stock of Paris.

Figure 2.19: Various examples of HBIM neighborhoods in Paris (Arup,2019)

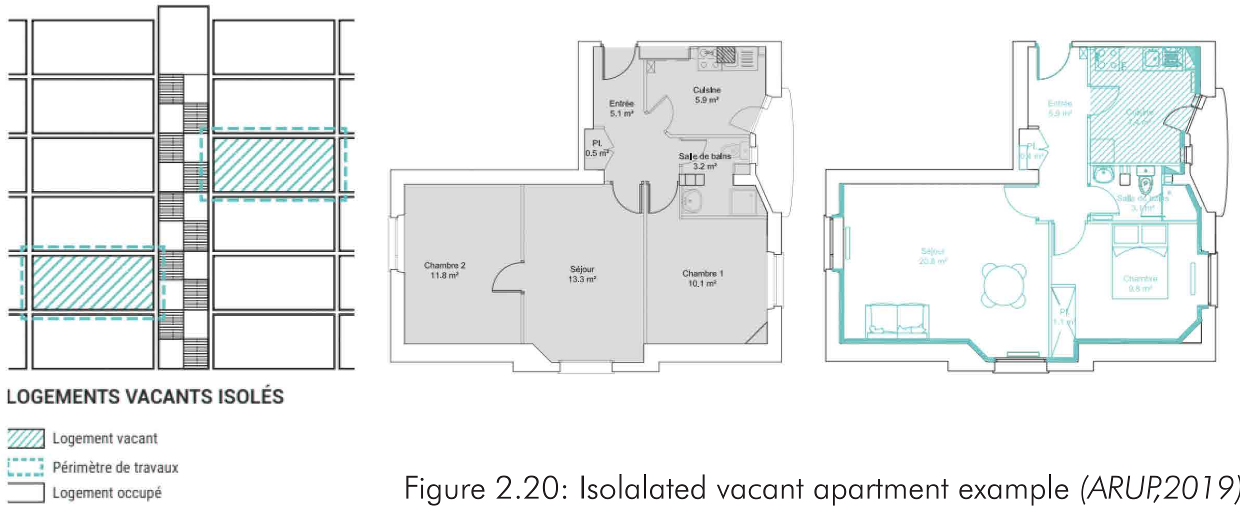


Figure 2.20: Isolalated vacant apartment example *(ARUP,2019)*

Vacant Apartment Typology 1

The first intervention is for the isolated vacant apartments. The apartments are insulated, and appropriate windows are placed. Also, kitchens and bathrooms are updated to current standards. Accessibility is taken into account. The characteristics of the dwellings were protected, and original materials were kept.

Vacant Apartment Typology 2

The second intervention type is to renovate the units by changing the whole floor plan and combining different dwellings. Two dwellings that are adjacent to each other and served by the same vertical circulation are connected together to create a new dwelling type. With this kind of solution, a clear interior plan is achieved and designed so that the existing plumbing and electrical networks can be used. Since the building typology used with this intervention is constructed with a reinforced concrete frame construction, this type of significant changes in room sizes with wall removals are not constrained by the structure.

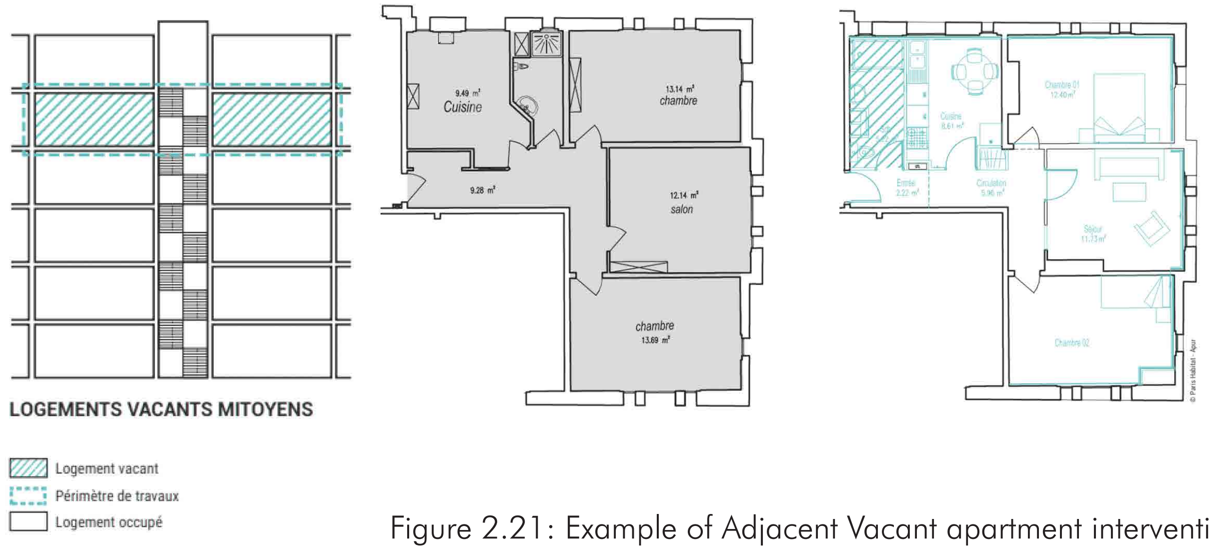


Figure 2.21: Example of Adjacent Vacant apartment intervention *(Arup,2019)*

Vacant Apartment Typology 3

The third significant intervention type is vertical intervention on the columns of apartments. This type of intervention needs good planning to enable the vacancy for the replanning. Cost is high compared to the other interventions naturally.
The main design move is to create a continuous line with the service core that continues through the whole building vertically. These services involve water, ventilation, and heating cores. In this way, a mechanical ventilation system is added to the kitchen and bathroom vents in the former floor plan.

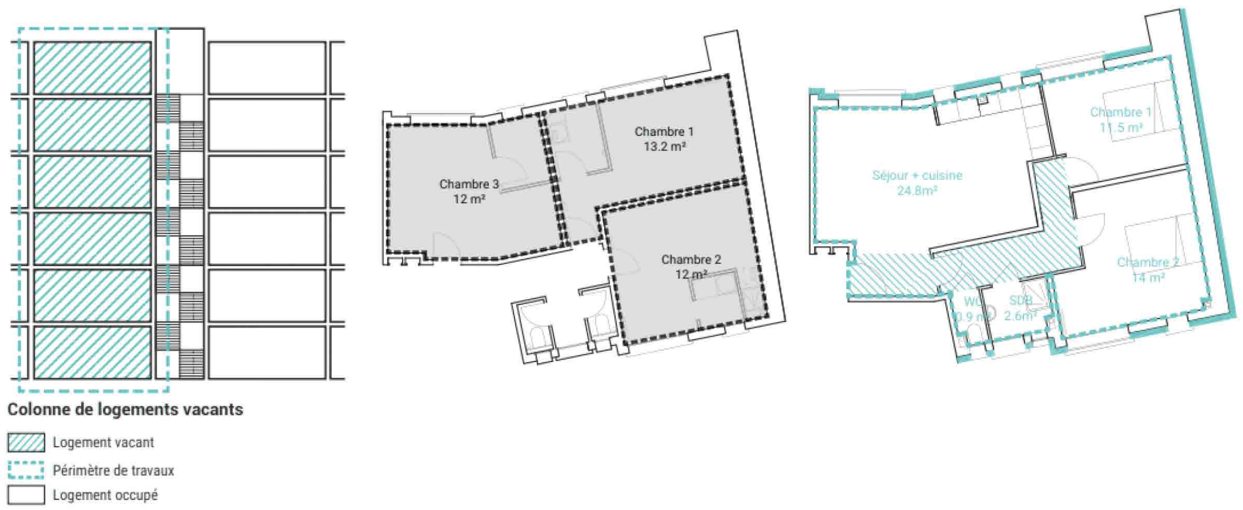
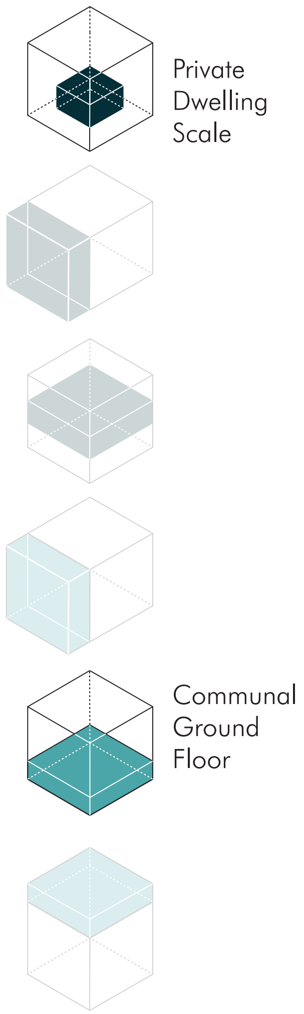


Figure 2.22: Example of vertical vacant apartment intervention(Arup,2019)

Conclusions related to objectives

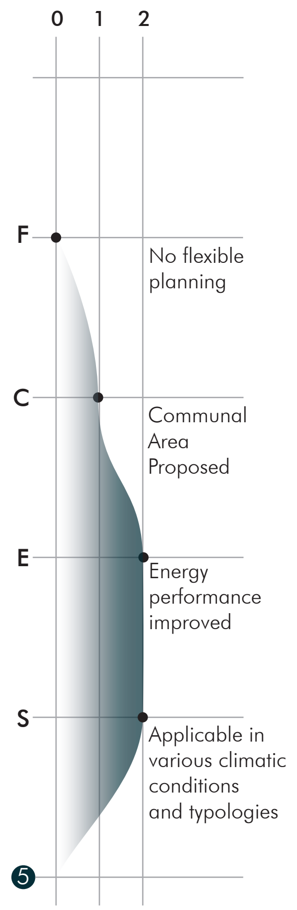
(F) Responsivenes and adaptibility to future scenarios: Different typology of dwellings are created for various user groups and families.
(C) Consideration of different co-living & user group needs: There is no communal consideration thought in the initiative. Main focus was to renovate and repopulate.
(E)Energy sensitivity and performance improvement: All of the typologies in different neighborhoods are insulated and their energy performance is improved.
(S) The economic feasibility & viability of the intervention and consideration of existing residents: Intervention is only done in dwellings which were vacant.

F	Adaptive to various user groups	Yes
	Adaptive to future improvement	No
C	Communal Area	No
	Communal Dwelling	No
E	Enegy Saving & Performance Improvement	Yes
S	Residents remained	No
	Applicable to various sites	Yes
	Cost	€ 1,5B
	Funding	Public&Private



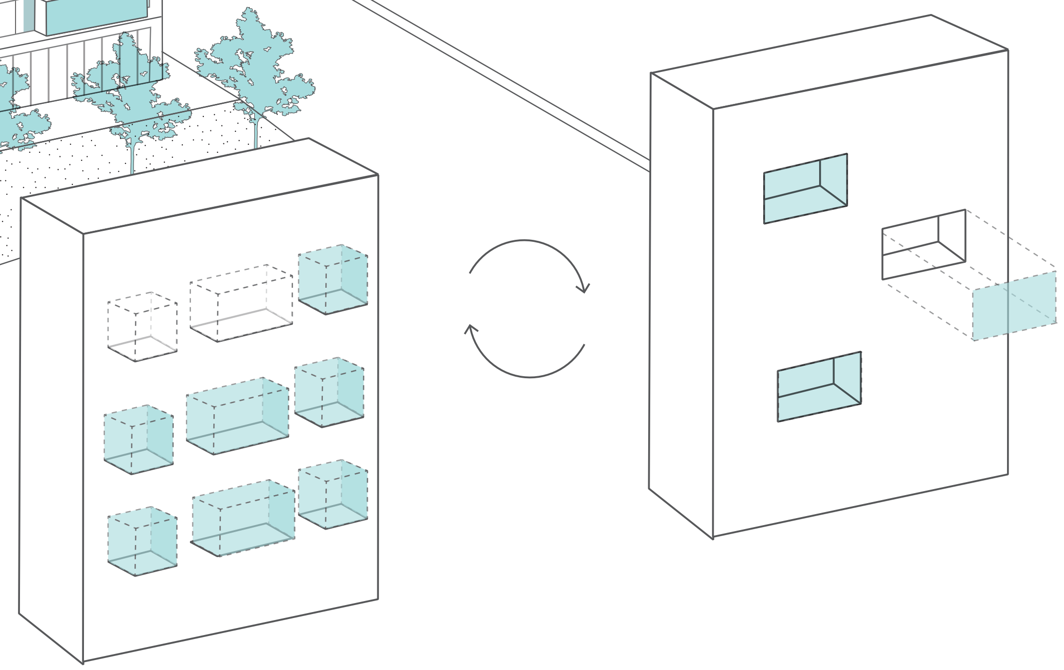
2.1.6_Woodside Multi Storey Flats

Location: Glasgow, GBR(Sco)
Designers: Collective Architecture
Building Typology: Linear Block
Ownership: Social Housing
Built Period: 1964
Year of Refurbishment : 2016- 2019
Structure: Concrete Cross wall Construction



Enclosing Balconies & Loggias

The design strategy was todecrease the exterior area relative to the volume. Therefore the engineers and architects calculated the energy performance. The communal ground floor is also implemented.



General Scope of the Refurbishment

Project was funded primarily by the Queens Cross Housing Association as part of its strategic vision for regenerating the area. The project was the largest of its kind in Scotland and was aimed at improving energy efficiency, tackling fuel poverty, and enhancing the overall living conditions of 1,350 flats.

The original buildings are constructed with prefabricated concrete structural frames with poor insulation. Also, the interiors were lacking in satisfying the acoustic needs due to thin internal partitions. With time, the building deteriorated, and security became a problem for residents. Residents also raised concerns about fuel poverty and the lack of safe communal areas. Architects worked and communicated with the local people to hear the problems with organizing the community workshops and interviews.
While designing the project, the team noticed that the envelope-to-floor area is very efficient in lowering the heat transfer coefficient. In the design, designers optimized this advantage by enclosing the recessed balconies. This solution not only lowered the possibility of encountering the thermal bridges but also reduced the required insulation thickness.

Figure 2.23: New façades of the three towers (12)

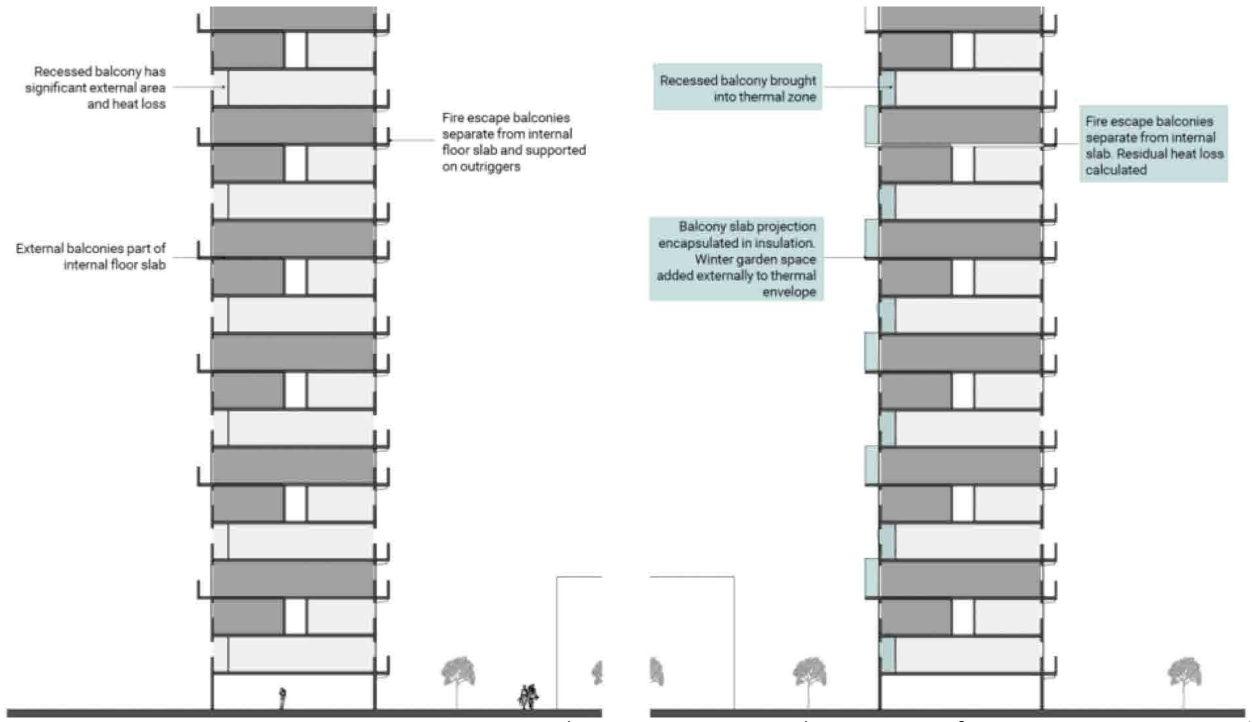


Figure 2.24: Change in sections by means of energy conservation (12)

(F) Responsivenes and adaptibility to future scenarios

Arrchitects wanted to keep winter gardens as operatable semi-open places for residents' needs. But the units are not reproposed for different user groups.

(C) Consideration of different co-living & user group needs

The entrances of the three towers have been transformed, establishing a dual-access lobby with green zones and community notice boards. Additionally, community meeting rooms, children's play areas, and art studios were introduced in the ground floor plan. Communal areas were also significantly upgraded, with new lifts, refuse areas, and increased security systems.

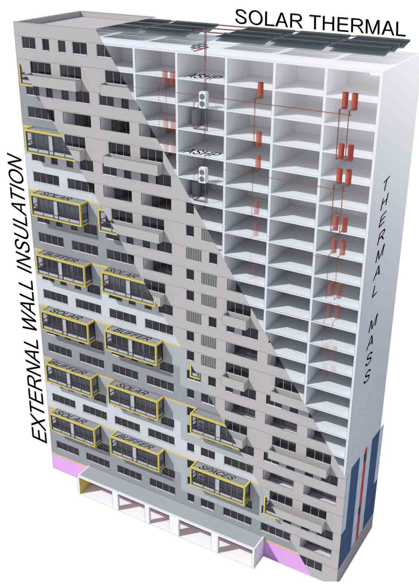


Figure 2.26: Interventions done in multiple layers (12)

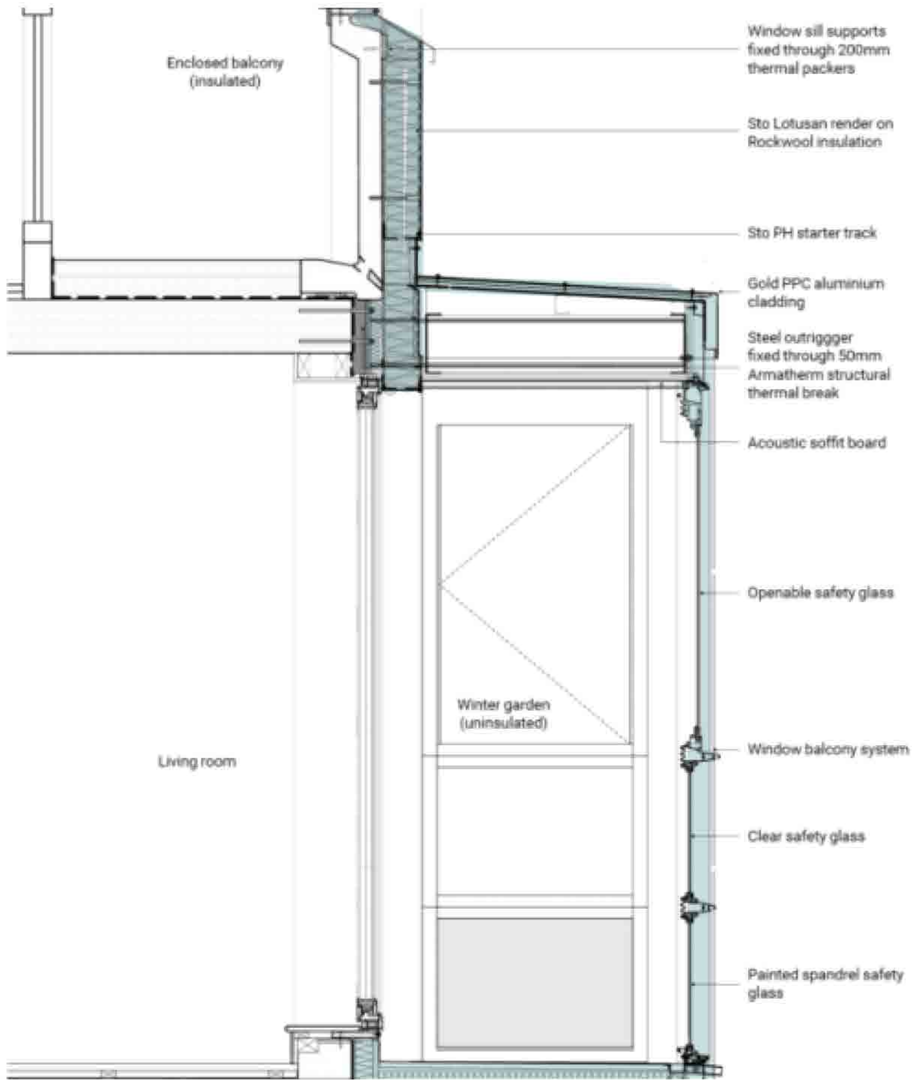


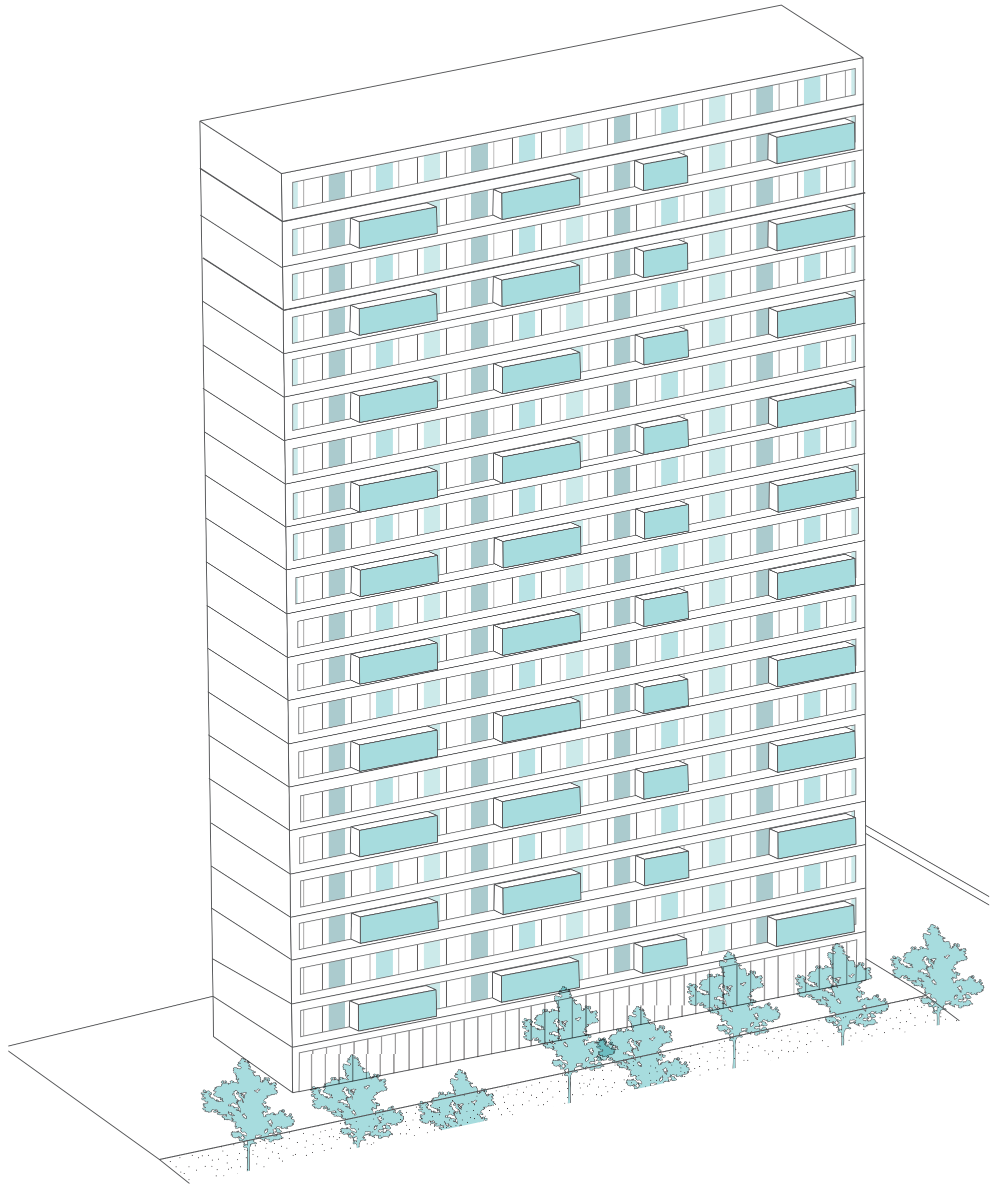
Figure 2.25: Detail section of the enclosed balconies (12)

(E)Energy sensitivity and performance improvement

The firm insulated the envelope and changed the windows to triple-glazed windows to meet the heat loss goals. Also, duplex apartments were highlighted with different colors, enabling a visual relation between space organization to be perceived from outside to see the different energy improvements. Balconies enclosed to create a continuous thermal line in case form winter gardens. This reduced also the area exposed to exterior environment per volume.

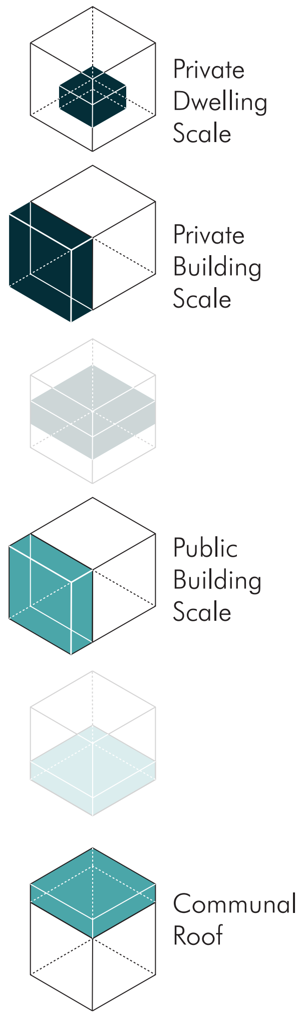
(S) The economic feasibility & viability of the intervention and consideration of existing residents

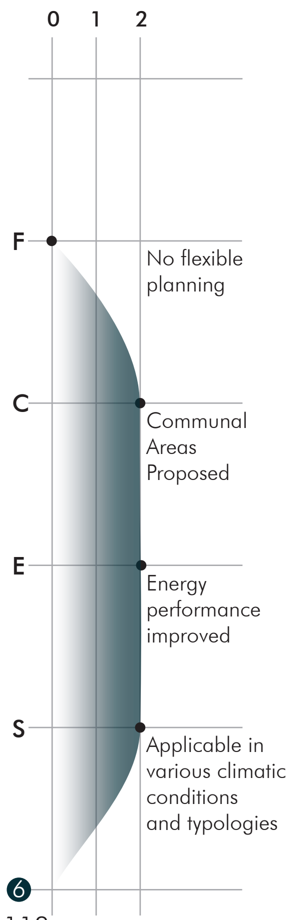
The critical challenge, was to keep resident occupation during the entire retrofit. Therefore, detailed scheduling and site management played an important role. Additionally, careful detailing reduced the energy demand by 80% without extensive spending on retrofit plan even with the triple glazing that is used.



The design successfully reduced the bills with minimum intervention. Residents were not disturbed whie construction of the glazing units and façade interventions.

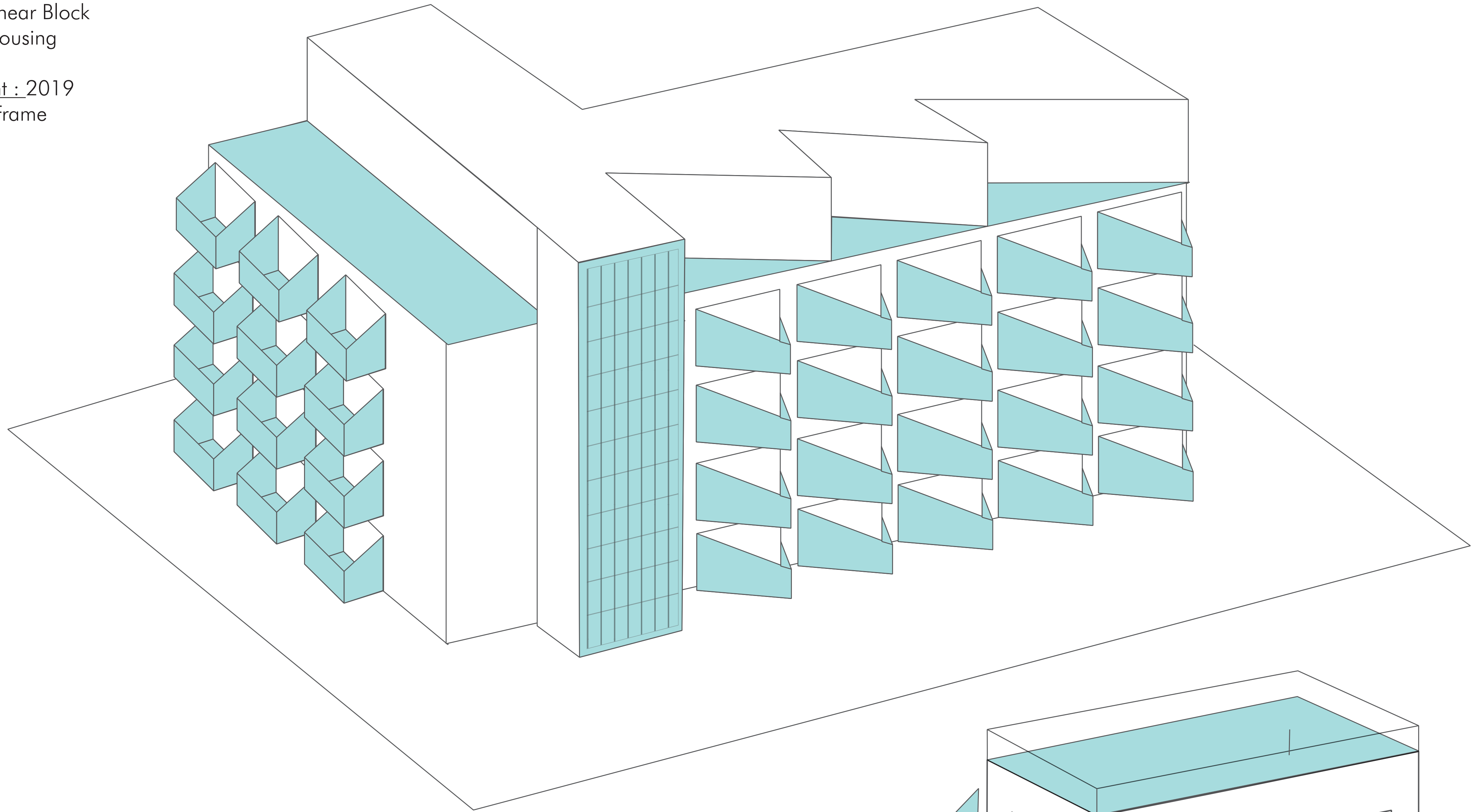
F	Adaptive to various user groups	No
	Adaptive to future improvement	No
C	Communal Area	Yes
	Communal Dwelling	No
E	Enegy Saving & Performance Improvement	Yes
S	Residents remained	Yes
	Applicable to various sites	Yes
	Cost	€ 16M
	Funding	Private

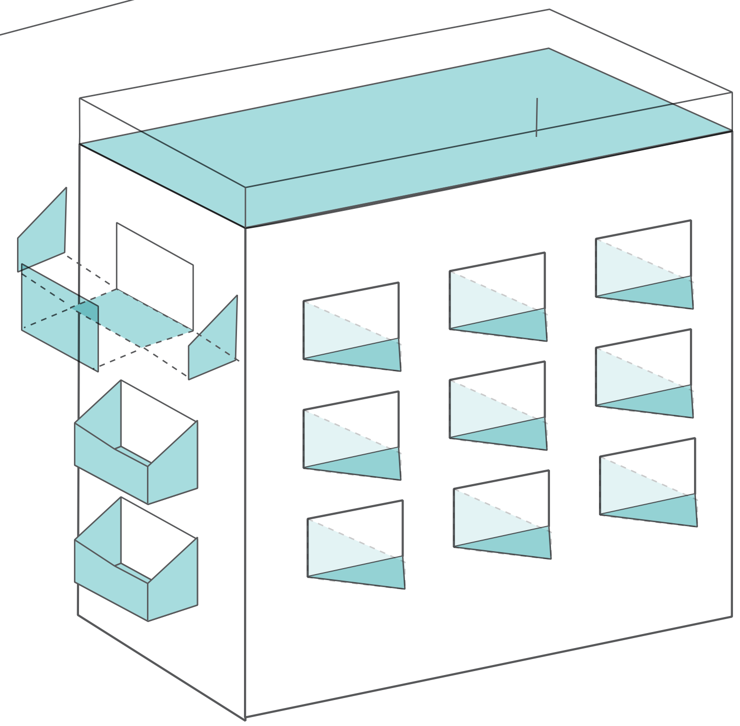




2.1.7_Croydon retrofit

Location: Croydon, GBR(Eng)
Designers: alma-nac
Building Typology: Linear Block
Ownership: Social Housing
Built Period: 1960s
Year of Refurbishment : 2019
Structure: Concrete Frame
N. of Dwellings: 43





Balconies & Communal Areas

The design strategy used seperate morphologies for creating the balconies in different orientations. The architects have also created a communal roof for social activities proposed. Additionally they have created flexible room typologies in the roof for responding urgent demands for the future.

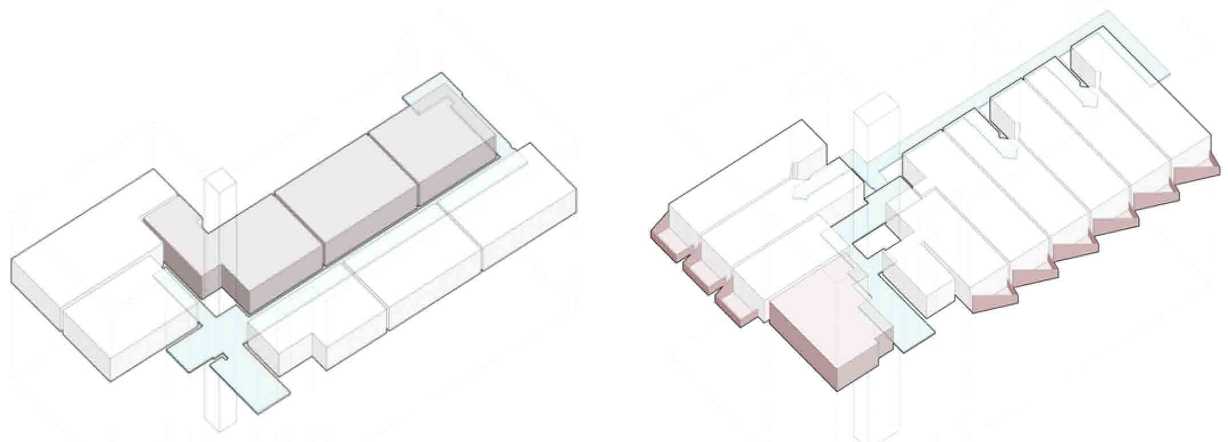


Figure 2.28: Removal of the units from the northern side and the inplementation of the angled balconies [14]

General Scope of the Refurbishment

The building was constructed in the 1960s just next to the station. It is converted from an unused office building into a residential building with 43 dwellings after the refurbishment of the alma-nac. The central organization of the design followed a circulation axis located on the northern side of the building by adding a communal corridor.

On the southwest side of the building, living spaces are designed. Since each unit has a south-facing façade in the living spaces, balconies have been created to extend the living areas. The balconies are designed in an angled way to provide privacy from neighboring apartments that are parallel to the façade. Building mass is differentiated from the vertical timber elements selected on the façade extensions. Spare rooms and workspaces are created on the roof to allow residents to share.

Figure 2.27: Difference in façades from different orientations [14]

(F) Responsivenes and adaptibility to future scenarios

Only one type of dwelling is introduced in the refurbishment. Different user gourps are not introduced.

(C) Consideration of different co-living & user group needs

Communal corridor is created which acts as a service corridor for internal service transfer, which is also designed with acoustic properties by using chipped rubber.
On the roof, a space is created to enhance communal interaction, and a built-in grill is used to encourage the residents to participate in communal gatherings.
On the ground floor, a communal approach is also thought to create a collaborative workspace with different types of dwelling units, adding a studio apartment and one-bed apartments to satisfy London's increasing need for apartments.

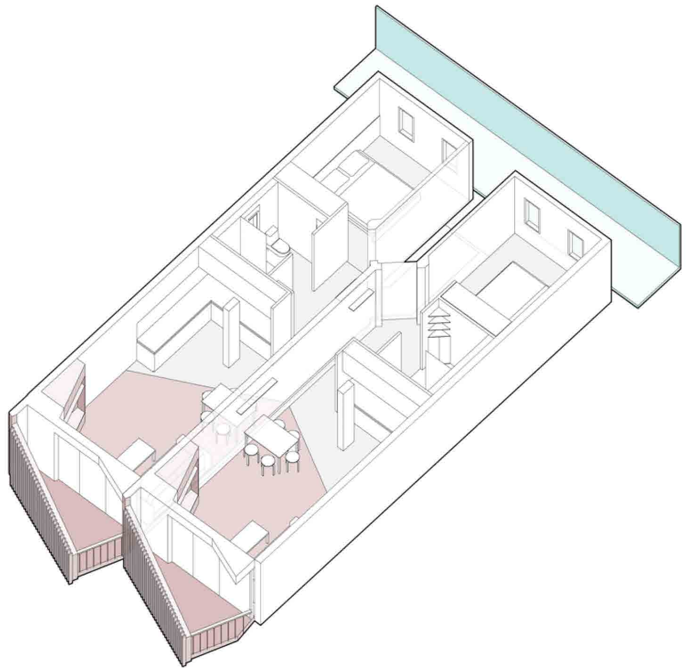


Figure 2.29: Couple units that are designed and replicated [14]

Figure 2.30: Façade detail [15]

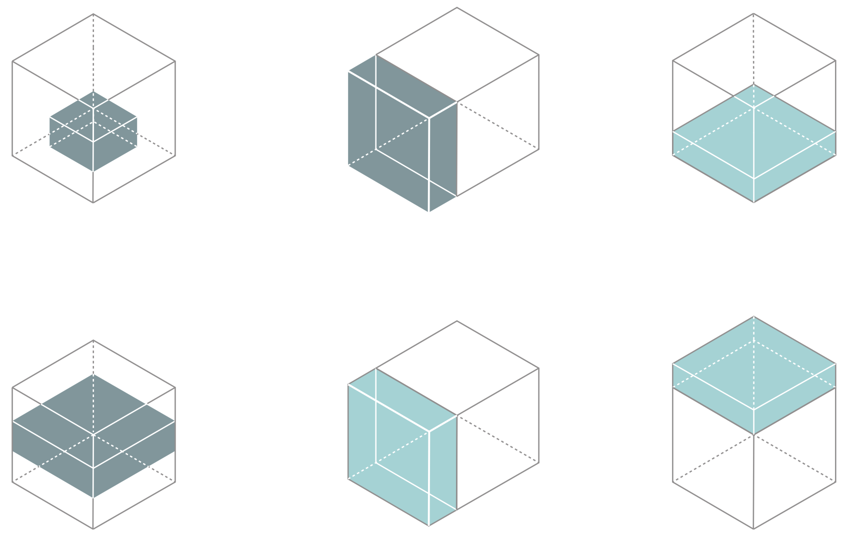
(E)Energy sensitivity and performance improvement

The design incorporated energy-efficient passive design actions, such as angled balconies to enhance sunlight and reduce the need for artificial lighting.
In the design, architects also used motion-sensitive LED strips to reduce electric costs in the communal areas.

(S) The economic feasibility & viability of the intervention and consideration of existing residents

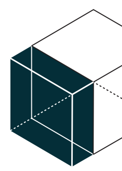
The project was very cost-effective even the intervention won several awards, including the Architects' Journal Retrofit Award for Best Housing Under £5m in 2018.

F	Adaptive to various user groups	No
	Adaptive to future improvement	No
C	Communal Area	No
	Communal Dwelling	Yes
E	Enegy Saving & Performance Improvement	Yes
S	Residents remained	No
	Applicable to various sites	Yes
	Cost	€ 6M
	Funding	Private

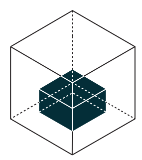


Conclusion
Some examples were succesful in terms of the resident awareness as well as the energies but some had struggle dealing with the problems. Overall the design have each different argets that they achieve. As a summary main actions following the social housing buildings could be:
1_ intervention on envelope
This is the action of retrofitting the building envelope to increase the energy performsance as well as it can create architectural space for needs of the residents
2_intervention in dwelling
These actions could be summarized by the change of the organization of the dwellings for the residential needs and flexible living-quarters. These needs to be cordinated well with the family demographic to respond different needs. There could be also an addition of the communal spaces and dwellings for enhancement of co-living spaces that will be later mentioned in Part 5.

Summary of the architectural examples that are discussed:



Building Scale Intervention

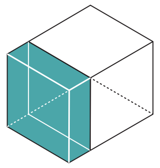


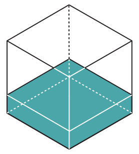
Dwelling Level Intervention

01

F	Adaptive to various user groups	No
	Adaptive to future improvement	Yes
C	Communal Area	No
	Communal Dwelling	No
E	Enegy Saving & Performance Improvement	Yes
S	Residents remained	Yes
	Applicable to various sites	Yes
	Cost	27,2M €
	Funding	Public

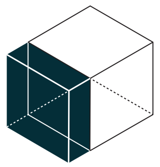
02





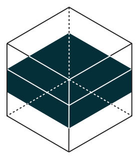
F	Adaptive to various user groups	Yes
	Adaptive to future improvement	Yes
C	Communal Area	Yes
	Communal Dwelling	Yes
E	Enegy Saving & Performance Improvement	No
S	Residents remained	No
	Applicable to various sites	Yes
	Cost	/
	Funding	Private

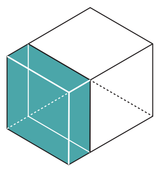
03



F	Adaptive to various user groups	No
	Adaptive to future improvement	No
C	Communal Area	Yes
	Communal Dwelling	No
E	Enegy Saving & Performance Improvement	Yes
S	Residents remained	Yes
	Applicable to various sites	Yes
	Cost	€90,1M
	Funding	Private

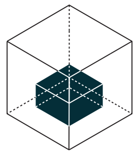
04

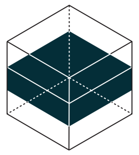




F	Adaptive to various user groups	No
	Adaptive to future improvement	No
C	Communal Area	Yes
	Communal Dwelling	No
E	Enegy Saving & Performance Improvement	No
S	Residents remained	Yes
	Applicable to various sites	Yes
	Cost	/
	Funding	Public

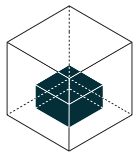
05

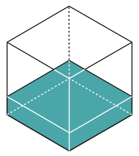




F	Adaptive to various user groups	Yes
	Adaptive to future improvement	No
C	Communal Area	No
	Communal Dwelling	No
E	Enegy Saving & Performance Improvement	Yes
S	Residents remained	No
	Applicable to various sites	Yes
	Cost	€ 1,5B
	Funding	Public&Private

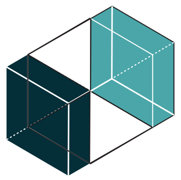
06

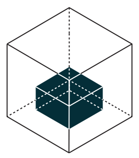


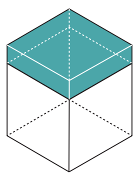


F	Adaptive to various user groups	No
	Adaptive to future improvement	No
C	Communal Area	Yes
	Communal Dwelling	No
E	Enegy Saving & Performance Improvement	Yes
S	Residents remained	Yes
	Applicable to various sites	Yes
	Cost	€ 16M
	Funding	Private

07







F	Adaptive to various user groups	No
	Adaptive to future improvement	No
C	Communal Area	No
	Communal Dwelling	Yes
E	Enegy Saving & Performance Improvement	Yes
S	Residents remained	No
	Applicable to various sites	Yes
	Cost	€ 6M
	Funding	Private

2.2 Transformations Through Economical Focus

Methodology of the Selection and comparison

It is crucial to identify the viability of the interventions to define the actors of the refurbishment. Considering the difficulty of this situation, a few examples were found that are neccessary to reframe the feasibilty of the interventions. These cases are selected due to their energetic concerns. Different than the previous cases, these do not respond to the multi-dimensional needs of the residents such as the rethinking of the living conditions or the public-private relationships. Sole purpose to regeneration of the building envelope to create a better energy performance in the buildings. Unfortunately, not much data can be obtained due to the lack of accessibility of retrofits and building renovation costs. For this reason, different sources were used while examining the strategies economically to create a paramteric average to define the costs. In this way, the approximate expenses of the design strategies were tried to be revealed.

To define this, few realized examples are listed which are representing the different actions for the variable economic goals. These are included with their unit cost to reduce the effect of the variety of buildings by disregarding their shape and size of buildings by dividing the application surface.

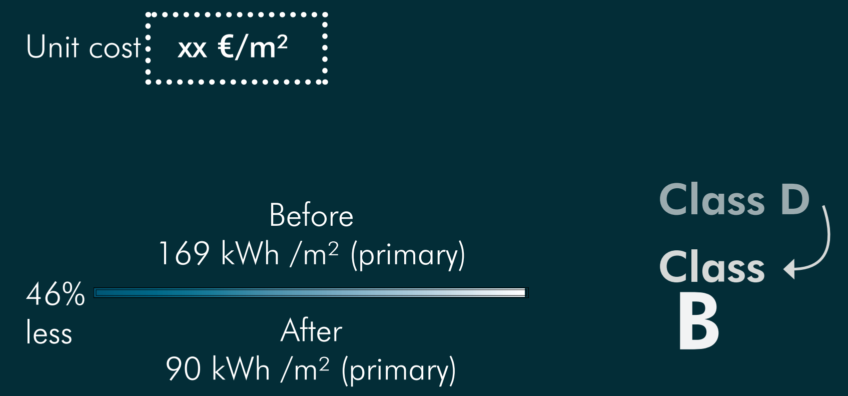
The research process has been comprehensive, with a focus on academic papers , particularly recent articles, to determine the approximate pricing in Italy. I have compiled a list of research articles related to the concept of cost optimality, along with examples of articles that draw estimations from previously collected and examined case study conclusions.

Finally, the potential material list that can be used was compared by considering the prices and performances of the general pricing list of work items and materials in Italy dated 2023.

In conclusion, the approximate cost range of the design strategies that can be hypothetically made in the current situation and the price relationship and comparison between them are concluded. In the following chapters, this information helps us see that the feasibility of the design strategies is defined by their degree of intervention and economic costs.

Realized Cases

Unit costs were included to standardize the variables in constructed projects for the purpose of making a general approximation. Furthermore, when available, the energy performances related to the projects were displayed in terms of their before and after states, with the percentage of energy saved indicated on adjacent bars. Energy classes may also be included to demonstrate the effectiveness of a refurbishment.



Academic Studies

The academic research focuses on identifying the optimal cost of refurbishment types in Italy, providing valuable insights into the variations between Italy and other European countries. It also offers a comprehensive understanding of the Italian context. Two case studies illustrate cost optimization by combining retrofit packages sourced from Tabula and considering different building archetypes. The other one gives a general global cost and cost optimality scope to understand the effects of external envelope improvement on global cost and energy saving using different materials.

2.2.1 Realized Cases

2.2.1.1 Advanced Façade Solutions

These examples are selected due to their extraordinary improvements in energy consumption and façade solutions.

Class
A

RC1_Advanced Trombe Wall

Location: Graz, Austria
Built Period: 1970
Ownership: Social Housing
Year of Refurbishment : 2009
Cost: 8.8 Million €
Refurbishment scope: Heat storage tanks for ground water heating, DHW, Façade Intervention
Heating Degree Days: 3500 days(Torino:3430 days)

Unit cost: **816 €/m^2**

In the project GAP façade is used while refurbishing as passive solar heating which can be said that it is similar to how a trombe wall functions. The outermost layer of the wall is designed to allow sunlight to pass through a translucent layer, the GAP solar facade, which is made of glass held in place by aluminum frames. The solar radiation penetrate this translucent layer and reach the wooden structure behind it. This wooden structure functions as a thermal mass, similar to the mass wall in a trombe wall system. It absorbs the solar radiation during the day, storing the heat. As the day progresses, the heat is released gradually, with a time delay, transferring warmth to the existing wall and then into the interior spaces. This time-delayed heat release helps maintain a more stable indoor temperature, preventing the space from overheating during the day and reducing cooling during the night.

Figure 2.31: Trombe wall façade renovation [17]

Before
184 kWh /m^2 (primary)
93% less
After
12 kWh /m^2 (primary)

Construction of the system

Figure 2.32: Trombe wall façade with honeycomb cardboard filling [18]

Wood construction + insulating material : ≥ 60 mm
Framework wall in solid wood+ insulating material : 151 mm
Wood panel: 19 mm
GAP-Honeycomb panel in cellulose: 30 mm
Air gap (slightly ventilated): 29 mm
ESG float glass panel: 6 mm
Attaching parts in aluminium

Class
B

RC2_ ETICS (External Thermal Insulation Composite Systems) Refurbishment

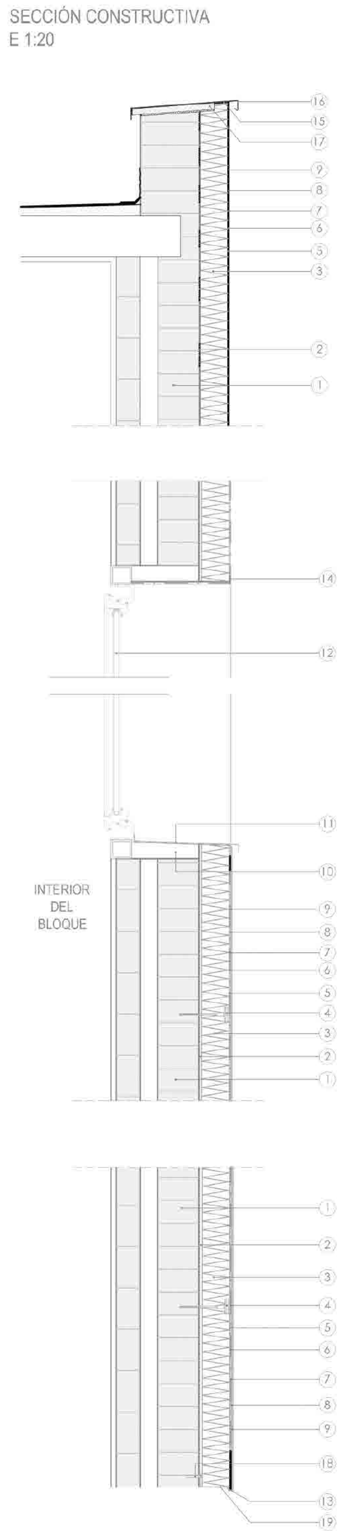
Location: Torrelago, Spain
Built Period: Late1970s
Ownership: Multiple Family
Year of Refurbishment : 2018
Cost: 16.4 Million €
Refurbishment scope: District heating renovation, 3 high-efficiency biomass boilers, high-performance CHP, Optimized control strategies Smart energy metering, Home temperature controle, Façade Insulation &, Connection to district heating system
Climate: Cold Semi-arid

Unit cost: **118 €/m²**

The renovation of the Torrelago district includes deep façade retrofitting called as ETICS as well as connection and maintenance of the district heating system. The aims of the project are to reduce the energy demand by improving buildings insulation holistically. The main challenge was the ownerships were divided. The project was one of the Cityfieds initiatives together with different public bodies and commissions. Buildings are refurbished with smart monitoring systems (thermal energy meters) for to evaluate the consumption online for the whole building. Also they have implemented thermometers for residents.
The half of the projects costs was supported by European commission. However IRR(Internal Rate of Return) is only 10% and they have calculated that residents needed long term contracts as long as 15 years. (9)

Figure 2.33: ETICS Implementation for the whole neighborhood. (19)

Before
138.6 kWh /m² (primary)
35% less
After
89 kWh /m² (primary)



Existing wall (interior to exterior)

plaster=1.5 cm
tile board=7cm
air= 5cm
1/2 foot of brick

Retrofitting(interior to exterior)

Adhesive mortar
Mapetherm AR1 gg
EPS plate=8cm
Fixing pin
Mortar
Fiberglass mesh
Mortar
Paint primer
Finishing mortar
Paint

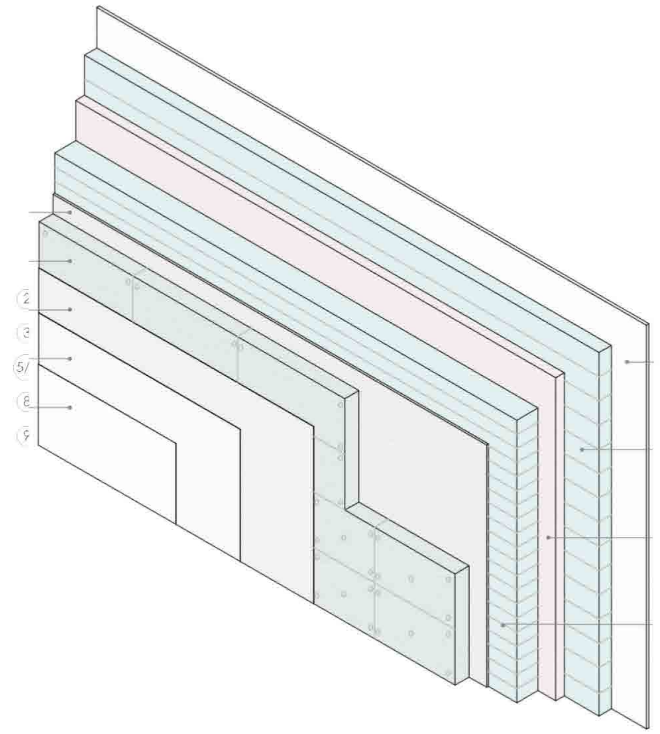


Figure 2.34: Detail section of the intervention (19)

Class D

Class B

RC3_Prefabric Façade Panels

Location: Lyon, France
Built Period: Multiple Buildings
Ownership: Social Housing
Year of Refurbishment : 2021
Cost: 25.288 million €
Refurbishment scope: Façade intervention
Climate: [Csa] Interior Mediterranean - Mild with dry, hot summer.

Unit cost: **385 €/m²**

The intervention was done for 1000 units of dwellings by installing pre-fabricated panels on the existing façade. Intervention is constructed on existing façade with a mobile crane throughout the neighborhood. Since there was no demolition process and no scaffolding, it was relatively cost effective. In addition to that, residents did not have to move within the process of installation.
Panels are used with wooden frames infilled with an insulation which is produced from recycled plastic bottles. The project is labeled as BBC Effinergie Rénovation (low-energy building), thus considerably improving energy performance with using recycled materials.

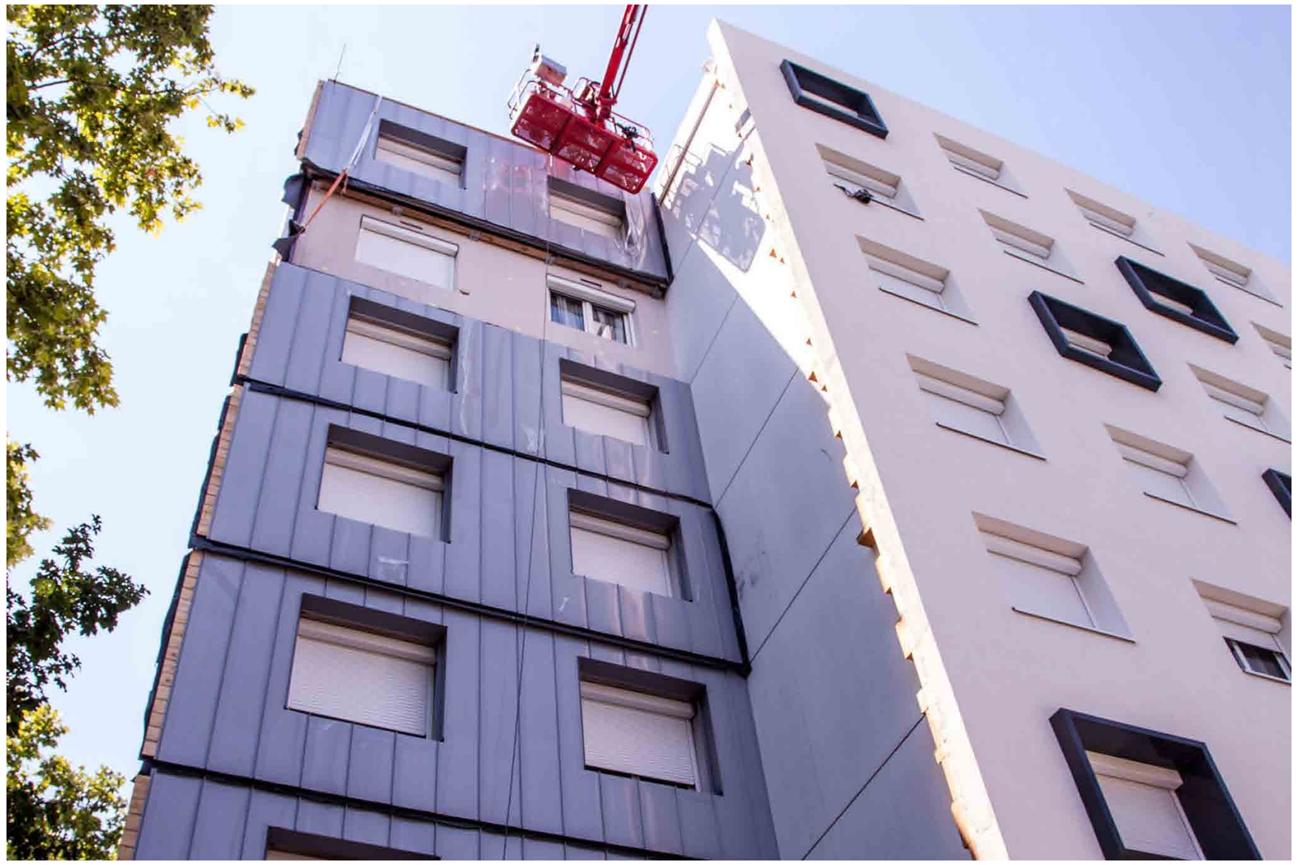
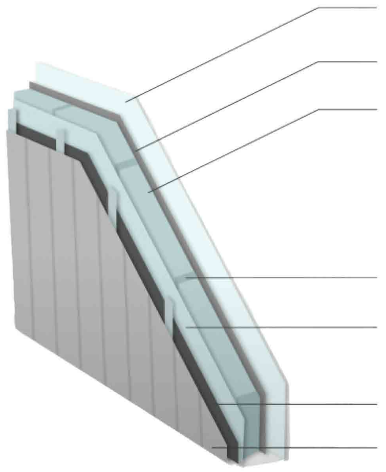


Figure 2.35: Pre-fabric panel insulation montage with crane [21]

Before
215 kWh /m² (primary)
58% less
After
90 kWh /m² (primary)



Prefabric Panels (from interior to exterior)

Interior cladding
Vapor barrier film
Ecopeg insulation made from polyester fibres from the recycling of plastic bottles from selective sorting
Wooden frame
Bracing panel
Rainproof film
Exterior coating

Figure 2.36: Layers of the constructed wall [22]

Figure 2.37: Construction process screenshot taken from the refurbishment video [22]

Class
A

RC4_Façade & Balcony Intervention+Shading system

Location: Vitoria-Gasteiz, SP
Built Period: 2014
Ownership: Multiple Family
Year of Refurbishment : 2015
Cost: 1 million €
Refurbishment scope: Façade intervention, Glazing addition, Shading
Climate: [Dfb]

Unit cost: **577 €/m²**

A thermal coating of the envelope and addition of elements targeted to lower energy consumption and CO_2 emissions. Since the building is located in a humid zone, ventilation and condensation are taken into account. Winter and summer conditions thought while installing the shading elements on the enclosed balconies to achieve desired comfort levels. Glazing units were updated according to the regulations with Low-E coating and argon air cavity. On the façade rockwool insulation is used with polyurethane sandwich panels. In the end, building is given Class A energy certificate.

Figure 2.38: Coverage of the existing balconies designed to show as one mass [23]

Refurbishment:

Roof U-Value : 0,2
Envelope U-Value :0,25
Window U-Value :1.5

Façade Insulation:
1_rock wool (120 mm thick and 70 kg/m3 density)
2_pre-lacquered sheet metal sandwich panel with 8 cm polyurethane insulation

New Glazing Used:

Double glazing: Low-E coating, 4/12/6 with Argon Gas

Mobile Shading Elements: Movable vertical slats on the west facade allow sunlight to pass through in winter and stop it in summer.

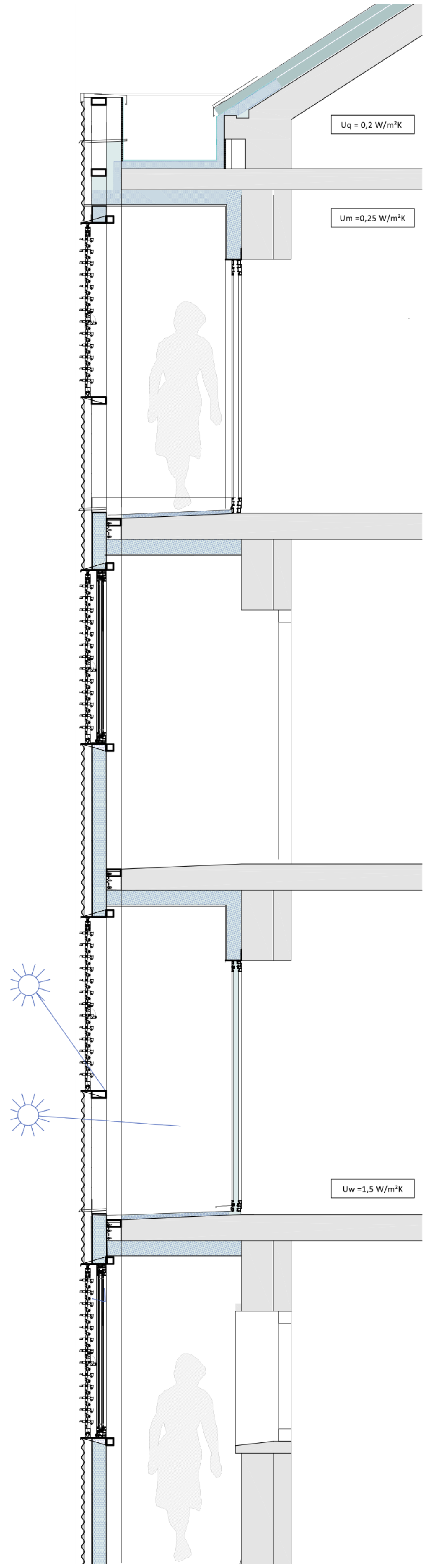


Figure 2.39: Detail section drawn by the architects [23]

2.2.1.2 Conventional Façade Solutions

Selection of Low cost Façade Renovation Cases

In this sub-title, interventions are selected based on their practicality and ease of implementation. The selected interventions are solely based on improving the existing façade by insulation installation, without the need for panels or high-end energy performance solutions.

These on-site insulation montages are relatively low-cost and do not mainly target a high-energy performance building but only to reduce energy costs. Their transparent explanation of the improvement works allows for a general cost estimation of the external insulation. The built year is selected around the late 60s- early 70s, and the climate selected is identical to Torino to create a better estimation.

However, these examples are not located in Italy. Therefore, it is crucial to conduct additional paper research for Italy (specifically Northern Italy) to ensure a comprehensive understanding and application of these interventions on Corso Taranto case.

Class E → Class C

RC5_Low cost Façade Insulation [24]

Location: Maxeville, FR
Built Period: 1979
Ownership: Multiple Family
Year of Refurbishment : 2020
Cost: 1 Million €
Refurbishment scope: Façade and ground floor insulation, communal area improvements
Climate: Cfb

External thermal insulation was carried out on all the facades. The crawl space was also insulated using flocking to prevent losses from the lower slab. Extensive work was carried out at the entrances of the various buildings to restore airtightness and limit thermal bridges. The entrance doors were replaced, and the ceilings of the entrances were changed to create a separation between the inside and the outside. Hygroregulated CMVs and air inlets were installed, improving the air quality of each dwelling.

Unit cost: **158 €/m^2**

Before: 250 kWh /m^2 (primary)
58% less
After: 105 kWh /m^2 (primary)

Class E → Class D

RC6_Low cost Façade Insulation [25]

Location: Bois D'arcy, FR
Built Period: 1966
Ownership: Multiple Family
Year of Refurbishment : 2022
Cost: 1.7 Million € (Façade insulation:990,000, Entrance doors: 40,000)
Refurbishment scope: Façade and ground floor insulation, communal area improvements, Mechanical Roof Ventilation
Climate: Cfb

The project consists of six buildings with nearly 120 apartments. The intervention is done with rock wool and polystyrene insulation. The building envelope is insulated thoroughly to ensure airtightness. A mechanical ventilation VMC has been installed on the apartment's vent connection. The entrance hall has also been renovated, and the entrance doors have been changed.

Unit cost: **236 €/m^2**

Before: 288 kWh /m^2 (primary)
25% less
After: 215 kWh /m^2 (primary)

Class D → Class B

RC7_Low cost Façade Insulation [26]

Location: Rambouillet, FR
Built Period: 1977
Ownership: Multiple Family
Year of Refurbishment : 2020
Cost: 3 Million € (Façade insulation:2.2M)
Refurbishment scope: Façade and ground floor insulation, communal area improvements, Mechanical Roof Ventilation
Climate: Cfb

The renovation of the building focuses on upgrading the building envelope and improving ventilation and heating systems. Exterior walls, attic floors, and lower floors are insulated to reduce heat loss, while shutters and carpentry are replaced for better energy efficiency. Ventilation is enhanced, refuse chutes are adapted or sealed, and radiators are upgraded with heating cost allocators for more efficient energy use. Improvements also include better intercom systems and lighting in common areas, contributing to a more energy-efficient and comfortable living space.

Unit cost: 230 €/m^2

Before: 169 kWh /m^2 (primary)
46% less
After: 90 kWh /m^2 (primary)

Class D

Class C

RC8_Low cost Façade Insulation [27]

Location: Paris, FR
Built Period: 1971
Ownership: Multiple Family
Year of Refurbishment : 2023
Cost: 3.6 Million € (Façade insulation:2.2M)
Refurbishment scope: Façade and ground floor insulation, communal area improvements, Glazing Improvements
Climate: Cfb

The renovation includes adding 13 cm of rock wool insulation to all facades, 20 cm of expanded polystyrene to roofs, and 9 cm of phenolic foam. Balconies are waterproofed, guardrails are replaced, and low floors are insulated. The heating and hot water networks receive additional insulation and upgraded single-glazed windows. Project achieved over 35% energy savings.

Unit cost: **198 €/m²**

Before
174 kWh /m² (primary)

42% less

After
101 kWh /m² (primary)

Class D

Class B

RC9_Low cost Façade Insulation+Glazing [28]

Location: Paris, FR
Built Period: 1973
Ownership: Multiple Family
Year of Refurbishment : 2018
Cost: 2.6 Million €
Refurbishment scope: Façade and ground floor insulation, communal area improvements, Glazing Improvements
Climate: Cfb

The Rimini Tower, a high-rise building in Paris 13, underwent a comprehensive energy renovation, including 16 cm of exterior rock wool insulation, roof and hot water network insulation, improved ventilation, and window replacements. Managed by the institutional lessor Coopération et Famille, this renovation addressed the building's severe deterioration. The project resulted in a nearly 60% reduction in annual energy consumption and greenhouse gas emissions, which was highly cost-efficient.

Unit cost: **110 €/m²**

Before
218 kWh /m² (primary)

59% less

After
89 kWh /m² (primary)

2.2.2 Academic Studies on Cost Analysis

Academic studies related to cost and cost-optimality are selected for gathering a reference from the Italy.

AS1_Whole cost analysis of building envelope technologies by different retrofit packages

In the study, Whole Cost Analysis of Building Envelope Technologies According to the European Standard EN 15459, evaluate the economic and energy performance of different building envelope technologies for high-rise office buildings. The research applies the whole cost analysis method outlined in the EN 15459 standard to compare six façade solutions, each with the same U-value but varying in terms of materials and structural complexity (Fig.2.40). The authors use dynamic simulations to determine energy consumption for heating and cooling and focus on balancing the initial construction costs, replacement costs, and operational energy costs which later summed up as global cost comparison (Becchio et al., 2011).

The findings suggest that lighter building envelope configurations, are more cost-effective in the long term, achieving the lowest global cost. This is in contrast to more complex solutions like ventilated facades, which, while reducing energy costs, do not compensate for their higher upfront expenses through the life-span of the buildings.

Table 3. Thermal and geometrical features of the six different façade technologies

ID	Materials (from external to internal)	Thickness [cm]	U [W/m^{2}K]	M_s [kg/m^2]
1	Brick – Insulation – Lightweight Masonry – Plaster	56	0,22	654
2	Plaster – Insulation – Lightweight Masonry – Plaster	48	0,22	405
3	Concrete block –Insulation – Plaster	41	0,22	655
4	Brick – Insulation – Lightweight Masonry – Air Gap – Clay block	59	0,22	650
5	Aluminum Foil– Air gap – Insulation – Lightweight Masonry – Air Gap – Plasterboard	62	0,22	235
6	Stone – Air Gap – Insulation – Lightweight Masonry – Plaster	49	0,22	554

Figure 2.40: Showing the different layers for different options. (Becchio et al., 2011).

AS2_Passive envelope measures for improving energy efficiency in the energy retrofit of buildings in Italy

In the study, Passive Envelope Measures for Improving Energy Efficiency in the Energy Retrofit of Buildings in Italy, Brunoro (2024) investigates the impact of passive design strategies on improving the energy performance of residential buildings in climate of Italy. The research focuses on various envelope measures, including external thermal insulation systems (ETICS), high-performance windows, and solar buffer spaces, to enhance the thermal efficiency of older residential buildings, particularly those constructed in the post-war era. By analyzing these measures, the study provides practical guidelines for energy retrofits, aiming to align with the European Union's nearly zero-energy building (NZEB) standards.

The study concludes that integrating passive envelope measures, such as external thermal insulation (ETICS), high-performing glazing, and solar greenhouses, can significantly reduce energy consumption in retrofitted buildings. These measures help to minimize heat loss in winter and mitigate overheating in summer, contributing to the overall comfort and energy efficiency of buildings in Italian building stock. The costs of the intervention and the material types are also listed in the research. This lated becomes beneficial for a general framework of costs and reference for a comparison of cost-efficiency in fifth chapter of the thesis.

There are three alternatives mentioned in the paper for a reference of cost in Italy. he holistic insulation of the envelope (ETICS) range from 60 to 80 € per square meter, while a ventilated façade typically costs around 120 to 150 € per square meter. More complex interventions include double-layer glass façades and solar greenhouses, with costs varying based on the size of the project but it is estimated as 1000 to 1300 € per square meter. (Brunoro ,2024)

Table 1. Most common insulation materials for ETICS and their properties.

Insulation Material	Density ρ kg/m^3	Thermal Conductivity λ (W/mK)	Water Vapor Diffusion Resistance Index μ	Insulation Thickness for U Value 0.2 W/m^2 K
Expanded Polystyrene (EPS) *	15–30	0.03–0.04	5–23	15–18
Rockwool	20–40	0.031–0.04	1–2	15–22
Wood fiber	150–250	0.04–0.08	2–5	18–36
Cork	100–120	0.038–0.05	10–18	16–25
Foam glass	10–120	0.04–0.05	-	18–25
Vacuum Insulation Panel	150–180	0.007–0.01	-	3–4

Figure 2.41: Common insulations that are used for holistic envelope insulation in Italy (Brunoro ,2024)

AS3_Energy and cost analysis through the application of the building typology in differente Italian climate zones

The study analyze the effectiveness of various energy efficiency measures for different residential building types in Italy. By applying a building typology method, the research evaluates 120 building types based on construction periods, climatic zones, and building sizes, offering a comprehensive view of the country's building stock. Utilizing the EU's Directive 2010/31/EU cost-optimal methodology, the study compares the economic feasibility of different actions of energy improvements, including thermal insulation, advanced glazing, and upgrades to heating systems. The investment costs for the apartment block typology is given as 148 € for opaque envelope improvement, 90 € for window upgrades.

There are few intervention packages listed in the study. Then these are combined with different buildings that are constructed in certain periods. Different combinations of the interventions are a mix of improving heating, refurbishing walls and upgrading the glazings. For the construction periods, the important period is relevant to this thesis is 1961-75 period buildings that are built in same climate zone (Fig.2.42).Althought there were higher energy saving options, in the paper, its is concluded that in Milano, compared to other refurbishment actions, opaque envelope and window improvements tend to be more cost-effective due to climate. (Zone E which is same as Torino). The other combinations including different actions are better performing in the operational costs, but it is stated that it becomes cost-effective and even the payback period is exceeding 30 years (which is decided as lifetime of the building in the study).

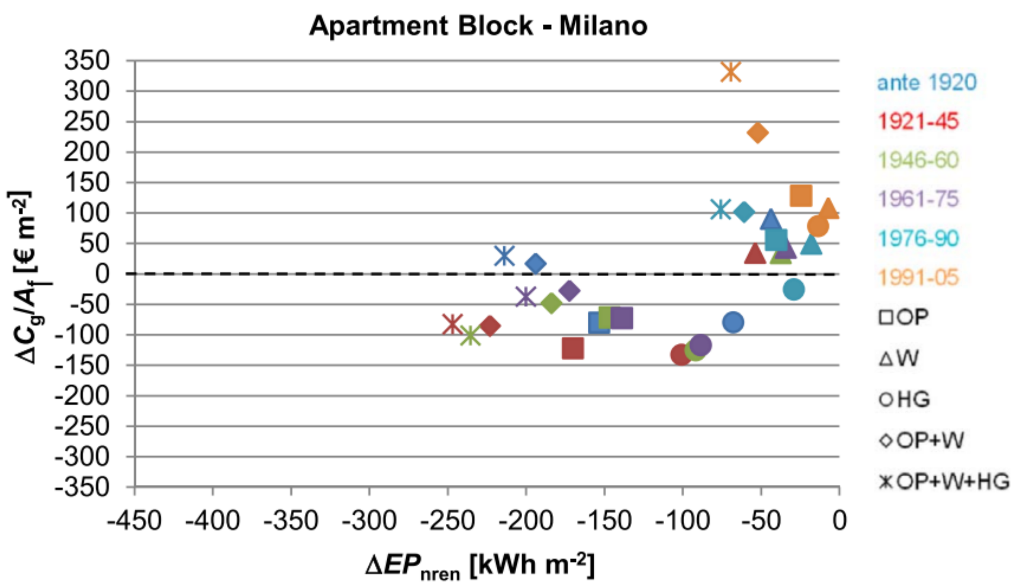


Figure 2.42: Global cost reduction and primary energy saving comparison in Milano with different interventions. OP: Opaque Envelope Insulation W: Window upgrade HG: Heating system improvement(Ballarini et al. ,2017)

The Final Framing the Costs of the Interventions

	FAÇADE INSULATION	ADVANCED FAÇADE INTERVENTION	GLAZING IMPROVEMENT	DOUBLE SKIN	TOTAL
RC_1	x	544 (2/3)	x	x	816
RC_2	118	x	x	x	118
RC_3	x	385	x	x	385
RC_4	x	384 (2/3)	193 (1/3)	x	577
RC_5	158	x	x	x	158
RC_6	137	x	x	x	137
RC_7	168	x	x	x	168
RC_8	121	x	60	x	181
RC_9	73	x	37	x	110
AS_2	60-80	120-150	x	1000-1300	x
AS_3	148		90		x

To sum up, various results are considered due to differences in multiple situations, such as city, country, year of refurbishment, logistic costs, market, cost of materials, etc. However, if we look at general observations both in Europe and Italy, we can estimate some average values to proceed to the design strategies and, eventually, possible scenarios.

The first possibility is to refurbish the building throughout the whole envelope with basic insulation. It directly affects energy consumption since the analyzed buildings are residential buildings with higher Awall/Awindow ratios. Therefore, the most effective solution is increasing the thermal properties of the opaque envelope, especially in climate "Zone E" areas (Ballarini, Corrado, Madonna, Paduos, & Ravasio, 2017). The table shows that basic insulation improvement costs in realized cases are between 118 and 168 €/m². In the research papers, with the inspection of different examples, the number can be between 60 and 148 €/m². It can be said that in Italy, the costs of the work of insulation (especially with a "110% Super Bonus"*) are lower compared with Europe, but this changes, of course, with the region and what type of insulation is used. Therefore, further simulation is done for the materials mentioned in this chapter which is related to the façade refurbishment to roughly estimate the base costs of the insulation materials to have a general scope of perspective that is taken as 125 €/m² for the façade insulation.

The second renovation type can be refurbishing the building with highly efficient materials and technologies to achieve lower energy consumption. Using advanced façades increases the cost, but there are various options to choose from. As an example of RC1, the whole façade is covered with a Trombe wall. This improved energy consumption to as high as 544 €/m². In the case of pre-fabric walls, it was more respectful towards existing buildings since the installation process was fast and efficient due to easily stackable pre-fabric panels. Even though the insulation material was recycled plastic insulation pieces, the cost was lower at 385 €/m². In the example of RC4, two layers of insulation are used, including the roof and ground floor. The insulation intervention cost was similar to RC3; however, with the implementation of glazing units on balconies and shading elements, the performance was much better compared to other examples. In the research paper, the ventilated façade is thought to be around 365 €/m² as average in Italy. These façades are primarily effective in humid regions, but with the façade caps, they could be beneficial in winter due to the air barrier, which acts as an extra insulation layer. Thirdly, the improvement of existing glazing is crucial to achieving regulation and reducing heat loss. This refurbishment is intervened together with envelope insulation. The cost is dependent on the region, but it is dependent mainly on the type of glazing and frames. In examples of realized projects, we can observe that cost is not possible to approximate since it fluctuates highly. However, according to the research paper, we can generalize the cost of the double glazing application to be around 63 €/m² while for the triple glazing it can raise to 190 €/m². These two numbers are taken for the assumption of the intervention cost of the glazing units.

The last intervention could be adding a double skin layer to the building, which would act as a buffer zone. This option, compared to others, greatly affects and changes the architectural appearance and features of the building. The cost is nearly x10 more costly than the other options which is 1200 €/m² in average.

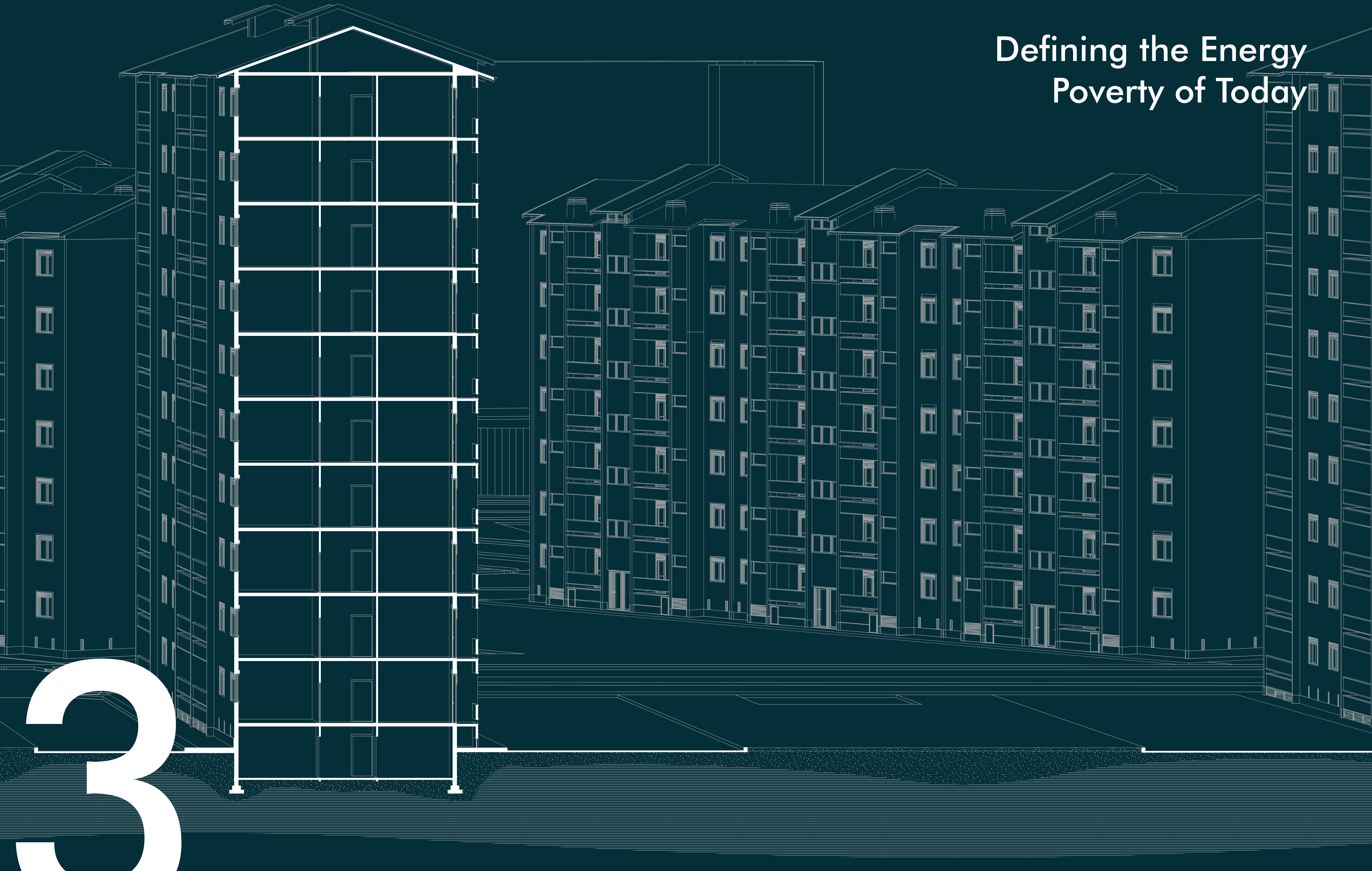
For the future scenarios central heating system changed to the heat pump combined with the PV panel implementation that needs to be added to the cost assumption. It is added to the scenarios which improved the current system (Scenario 4&5) are added with 430 €/m² which is applicable to the building archetypes built in 1961-1975. (Dell'Anna et al., 2019)

In summary, the most cost-efficient option for the refurbishment of the building is only retrofitting the building envelope, which could be reduced in cost by using different materials if the residents want to improve and upgrade the glazings for the holistic renovation of the building. This increases the energy class mildly. Using advanced façade technologies or a double skin façade significantly increases energy performance. However, its cost is high, which would have a higher payback period (Ballarini et al. ,2017) Therefore, this option can be only possible if the funding is higher and cannot be individually funded by the residents.

* The Superbonus is a tax incentive established by Article 119 of D.L. n. 34/2020 in Italy, aimed at supporting energy efficiency upgrades and seismic improvements in buildings. The initiative is for interventions that improve the energy performance of a building (both condominiums and single homes) by at least 2 classes or reduce the seismic risk.

CHAPTER 3

Defining the Energy Poverty of Today



3

3.1 The 1 Detail, 16 Buildings

SITE PLAN

1_ Commercial Center
2_ Church
3_ Meeting Point
4_ Communal Treatment Center
5_ Kindergarten "G. Fanciulli"
6_ Musical Training Center
7_ San Carlo Technical School
8_ Kindergarten "Iqbal Masih"
9_ Inter-cultural Center

3.1.1 The four Building Types of the Neighborhood

The site is located between Via Giambattista Pergolesi and Corso Taranto. Sixteen buildings built are the site belongs to ATC as administration and ownership. The buildings are repeated for four different typologies. Typologies consist of only two types of dwelling types that are identical to each other.

Typology A has only "Room 6" type dwelling and it is 10-story high. In each floor 4 dwellings and 2 vertical circulation cores are placed. This typology is oriented towards north-west direction in front, south-east in back of the buildings. There are four buildings that constructed with this typology.

Typology B is similar to the "Type A" in terms of the orientation and height. This typology has four dwellings and it is 10-story high. There are 2 vertical circulation cores with "Room 6" typology on the corners and "Room 5" dwelling typology in the middle of the building. This typology of buildings repeated six times in the site.

Typology C is oriented almost perfectly to the coordinate system according to the exact north. The entrance door is located towards east, and back of the building oriented towards west. The building has six dwellings per floor and it is 6-story high. The building has 3 vertical circulation cores. The typology consists of "Room 6" at the northern corners of the each floor and five "Room 5" typology dwellings in the rest. This typology of building is repeated by three times.

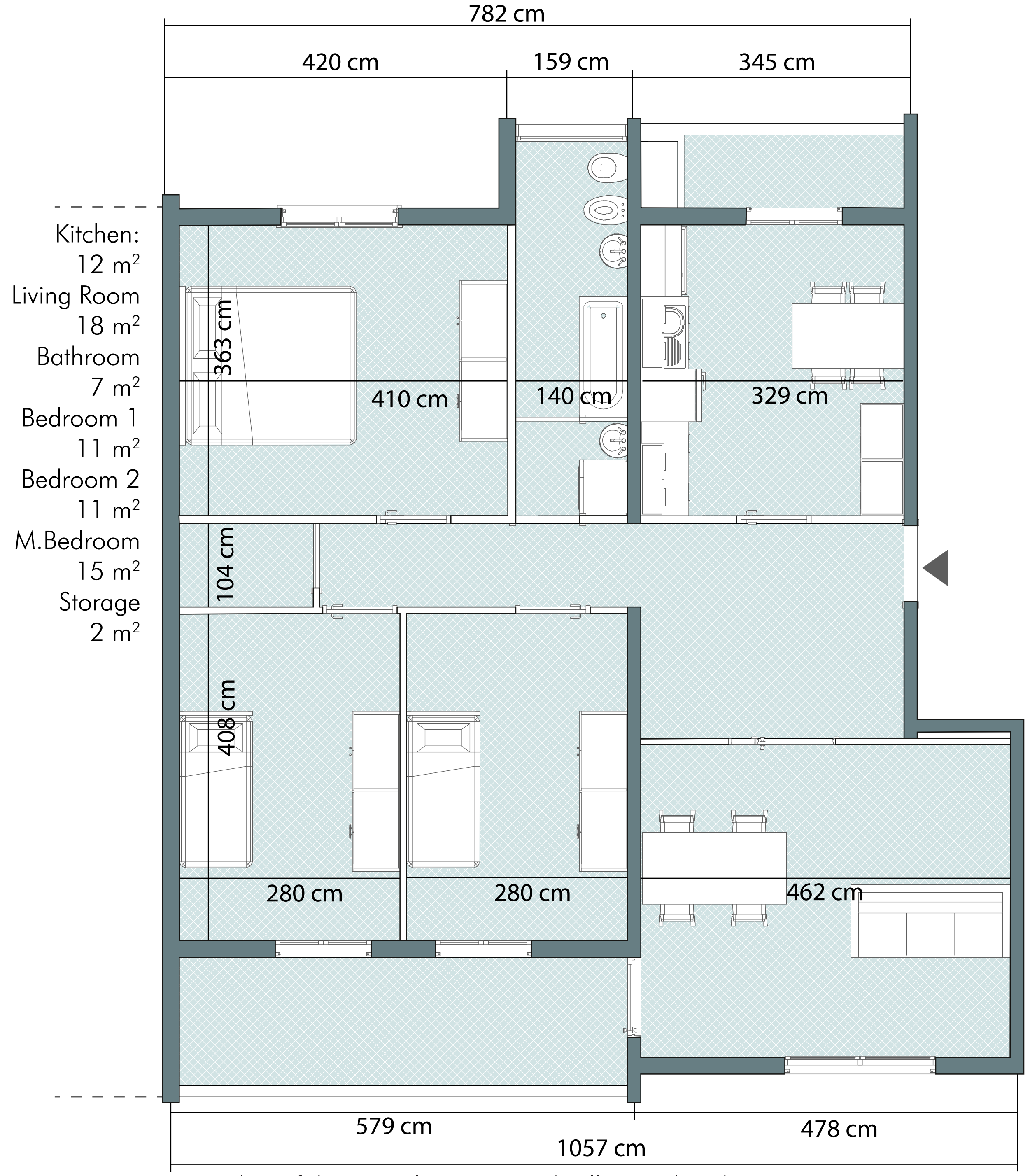
Typology D is oriented similar to the "Type C" building and it is also 6-story high. It has 3 vertical circulation cores and six dwellings per floor. The dwelling typology is only consists of "Room 5" typology. This type of building is repeated three times in the site.

3.1.2 Room 6

Family 3-6 people

Walls facing exterior environment are prefabric wall units that are insulated walls from the 1969 construction period. Later on exterior walls are covered with the insulation material to satisfy the 2006 legislation. This typology is nearly identical to the Room type 5 with only increase in size of the bedrooms by moving the wall by 1.5m to the left. By this way one more room is introduced to the original plan and storage room is carried to the end of the corridor.

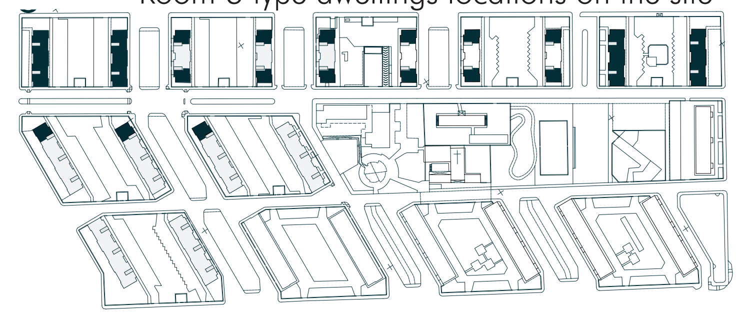
Initial room arrangement has done for the large families which were 3 to 6 people in the beginning of the construction.



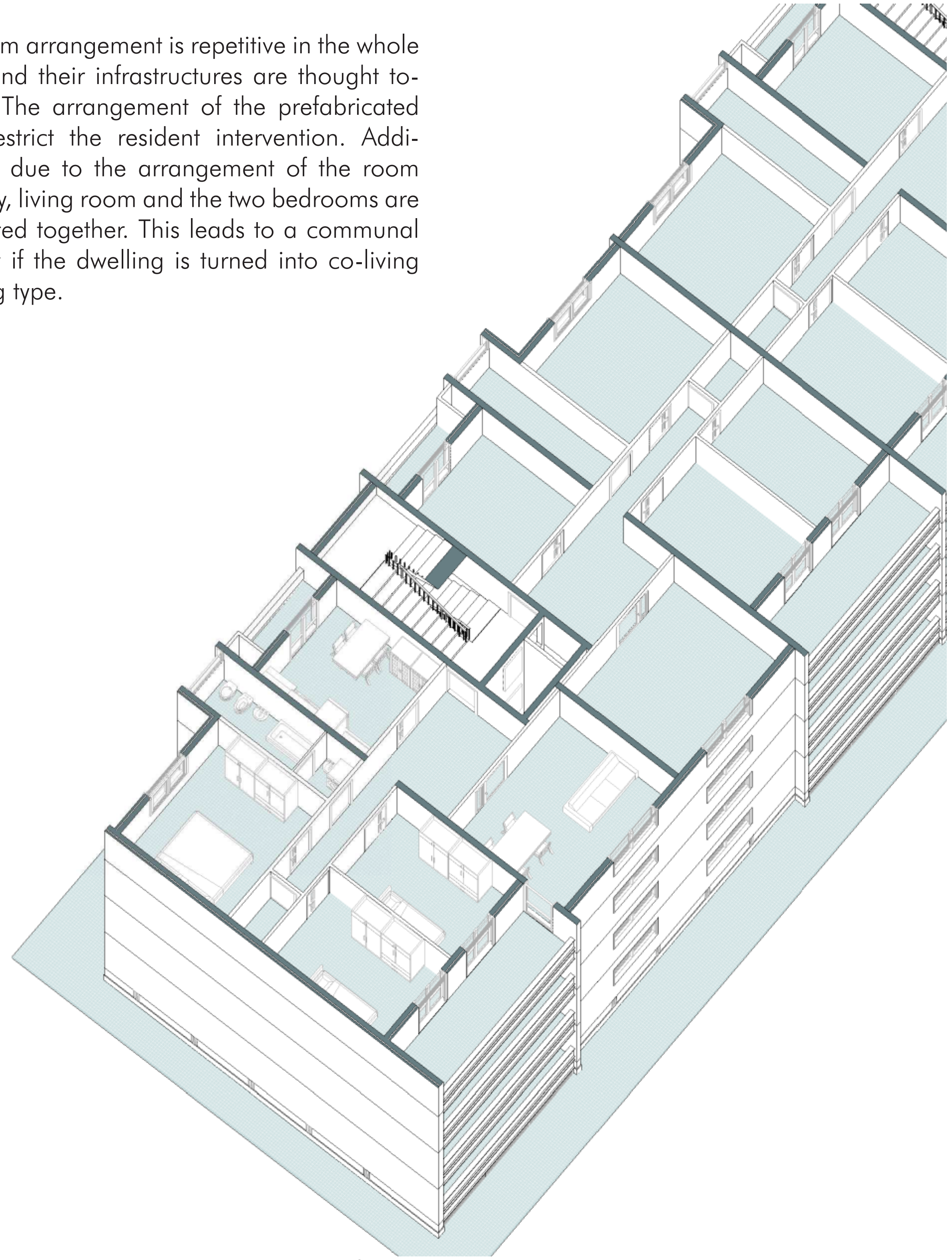
Plan of the typical "Room 6" dwelling isolated as one unit

Room type 6 can be found in Type A & B & C buildings.

Room 6 type dwellings locations on the site



The room arrangement is repetitive in the whole floors and their infrastructures are thought together. The arrangement of the prefabricated walls restrict the resident intervention. Additionally, due to the arrangement of the room typology, living room and the two bedrooms are connected together. This leads to a communal balcony if the dwelling is turned into co-living dwelling type.



Isometric view of the dwelling "Room 6"

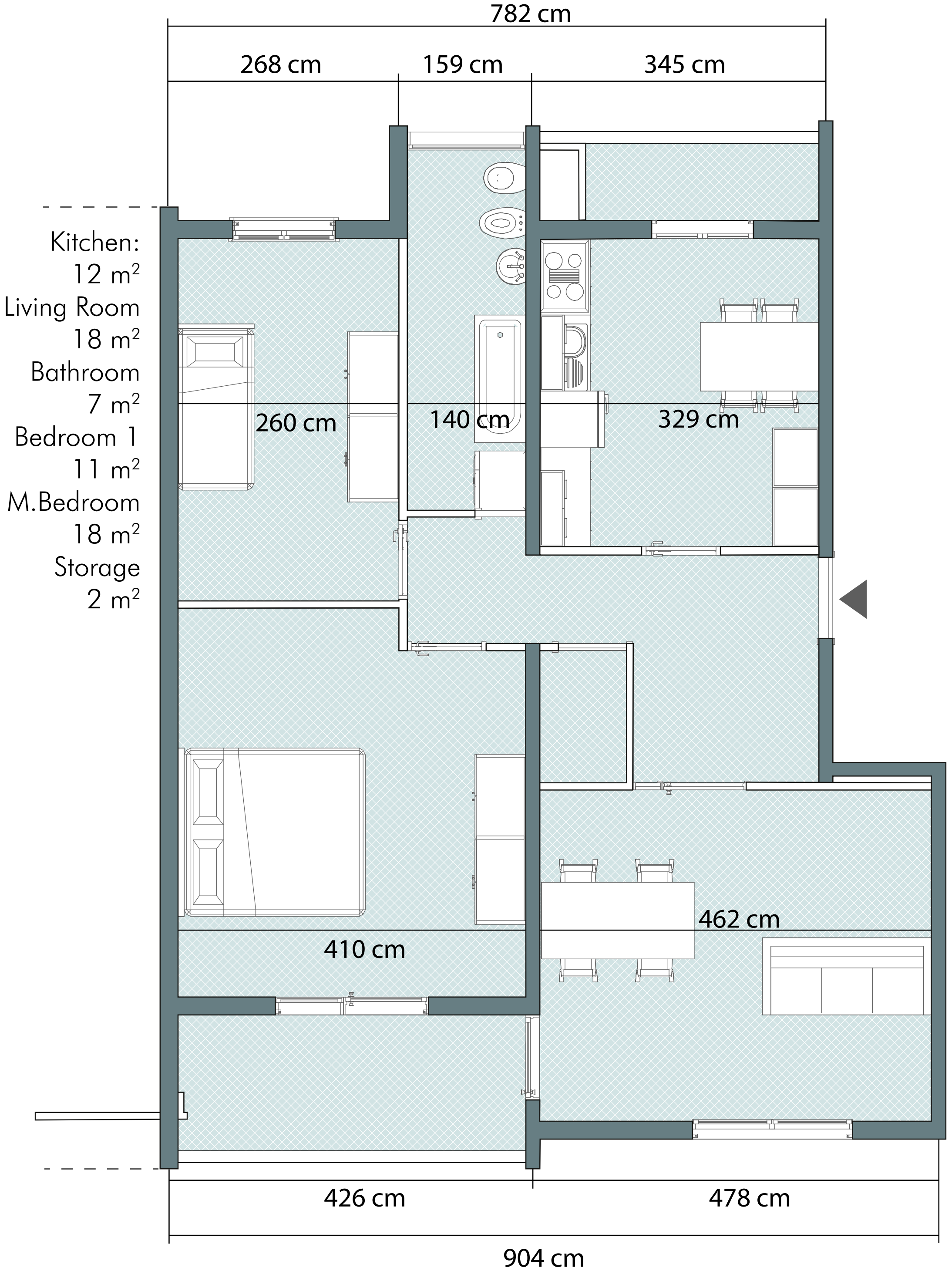
3.1.3 Room 5

Family 2-4 people

This typology is nearly identical to the Room type 6 with only decrease in size of the bedrooms by moving the wall by 1.5m to the left.

Initial room arrangement has done for the large families which were 2 to 4 people in the beginning of the construction.

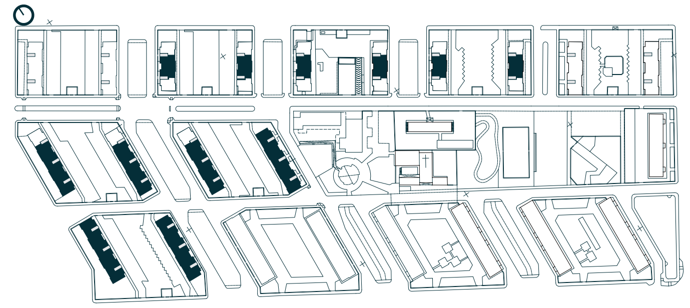
Kitchen: 12 m²
Living Room 18 m²
Bathroom 7 m²
Bedroom 1 11 m²
M.Bedroom 18 m²
Storage 2 m²



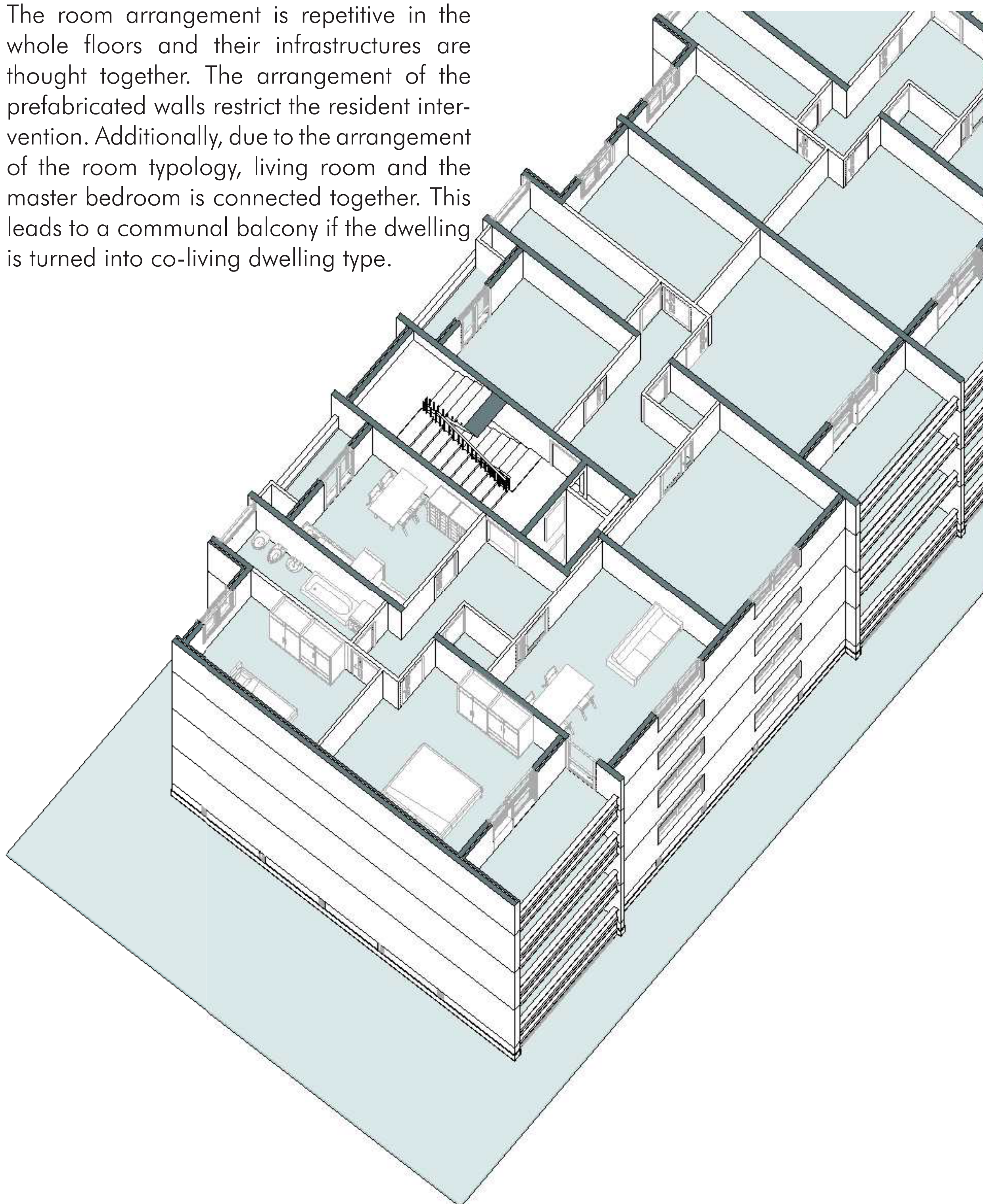
Plan of the typical "Room 5" dwelling isolated as one unit

Room type 5 can be found in Type B & C & D buildings.

Room 5 locations on the site



The room arrangement is repetitive in the whole floors and their infrastructures are thought together. The arrangement of the prefabricated walls restrict the resident intervention. Additionally, due to the arrangement of the room typology, living room and the master bedroom is connected together. This leads to a communal balcony if the dwelling is turned into co-living dwelling type.



Isometric view of the dwelling "Room 5"

3.1.4 Technical Definitions

Tabella 2.1 Valori limite della trasmittanza termica U delle strutture opache verticali espressa in W/m²K			
Zona climatica	**Dall'1 gennaio 2006** **U** (W/m²K)	**Dall'1 gennaio 2008** **U** (W/m²K)	**Dall'1 gennaio 2010** **U** (W/m²K)
A	**0,85**	**0,72**	**0,62**
B	**0,64**	**0,54**	**0,48**
C	**0,57**	**0,46**	**0,40**
D	**0,50**	**0,40**	**0,36**
E	**0,46**	**0,37**	**0,34**
F	**0,44**	**0,35**	**0,33**

Figure 3.1: Opaque envelope regulations at the time of the retrofit (TC192-311)

1_Opaque envelope layers with the intervention

In 1969 construction, neighborhood have built with prefabricated panels for walls with EPS layer in the middle. Both 7-storey and 10-storey buildings had same structural configuration. Later, renovation conducted between 2007 to 2013, we know that the building envelope is covered with appropriate insulation thickness to fulfill the legislation n.311 of year 2006. Frames, windows and wall envelope was retrofitted according to the regulation stated.

Known 1969 construction is firstly created in involucro to calculate the thermal transmittance.

Type of Component	External Wall

	Layers	d	ρ	μ		λ
		cm	kg/m³	-	J/kg°CW	/kg°C
Interior Surface						
I	concrete	13.0	2200	69	840	1480
II	EPS	3.0	25	64	1250	0.042
III	concrete	5.0	2200	69	840	1480
Exterior Surface						

Thermal Transmittance (U- Value)	0.994 W/m²K

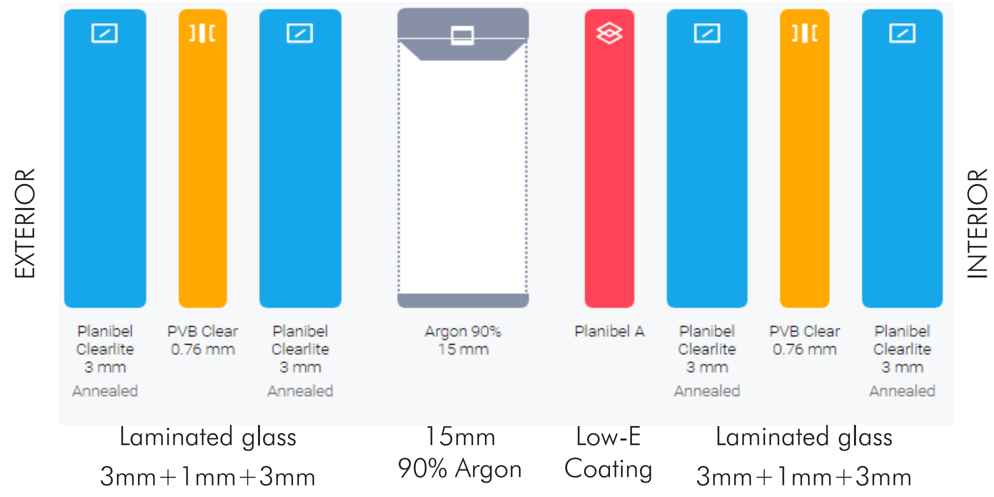
Observations from the site visit, its known that EPS is used to insulate the envelope. Following this fact, deducted thickness of EPS layer is added and found out that its 5 cm thick to satisfy the 2006 n.311 legislation regulation.

Type of Component	External Wall

	Layers	d	ρ	μ		λ	
		cm	kg/m³	-	J/kg°CW	/kg°C	
Interior Surface							
I	concrete	13.0	2200	69	840	1480	1969
II	EPS	3.0	25	64	1250	0.042	1969
III	concrete	5.0	2200	69	840	1480	1969
IV	EPS	3.0	25	64	1250	0.042	2007
V	Exterior Paint	1.0	2000	24	1000	1400	2007
Exterior Surface							

Thermal Transmittance (U- Value)	0.454 W/m²K

2_Transparent envelope constructed with AGC glass configurator



Glass Performance Data Simulation (AGC)(1)

Light properties - EN 410

Light transmittance/ Tvis (%)	72
External Light Reflection/ ρv (%)	17
Internal Light Reflection/ ρvi (%)	15
Colour rendering/ Ra (%)	98

Energy Properties - EN 410

Total solar energy transmittance/ g(%)	68
External energy reflection/ ρe (%)	14
Internal energy reflection ρe (%)	13
Direct energy transmission/ Te(%)	54
Shading Coefficient/ SC	0.78
Selectivity	1.06

Thermal Properties- EN 673

Thermal transmittance/ U-value(W/m²K)	1.3

As for the transparent envelope, according to the published article related to the intervention by Fresia Alluminio (2), glass construction layer details are given. The given configuration as such:
33.1a./15 Argon 90/33.1 b.e.
Ug 1,1 W/m²K
Uw ≤ 2,0 W/m²K
Uf 2,9 W/m²K
Meaning that the glass is double glazed with two laminated glass. Construction consists of 3mm+3mm exterior pane without a coat, 3mm+3mm interior pane has a low-e coating and 90% 15mm thickness argon mixed with air in the middle.

Therefore, I have created the glass construction system with the AGC glass configurator to calculate required glass characteristic values. Given glass characteristics are created in the AGC with the existing laminated double glazing template then Low-E coating is added interior side of the interior glazing.

Cold Roof (top to bottom)

Year	Construction	Layers	Thickness(cm)	U-Value	Notes
1969	On site	Clay Roof Tiles	5	3.689 W/m2K	
1969	On site	Reinforced concrete & brick slab	12		BISAP Type Slab

Floor Below Roof (top to bottom)

Year	Construction	Layers	Thickness(cm)	U-Value	Notes
Renovation 2007-2013	On site	EPS Insulation	9	0.43 W/m2K	According to lgs.311/06
Renovation 1985	On site	Polyurethane Insulation(partial)	4		Located only on projected part
1969	Prefabricated	Reinforced concrete & brick slab	13		SAP Type Slab

Floor (top to bottom)

Year	Construction	Layers	Thickness(cm)	U-Value	Notes
1969	On site	Vinyl Flooring	1		
1969	Prefabricated	Reinforced concrete & brick slab	16		SAP Type Slab

External Wall (internal to external)

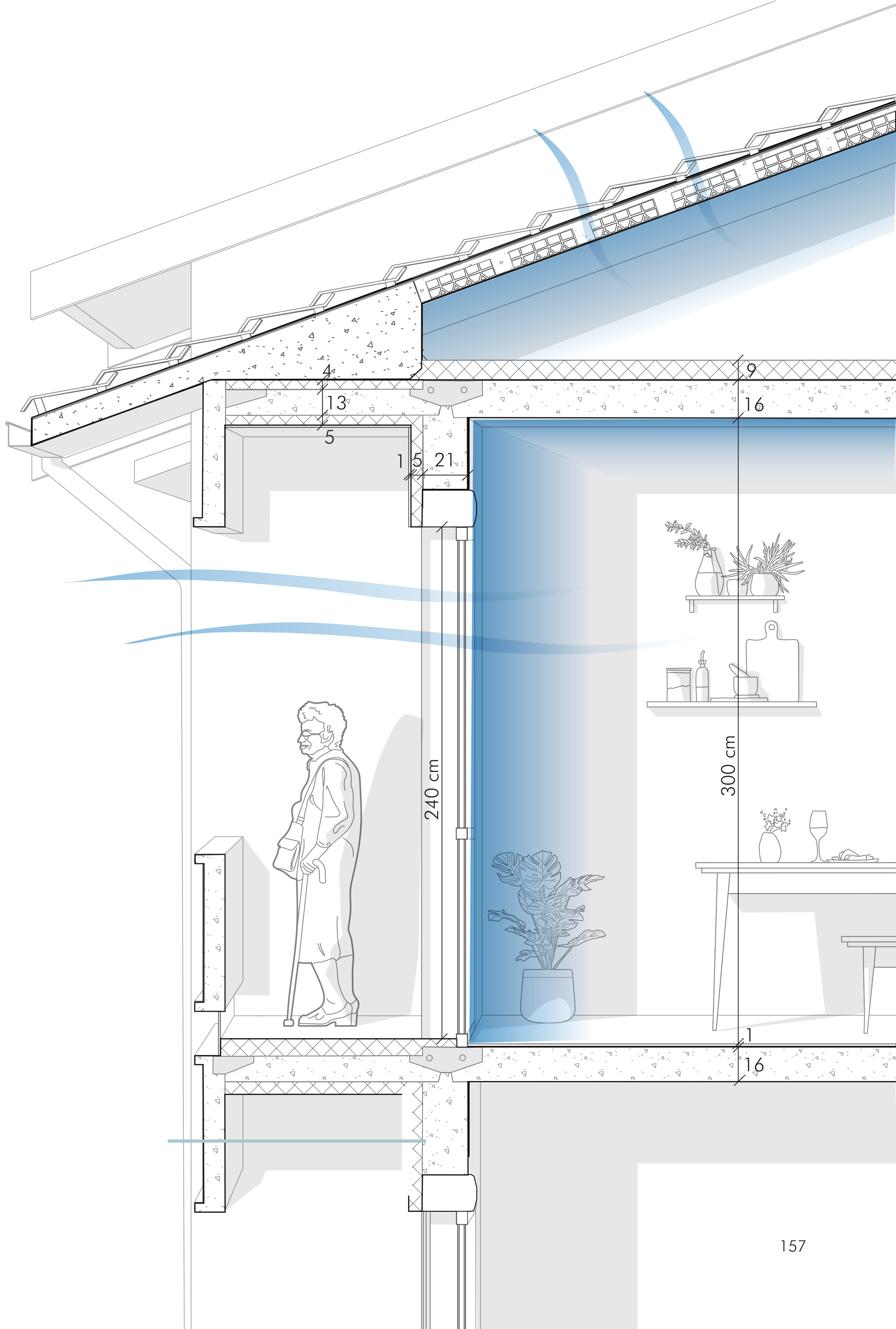
Year	Construction	Layers	Thickness(cm)	U-Value	Notes
1969	Prefabricated Wall	Concrete	13	0.46 W/m2K	
1969		EPS Insulation	3		
1969	Prefabricated	Concrete	5		
Renovation 2007-2013	On site	EPS	5		According to lgs.311/06
Renovation 2007-2013	On Site	Paint	1		

Internal Wall (top to bottom)

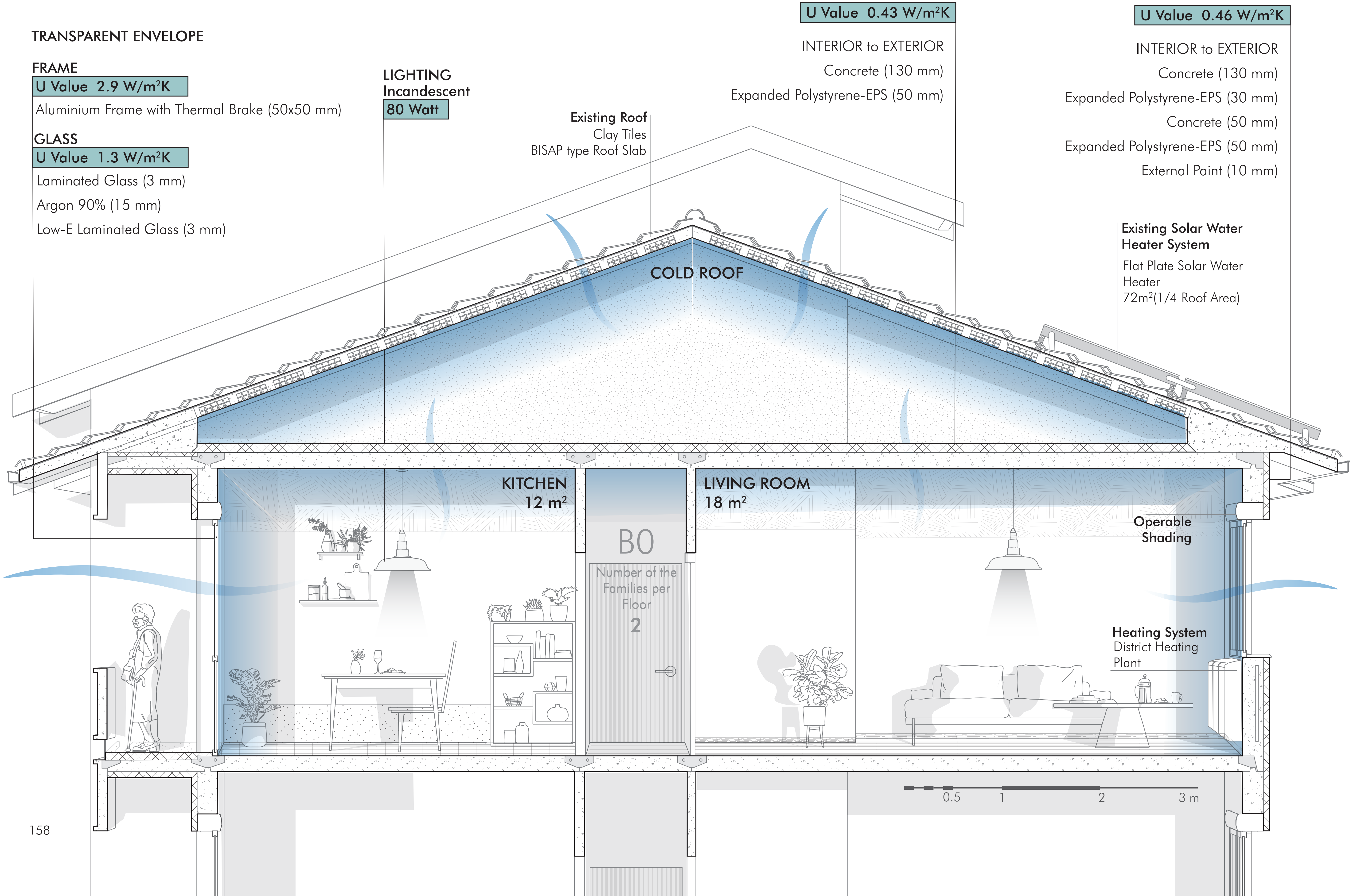
Year	Construction	Layers	Thickness(cm)	U-Value	Notes
1969	On site	8x12x24 perforated brick partitions	8 or 10		Not Structural
1969	Prefabricated	Concrete	16		Structural

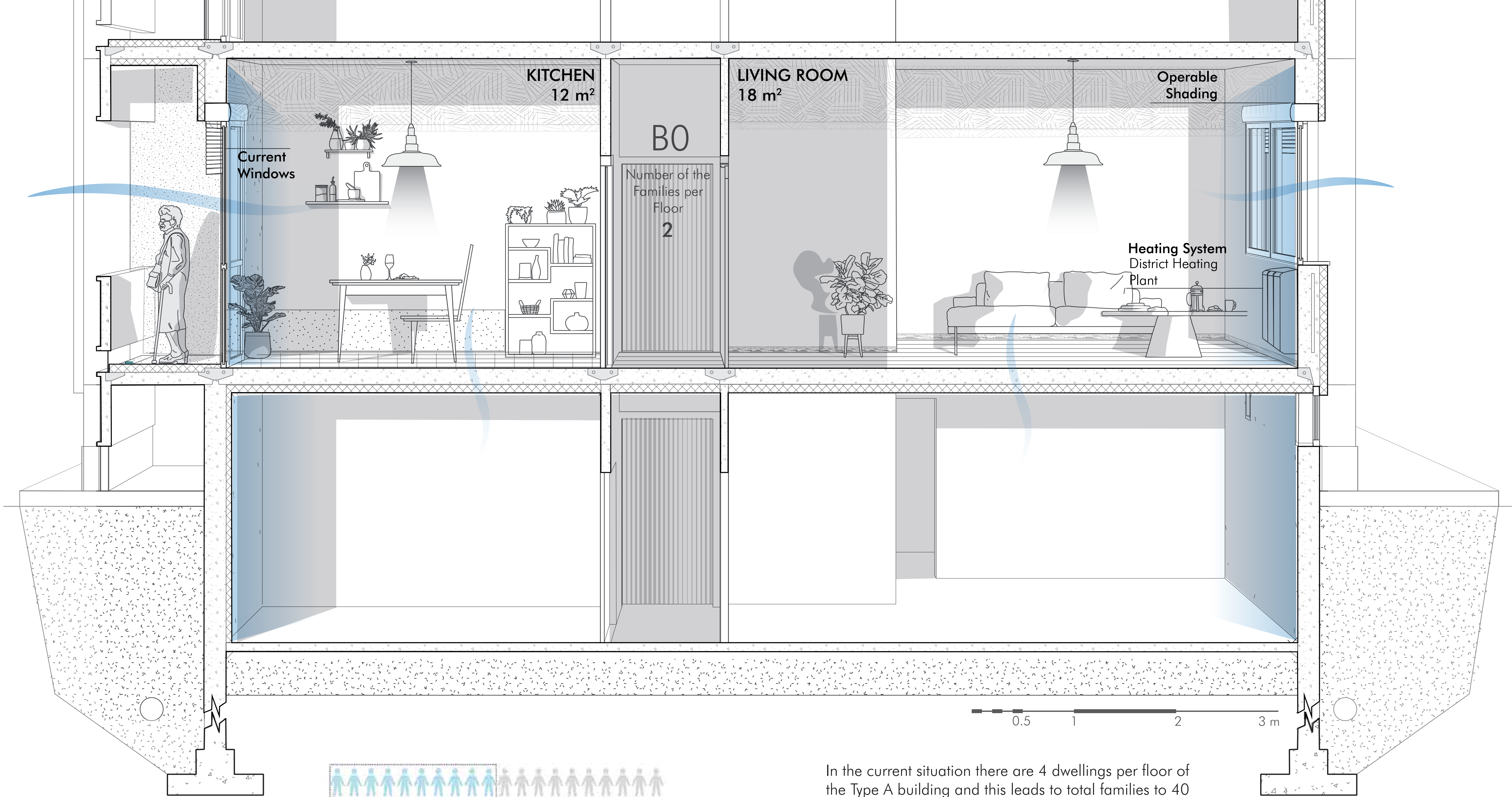
Window

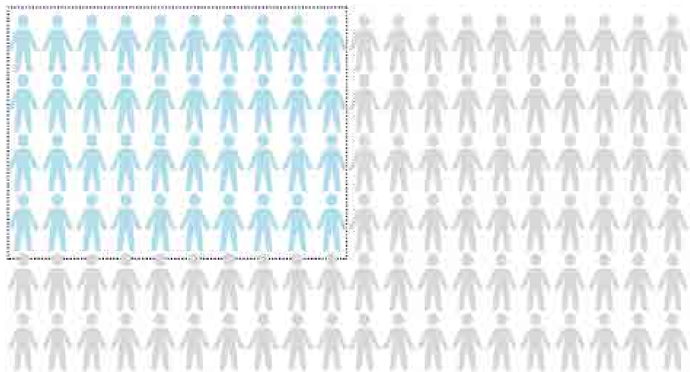
Year	Components	Thickness(mm)	U-Value	Notes
Renovation 2007-2013	Laminated double glass with low-E coating	3+0.1+3	Ug (W/m2K)=1.3	According to lgs.311/06
Renovation 2007-2013	Aluminum Frame with thermal break	50x50 mm	Uf(W/m2K)= 2.9 Ψg=0.11	According to lgs.311/06 EN ISO10077-1



In the current situation, the insulation is not enough for the satisfy current regulations. This leads to the higher bills that increases the energy poverty rate among the residents. Additionally existing rooms consist of 3 rooms that are for the larger families. Therefore the need for social housing is not satisfied.

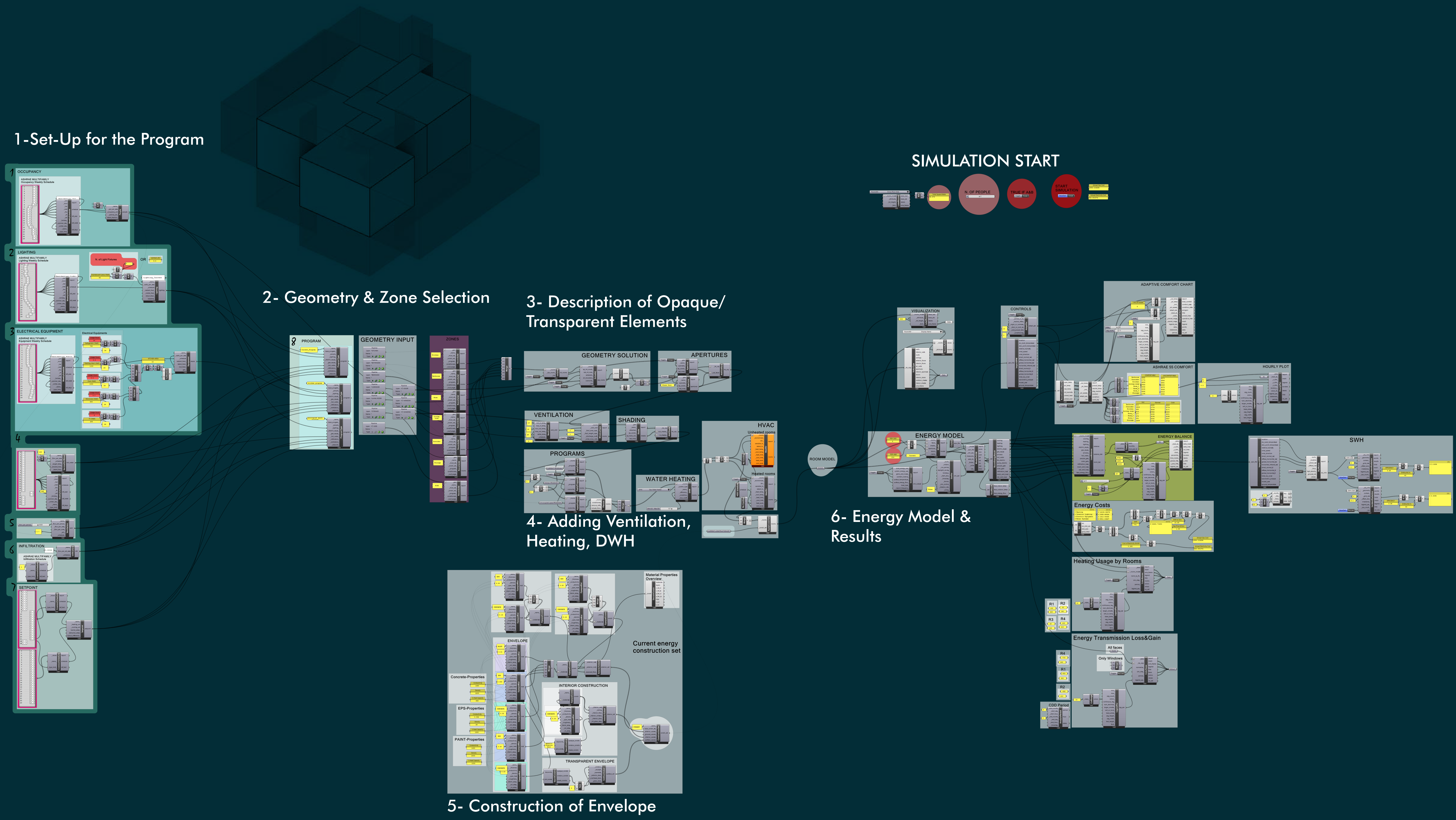






In the current situation there are 4 dwellings per floor of the Type A building and this leads to total families to 40 by the whole building. However this is not enough for to satisfy the housing needs and it is not responsive to the demographic changes since there are only 1 or 2 people in the current family demographics. For this reason, maximum individuals can reach 3 person to reach total number of residents to 120 people. But for the today's situation there are 40 individuals in 40 families in most cases.

3.2 Script and Process of the Simulation Base



3.2.1 Definition of Base Scenario: Calibration Setup

The simulation is selected to be done in the Grasshopper's Ladybug plug-in. Before starting on the simulation, building typology needs to be selected in order to calibrate the model. To do that there are two different references for the calibration.
First one is the existing energy certificates of the dwellings that are documented by ATC for APE [3]. Excel sheet documented from each energy certificate by author collected from the APE certificates created by the ATC. These are currently valid and there are totally of 126 dwellings are available to find related to Corso Taranto. The table is listed end of the document in the Annex. With the information of addresses and the meter-square data, I could gather the information of the dwellings if they are Room type 6 or 5. We can observe from the data that is created in excel that most of them are Class E apartments. This means that they are already in current regulation scope.

For the calibration Type A building is selected since the highest energy consumption is seen in Room 6 types. The reason is the room typology has more exposed surface and glazing area compared to its volume.

Energy certificates arranged from highest consumption:

Highest ↑ … Lowest

				CONSUMED ENERGY		
B_ TYPE	DWELLING	Piano	E_Class	Energia elettrica	Solare termico	Teleriscaldamento
C	6	0	G	48	813	20848
B	6	0	F	92	796	20610
B	6	0	G	61	774	20058
C	6	0	F	59	811	19273
B	6	0	E	62	803	19031
A	6	0	G	57	771	17248
A	6	0	E	82	788	17224
D	5	0	G	43	739	16941
B	5	0	G	55	718	16870
A	6	0	E	81	789	16438
D	5	0	F	106	774	16419
B	6	0	E	71	769	15865
B	5	0	F	54	718	15835
C	5	0	F	40	726	15602
B	5	0	G	54	718	15577
D	5	0	F	105	781	15110
C	5	0	F	47	722	15096
D	5	0	F	101	714	14737
D	5	0	F	105	713	13260
A	6	9	E	76	765	12250
B	6	9	E	52	802	11968
B	6	9	D	52	803	11848
B	6	9	D	52	803	11848
A	6	9	D	45	779	11682
B	6	9	D	52	803	11642
A	6	2	G	2848.6499	1018.25	11215.79
C	5	6	D	34	727	11137

Energy certificates ranges from Class G to Class C. Most frequent one is Class E with 51 dwellings.

For the calibration Type A building is selected since the highest energy consumption is seen in Room 6 types. The reason is the room typology has more exposed surface and glazing area compared to its volume.

In conclusion Type A and Dwelling type 6 is selected for the calibration and reference for the case study.

Consumed Gas (kWh)

The gas is turned into energy in district heating center located in the neighborhood. The consumed gas is derived from the APE certificates. The result of the Room Type 6 values:

Highest= 20848
Lowest=6618

Average gas consumption of 60 Dwellings of type 6;

Average(n. 60)=9954 kWh

Solar Water Heating

There are existing solar water heater panels on each roof of the typologies. These are consisting of 30 panels that seems to be flat plate collectors. These are taken as 2x1.2 unit panels and they are connected to district heating. To derive the total gas consumption of the dwellings, solar water heating is calculated for a accurate result. To achieve that, firstly , the efficiency is calculated then this result is subtracted from the total incident radiation falls on the panels.
Calculation used for efficiency:

$$\eta = a_0 - a_1 * \frac{\Delta T}{I}$$

For glazed water collectors, a0=0.65-0.8 and a1=3-8 value scales are taken as a reference and medium values are used.

a0med= 0.725
a1med= 5.5

For I(irradiance) LB Sky-matrix is used for simulation. The reference roof top angle is 20 degrees and solar water heater area is approximately 60 m^2. The area is modeled as one surface and rotated accordingly.

January Average Incident Irradiation = 308 W/m^2
July- Average Incident Irradiation= 800 W/m^2

Annual Average Incident Irradiation= 554 W/m^2

For ΔT mean collector temperature is calculated as;

Inlet Temperature= 40
Outlet Temperature= 50
Ambient Temperature = 15

ΔT =(45-10)=35

A a result we can conclude that the efficiency of the system is;

0.725 - (5.5x 35/554)
=0.38

System has %38 efficiency.

After that, calculated normalized result for the panels. Annual cumulative irradiation (kWh) is 81575 kWh. This result then multiplied with the efficiency and divided by number of dwellings to find the solar thermal energy used per dwelling.

N. of dwellings in Type A building=40
Efficiency= 38%
Solar Thermal Heating Energy per Dwelling=(85575 x 0.38) /40

= 775 kWh

In conclusion each dwelling is gaining 775kWh for the solar water heating panels. The result then subtracted from the gas consumption.

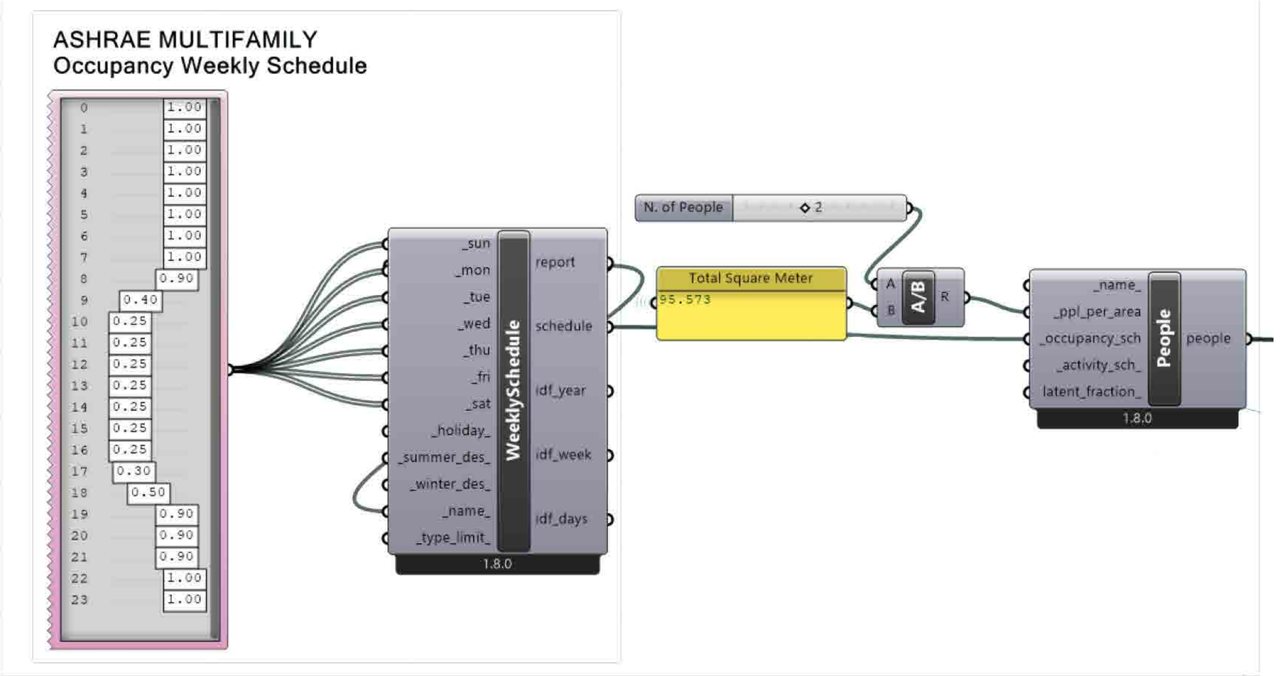
This result is also in-line with the energy certificates of the dwellings that are located in Type A building which have average of 768kWh consumed solar thermal energy with highest of 818kWh and 713kWh (data from 37 certificates of dwellings).

Electric Consumption

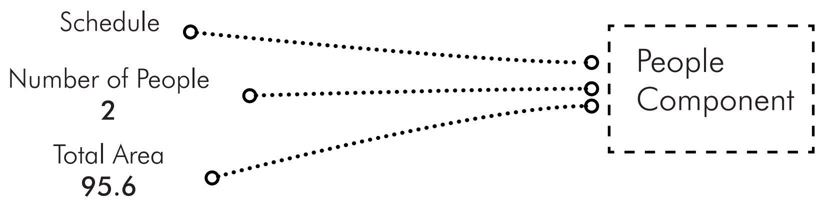
Calibration of the Electric consumption is not calibrated since the energy certificates are not considered the electrical equipment in the dwellings. However if we check the ARERA portal (4) for a general understanding. For 2 person family with basic needs such as oven, fridge, washing machine, TV the result is 1400-1500kWh. Due to unavailability of addition of number of lamps and type of lamp this result is used for the electrical equipment usage calibration.
For the usage of light, similar spaces given ASHRAE 90.1-2019 is taken as a reference for the lighting density per square meter.

Occupancy

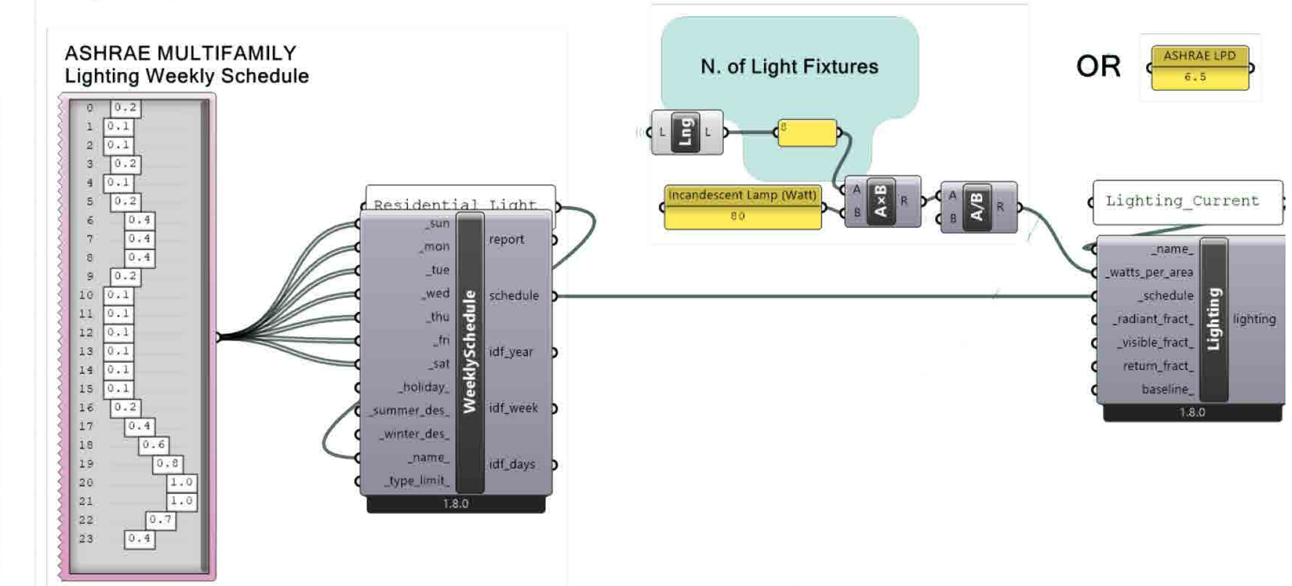
3.2.2 Set-Up for the Program



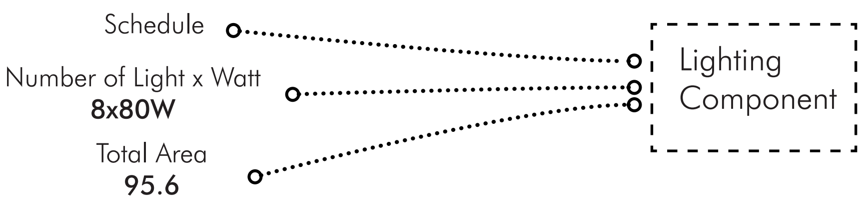
Taken from ASHRAE standard for multifamily apartment. This component connected to “People” component to define the people load.



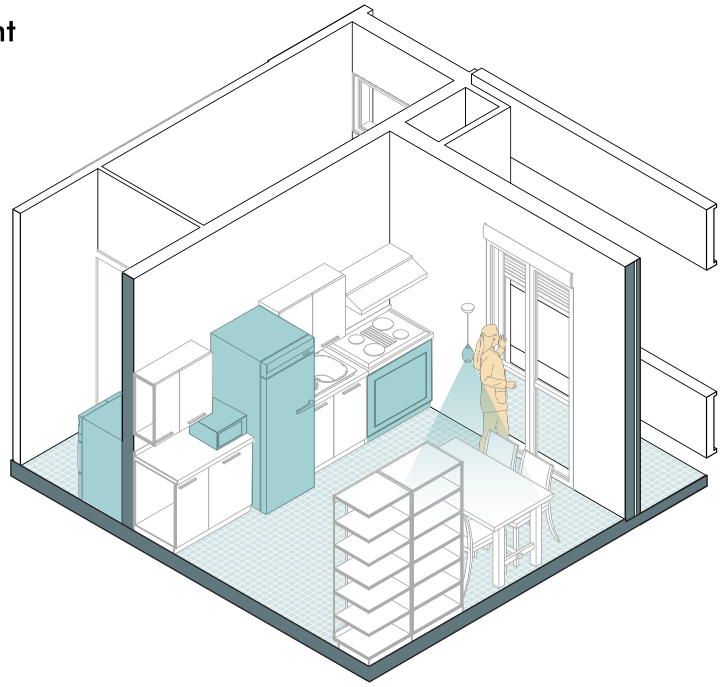
Lighting



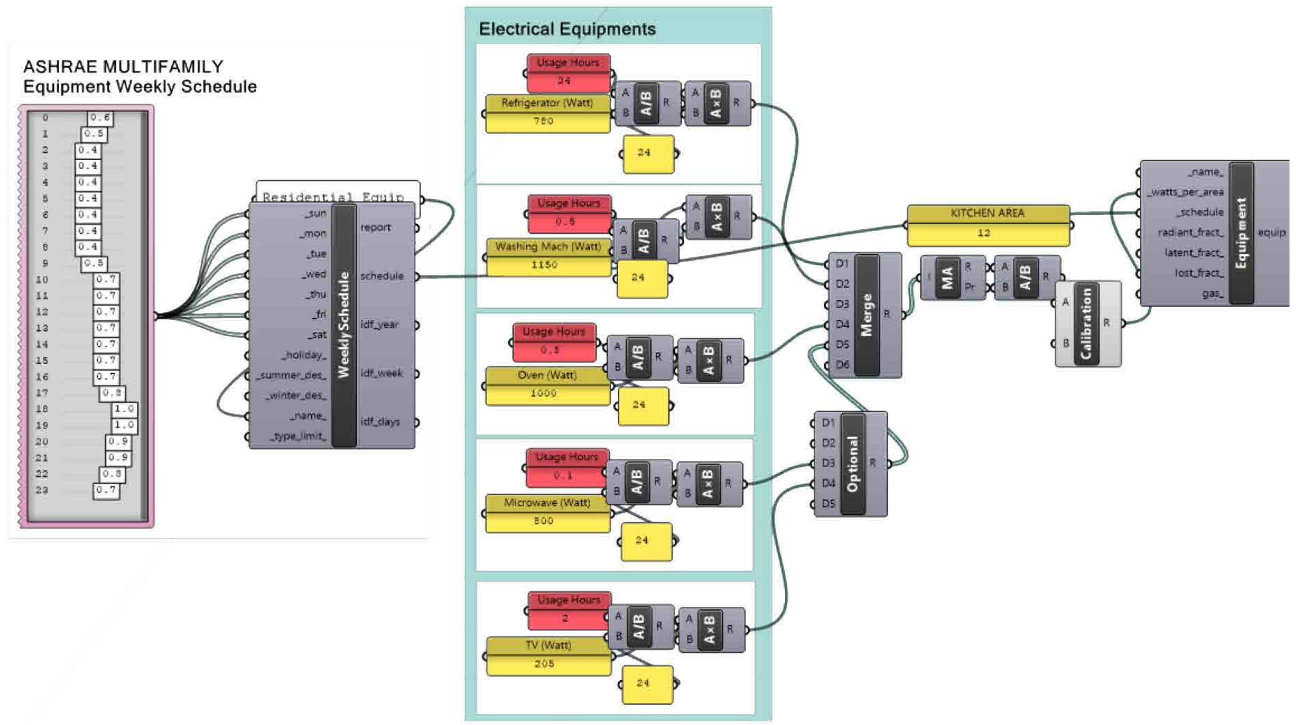
Incandescent lamp is thought as a default lighting. In each room 1 light is present. Standard for light power density is 6.5 as an optional value.



Equipment

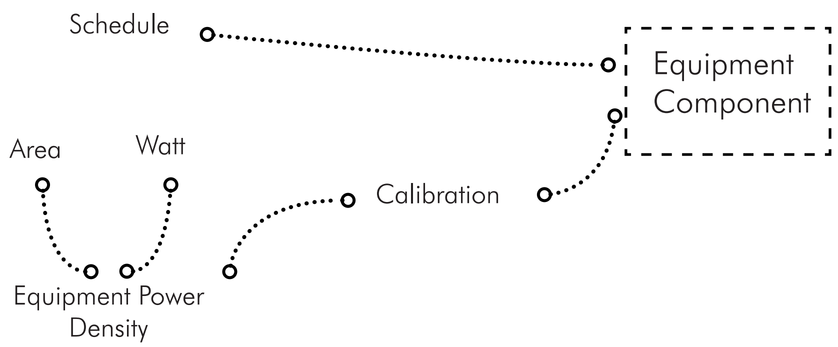


Equipments present in Italian houses* and common household appliances:
Fridge
Washing Machine
Oven
Microwave
TV

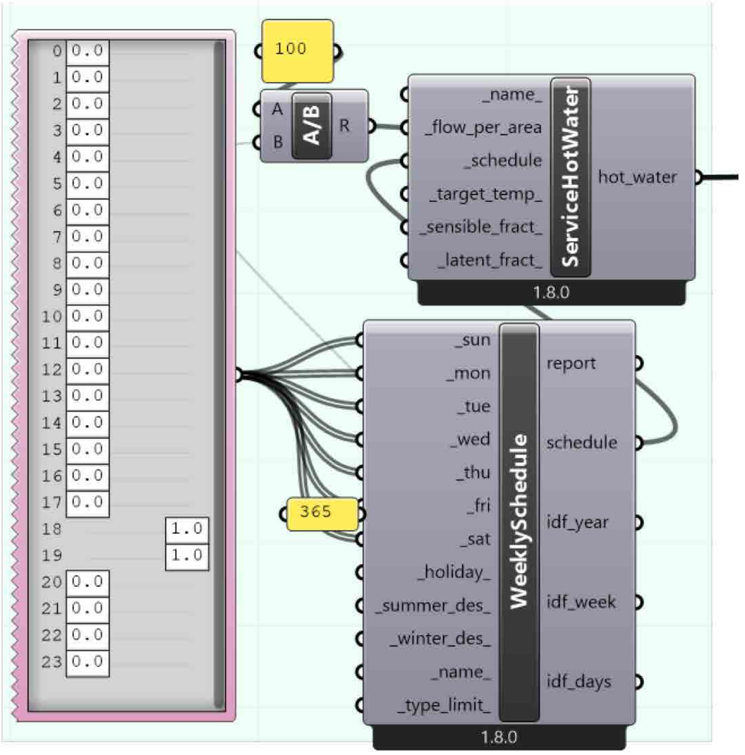


*Istat: Consumi Energetici delle Familglie Infografica

Equipment* watt values are multiplied by the usage time in a day. Then calibration factor added for correction of the results.

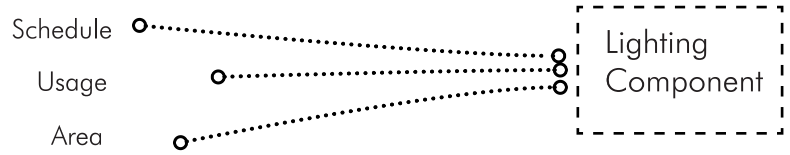


Hot Water



*FprEN 16798-1:2018

Daily schedule for domestic hot water is added for 2 hours a day. Usage of 100 l/m² year is decided based on the standard of TR 16798-2. According to the energy certification data,minimum efficiency of the gas boiler is 05 and maximum value is 0.9. Therefore 0.7 efficiency is used later on in the calculation.



Infiltration and ACH

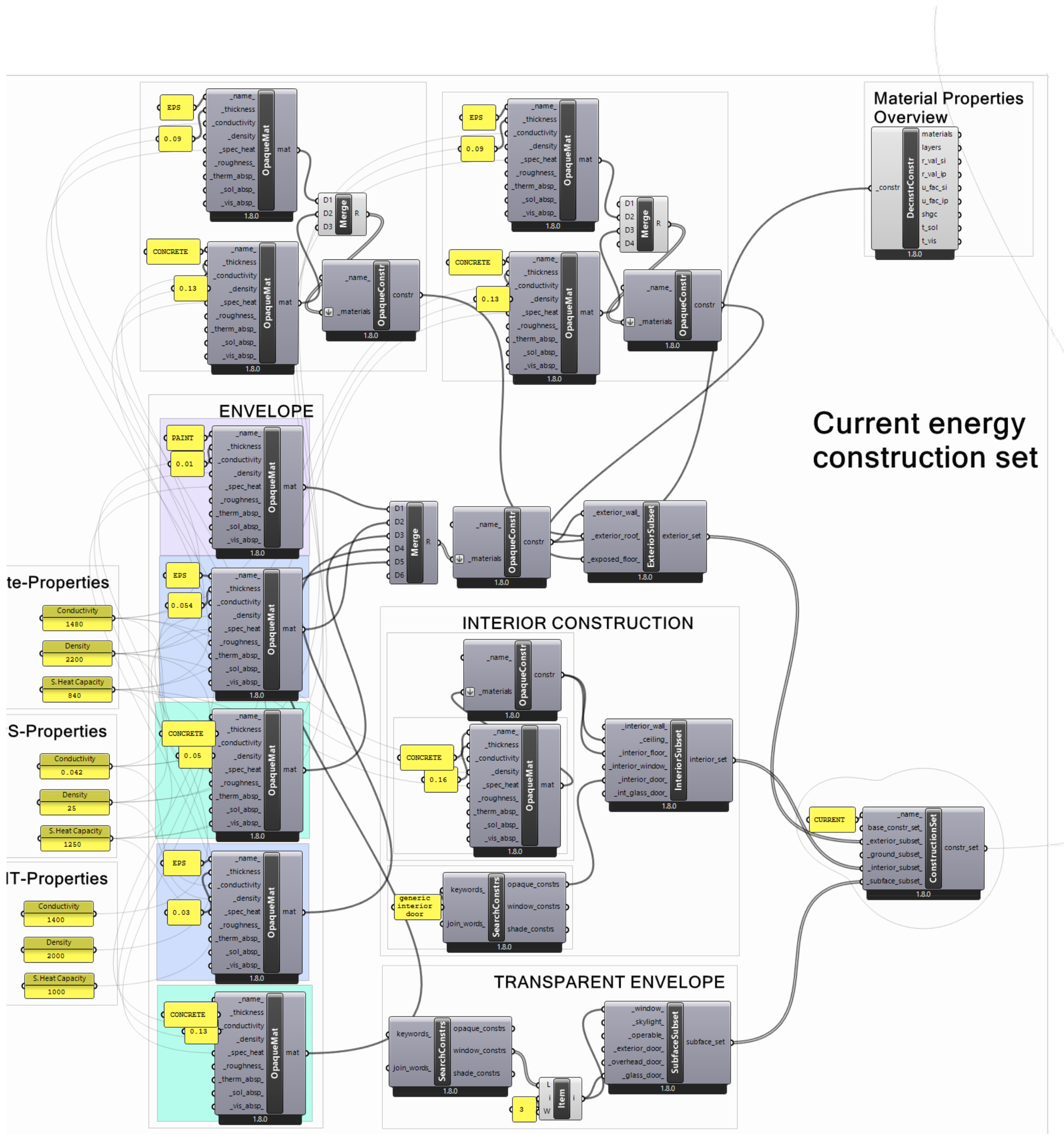
ACH(air changes per hour) is taken as 0.5

For the calibration of heating schedule, intensity of infiltration is increased to 0.0006 m³/per m² external façade

Set-point

Schedule:
Schedule of the heating is defined by the legislation. Heating degree days are given as between October and April.
In heating degree days period, according to the Piemonte region maximum 13 hours a day could be used for climate zone E in Italian legislation.
Time of the heating=9.00-22.00
Heating Set-point=21-25.5 degrees (ASHRAE)

Ventilation (when natural ventilation will happen)
Minimum indoor temperature=19
Minimum outdoor temperature to get air=16
Minimum outdoor temperature to get air=28
Delta Temperature=5 (temperature difference for to ventilation occur)
Schedule=Occupancy



Materials

Involucro layers are replicated in honeybee-grasshopper for same U-values and results.

***Heat Pump & PV**

For the future scenarios district heating system is changed to heat pumps, additionally, PV panels are added for the reduction of the electricity costs. To calculate the results, simulation done using the Solar Irradiance used before with the solar water heaters and then it is multiplied by the area of the PV panels and their efficiency of 20%. For the heat pump, needed energy is calculated according to coefficient of performance by 3.

$$COP=3=\frac{\text{Desired Output (from the simulation)}}{\text{Required Input}}$$

3.3 Different Demands of the 4 Room

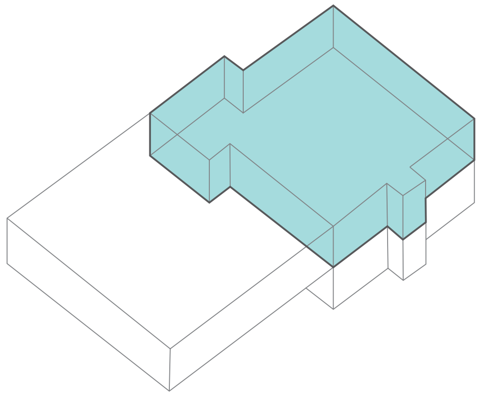
4 types of room are selected to define for clear estimation of the building consumption and different dwelling types.

1_ Room 6 Corner= Dwelling is located in corner of the building. One of the horizontal surface is facing towards un-heated space.

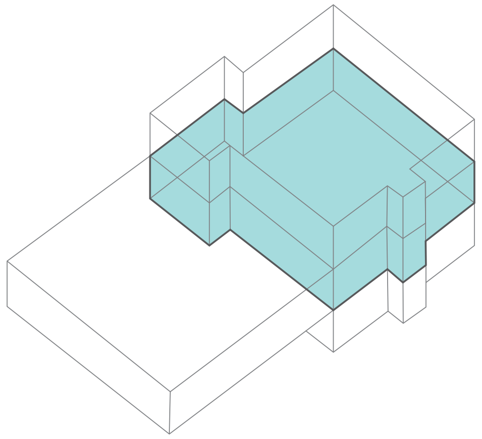
2_ Room 6 Mid-Corner=Dwelling is located next to the side of the building.

3_ Room 6 Adiabatic= Dwelling is surrounded by heated spaces

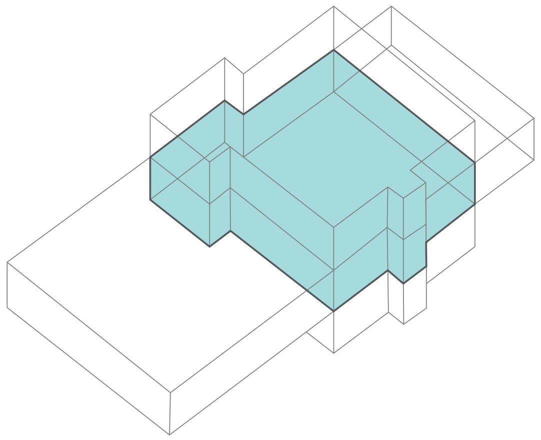
4_ Room 6 Corner= Dwelling is located in middle of the building. One of the horizontal surfaces are next to an unheated space. (Floor under roof and ground floor has same properties and U-values.)



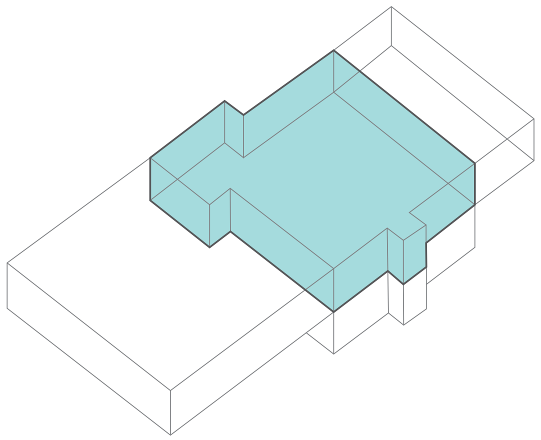
R1
Corner Room



R2
Middle-Edge Room

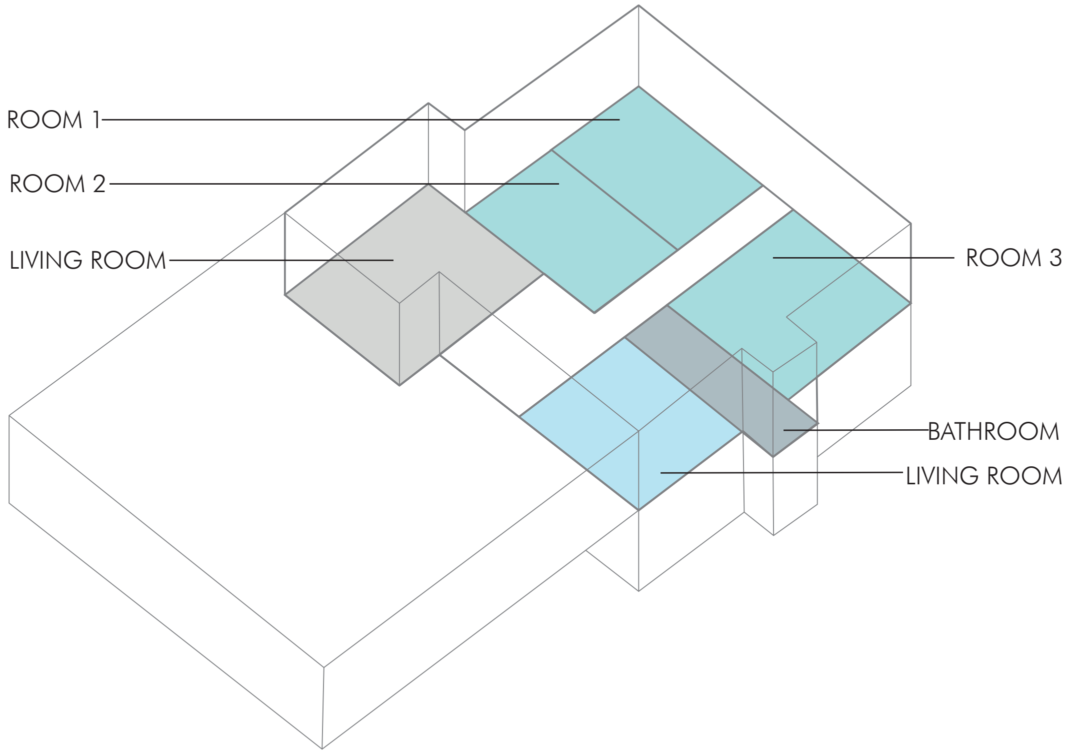


R3
Middle Room



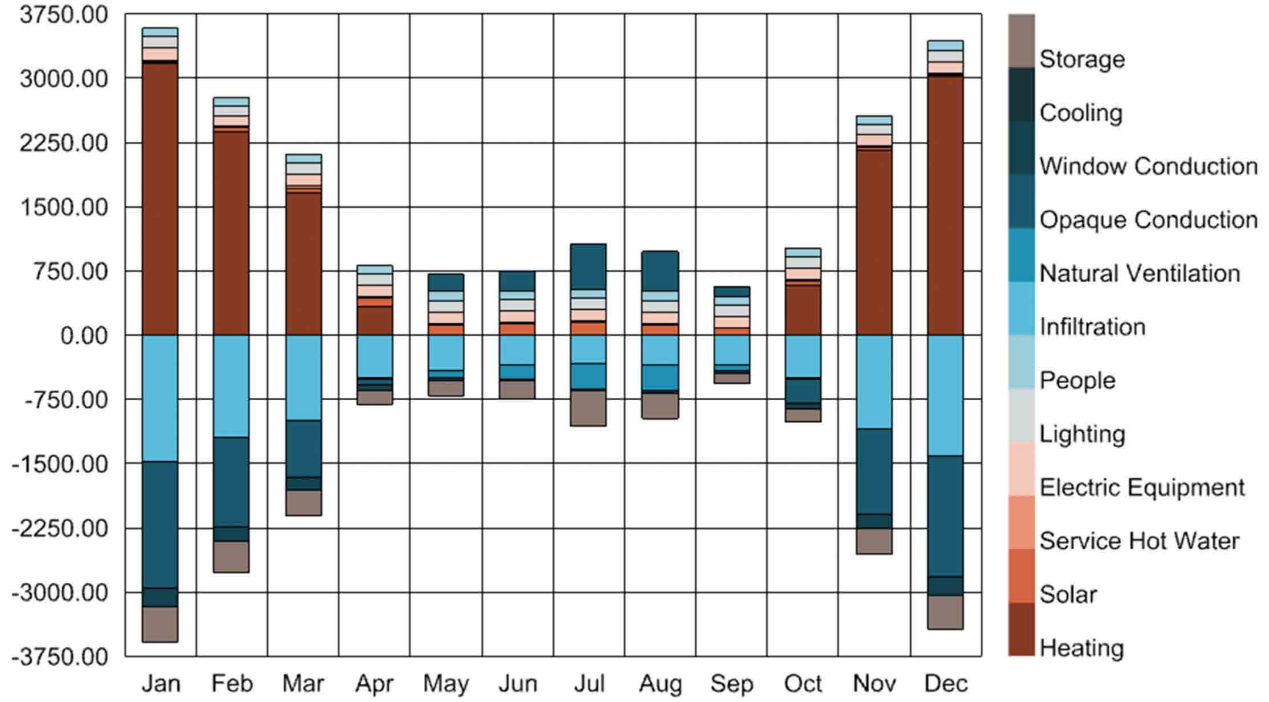
R4
Ground floor or Top floor Room

3.3.1 Room type -R1



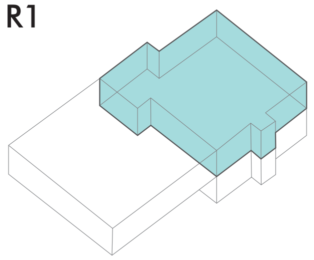
These room types are located in the corner of the building. They have only one side and one base adiabatic. The rest of the surfaces are exposed to the exterior environment. In the building Type A that simulation done, there are 4 dwellings.

Energy Balance Diagram (kWh per month)



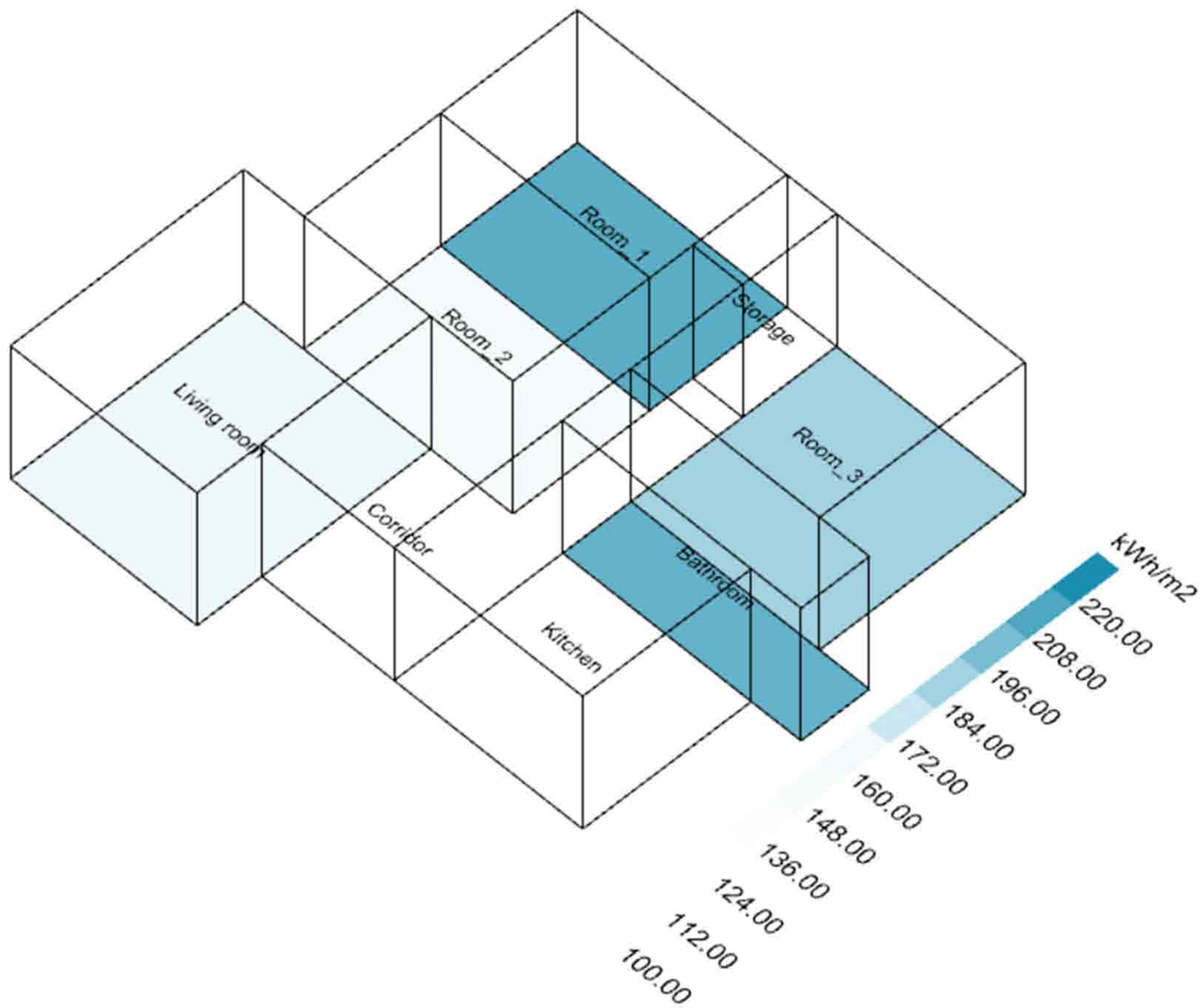
Annual Electricity Consumption (kWh)	Annual Gas Consumption (kWh)	Total Consumption (kWh)
3183	16441	19624

R1



The energy consumption is higher than the other room locations. The energy balance diagram shows the total energy transfer in the building in relation to the simulation. As can be seen from the chart the most energy need is the heating energy. Especially in the December and January this need increases due to the cold weather. And its observed that in this overall look we see that the more than 3000 kWh in these months.

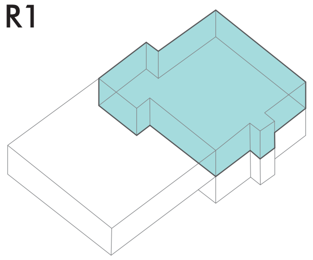
Normalized heat consumption for each room



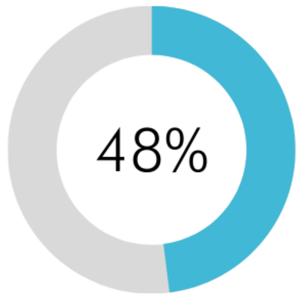
Annual Electricity Cost (€)	Annual Gas Cost (€)	Total Cost (€)
844	1676	2520

The corner type rooms are the highest cost dwellings. The highest energy need for heating is in the bathroom and the corner bedrooms. The rooms that are located to in the corner have higher exterior surface while bathroom is extruded in the design of the building, therefore it has higher gas consumption relative to its area. These highest gas consumption areas are consuming nearly 220 kWh per meter square.

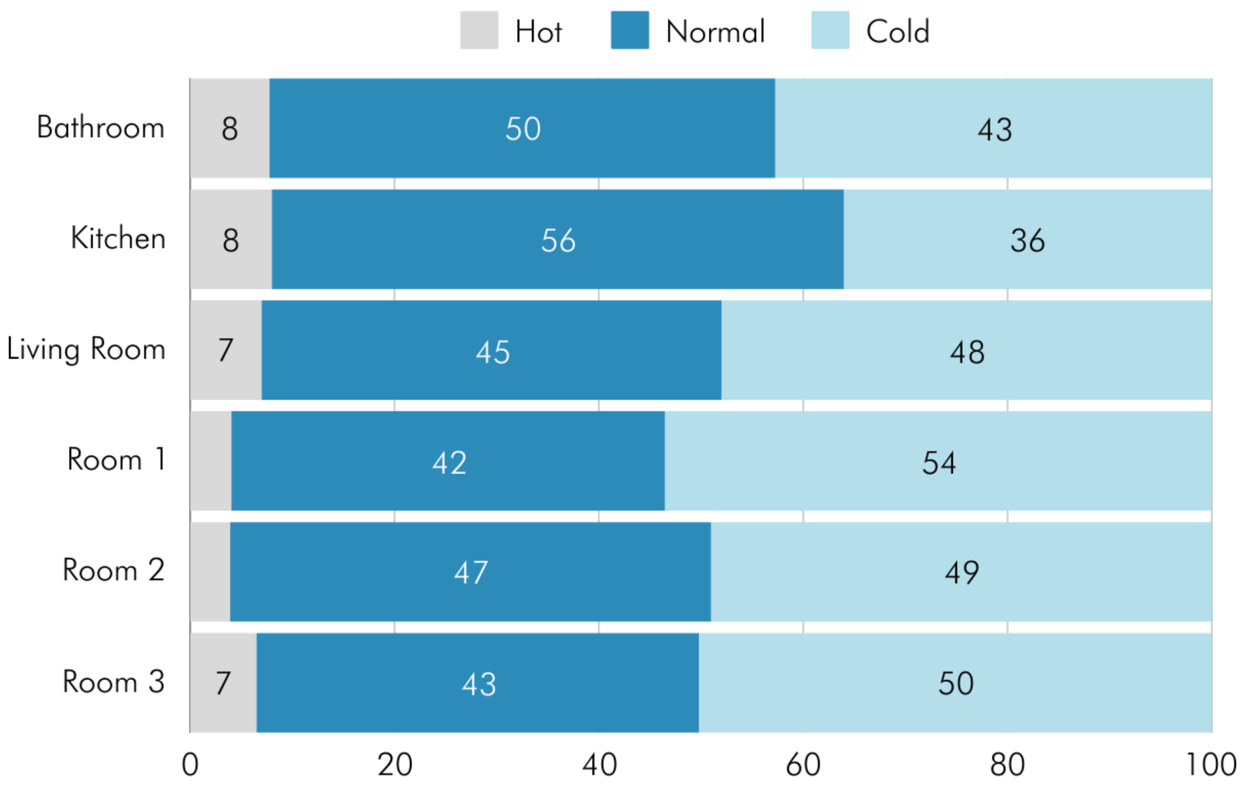
R1



According to the simulation results, for the corner rooms, comfort is drastically lower compared to the other locations. As can be seen from the overall comfort, residents are not comfortable half of the time annually in their own homes according to the ASHRAE-55 standards.

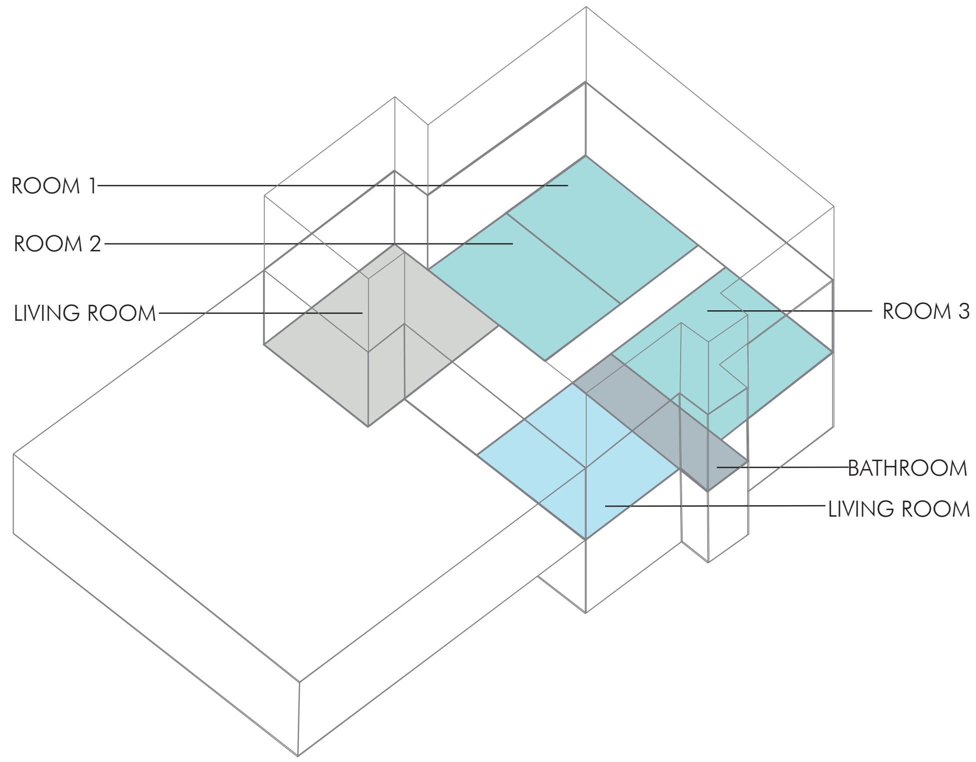


R1- Comfort Chart by the Rooms



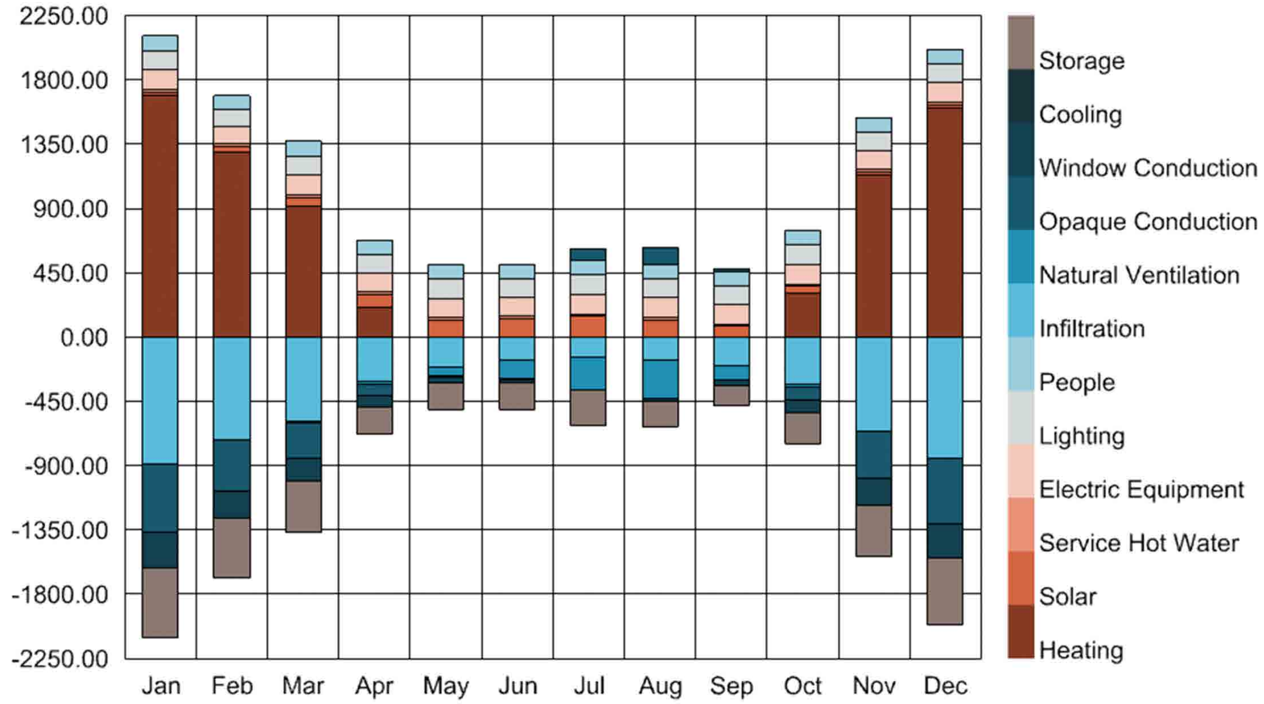
According to the chart, the most thermally comfortable room is Kitchen because of the electrical equipments. The least comfortable room is the Room 1 which has large exterior wall area exposed. This leads to a lower room temperatures less than the 21 degrees.
Overall, the dwelling is mostly cold due to limited heating design days restricted by the Piemonte region even thought it is scaled according to the E type climatic region.

3.3.2 Room type 6-R2



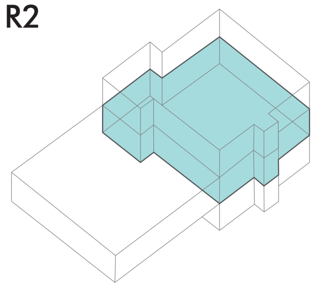
These room types are located in the edge of the building. They have only one side and two base surfaces adiabatic. The rest of the surfaces are exposed to the exterior environment. In the building Type A that simulation done, there are 16 dwellings.

Energy Balance Diagram (kWh per month)



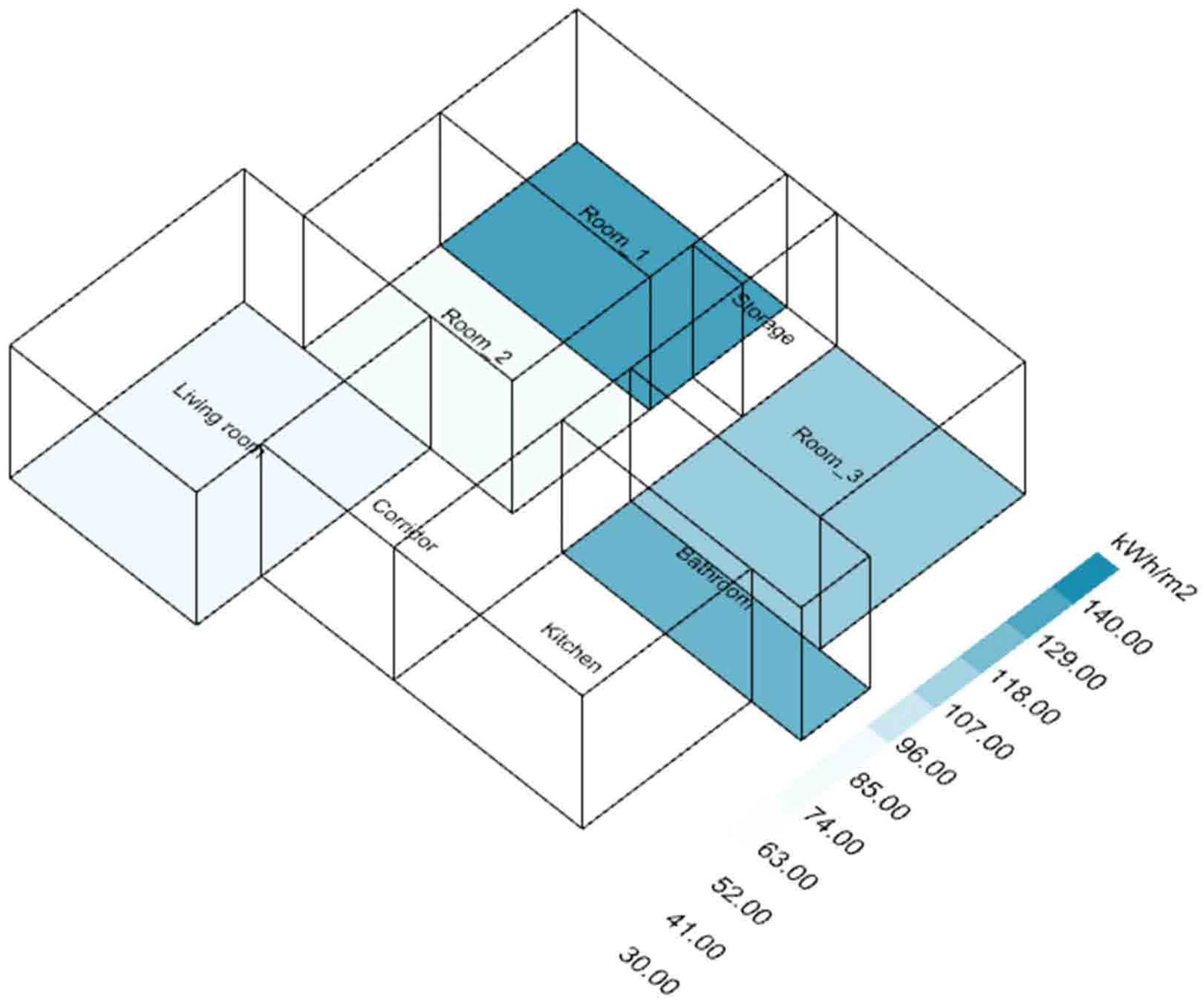
Annual Electricity Consumption (kWh)	Annual Gas Consumption (kWh)	Total Consumption (kWh)
3183	10291	13474

R2



The energy consumption is lower than the corner rooms. The energy balance diagram shows the total energy transfer in the building in relation to the simulation. As can be seen from the chart the most energy need is the heating energy, however it is observed that the energy demand for the heating is nearly half of the previous room type.

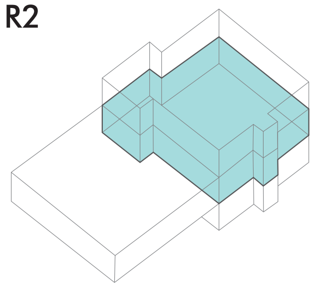
Normalized heat consumption for each room



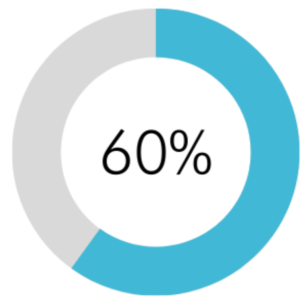
Annual Electricity Cost (€)	Annual Gas Cost (€)	Total Cost (€)
844	1050	1894

The highest energy need for heating is in the bathroom and the corner bedrooms similar to the previous. The rooms that are located to in the corner have higher exterior surface while bathroom is extruded in the design of the building, therefore it has higher gas consumption relative to its area. These highest gas consumption areas are consuming nearly 140 kWh per meter square.

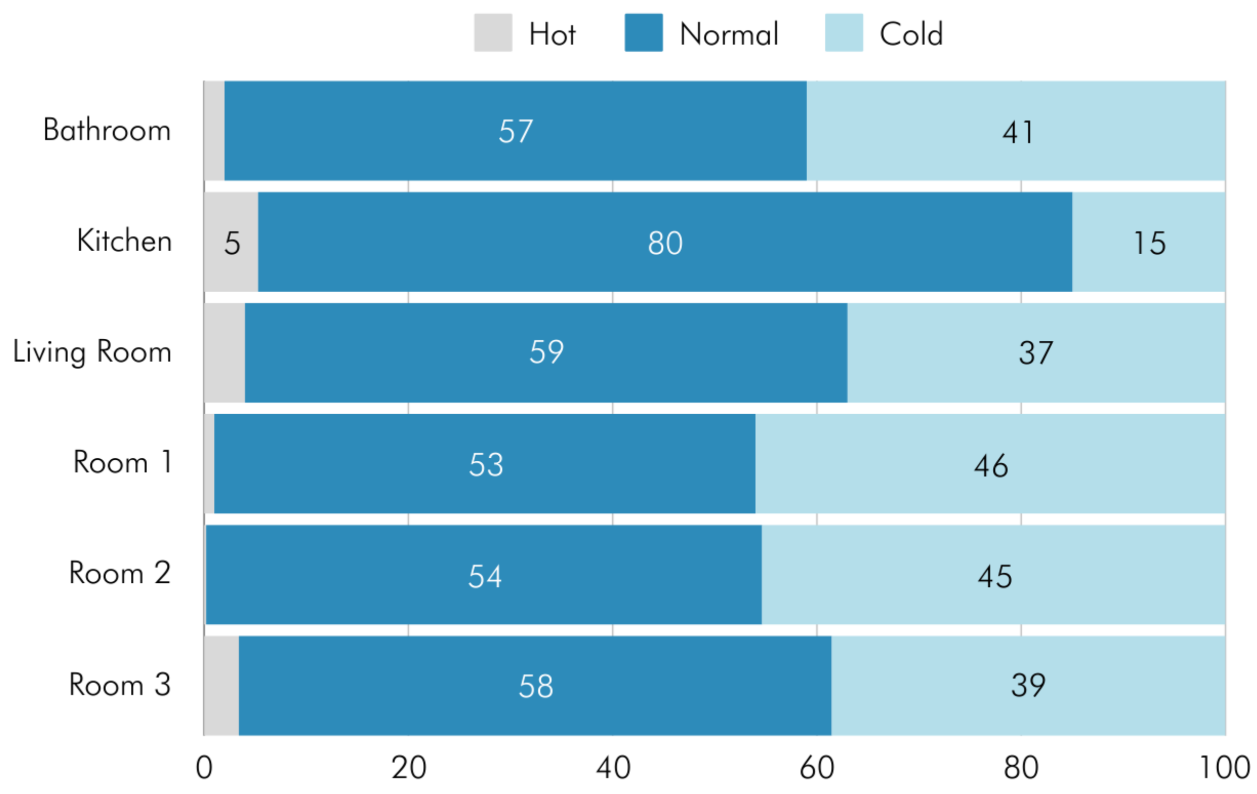
R2



According to the simulation results, for the edge rooms, comfortable more than half of the time annually.

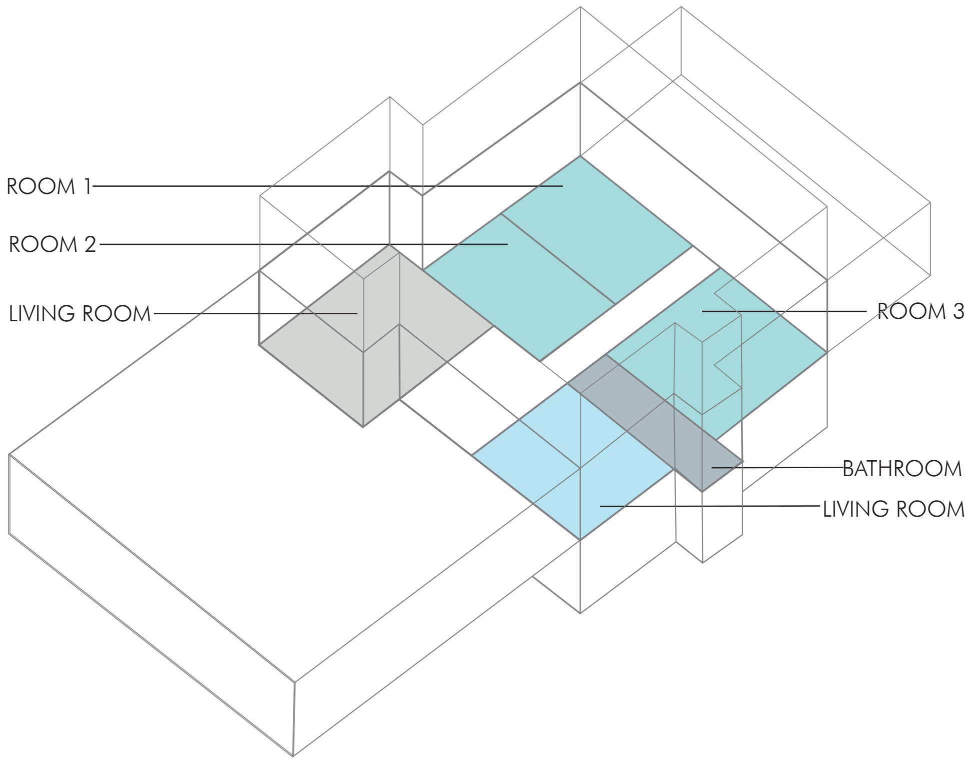


R2- Comfort Chart by the Rooms



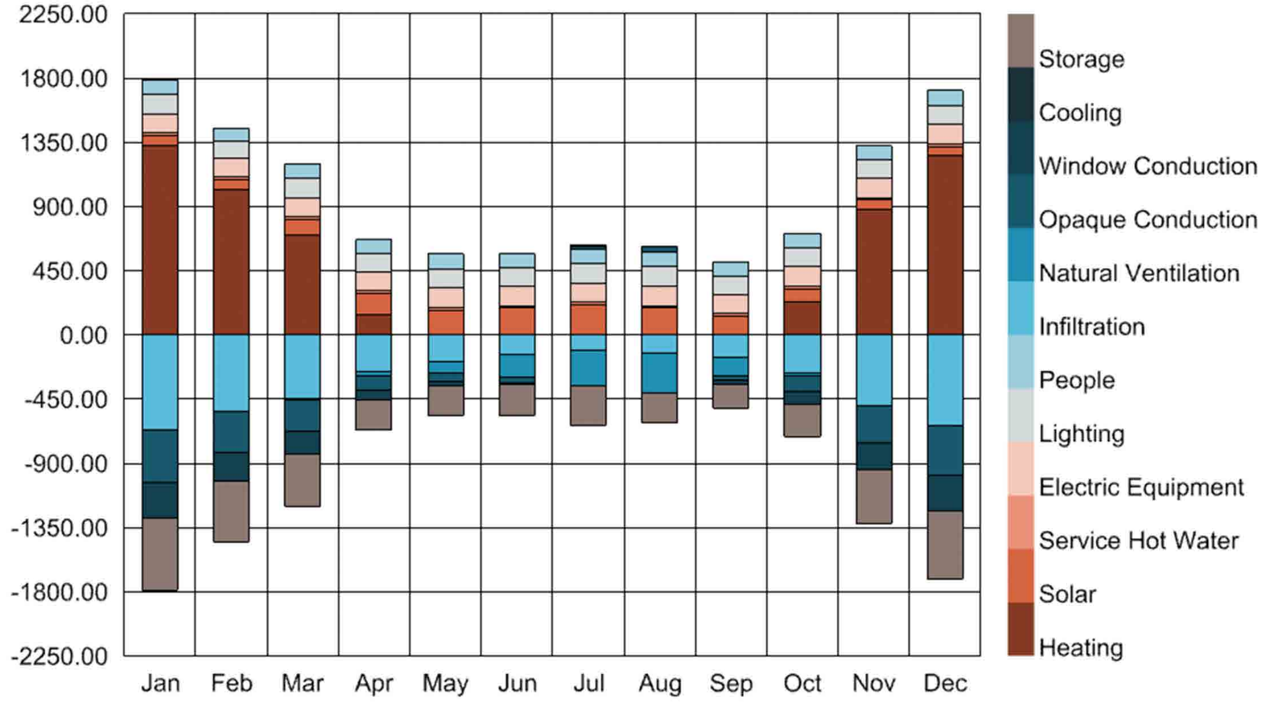
According to the chart, the most thermally comfortable room is Kitchen because of the electrical equipments and it is comfortable 80% of the year.
Overall, the dwelling is mostly comfortable however most of the winter is it uncomfortable to the residents especially in the bedrooms.

3.3.3 Room type 6-R3



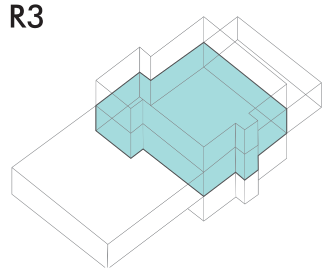
These room types are located in the middle of the building. They have all four sides adiabatic. These are the dwellings with minimum external area compared to the other locations. In the building Type A that simulation done, there are 16 dwellings.

Energy Balance Diagram (kWh per month)



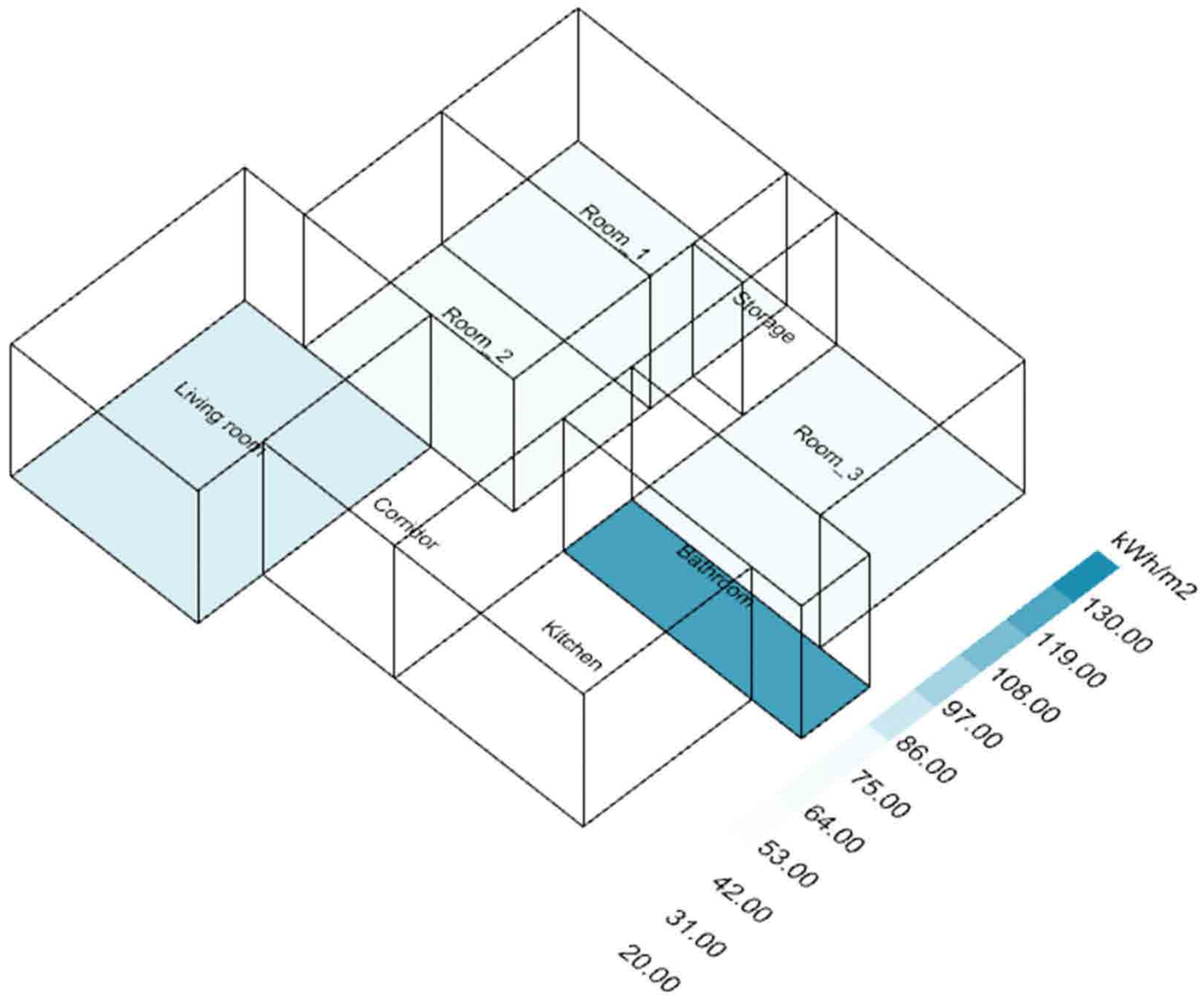
Annual Electricity Consumption (kWh)	Annual Gas Consumption (kWh)	Total Consumption (kWh)
3183	8683	11866

R3



The energy consumption is the lowest than the other rooms. The energy balance diagram shows the total energy transfer in the building in relation to the simulation. As can be seen from the chart the heating demand decreased greatly in this type.

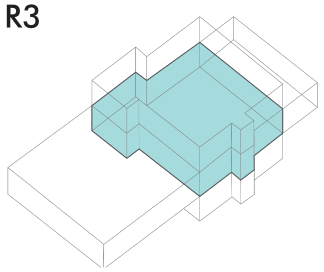
Normalized heat consumption for each room



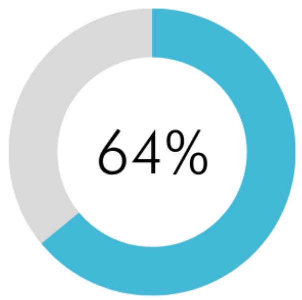
Annual Electricity Cost (€)	Annual Gas Cost (€)	Total Cost (€)
844	885	1729

Since there is minimum external exposure, the highest energy need for heating is in the bathroom. These highest gas consumption area is consuming nearly 130 kWh per meter square while the other ones are not nearly close.

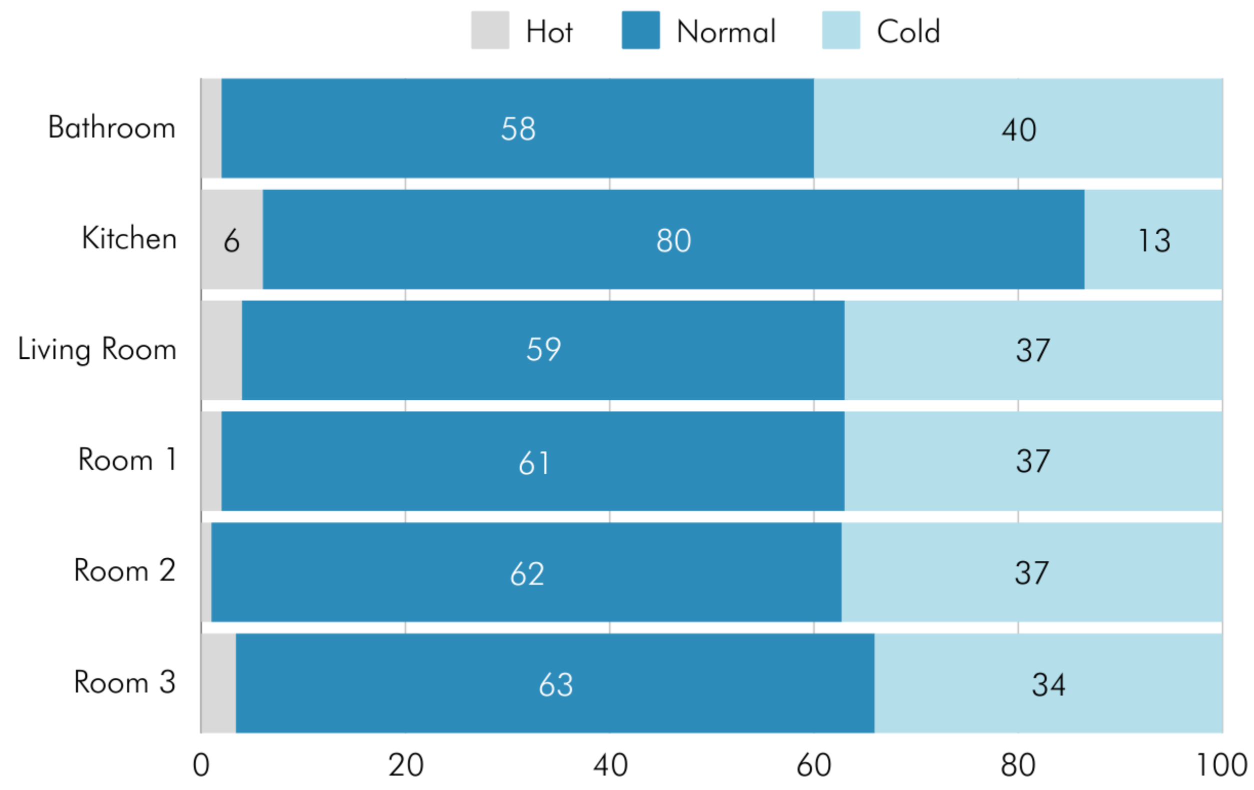
R3



Similar to the previous room, according to the simulation results, R3 is comfortable more than half of the time annually.

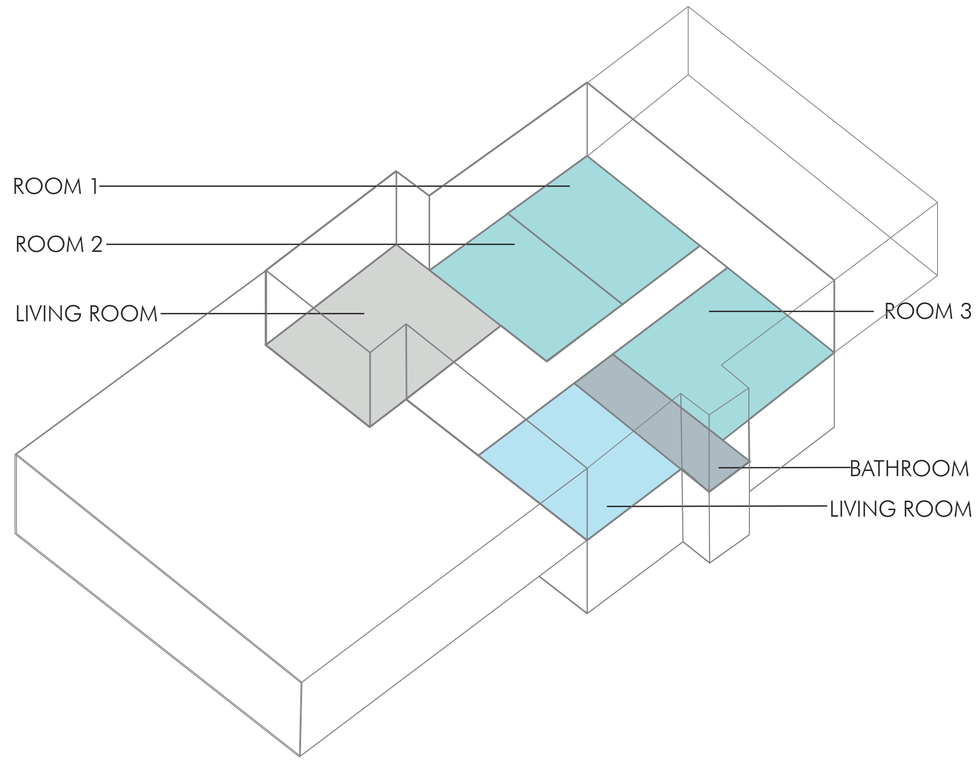


R3- Comfort Chart by the Rooms



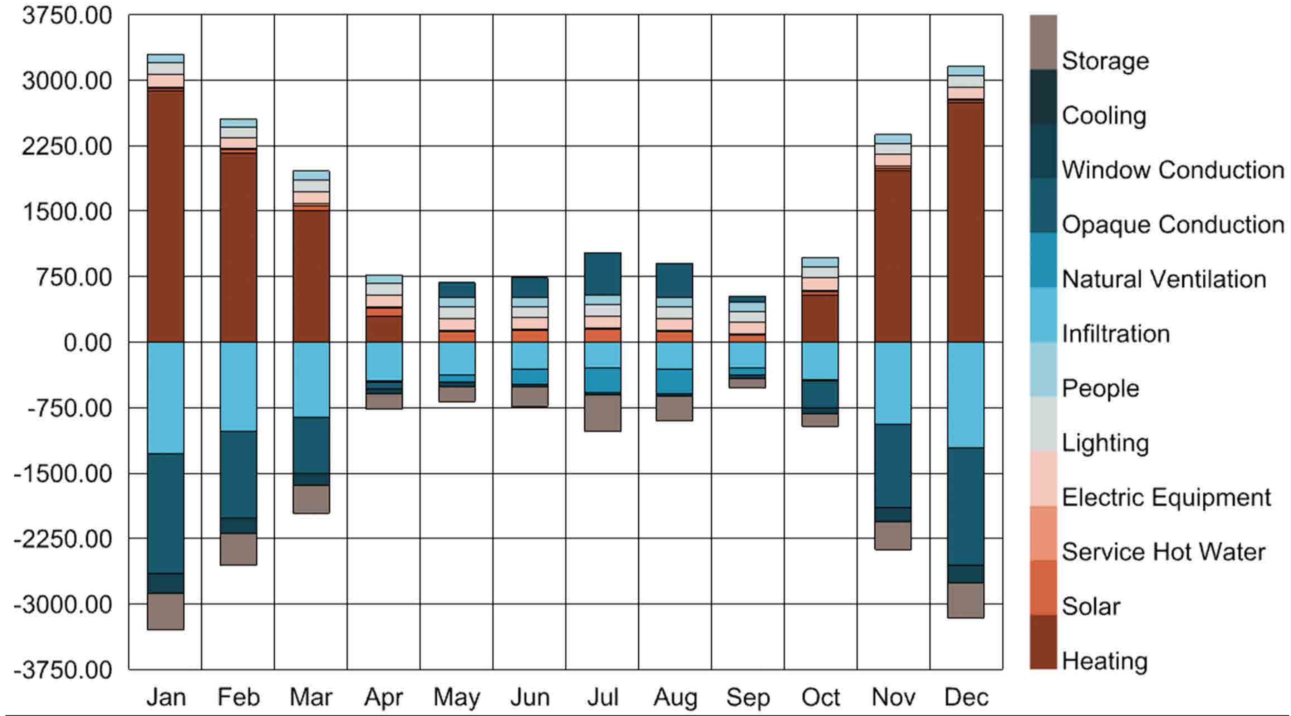
According to the chart, the most thermally comfortable room is Kitchen because of the electrical equipments and it is comfortable 80% of the year.
Overall, the dwelling is the most comfortable among the other dwelling locations. Because of this heat consumption is less and the energy poverty amount among middle dwelling residents is close to the threshold.

3.3.4 Room type 6-R4



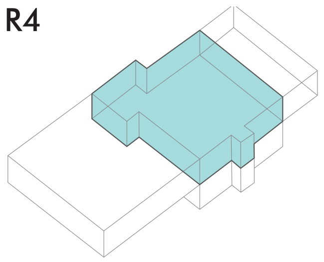
These room types are located in the ground floor or in the top floor of the building. They have only one side exposed and three surfaces adiabatic. The rest of the surfaces are exposed to the exterior environment. In the building Type A that simulation done, there are 4 dwellings.

Energy Balance Diagram (kWh per month)



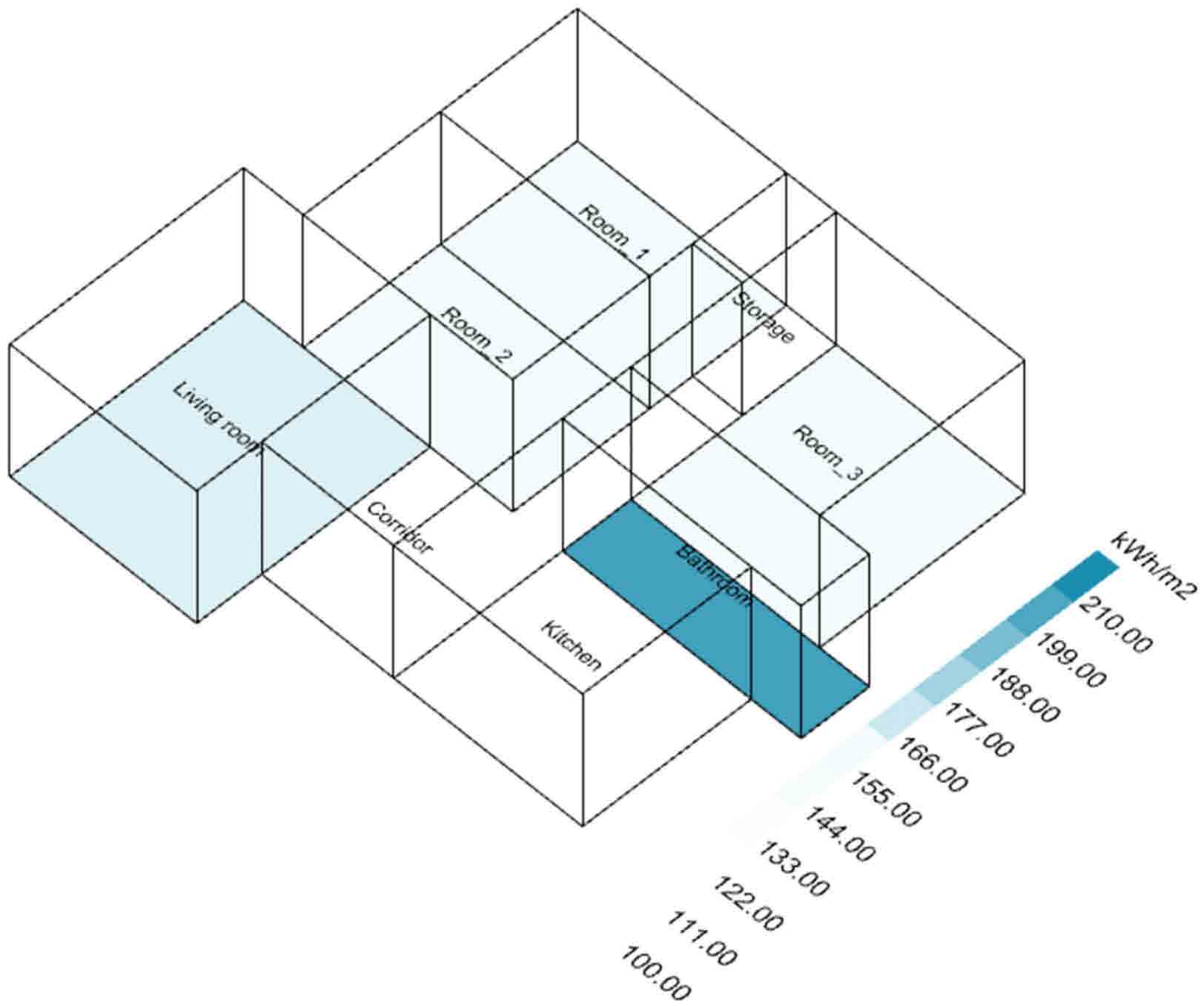
Annual Electricity Consumption (kWh)	Annual Gas Consumption (kWh)	Total Consumption (kWh)
3183	15241	18424

R4



The energy consumption is lower than the corner rooms however they are as much as low in energy performance. The energy balance diagram shows the total energy transfer in the building in relation to the simulation. As can be seen from the chart roof or ground floor being exposed to the unheated space affects the results greatly.

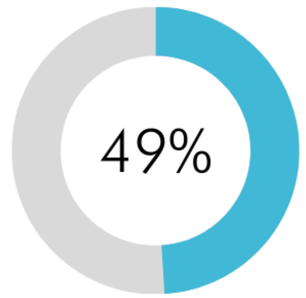
Normalized heat consumption for each room



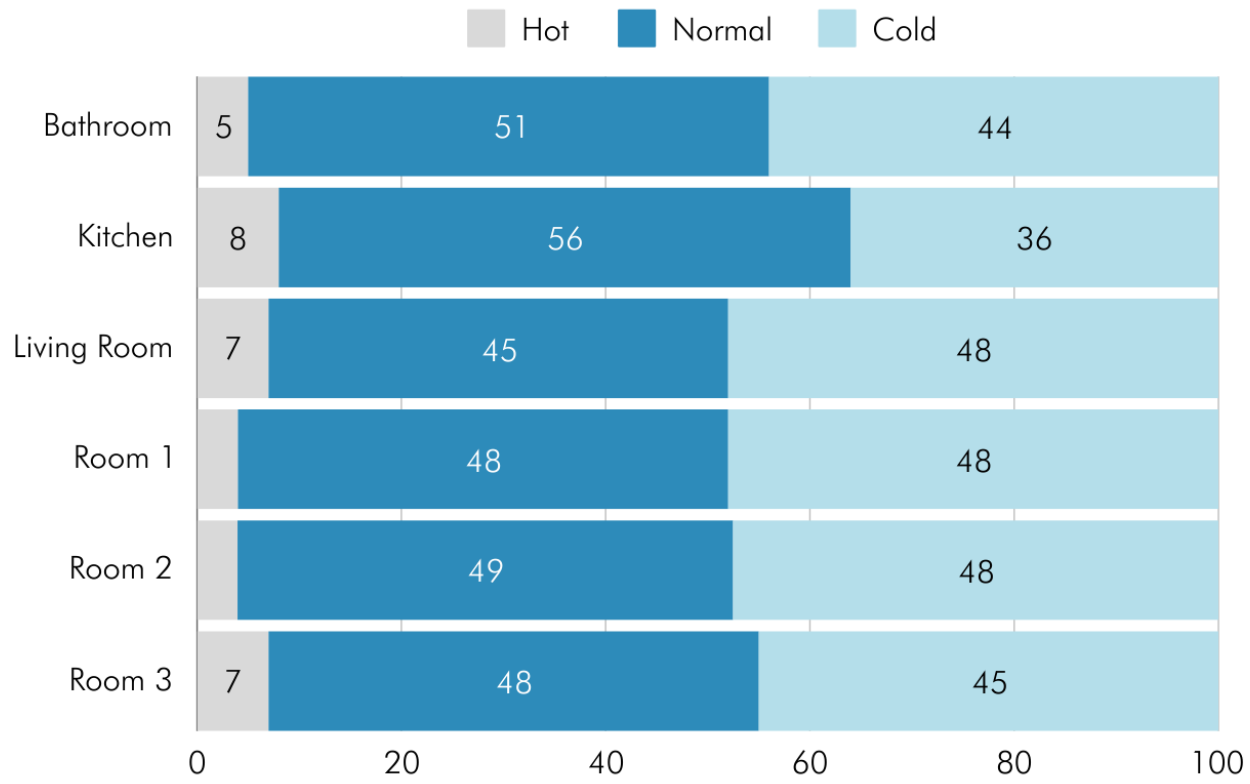
Annual Electricity Cost (€)	Annual Gas Cost (€)	Total Cost (€)
844	1554	2398

The highest energy need for heating is in the bathroom and the corner bedrooms similar to the previous rooms. These highest gas consumption area is consuming nearly 210 kWh per meter square.

Similar to the R1, According to the simulation results, R4 type rooms are not comfortable most of the time.



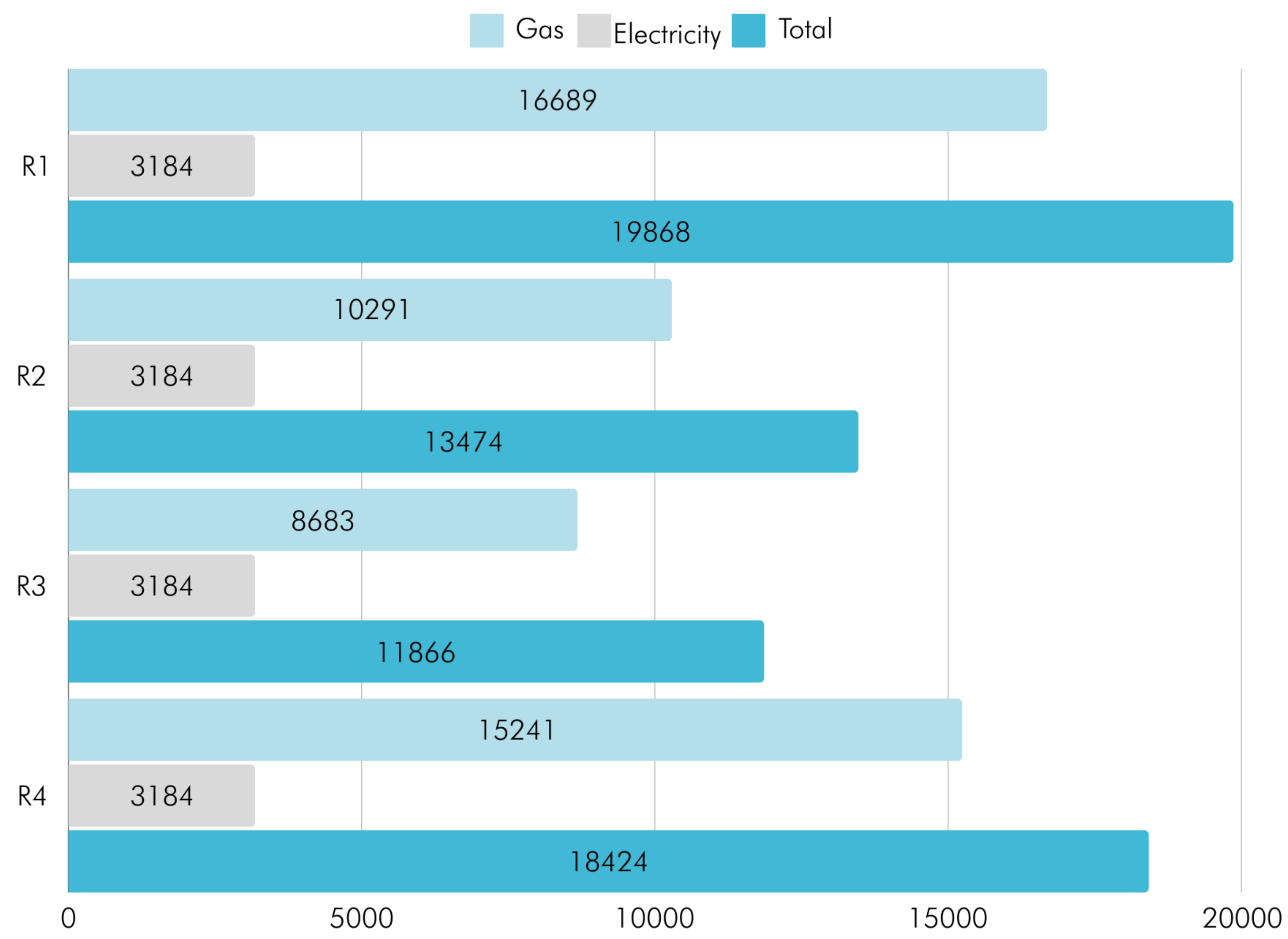
R4- Comfort Chart by the Rooms



According to the chart, the most thermally comfortable room is Kitchen because of the electrical equipments by 56%. The least comfortable room is the Living room.
Overall, the dwelling is mostly cold due to limited heating design days restricted by the Piemonte region even thought it is scaled according to the E type climatic region.

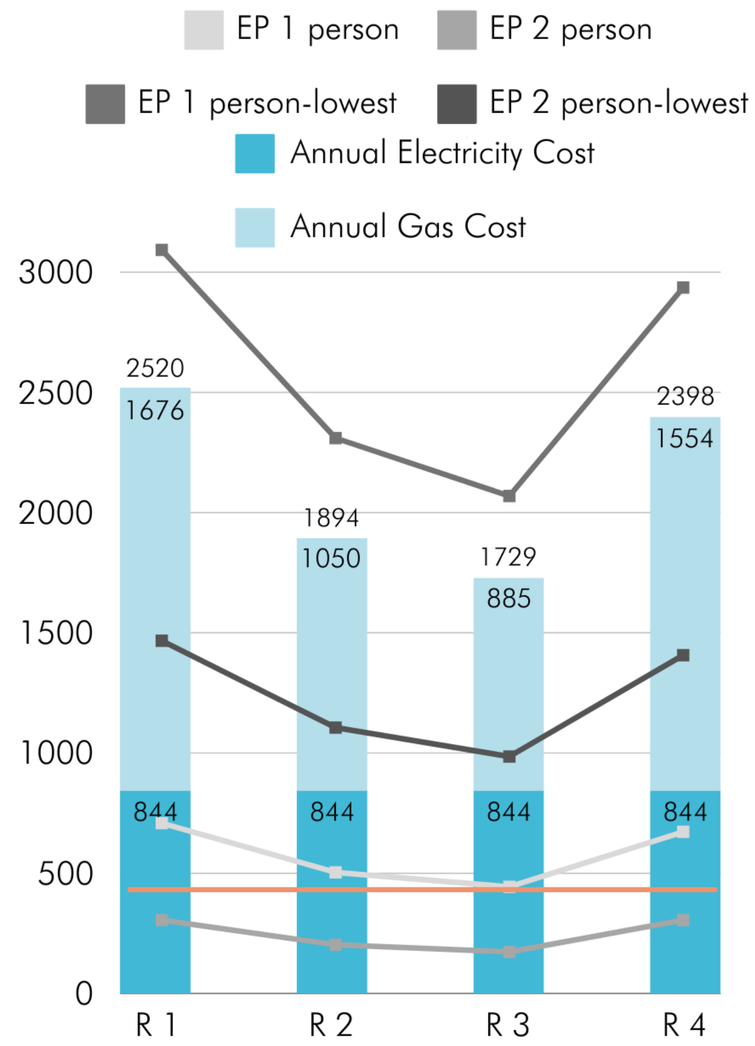
3.3.5 Comparison of Different Degrees of Energy Poverty

Annual Consumption of the Rooms by different locations



As can be seen from the chart respective to the simulation results, gas consumption affects the overall result more than the electricity consumption. The most energy demand is in the corner rooms.

Annual Cost with Energy Poverty Threshold according to the Number of people present in the nucleic family



As can we seen from the results of 4 dwellings, their energy performance is very low. Especially when we analyze the existing energy certificates from APE, energy class of the rooms are mostly Energy Class G.

In 2021, median of the Regio Parco region is 18762 Euros and lowest income is 4760 Euros. If we relatively analyze the cost of the energy in a year with the income, we can observe that the most of the residents are in energy poverty by spending their 10% of their income in energy costs. Simulations are conducted with the 2 person occupancy. Therefore, income of 1 or 2 people with different incomes are taken into account while calculating the energy poverty. Most effective result would be to use different scale design strategies to improve energy performance of the dwellings while introducing higher number of residents in the whole floor organization.

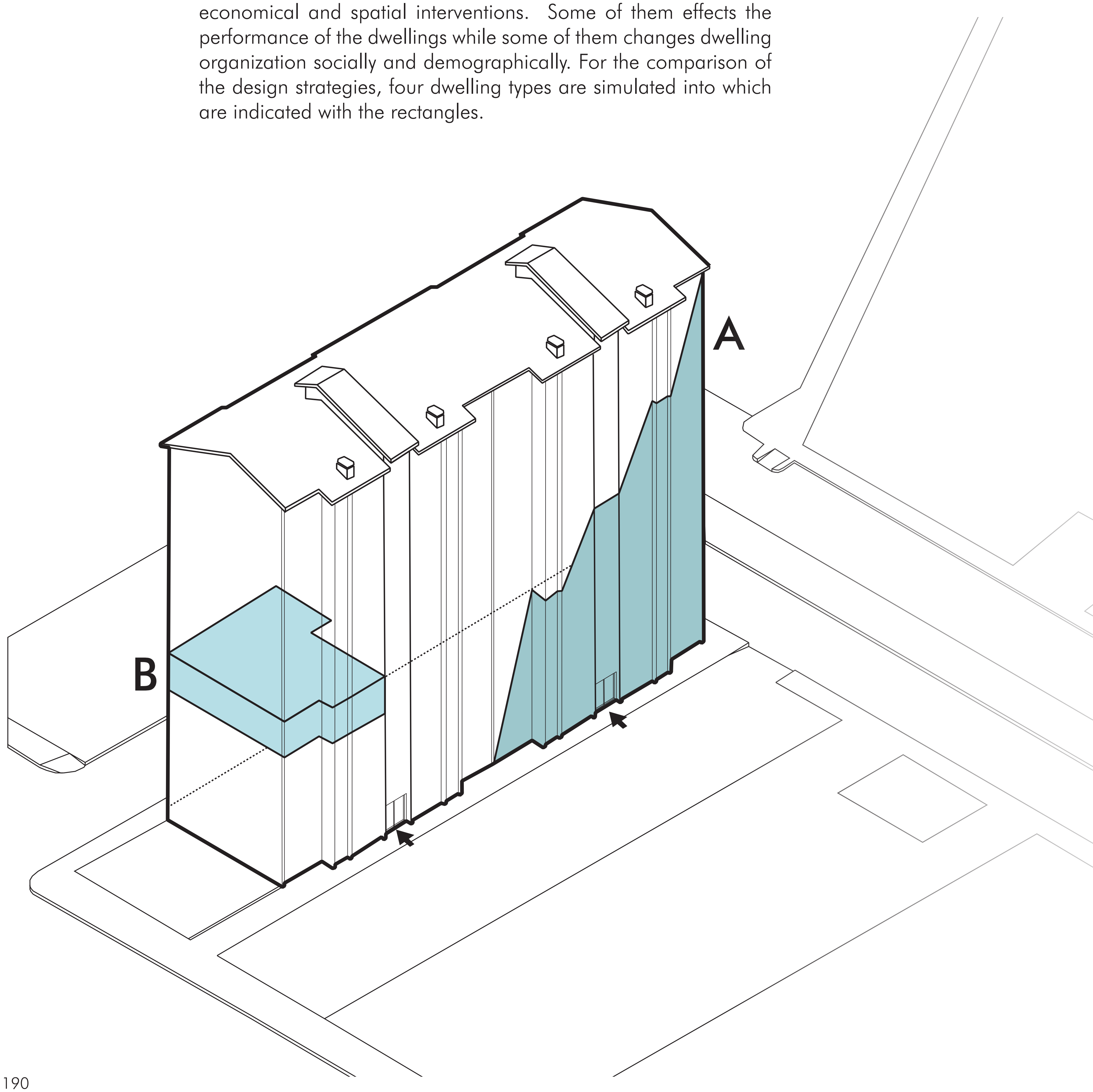
CHAPTER 4

Social and Economic Goals Across Multiple Scales

4

4.1 Multi-Scale Design Strategies

Two scales of intervention is selected for the design strategy. These are divided in terms of the intervention scope in relation to their economical and spatial interventions. Some of them effects the performance of the dwellings while some of them changes dwelling organization socially and demographically. For the comparison of the design strategies, four dwelling types are simulated into which are indicated with the rectangles.



A BUILDING SCALE INTERVENTIONS

ENERGY IMPROVEMENT

A1
Standard
Retrofit of the building to reach the current regulations

A2
High Performance
Ventilated façade with better performance with glazing

ENERGY & SPATIAL IMPROVEMENT

A3
Double Façade
Spatial addition to the dwellings to increase space use diversity and increase performance

B DWELLING SCALE INTERVENTIONS

ENERGY& SPACE IMPROVEMENT

B1
Enclosing the Balcony
Dwelling intervention of balcony glazing

SPATIAL IMPROVEMENT

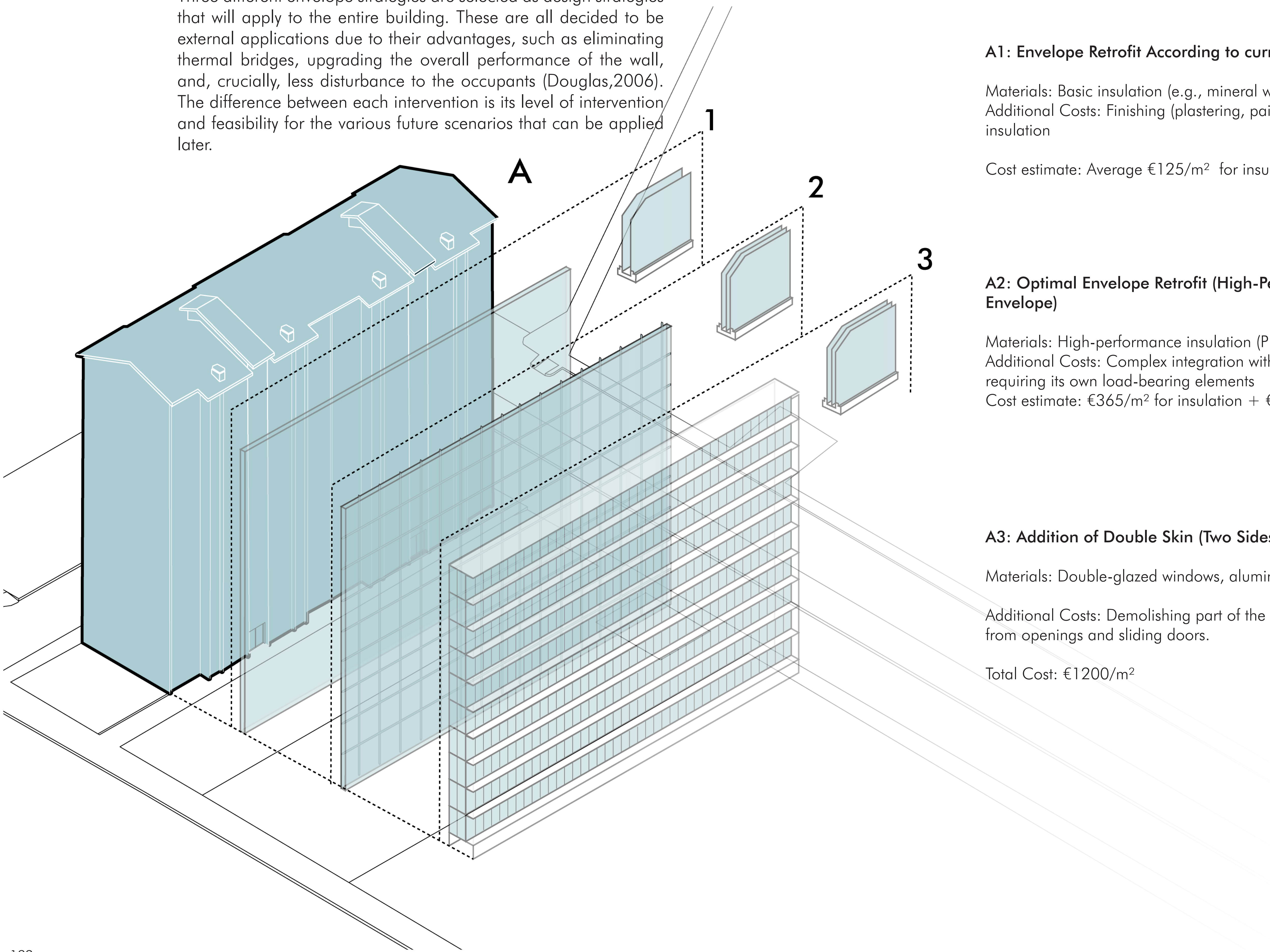
B2
Change in Contract
Dwelling with shared facilities , 1-person to 3-person contract

B3
Change of dwelling
Dwelling with shared communal areas and private bathrooms

B4
Change of the floor
Communal floor with shared communal areas and private bath-rooms

4.2 Building Scale Interventions

Three different envelope strategies are selected as design strategies that will apply to the entire building. These are all decided to be external applications due to their advantages, such as eliminating thermal bridges, upgrading the overall performance of the wall, and, crucially, less disturbance to the occupants (Douglas,2006). The difference between each intervention is its level of intervention and feasibility for the various future scenarios that can be applied later.



A1: Envelope Retrofit According to current Regulation

Materials: Basic insulation (e.g., mineral wool or EPS) & Low-E glazing
Additional Costs: Finishing (plastering, painting),Removal of existing insulation

Cost estimate: Average €125/m² for insulation+ €65/m² for glazing

A2: Optimal Envelope Retrofit (High-Performance Ventilated Envelope)

Materials: High-performance insulation (PIR) + selective low-E glazing
Additional Costs: Complex integration with existing structure, possibly requiring its own load-bearing elements
Cost estimate: €365/m² for insulation + €190/m² for glazing

A3: Addition of Double Skin (Two Sides of the Building)

Materials: Double-glazed windows, aluminum or steel frames

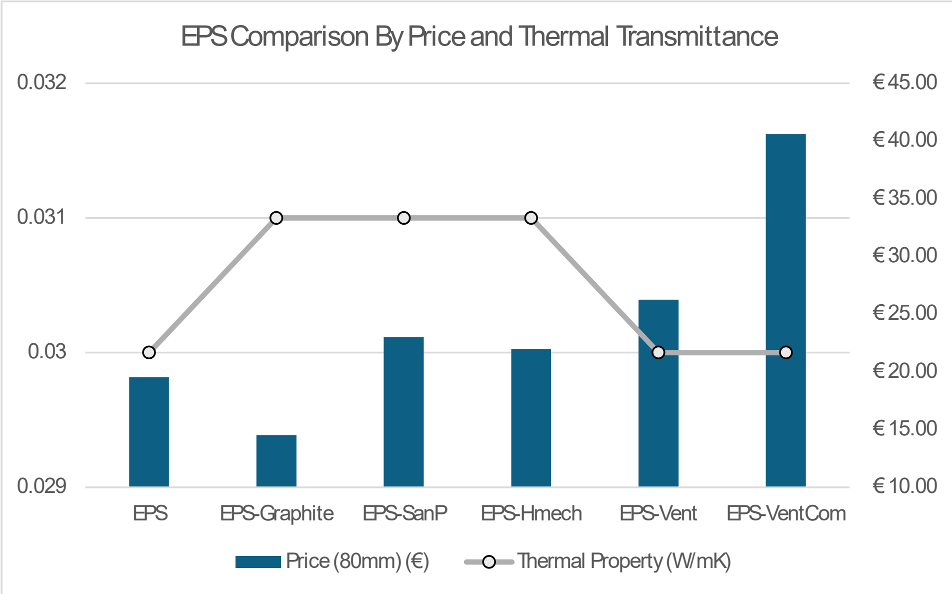
Additional Costs: Demolishing part of the envelope to create passage from openings and sliding doors.

Total Cost: €1200/m²

4.2.1 Cost comparison of Different Insulation Options

Building scale interventions are listed according to their intervention cost and extend. The first design strategy is decided to be economic as possible while third option targets highest feasible energy performance. For the approximation of the intervention costs, prices and thermal properties are taken from the general data list related to refurbishments published by DEI in 2023.

In the case studies one of the popular insulations is EPS(expanded polystyrene insulation) Thermal property of the EPS does not fluctuate greatly but its price is relatively different. These are related to their uses and physical properties as given together with their cost (80mm insulation):



		EPS	EPS-Graphite	EPS-SanP	EPS-Hmech	EPS-Vent	EPS-VentCom
Price (80mm)	(€)	€ 19.52	€ 14.53	€ 23.00	€ 21.99	€ 26.25	€ 40.60
Thermal Property	(W/mK)	0.03	0.031	0.031	0.031	0.03	0.03

EPS: For external wall insulation in ETICS (External Thermal Insulation Composite Systems). This is the common used EPS for the interventions.

EPS-Graphite : EPS with added graphite white polystyrene layer on the outer side, in sheets measuring 1000 × 500 mm. Its the cheapest option but low in terms of rigidity.

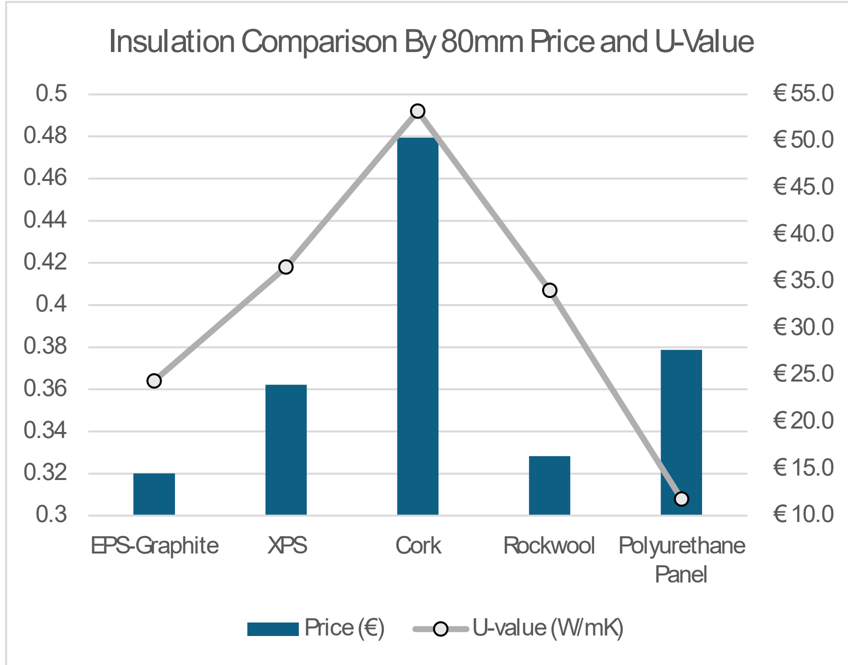
EPS-SanP: EPS Sandwich panel

EPS-Hmech: High mechanical strength EPS. Compliant with ETICS.

EPS-Vent: EPS Specifically used for ventilated façade

EPS-VentCom: EPS Sandwich panel combined with rock-wool

Thus, best option for cost-efficiency is using EPS-Graphite option. Durability is reduced compared with other options but it is best for the low funding.
The second table compares the prices and thermal properties of different insulation types mentioned in Part 2 case studies. The graph clearly shows the cost-efficiency with a same thickness material

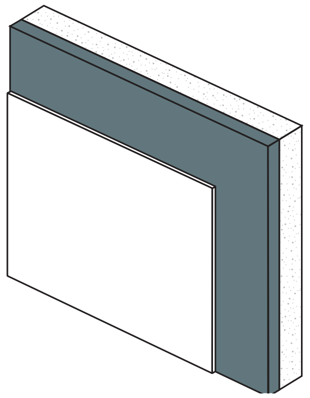


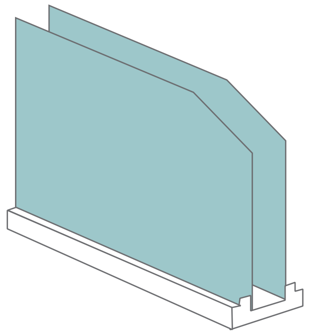
		EPS-Graphite	XPS	Cork	Rockwool	Polyurethane Panel
Price	(€)	€ 14.53	€ 24.00	€ 50.38	€ 16.38	€ 27.70
U-value	(W/mK)	0.364	0.418	0.492	0.407	0.308

The cheapest insulations are EPS-Graphite and Rock-wool insulation. EPS has better performance and it is more suitable for A-I intervention type.
We can see that XPS and Rock-wool has a close thermal performance, but a great cost gap. Additionally rock wool is cheaper in thicker amounts. So if the insulation thickness is required higher than 100mm, rock-wool is better option.(DEI,2023)
The cork is environmentally friendly and sustainable material, but its not very cost-effective compared to the other solutions since the goal is to reduce the energy bills. Therefore, it is not an viable option.
Polyurethane sandwich panel has a high thermal performance and it is nearly the same cost as the XPS. Therefore, for a high performing façade like A-III, polyurethane is a good option.

A1

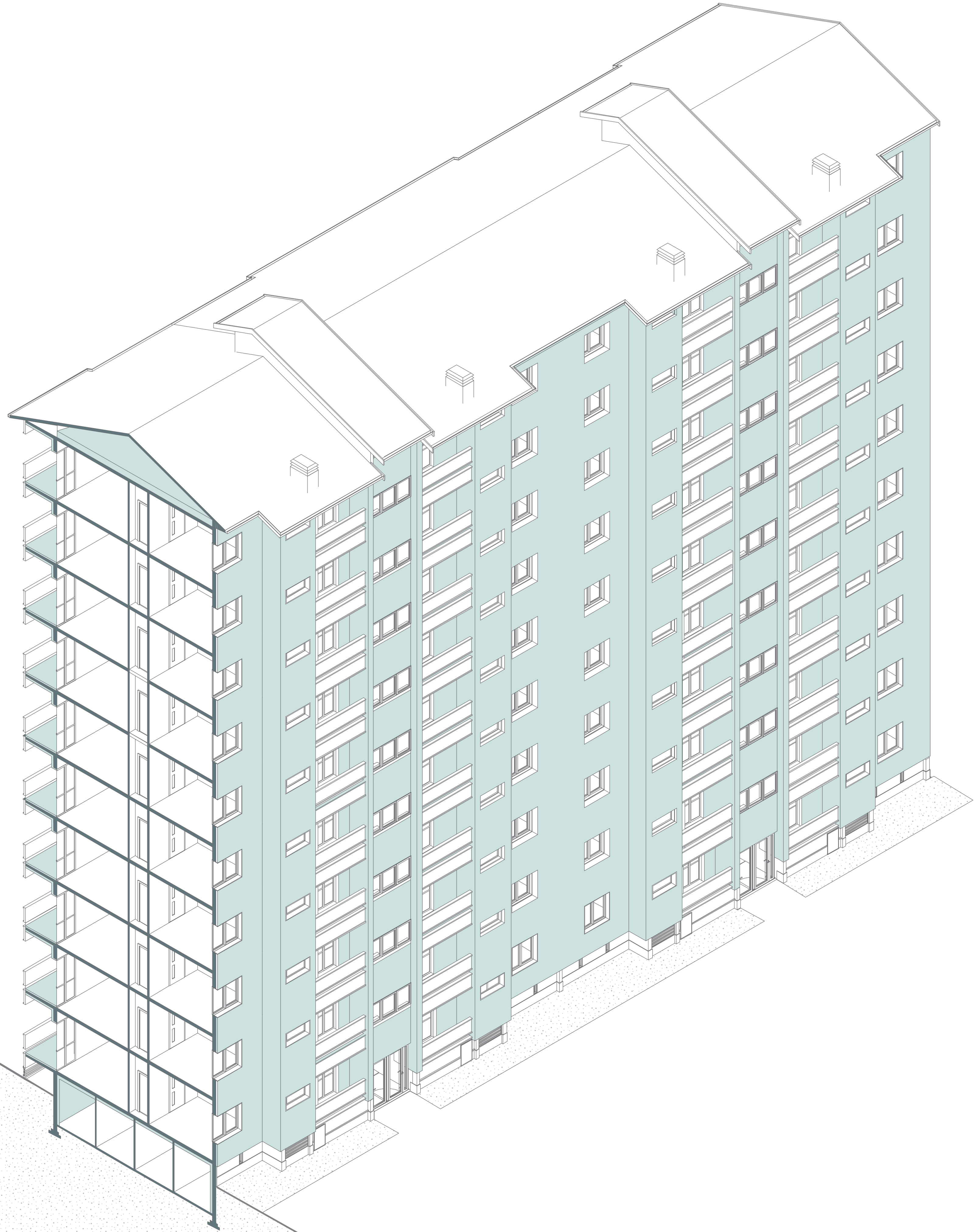
4.2.2 BUILDING SCALE INTERVENTIONS A1





This is one of the design strategies which could be beneficial in terms of economic viability for the ATC.

First, the existing layer of insulation is removed. Then double thickness EPS is added to reach to current standard for opaque walls that is 0.23 W/m²K. This layer of EPS is also added on top of the roof layer. This resulted in 0.18 W/m²K which is better than the regulations in this case. Glass type is also changed according to the regulations. For the frame, vinyl frame is used for better energy performance. For the transparent construction of the glazing, AGC configurator is used and “Thermobel: Stratobel Clearlite 33.1 - 24 mm Argon 90% - 4 mm Planibel A pos.3” construction is used. Together with frame and glass, new glazing achieved U_w 1.3 W/m²K regulation value.



A1

ROOF

U Value 0.17 W/m²K

INTERIOR to EXTERIOR

Concrete (130 mm)

Expanded Polystyrene-EPS (50 mm)

Expanded Polystyrene-EPS ETICS (100 mm)

TRANSPARENT ENVELOPE

FRAME

U Value 2.3 W/m²K

Vinyl Frame with Thermal Break (50x50 mm)

GLASS

U Value 1.3 W/m²K

Laminated Glass (3 mm)

Argon 90% (24 mm)

Low-E Laminated Glass (4 mm)

EXTERNAL WALL

U Value 0.23 W/m²K

INTERIOR to EXTERIOR

Concrete (130 mm)

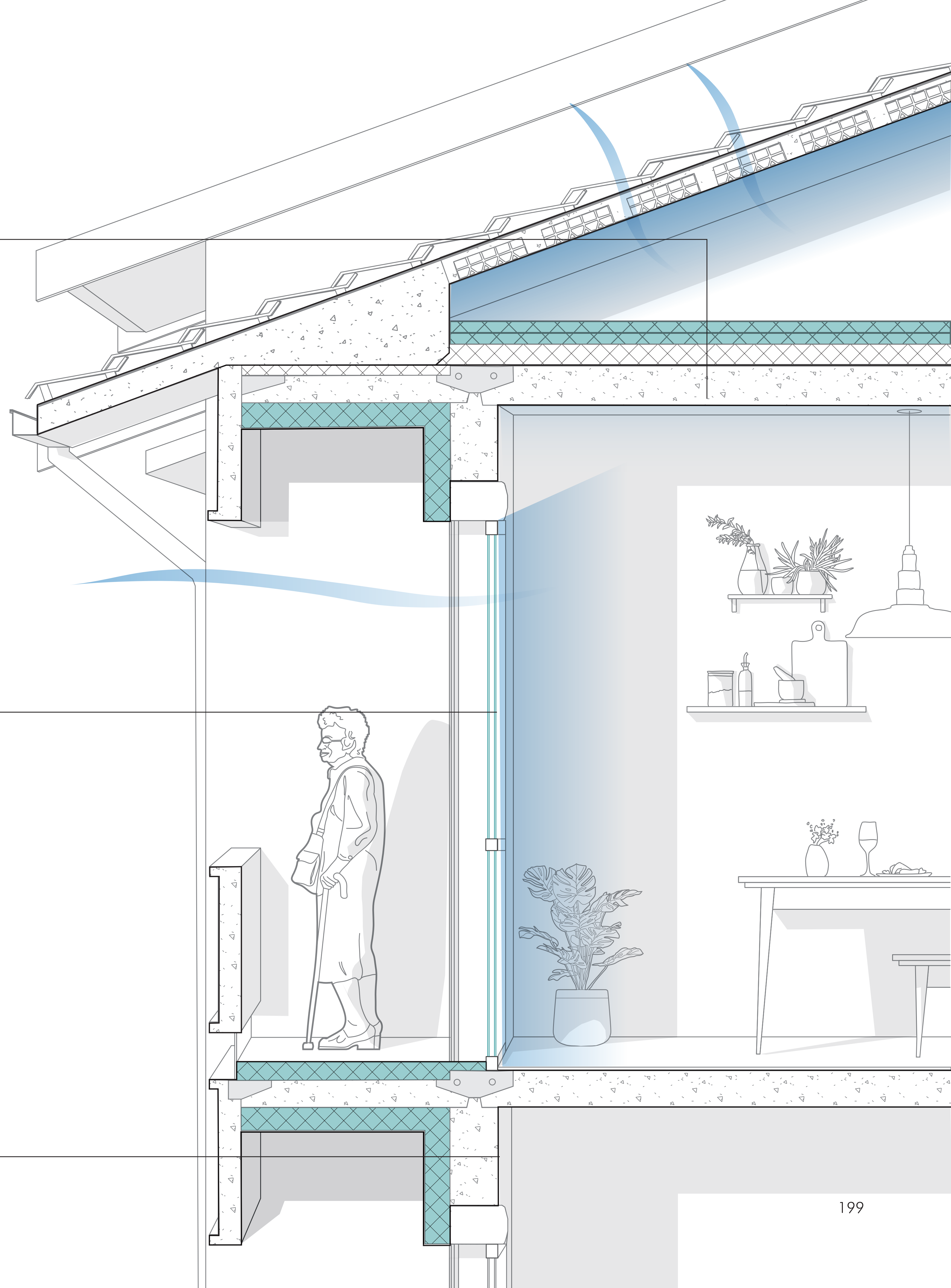
Expanded Polystyrene-EPS (30 mm)

Concrete (50 mm)

Expanded Polystyrene-EPS ETICS (100 mm)

External Paint (10 mm)

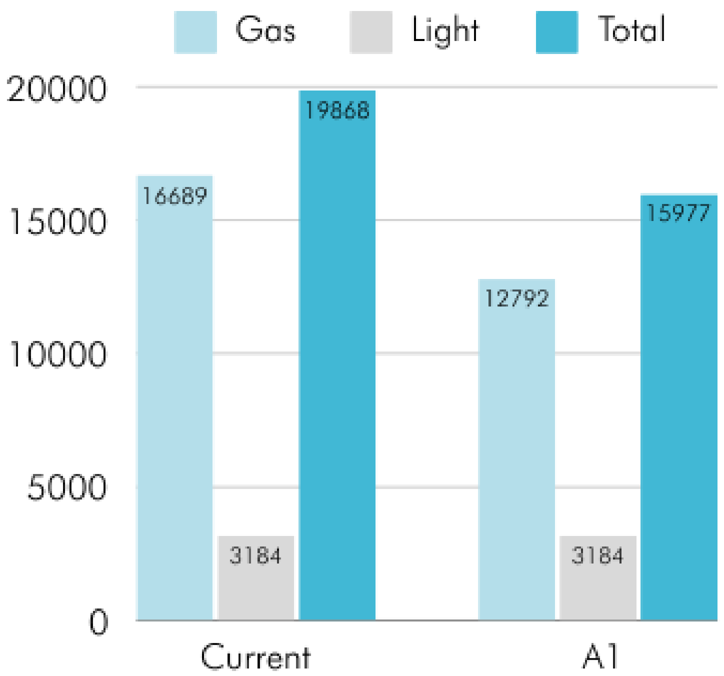
0.5 1 2 3 meters

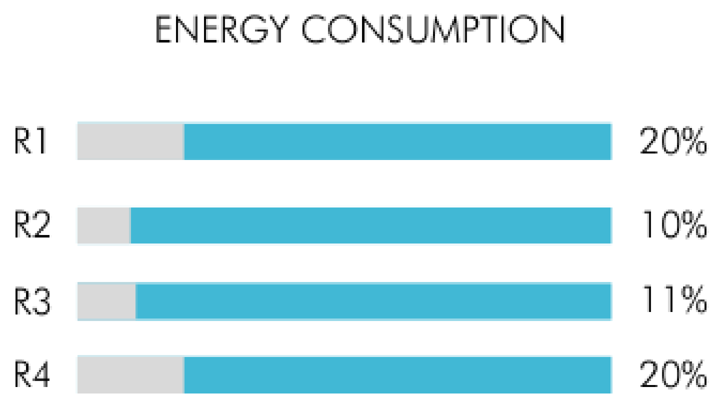


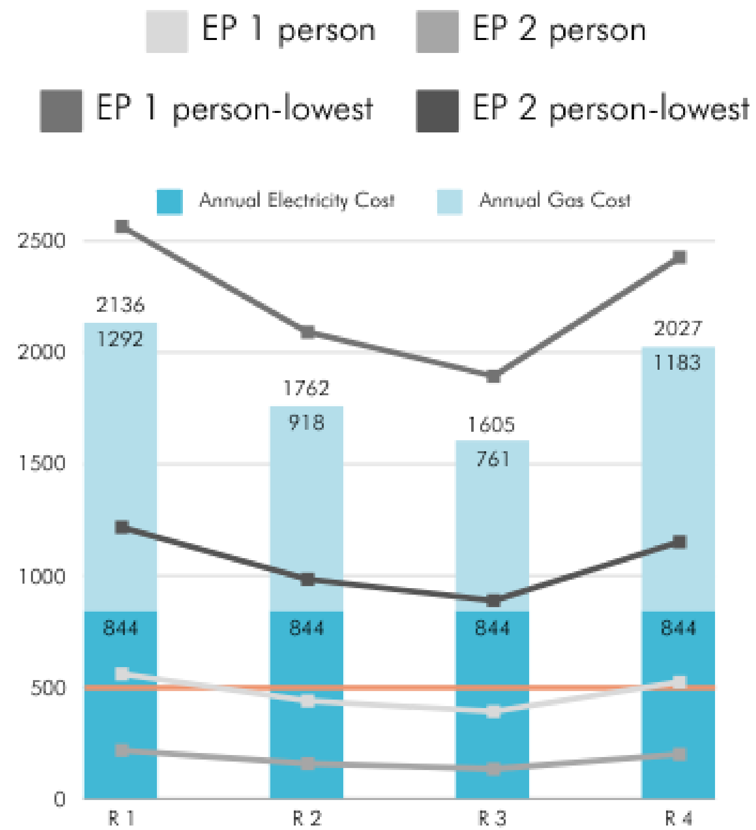
A1

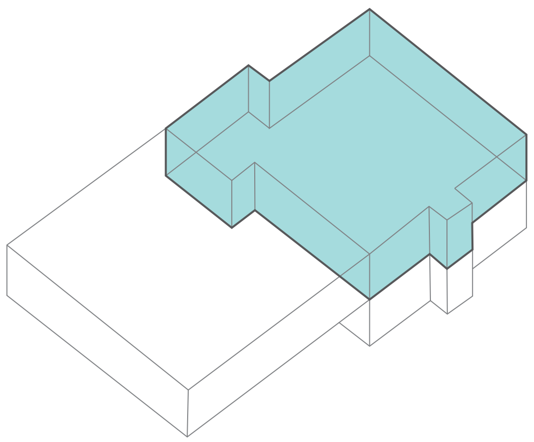
According to the graph, it can be observed that A1 type intervention decreased the energy consumption slightly than the previous strategy.

Annual costs are combined with the income of the residents to gather the energy poverty percentage. Annual salary for the Regio Parco region is defined as 18762 while the lowest income is 4760 for the year 2021.

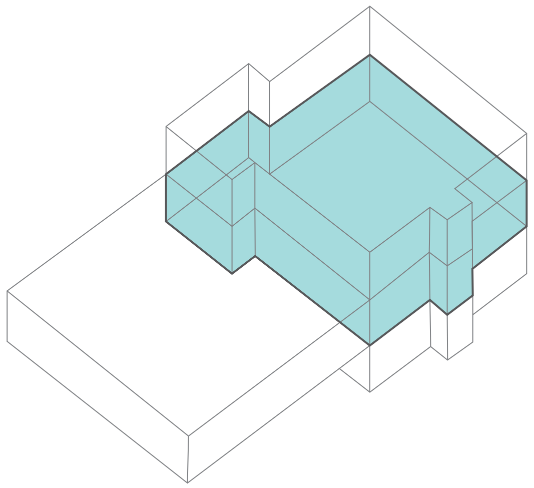




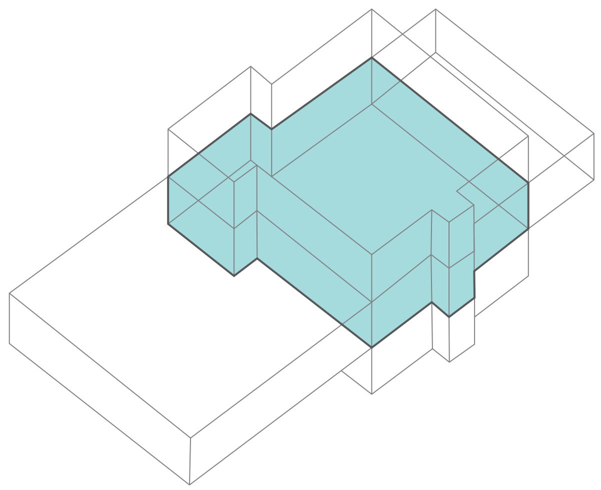




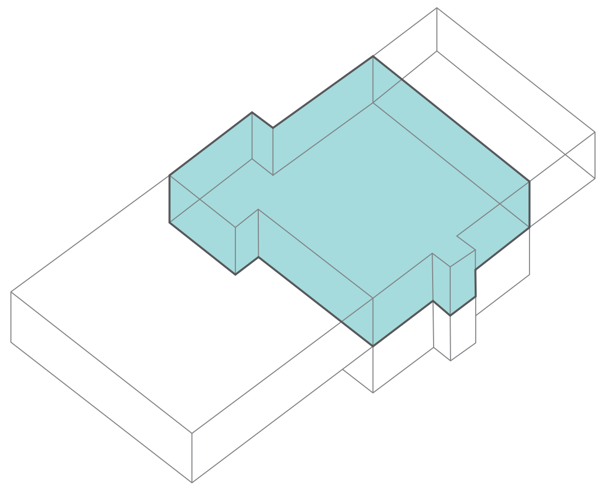
R1- Corner



R2- Middle-Edge



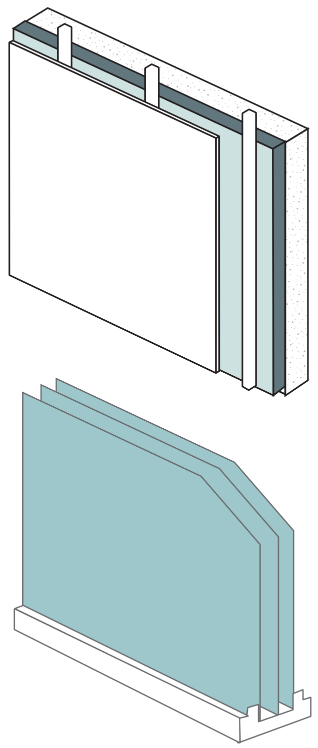
R3- Middle



R4- Top or ground

A2

4.2.3 BUILDING SCALE INTERVENTIONS A2



In this type of design intervention ventilated façade is used for better performance. Insulation is covered from ground floor to roof crawlspace. In the concave parts (such as balcony) insulation is solely used. While in exterior looking façades 5cm air gap is achieved with the steel vertical elements. Than a fiber cement board is used as a rain screen.

A2

ROOF

U Value 0.14 W/m²K

INTERIOR to EXTERIOR

Concrete (130 mm)

Expanded Polystyrene-EPS (50 mm)

Polyisocyanurate panel-PIR (100 mm)

TRANSPARENT ENVELOPE FRAME

U Value 2.3 W/m²K

Vinyl Frame with Thermal Break (50x50 mm)

GLASS

U Value 0.7 W/m²K

Laminated Glass (3.5 mm)

Argon 90% (12 mm)

Low-E Laminated Glass (3 mm)

Argon 90% (12 mm)

Low-E Laminated Glass (3 mm)

EXTERNAL WALL

U Value 0.13 W/m²K

INTERIOR to EXTERIOR

Concrete (130 mm)

Expanded Polystyrene-EPS (30 mm)

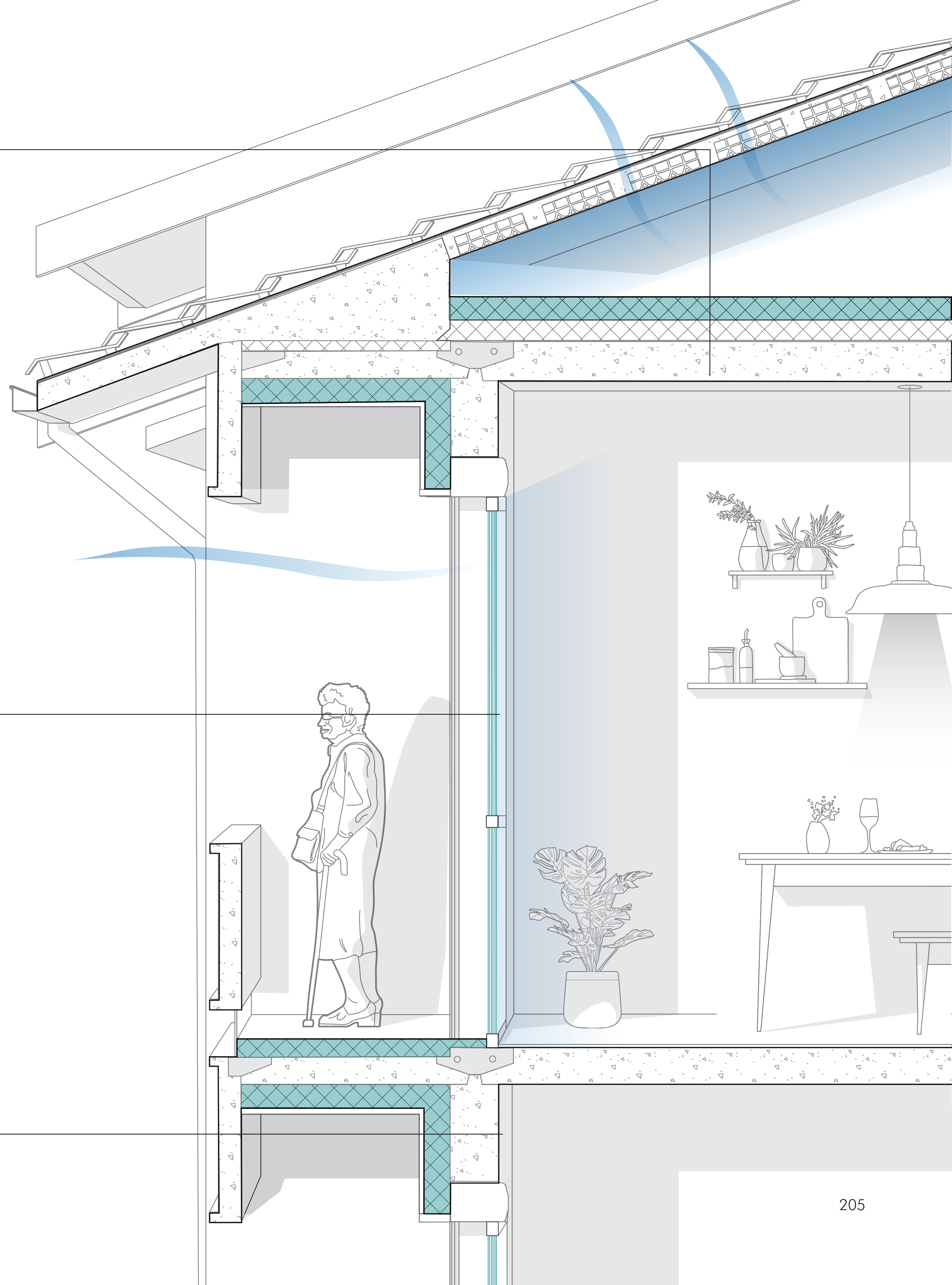
Concrete (50 mm)

Polyisocyanurate panel-PIR (100 mm)

Water Proof Membrane

Air Gap (5 mm)

Fibercement Rainscreen (8 mm)

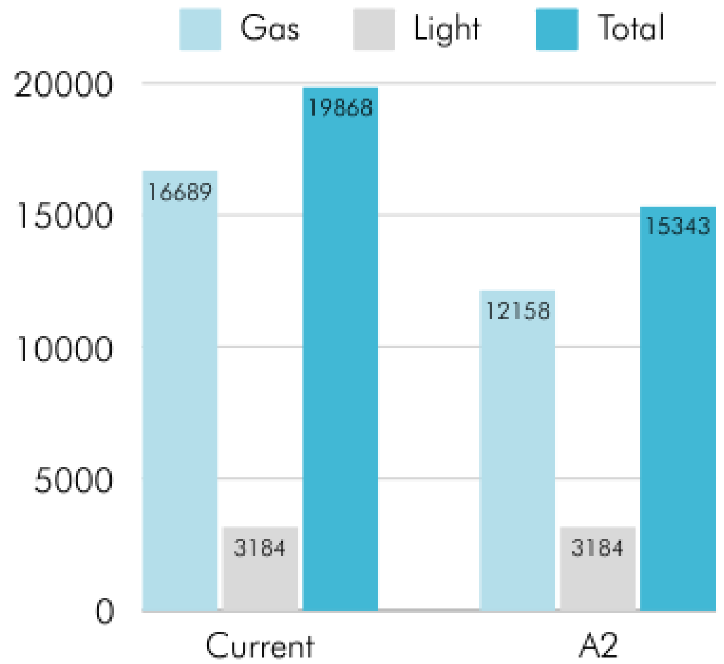


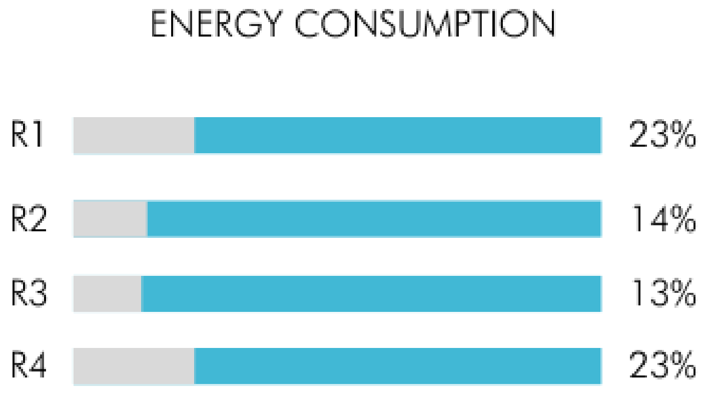
0.5 1 2 3 meters

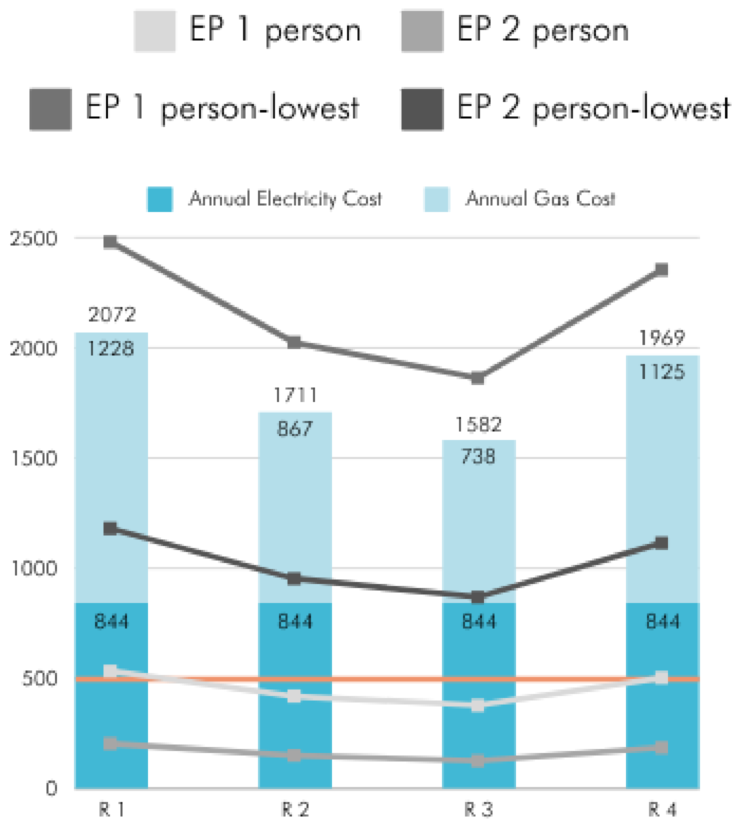
A2

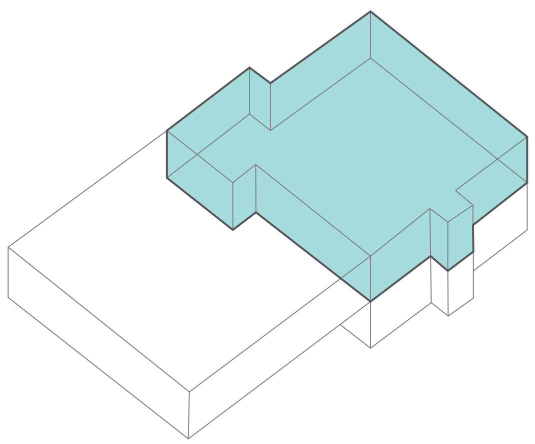
According to the graph,compared to the previous envelope strategy, energy consumption is reduced slightly.

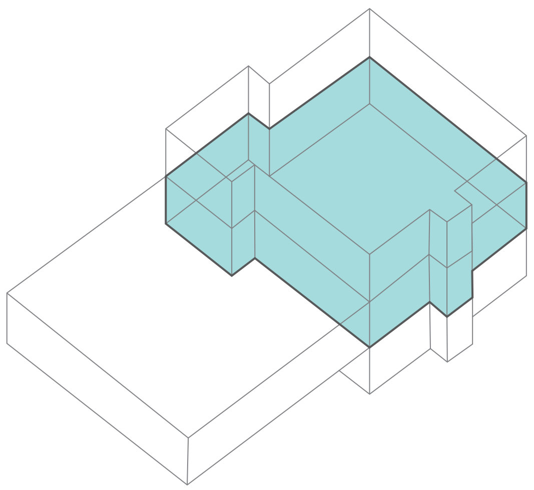
Compared to the previous strategy energy poverty is a concern to the income groups that are lower than the residents earning the average amount. If the families are earning double income, energy poverty is slight concern compared to the individual families.

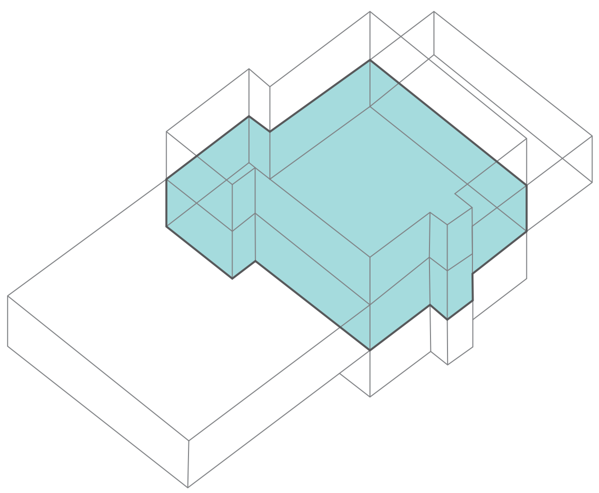


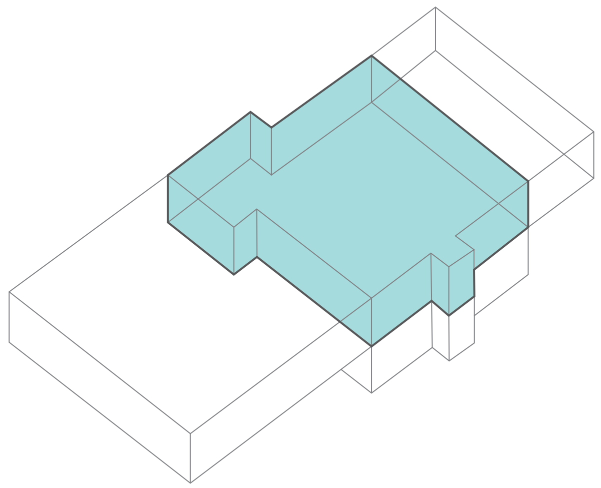





R1- Corner


R2- Middle-Edge


R3- Middle


R4- Top or ground

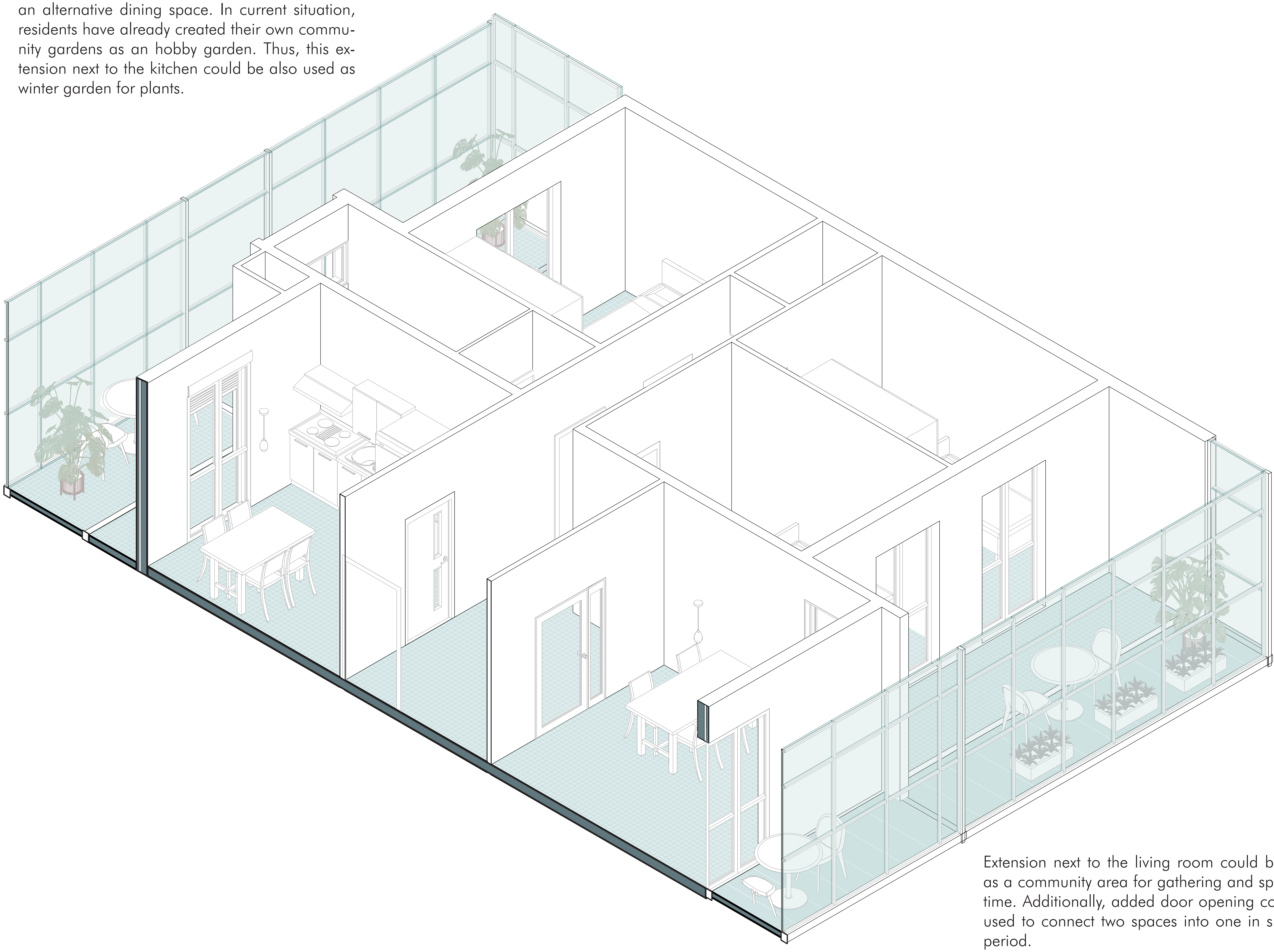
A3

4.2.4 BUILDING SCALE INTERVENTIONS A3

In this type of design intervention a double façade extension is designed for improvement in the dwellings for both spatial needs, as well as the energy needs. Existing slab is used for deciding the height of the floors. These are both mounted in the slabs as well as to a steel frame network that are supported from the ground floor. These are carrying the glazing elements as well as the floor cladding for the newly constructed floor. In this intervention, residents do not need to move out from the building. Only major change in the existing building layout is the change of the exterior facing windows to balcony doors to create passage to the new volume.

A3

These extensions could be used in multiple ways. Since it is connected to kitchen it can be used as an alternative dining space. In current situation, residents have already created their own community gardens as an hobby garden. Thus, this extension next to the kitchen could be also used as winter garden for plants.



Extension next to the living room could be used as a community area for gathering and spending time. Additionally, added door opening could be used to connect two spaces into one in summer period.

A3

ROOF

U Value 0.14 W/m^2K

INTERIOR to EXTERIOR

Concrete (130 mm)

Expanded Polystyrene-EPS (50 mm)

Polyisocyanurate panel-PIR (100 mm)

TRANSPARENT ENVELOPE

FRAME

U Value 2.3 W/m^2K

Vinyl Frame with Thermal Break (50x50 mm)

GLASS

U Value 0.7 W/m^2K

Laminated Glass (3.5 mm)

Argon 90% (12 mm)

Low-E Laminated Glass (3 mm)

Argon 90% (12 mm)

Low-E Laminated Glass (3 mm)

EXTERNAL WALL

U Value 0.13 W/m^2K

INTERIOR to EXTERIOR

Concrete (130 mm)

Expanded Polystyrene-EPS (30 mm)

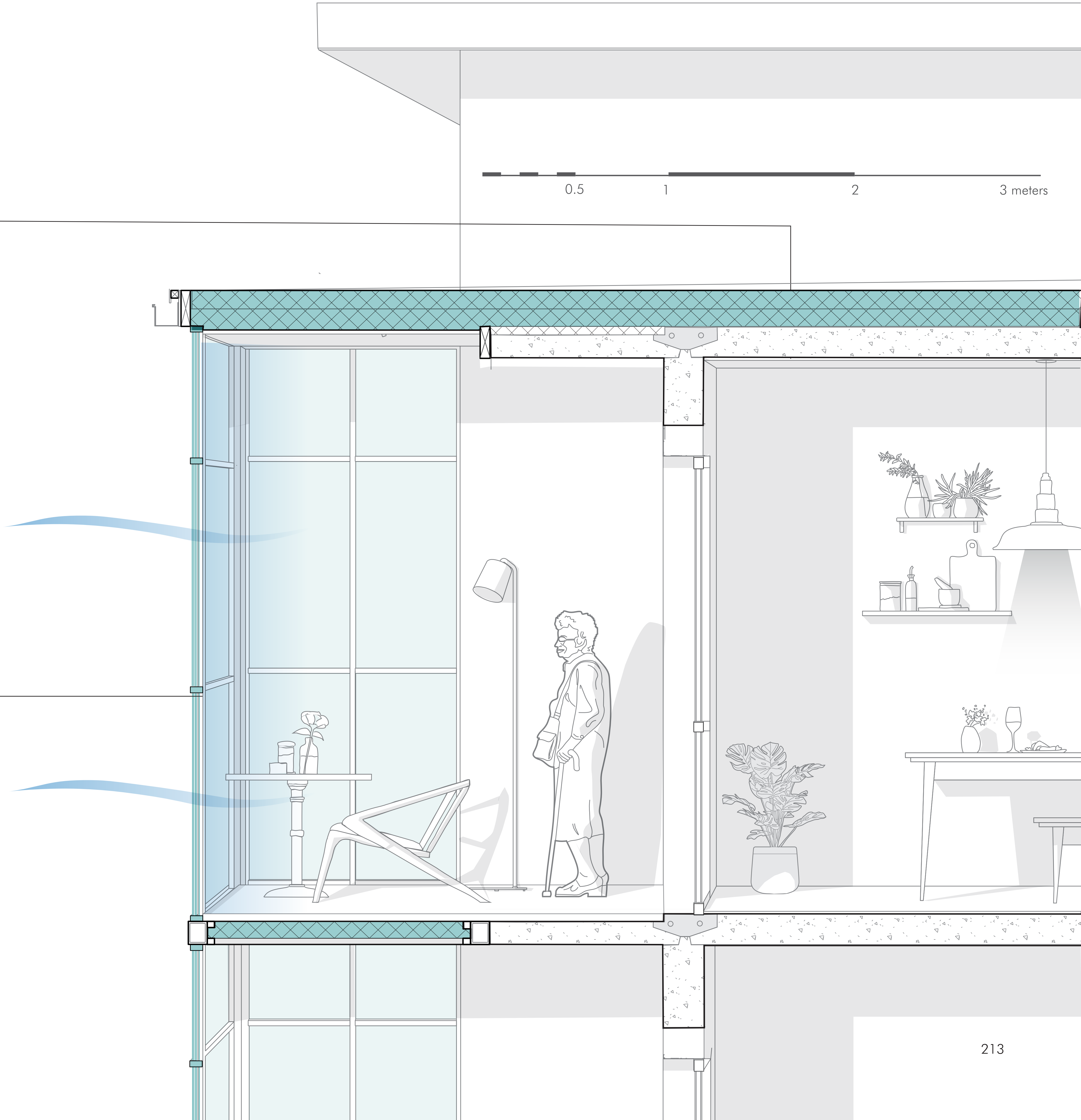
Concrete (50 mm)

Polyisocyanurate panel-PIR (100 mm)

Water Proof Membrane

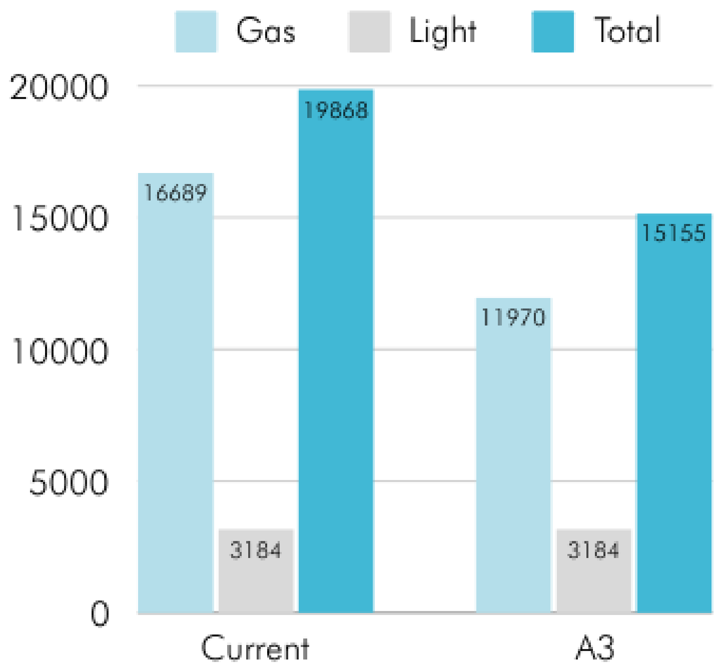
Air Gap (5 mm)

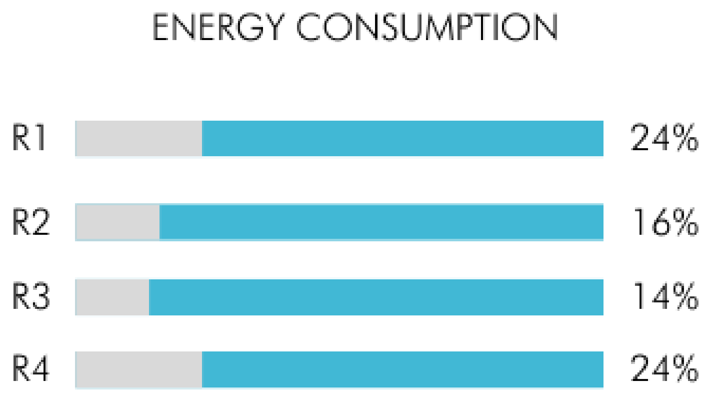
Fibercement Rainscreen (8 mm)



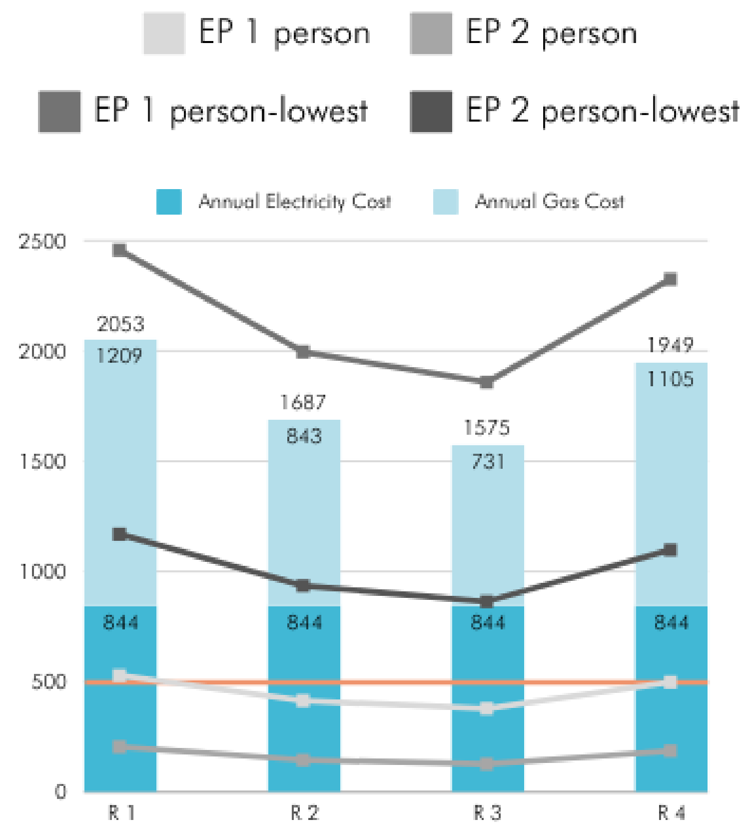
A3

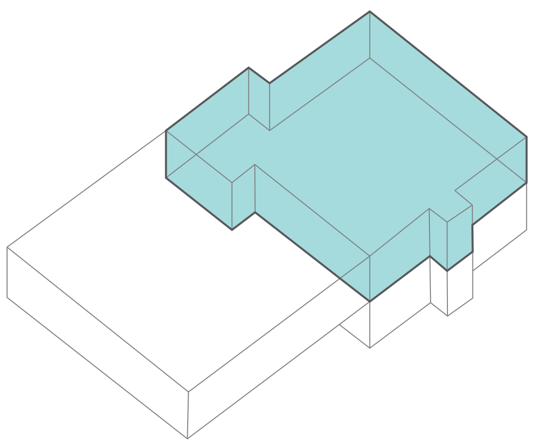
According to the graph,compared to the previous envelope strategies ,having a buffer area between the envelope affects the corner rooms greatly



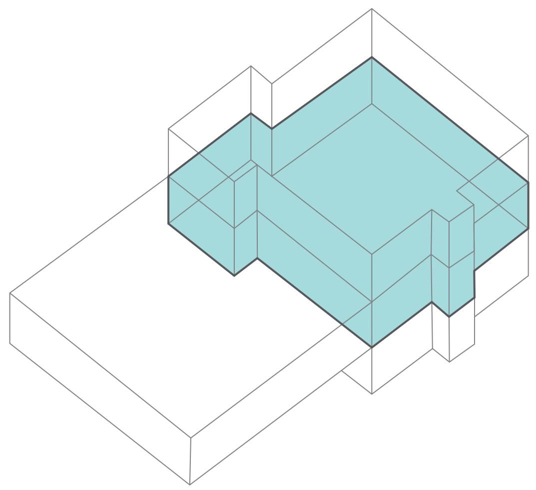


In this results the energy poverty is much higher than the orange line defined as the limit. The 2-person families are nearly out of the risk of energy poverty.

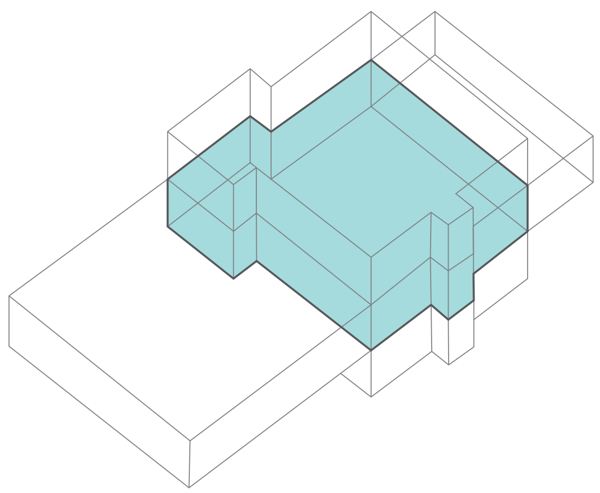




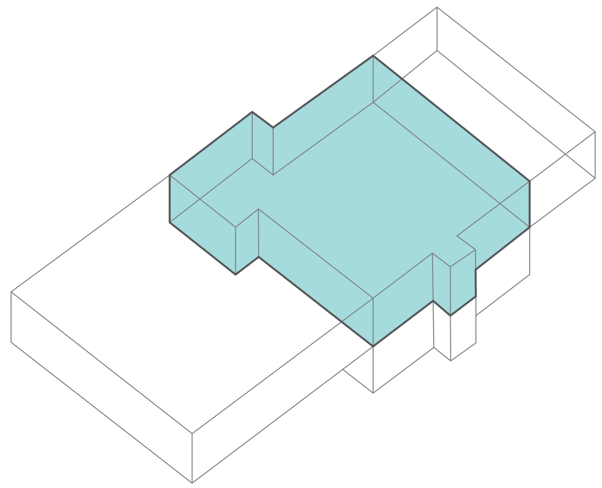
R1- Corner



R2- Middle-Edge



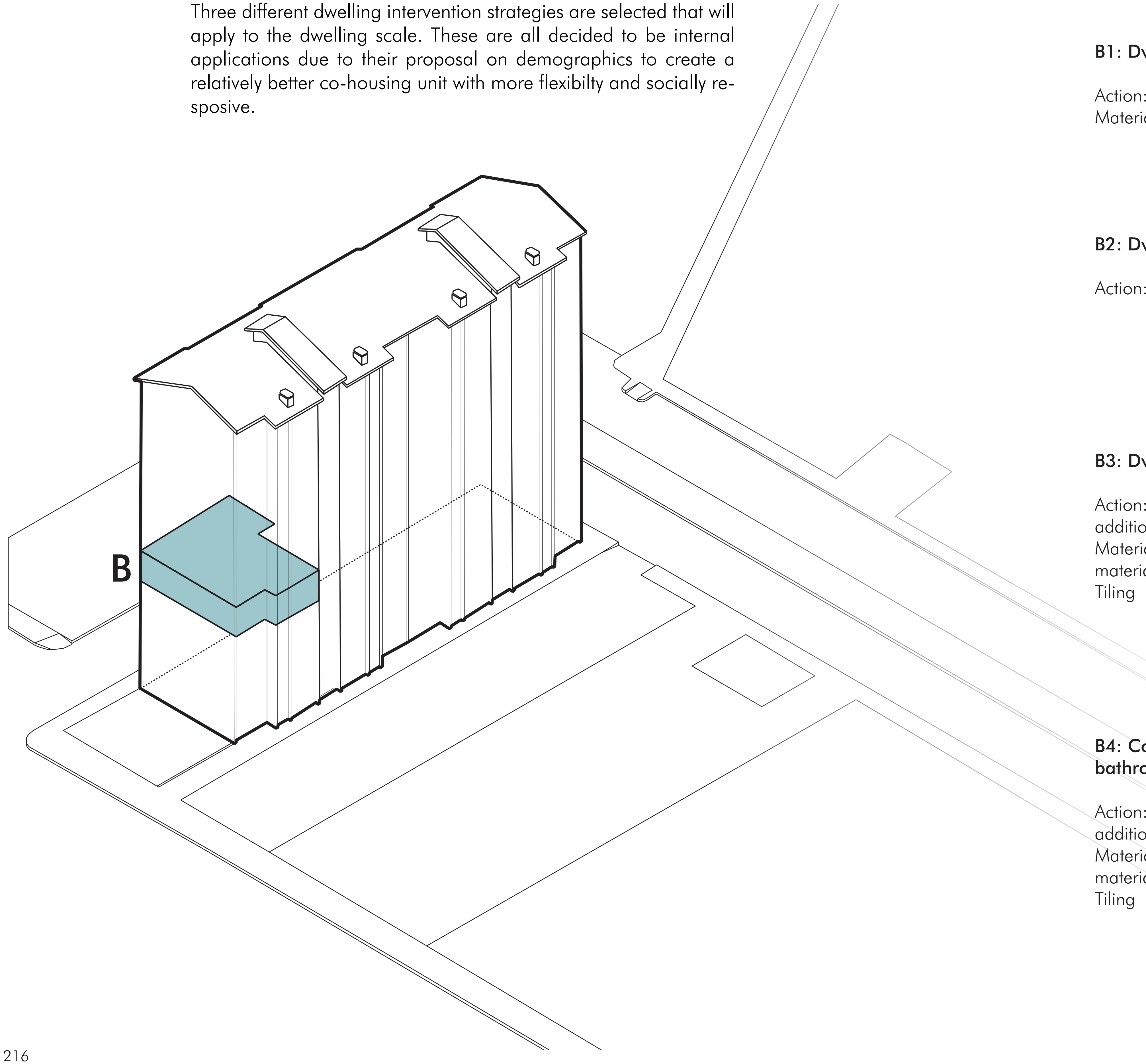
R3- Middle



R4- Top or ground

4.3 Dwelling Scale Interventions

Three different dwelling intervention strategies are selected that will apply to the dwelling scale. These are all decided to be internal applications due to their proposal on demographics to create a relatively better co-housing unit with more flexibilty and socially re-sposive.



B1: Dwelling intervention of balcony glazing

Action: Enclosement of the balconies by residents
Materials: Double glazing units

B2: Dwelling with shared communal areas from existing units

Action: Rearrangement of the attainment in the dwellings by ATC

B3: Dwelling with shared communal areas and private bathroom

Action: Demolition of Non-Structural Internal Walls and Bathroom addition
Materials: New bathroom fixtures (toilets, sinks, showers), Plumbing materials (pipes, fittings),Electrical wiring and lighting
Tiling

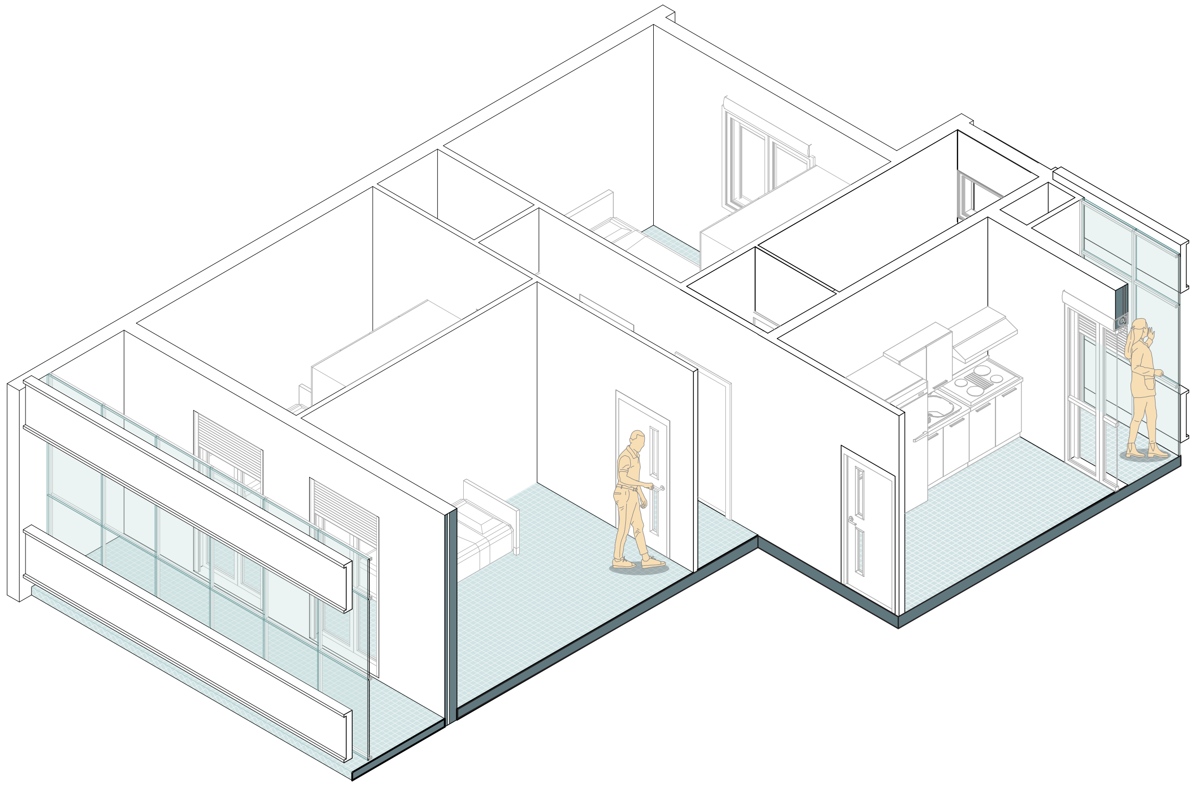
B4: Communal floor with shared communal areas and private bathroom

Action: Demolition of Non-Structural Internal Walls and Bathroom addition
Materials: New bathroom fixtures (toilets, sinks, showers), Plumbing materials (pipes, fittings),Electrical wiring and lighting
Tiling

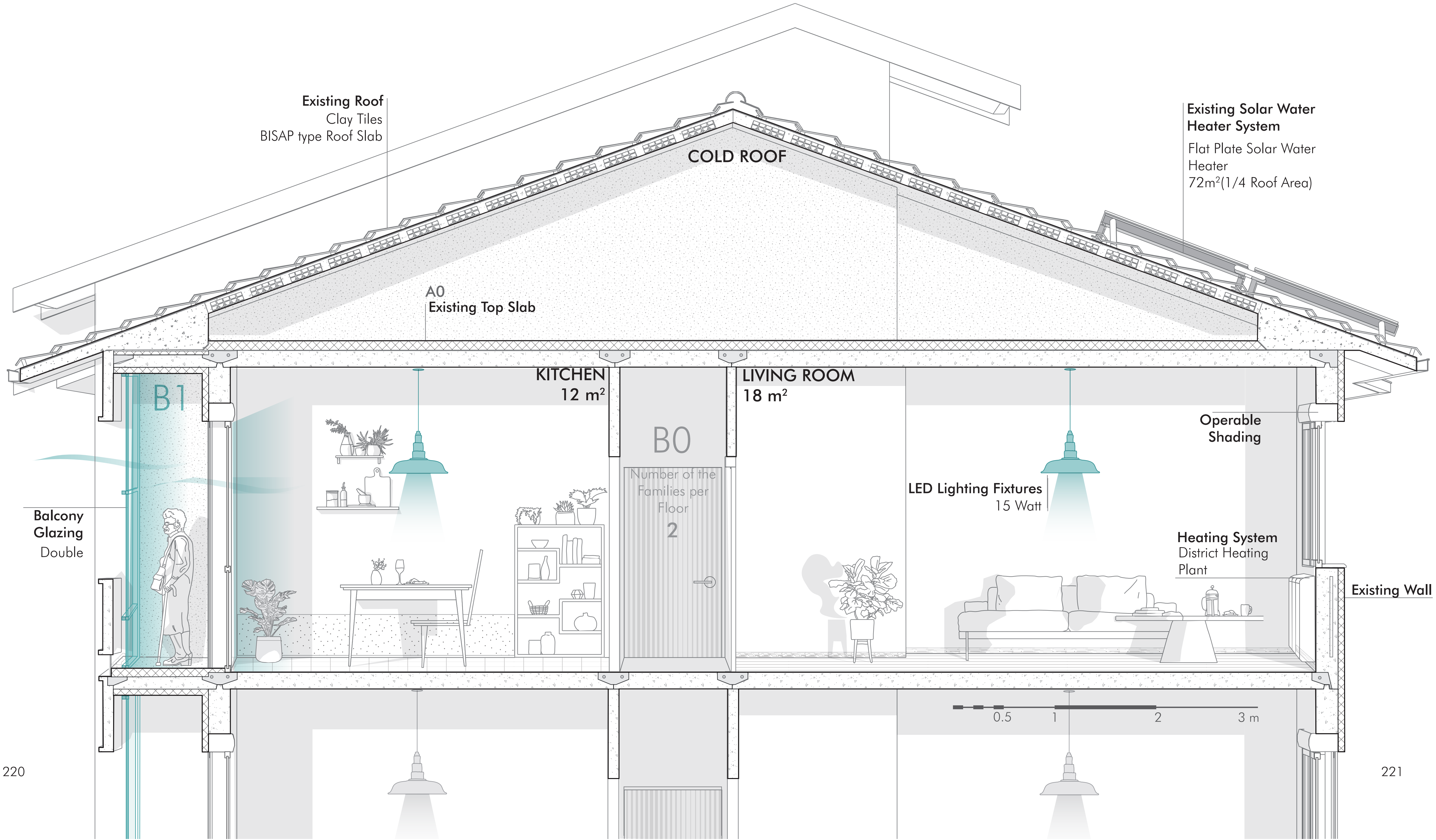
B1

4.3.1 DWELLING SCALE INTERVENTIONS **B1**

Inspired from the current residents tendency to close up the balconies, using a buffer zone could improve energy performance of the building while creating a space for residents to use also in winter period. Therefore, existing balconies located in kitchen and in two rooms are closed for decreasing the exposed wall area and benefit from the buffer zone acting as winter garden.



B1

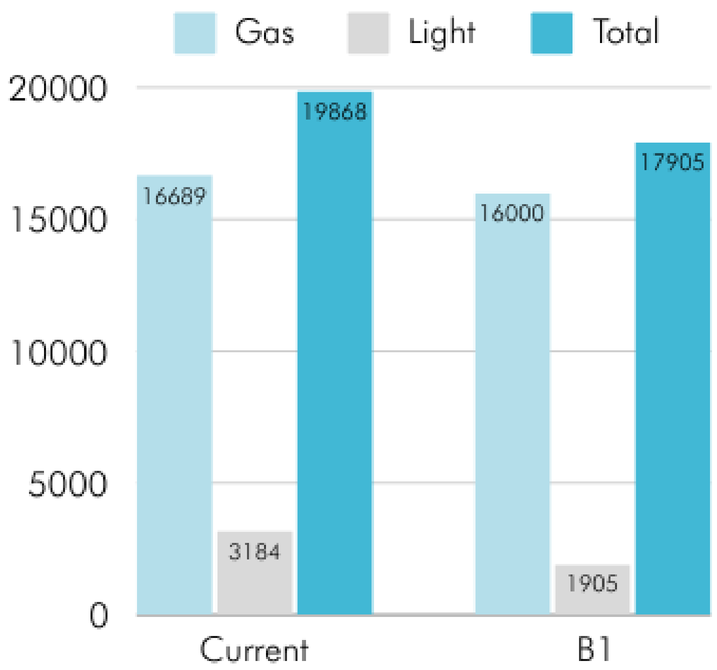


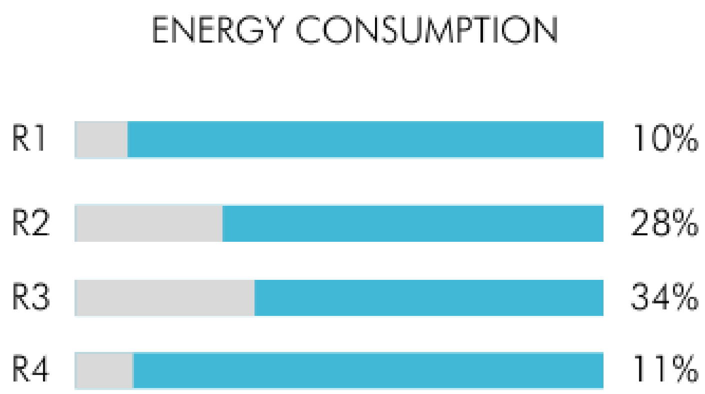
Existing Roof
Clay Tiles
BISAP type Roof Slab
Existing Solar Water Heater System
Flat Plate Solar Water Heater
72m²(1/4 Roof Area)
COLD ROOF
A0
Existing Top Slab
B1
KITCHEN
12 m²
LIVING ROOM
18 m²
B0
Number of the Families per Floor
2
Operable Shading
LED Lighting Fixtures
15 Watt
Balcony Glazing
Double
Heating System
District Heating Plant
Existing Wall
0.5
1
2
3 m

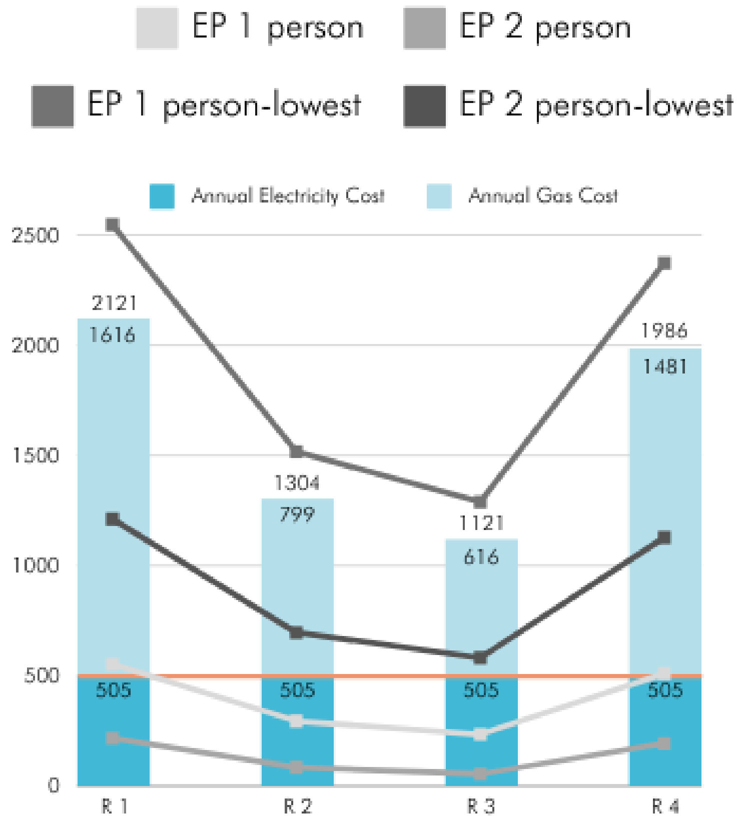
B1

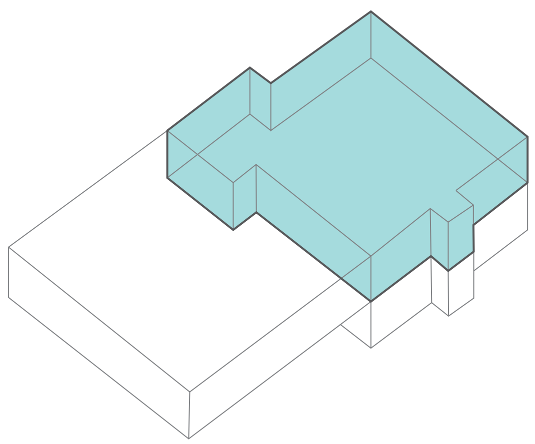
According to the graphs, surprisingly this result is highly effective in middle rooms even though the strategy is the most economic option. However in the case of the rooms that are exposed more to the exterior are not much affected by the strategy. Additionally lighting fixtures are changed by the residents since they are very cost-effective if LED type of lighting fixtures are used.

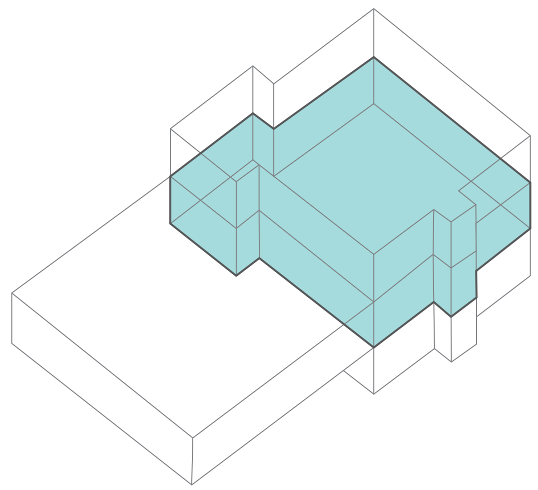
In this results the energy poverty is again higher compared to the previous strategies, but interestingly an individual person with an average salary is nearly reaching to the energy poverty limit.

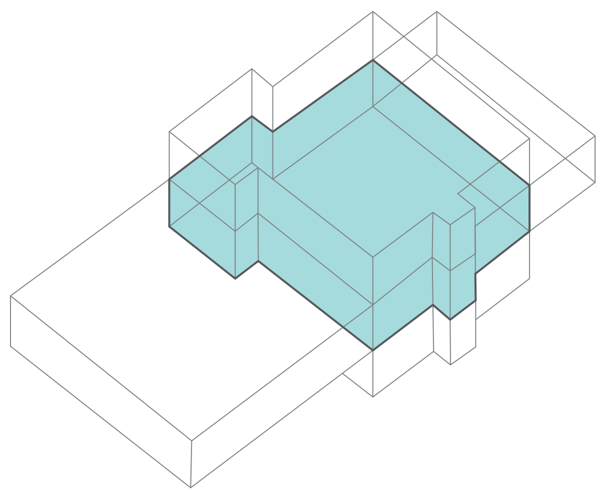


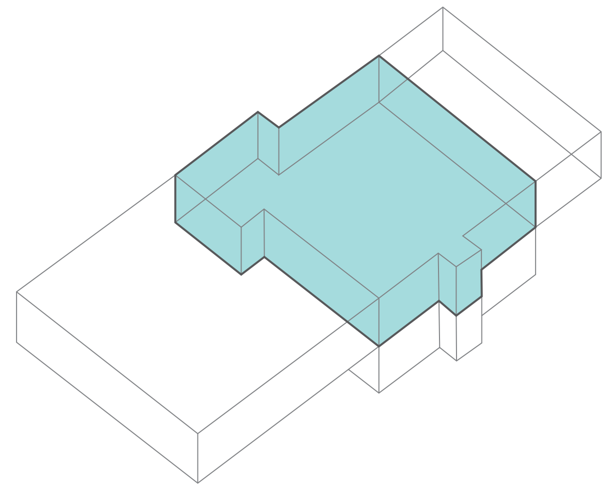





R1- Corner


R2- Middle-Edge


R3- Middle


R4- Top or ground

B2

4.3.2 DWELLING SCALE INTERVENTIONS **B2**

Ideal for 3 family

Workers

Seniors

Existing dwelling is turned into communal units with communal areas such as kitchen, bathroom and living room. This unit increases the 1-person family number higher. Also, there is no study or working area in the dwelling due to inadequate area. Due to every service being communal, only limited type of people are expected to stay in the rooms.

Room Type 1

Rooms with common balcony

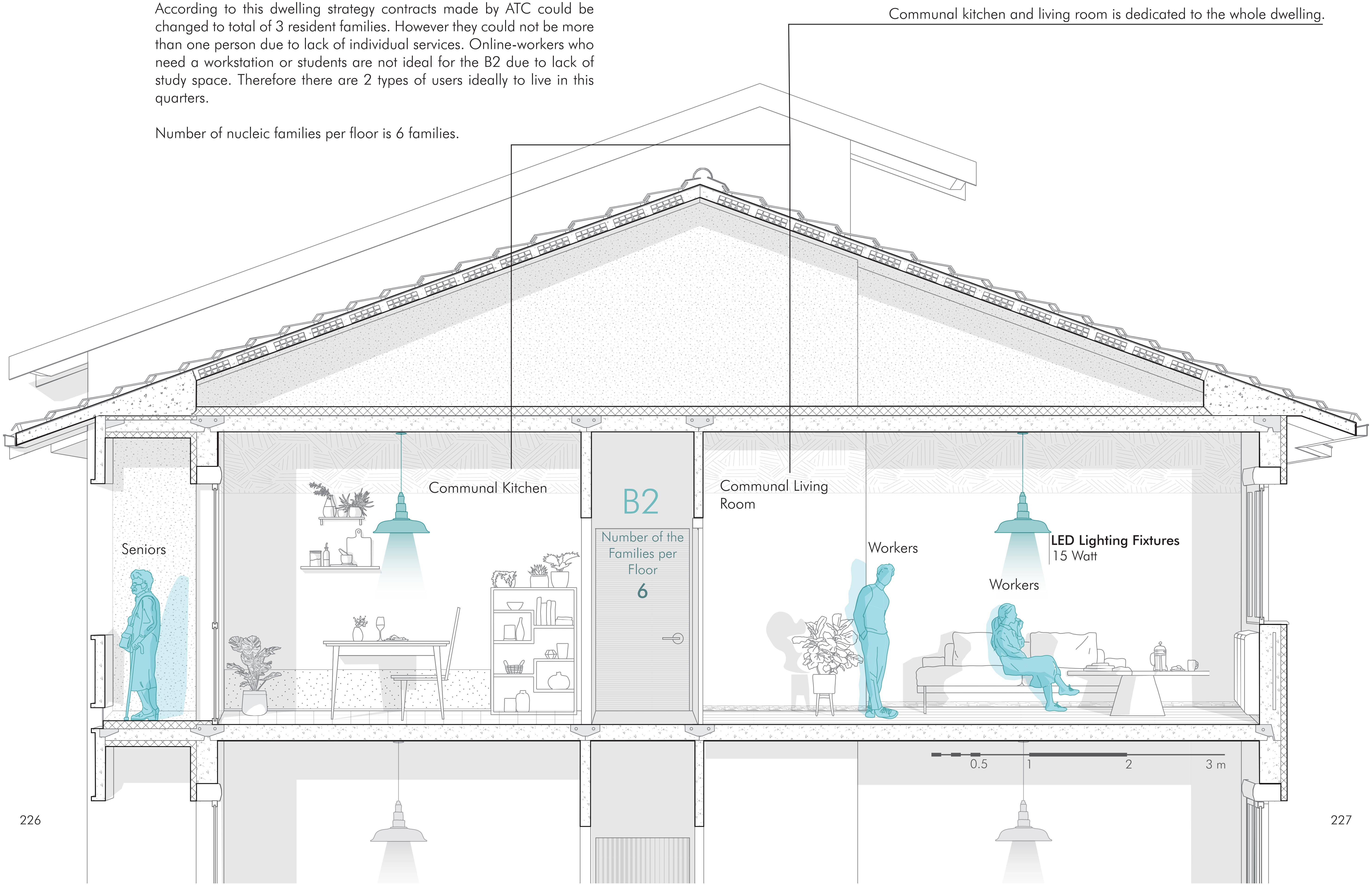
Room Type 2

Larger room with private workspace and basic amenities

B2

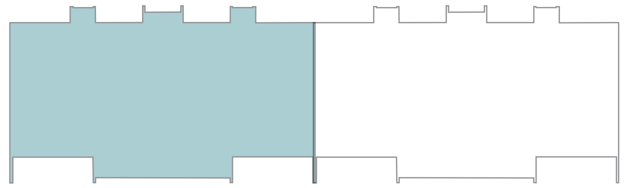
According to this dwelling strategy contracts made by ATC could be changed to total of 3 resident families. However they could not be more than one person due to lack of individual services. Online-workers who need a workstation or students are not ideal for the B2 due to lack of study space. Therefore there are 2 types of users ideally to live in this quarters.

Number of nucleic families per floor is 6 families.

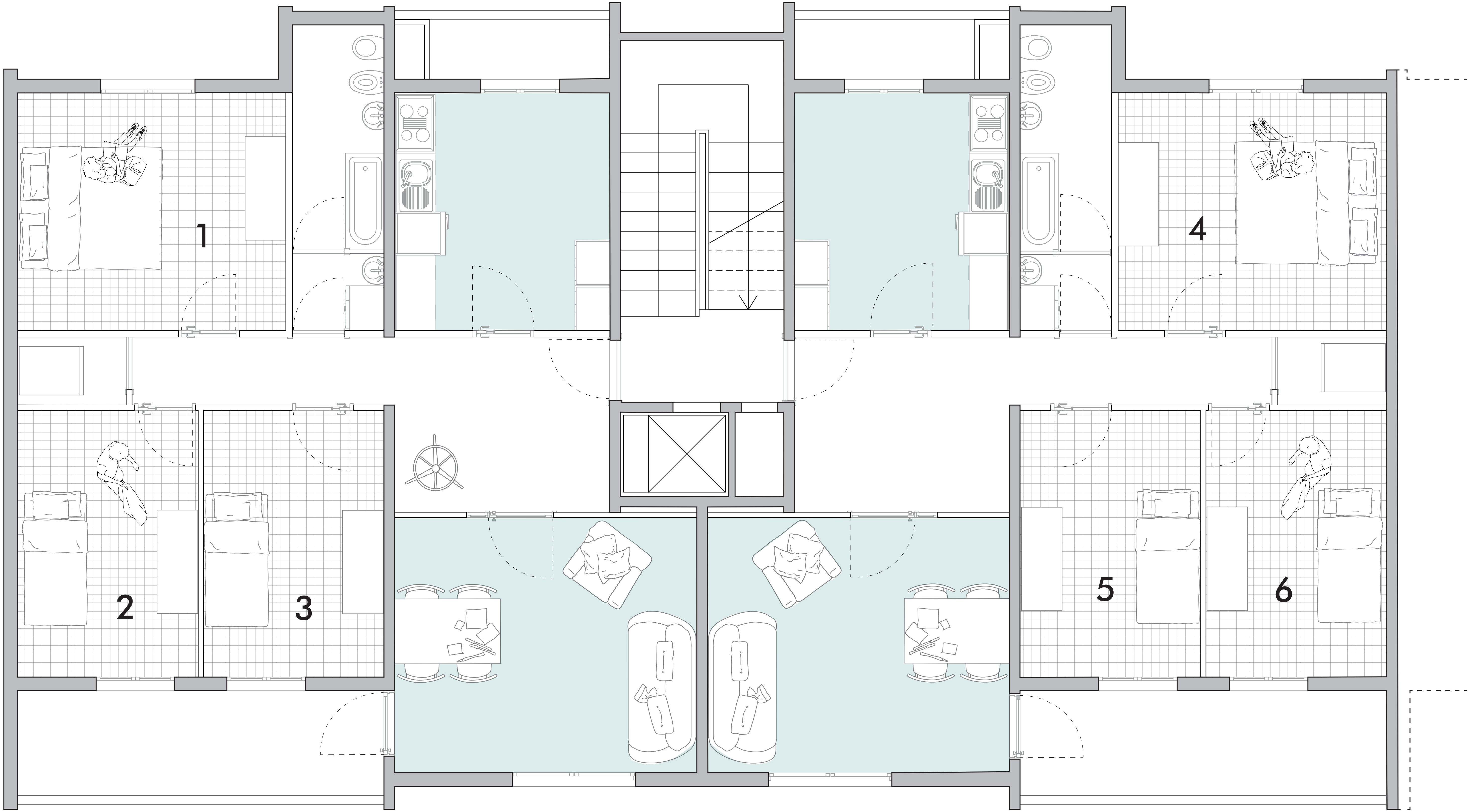


B2

Same with the current dwelling, B2 type dwelling does not change the interior organization of the building. The main change is the number of the people who are allocated by the ATC. As can be seen in the plan rooms are not for the different types of users such as couples or home-based workers.



TYPE A



B3

4.3.3 DWELLING SCALE INTERVENTIONS **B3**

Existing dwelling is turned into communal units with communal areas such as kitchen and living room. New bathrooms are added in this option. This unit increases the 1-person family number higher as well as the 2-person families due to private amenities.

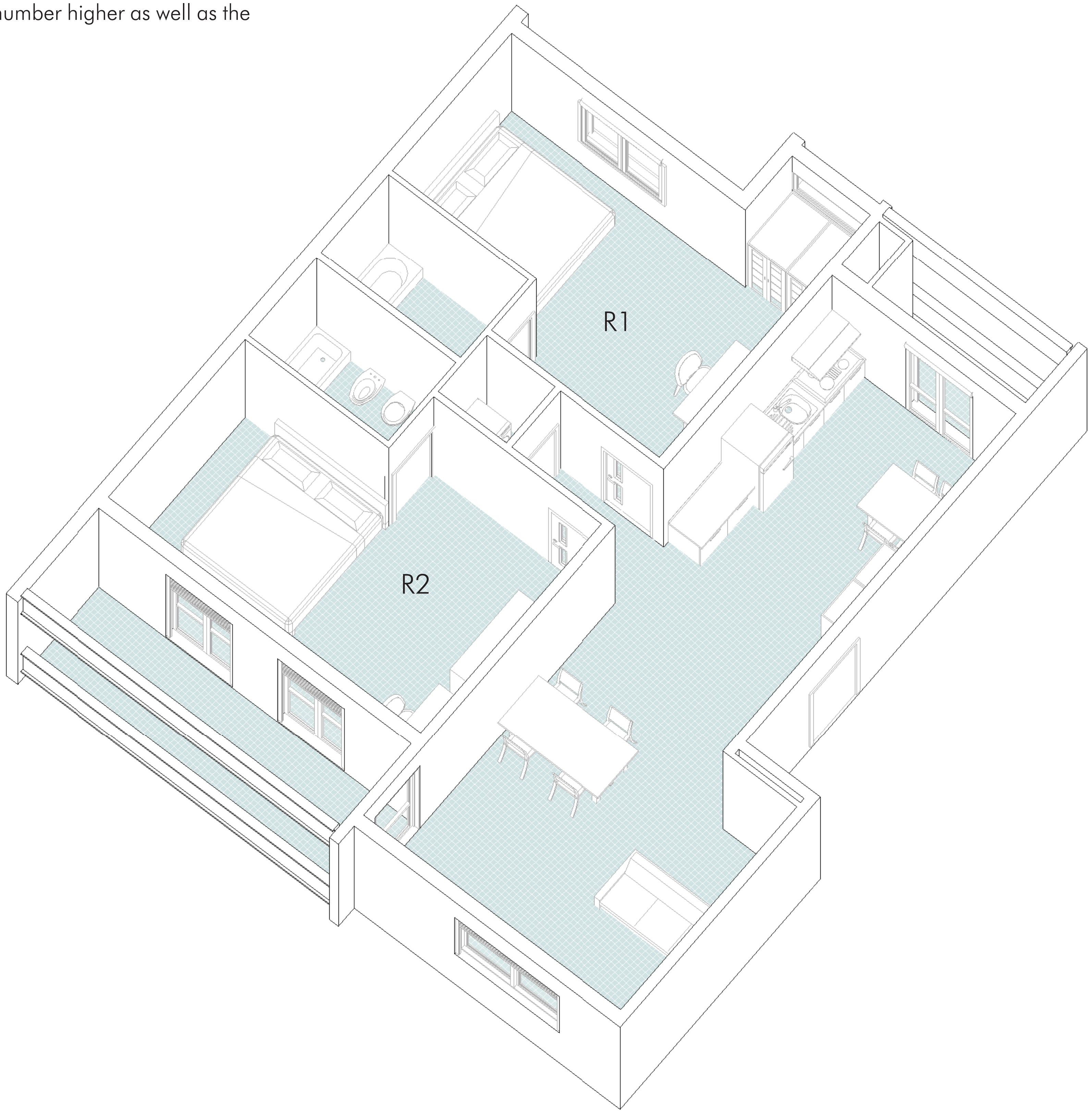
Total: 2-4 people

2-people families

Students

Workers&
online workers

Seniors



Room Type 1

Rooms with private workspace
and bathroom

Room Type 2

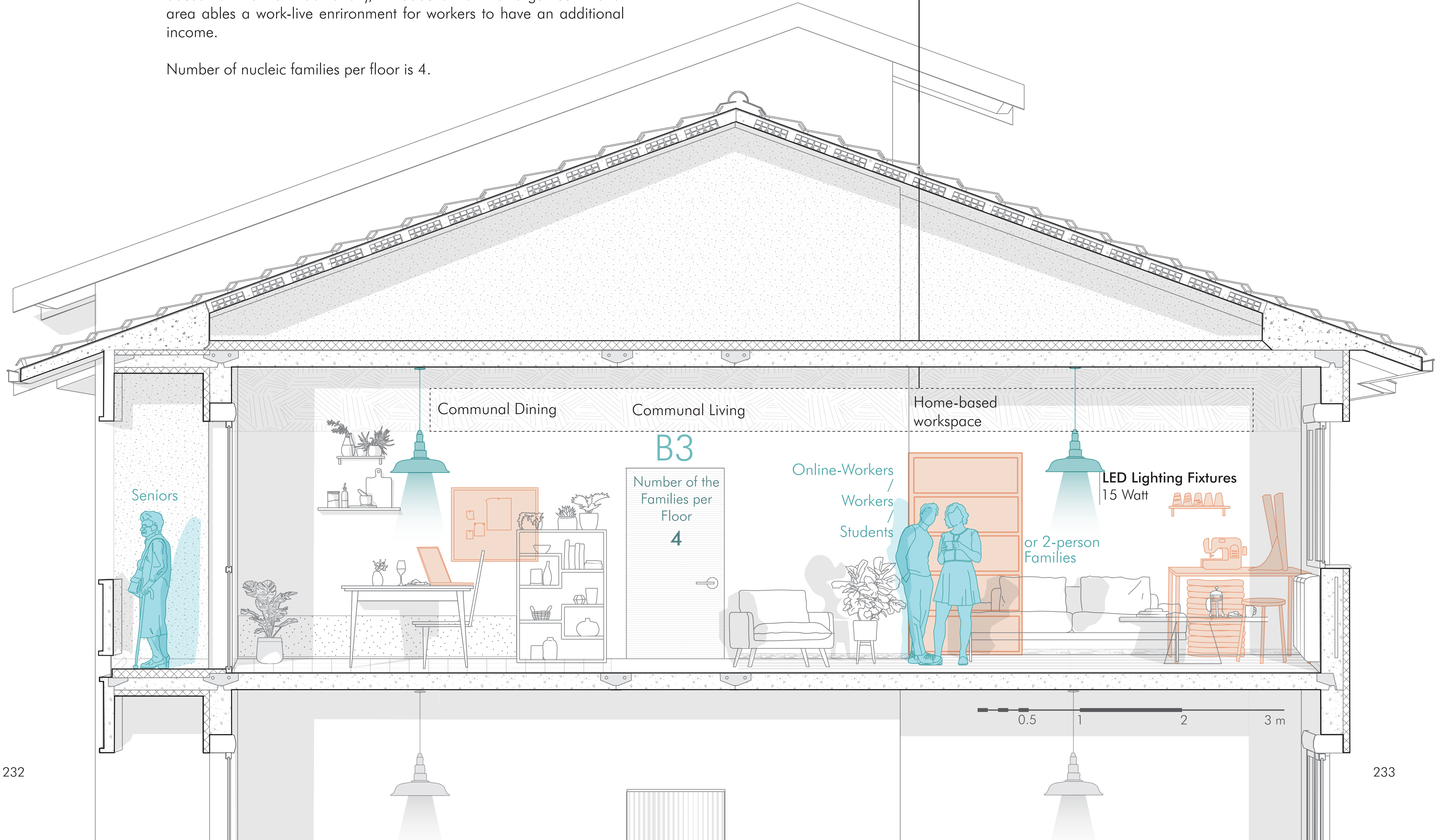
Rooms with private workspace
and bathroom +balcony

B3

According to this dwelling strategy contracts made by ATC could be changed to total of 2 resident families. These contracts could be for 1 or 2 person since there are enough private facilities as wet-spaces. The rooms are also has enough space for work to welcome different users. Online-workers who need a workstation or students are could be introduced for the B3. Additionally, introduction of the larger communal area ables a work-live enrironment for workers to have an additional income.

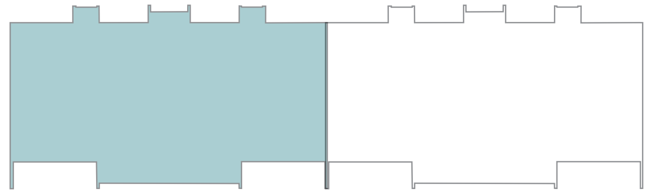
Number of nucleic families per floor is 4.

Common room is created to integrate a larger space for multiple activities. is dedicated to the whole dwelling. Work-live type of dwelling could be introduced.

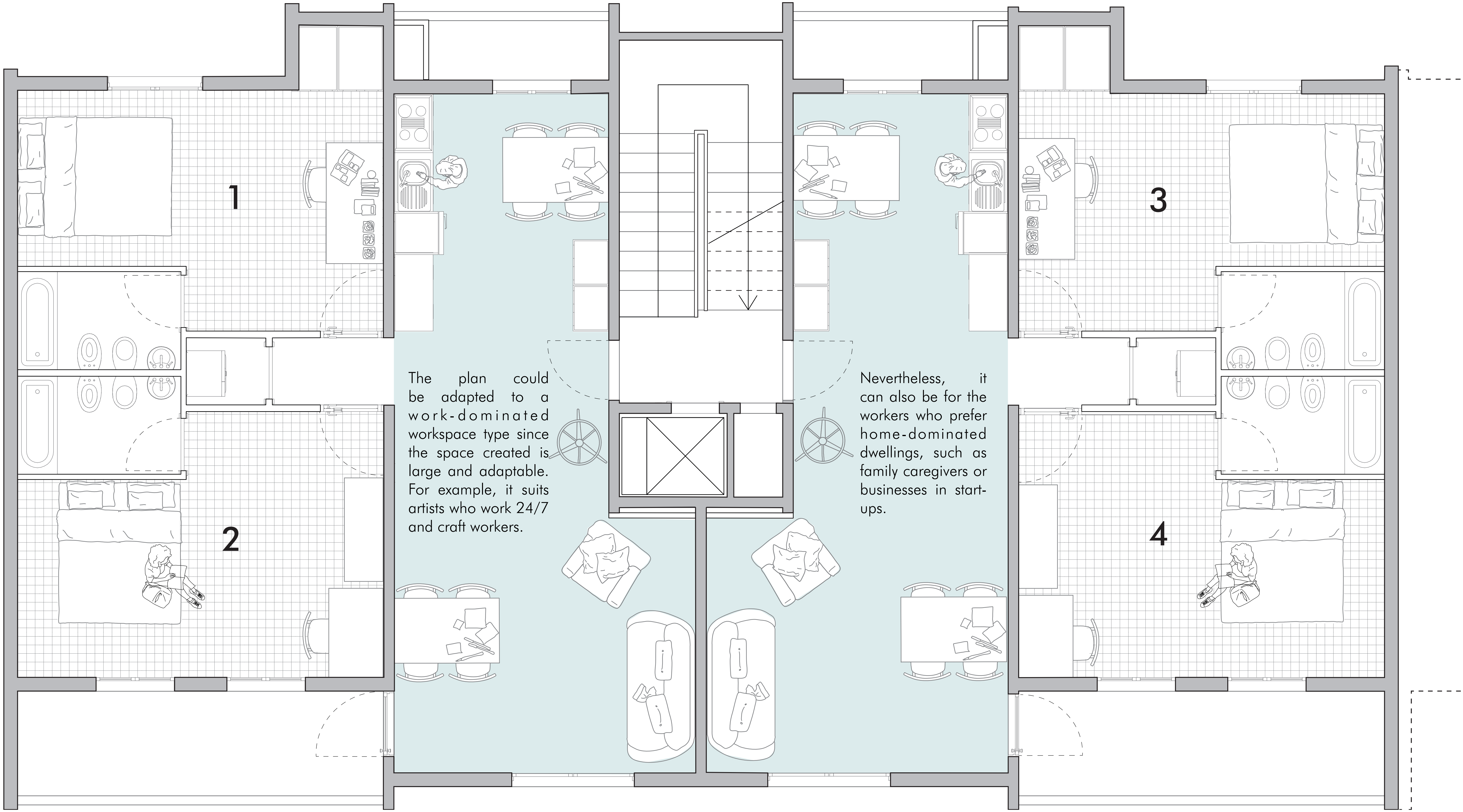


B3

The work-live type of the dwellings is highly important since they both satisfy the income needs of the residents, as mentioned. Foreseeing its future potential is necessary for the urban environment, especially with the increasing digitalization of work-oriented workspaces, primarily due to the sectors that now do not need a specific space for work. There are different needs for the different occupations related to the importance of the tasks to create a work-live dwelling. (Holliss, 2015)



TYPE A



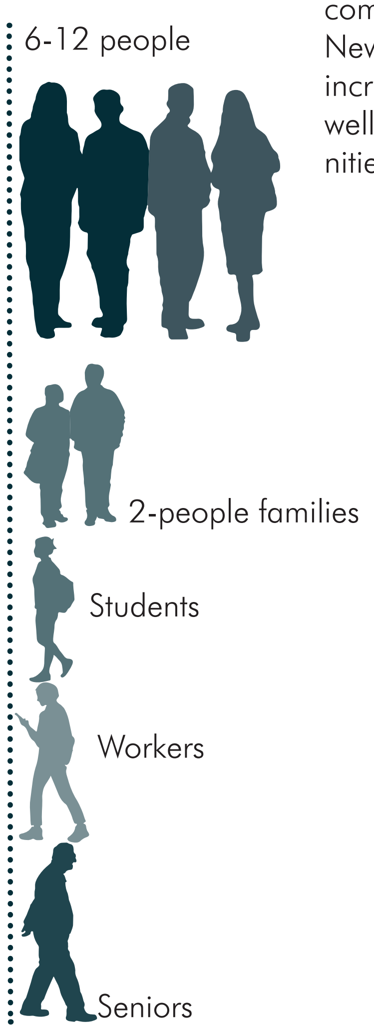
The plan could be adapted to a work-dominated workspace type since the space created is large and adaptable. For example, it suits artists who work 24/7 and craft workers.

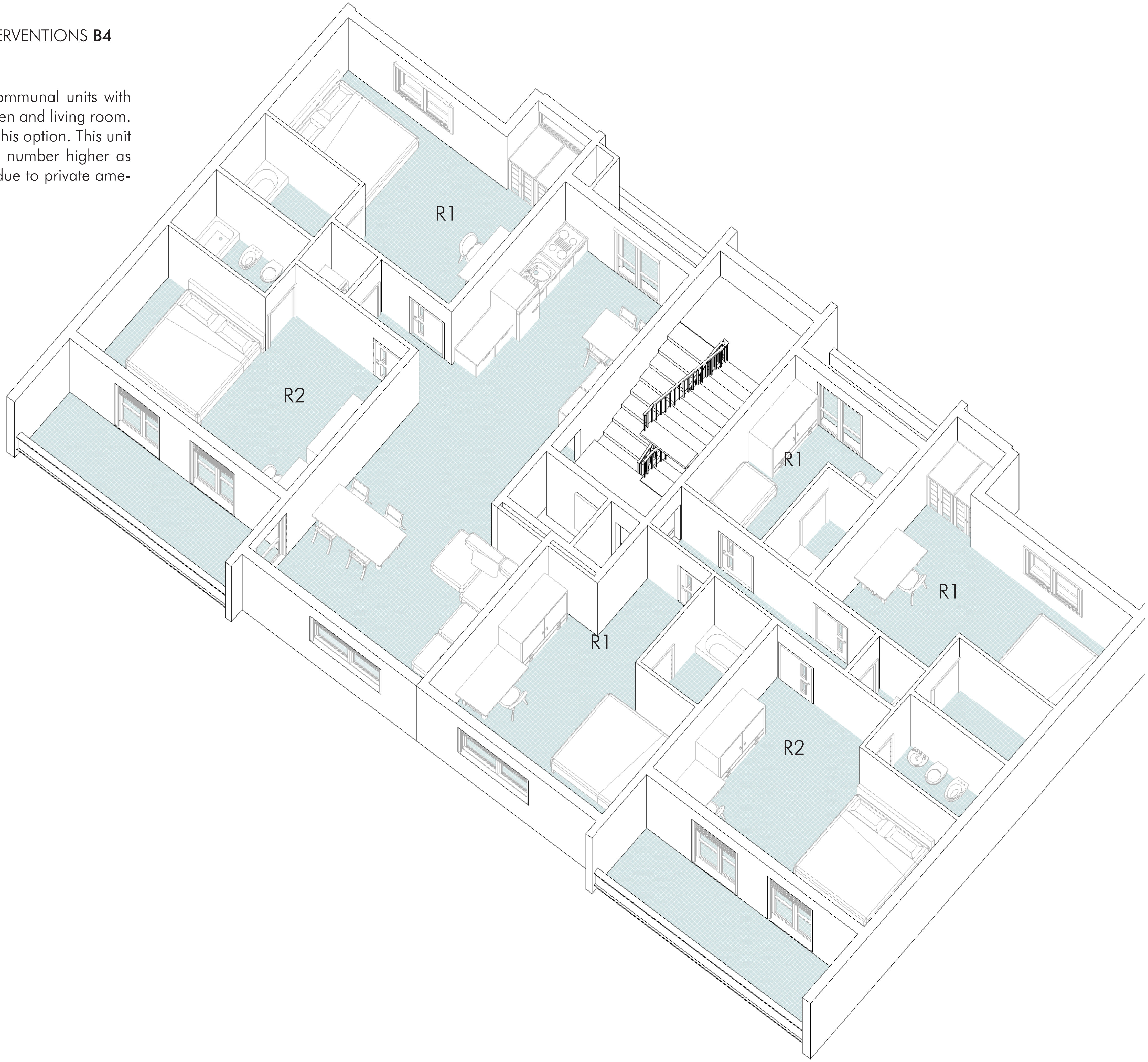
Nevertheless, it can also be for the workers who prefer home-dominated dwellings, such as family caregivers or businesses in start-ups.

B4

4.3.4 DWELLING SCALE INTERVENTIONS **B4**

Existing floor is turned into communal units with communal areas such as kitchen and living room. New bathrooms are added in this option. This unit increases the 1-person family number higher as well as the 2-person families due to private amenities.





Room Type 1

Rooms with private workspace and bathroom

Room Type 2

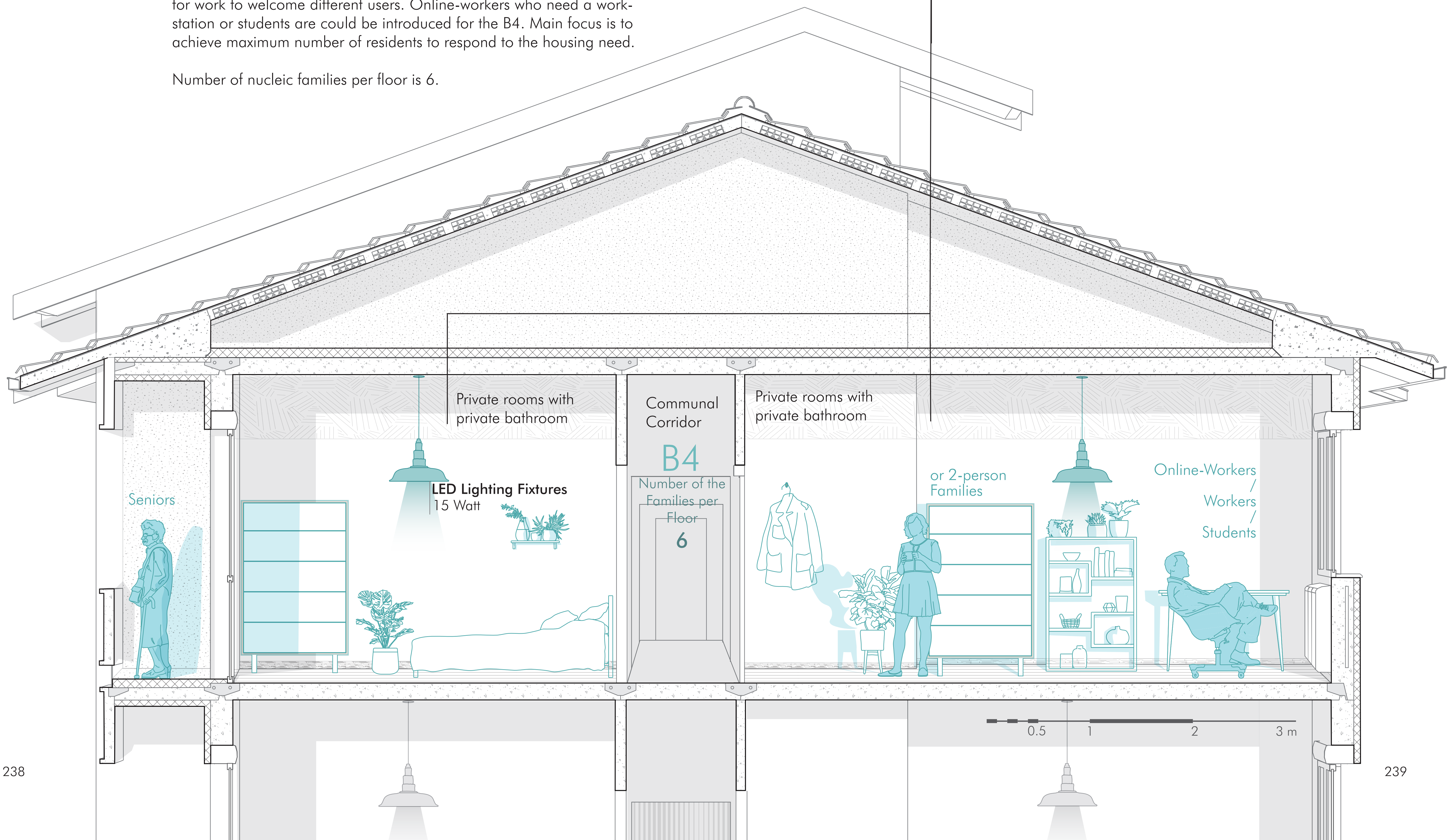
Rooms with private workspace and bathroom +balcony

B4

According to this dwelling strategy contracts made by ATC could be changed to total of 6 resident families in whole floor by connecting 2 dwellings and reducing communal areas to 1 to create 2 more dwelling. These contracts could be for 1 or 2 person since there are enough private facilities as wet-spaces. The rooms are also has enough space for work to welcome different users. Online-workers who need a workstation or students are could be introduced for the B4. Main focus is to achieve maximum number of residents to respond to the housing need.

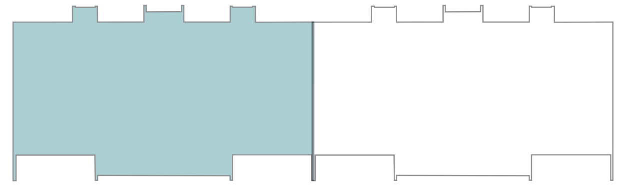
Number of nucleic families per floor is 6.

Common room is reduced to create 2 other rooms with private bathrooms. Number of residents are maximized. Different than B3 there can be no work-living area in communal zone.

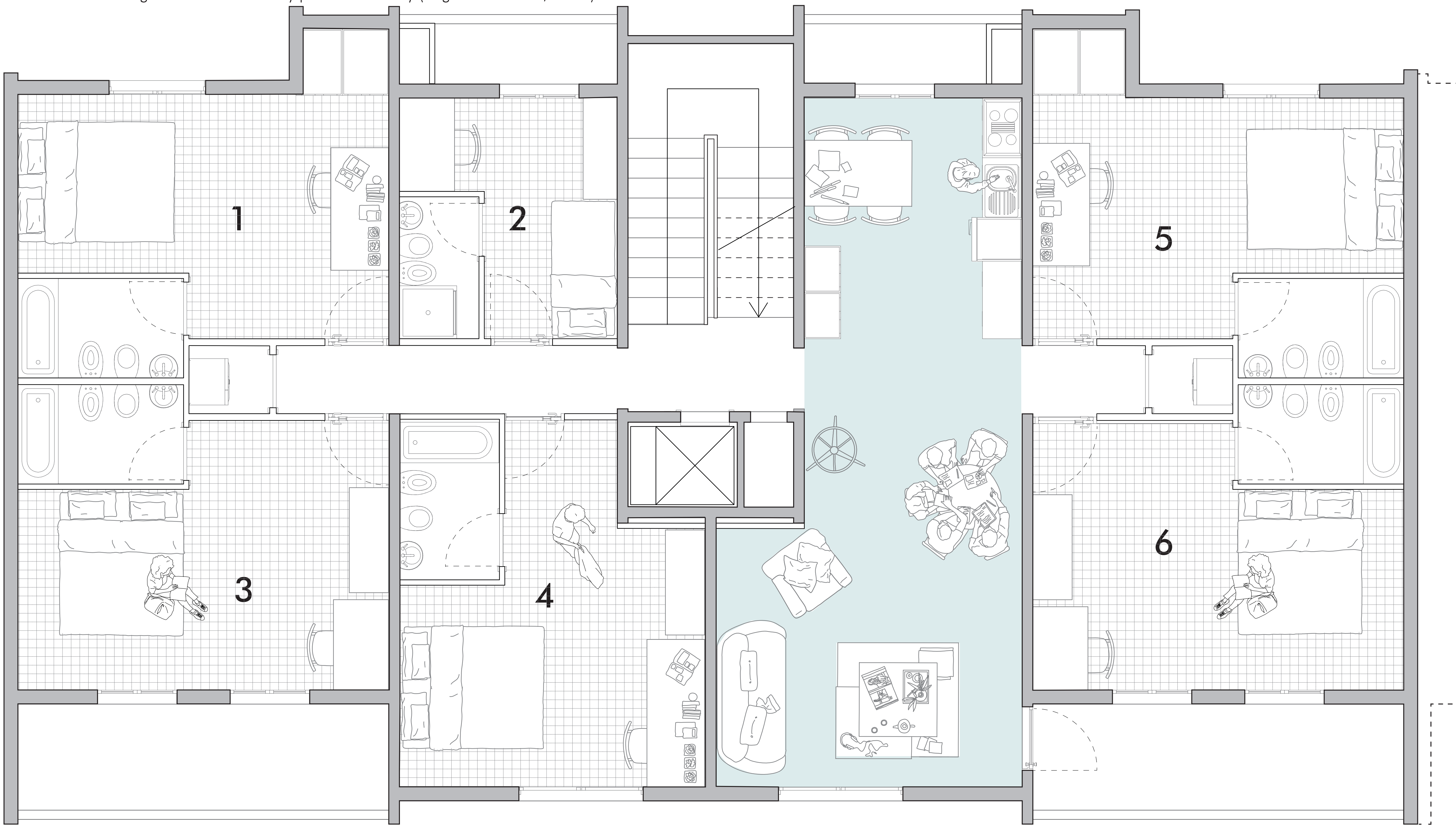


B4

The function of social housing architecture is to design spaces that encourage conversation and collectivity as well as privacy. An essential condition for residing here is that the individuals collectively consent to participate in the household tasks within the co-housing community. (Sandstedt & Westin, 2015) This function is proposed in one place on the floor by creating a communal floor. However, private amenities are also included in the individual rooms. Therefore, their biological functions are also combined with individual social functions, such as in the larger rooms with a study place availability (Teige & Dluhosch, 2002)

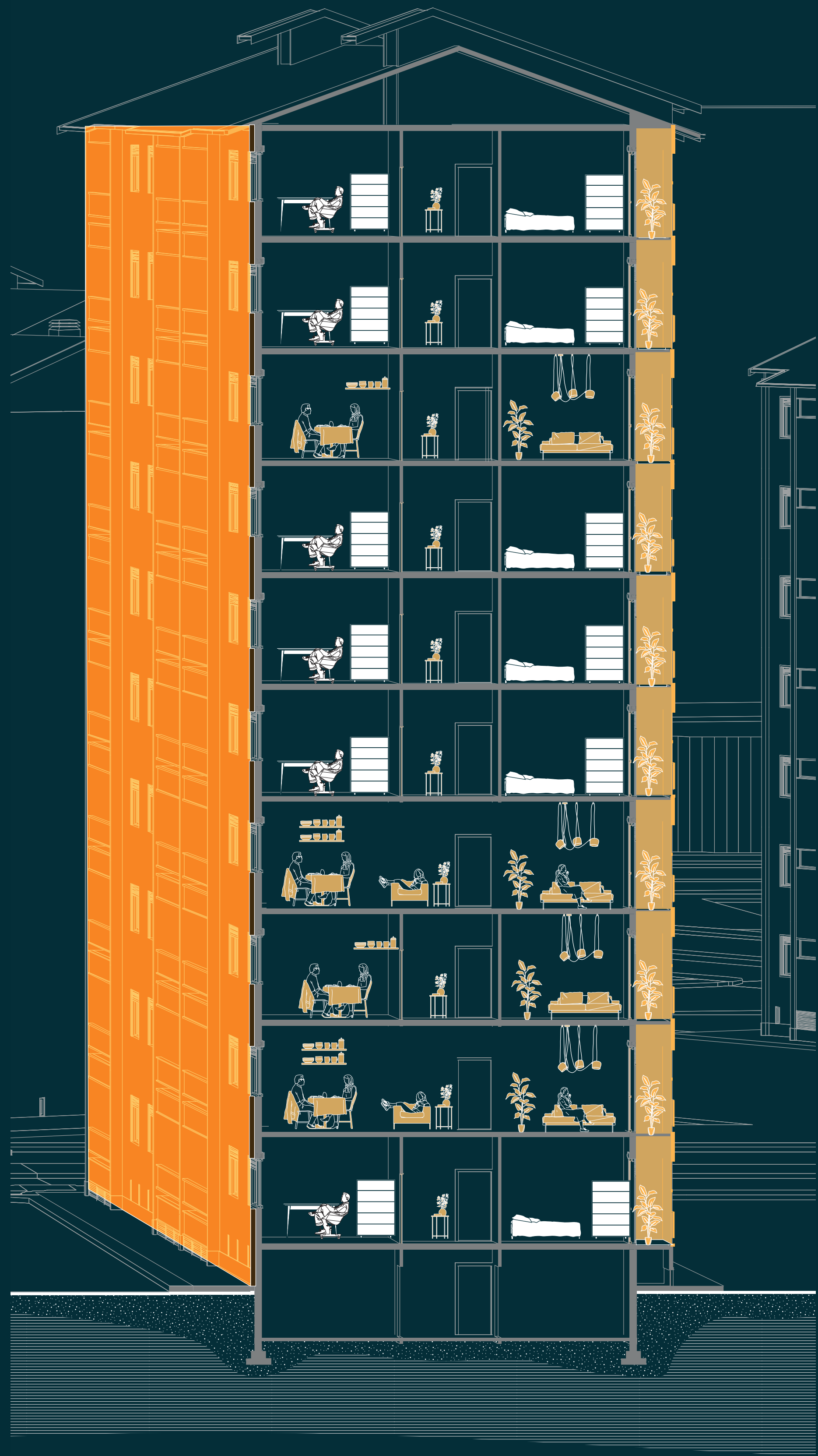


TYPE A



CHAPTER 5
Future Scenarios and 2 Different Actors

1



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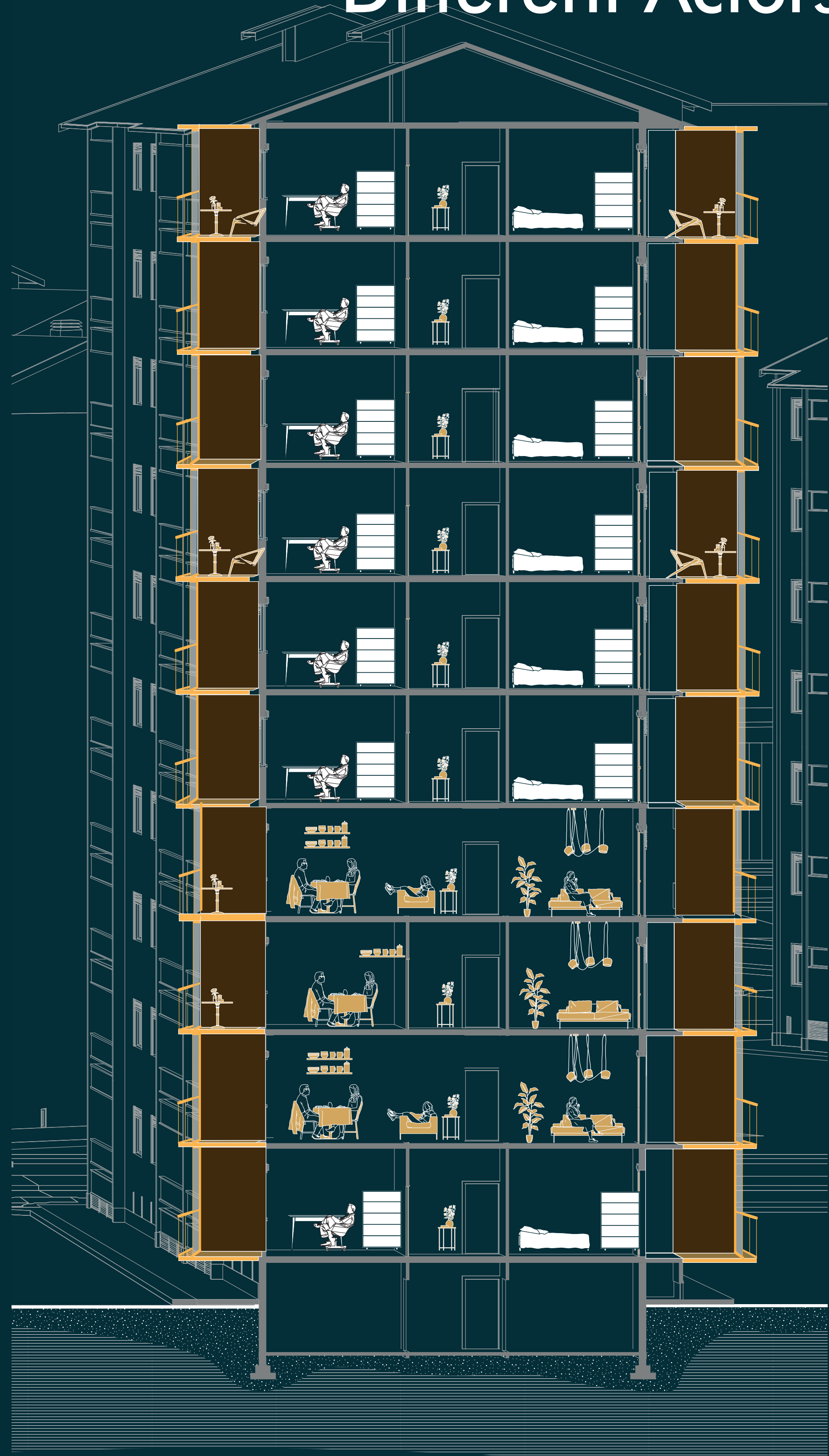
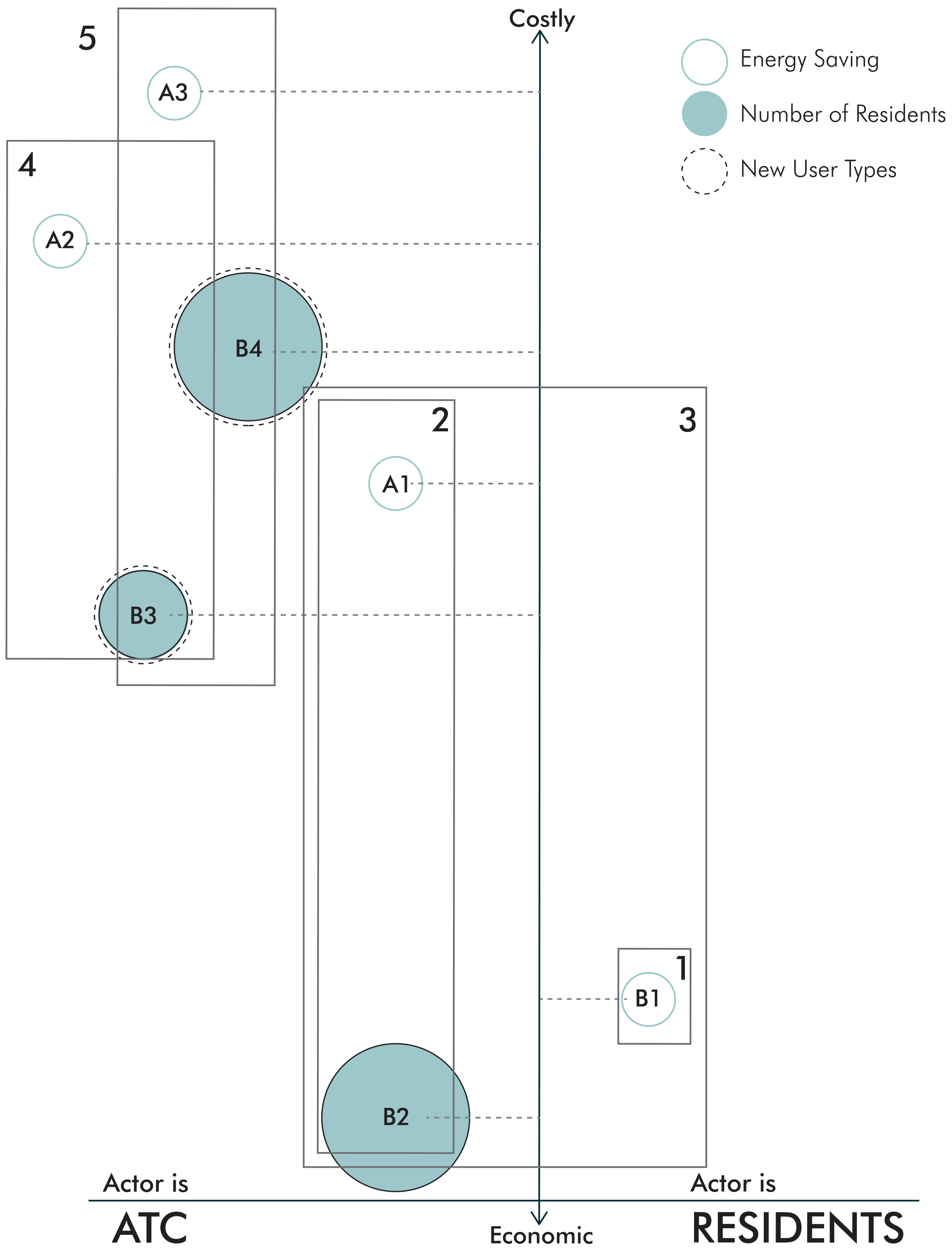


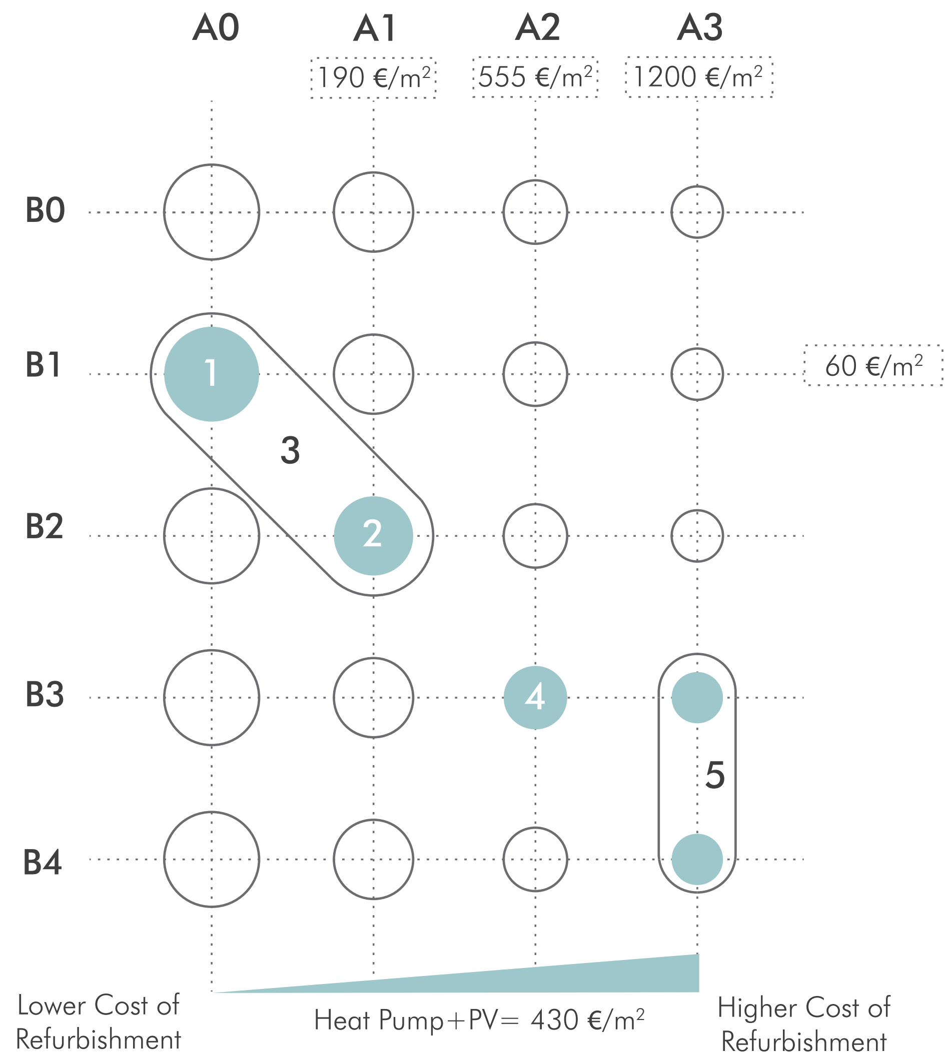
5

5

5.1 Who is the Actor?

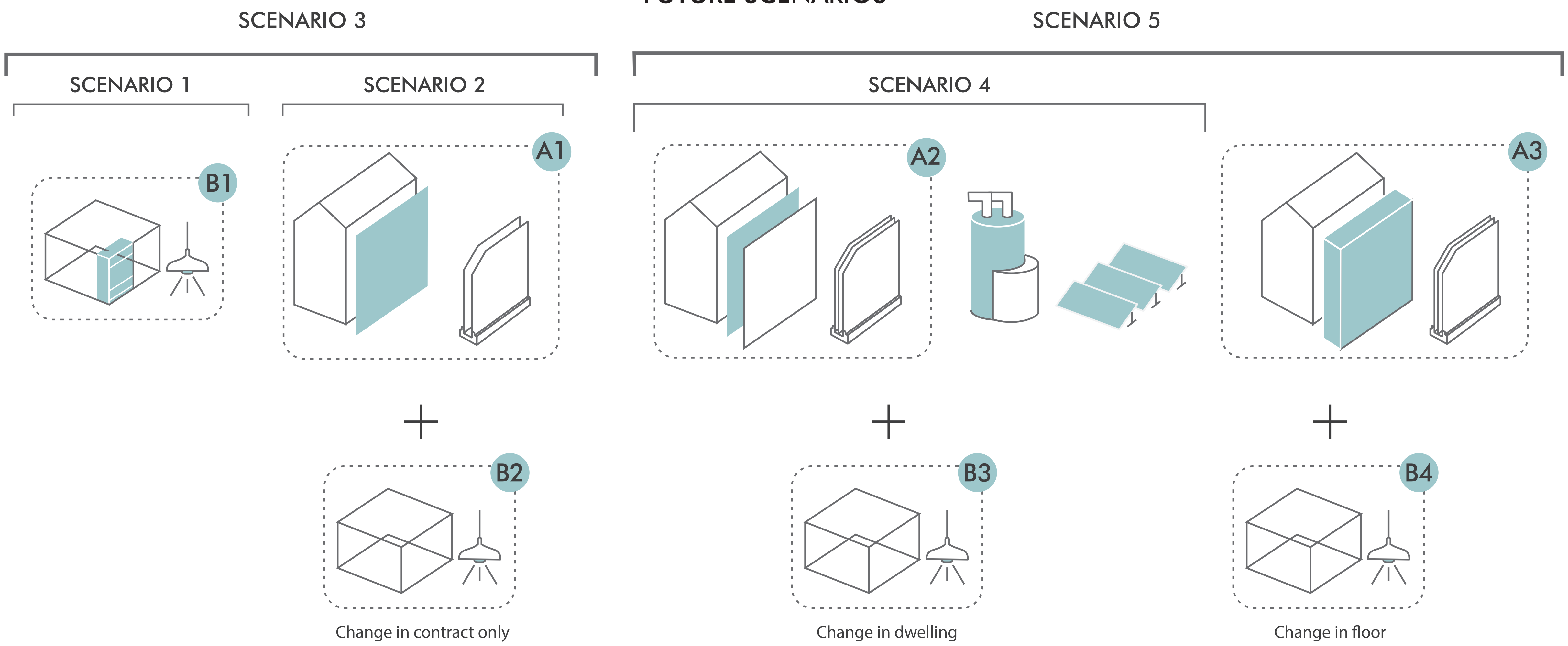


The scenarios are defined by their actors. The mentioned design strategies are combined with their relative actors. There are five different scenarios defined in the research; 3 with public actor that is ATC in this case, 1 scenario with only resident as an actor, 1 scenario with collective effort from both ATC and residents.



In the matrix the axes are defined in relation to the scale of the intervention and their economical unit costs derived from the table in Chapter 2 results. From left to right the cost of the envelope strategies are increasing. B0 and A0 is representing initial dwelling and initial envelope construction, respectively. Type B costs are not considered due to cost of the demolition of the internal walls and extending the plumbing is negligible compared with the envelope costs. Additionally after the payback period is estimated. These could be deducted from the cost of energy easily.

FUTURE SCENARIOS



SC1 RESIDENT SCENARIO

+B1

Dwelling intervention of balcony glazing

SC2 **PUBLIC** FUNDING SCENARIO -LOW COST

+A1

Envelope retrofit to update to current regulations

+B2

Dwelling with shared facilities 1-person to 3-person contract

SC3 **PUBLIC+RESIDENT COLLABORATION** SCENARIO

+A1

Envelope retrofit to update to current regulations

+B1

Dwelling intervention of balcony glazing

+B2

Dwelling with shared facilities 1-person to 3-person contract

SC4 **PUBLIC** FUNDING SCENARIO-MID COST

+A2

High-performance ventilated facade intervention

(+HP)

Addition of air-sourced heat pump COP=3

+B3

Dwelling with shared communal areas and private bathrooms

(+PV)

Addition of mono-crystalline Si-Cell PV panels remaining part of the roof

SC4 **PUBLIC** FUNDING SCENARIO-MID COST

+A3

High-performance ventilated facade intervention with double façade extension

(+HP)

Addition of air-sourced heat pump COP=3

+B3&B4

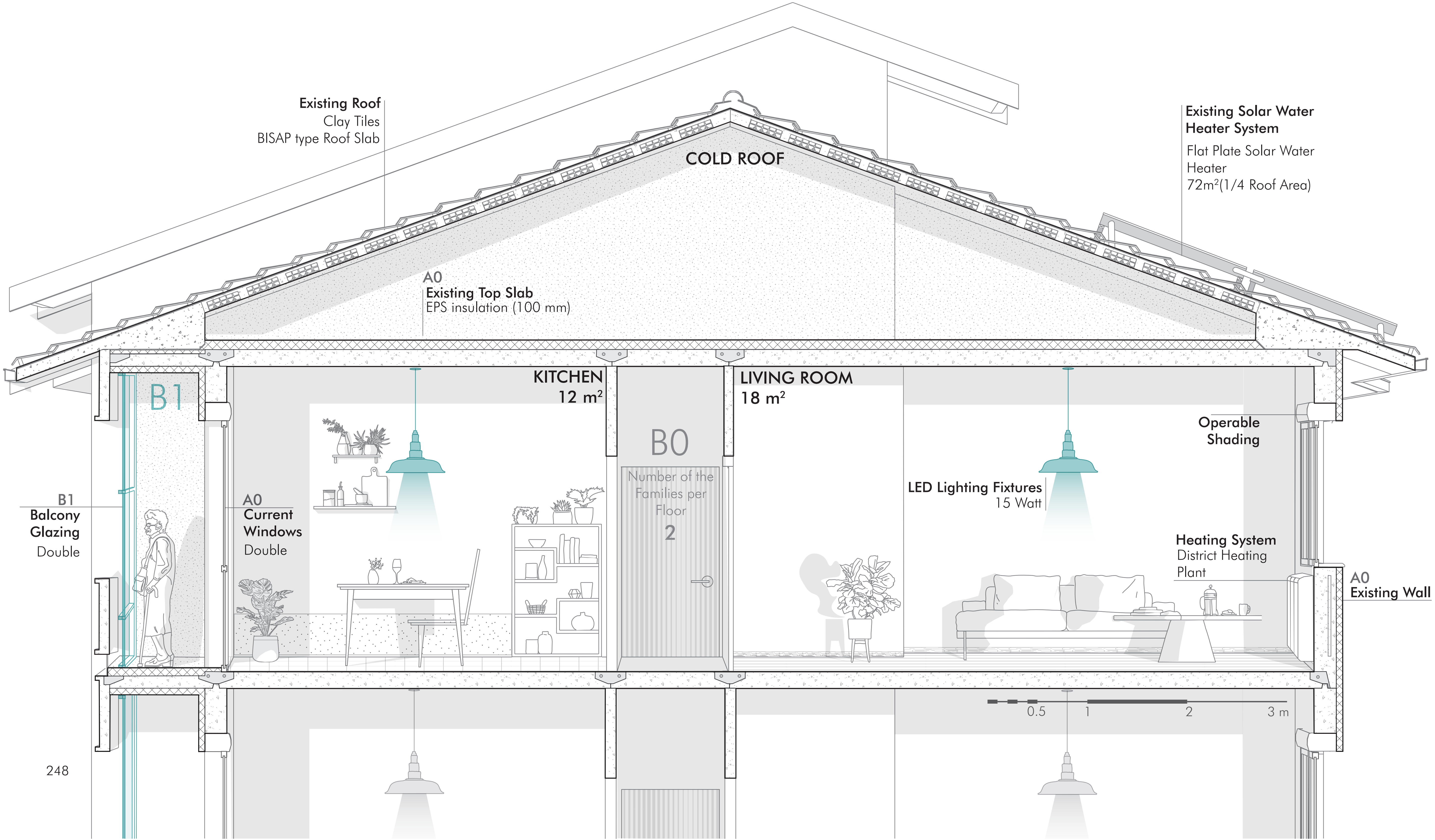
Communal floor or dwelling with shared communal areas and private bathrooms

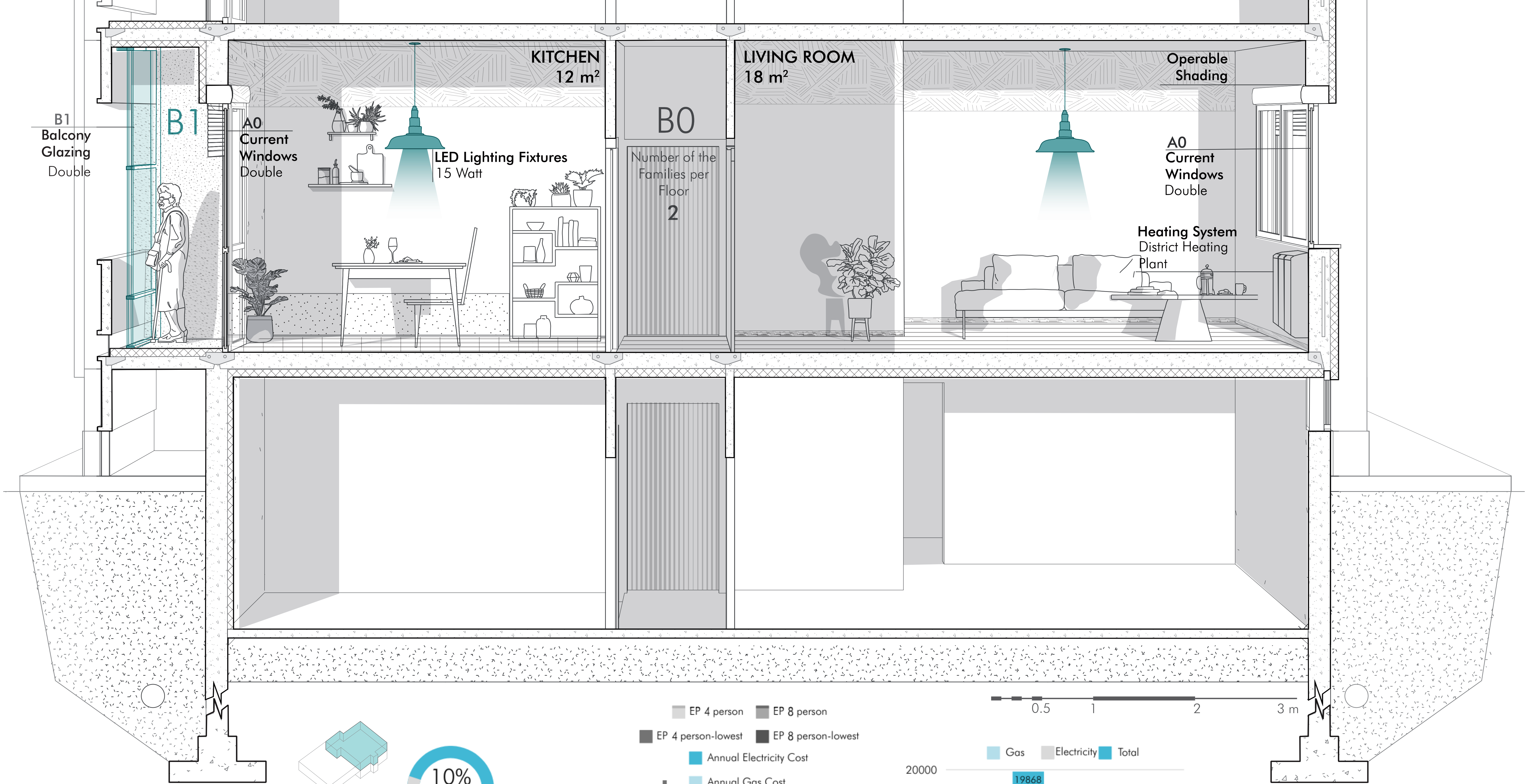
(+PV)

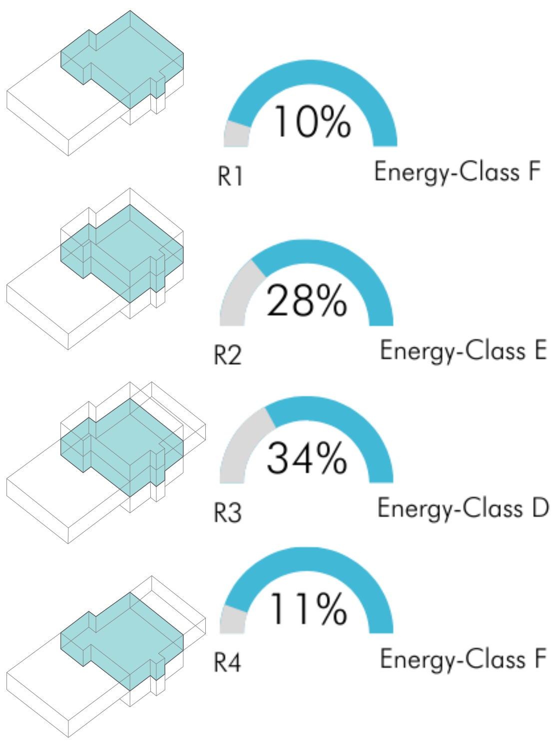
Addition of mono-crystalline Si-Cell PV panels remaining part of the roof

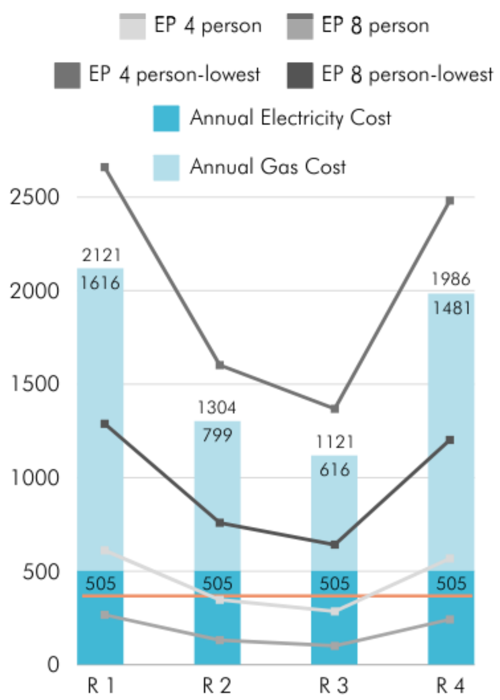
SC1 5.1.1 RESIDENT SCENARIO

In this scenario, residents are thought to be the actors. As mentioned in Chapter 1, residents of social housing does not have enough capital to reach higher energy performance values. Therefore there is no major change in the building. Similar to the existing conditions, the only intervention is the covering-up the balconies to create additional space as well as creating a buffer zone.

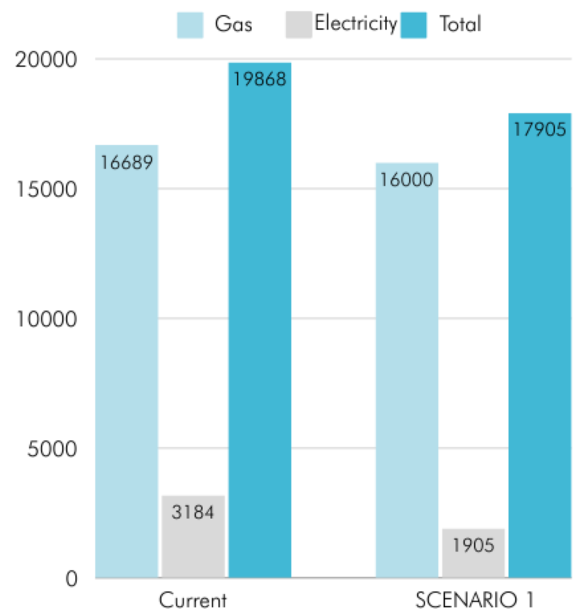








Annual Costs & Energy Poverty
According to Number of people

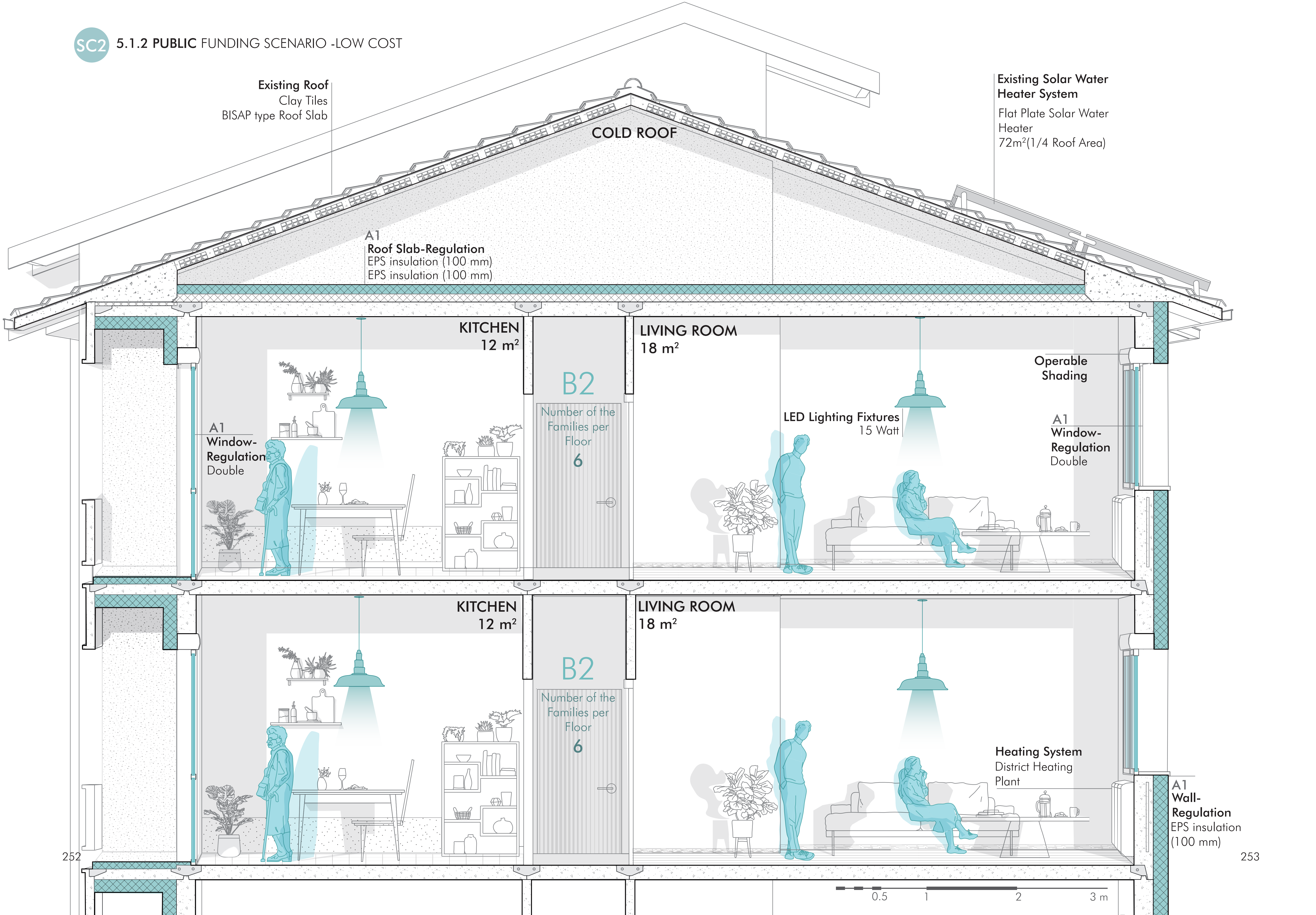


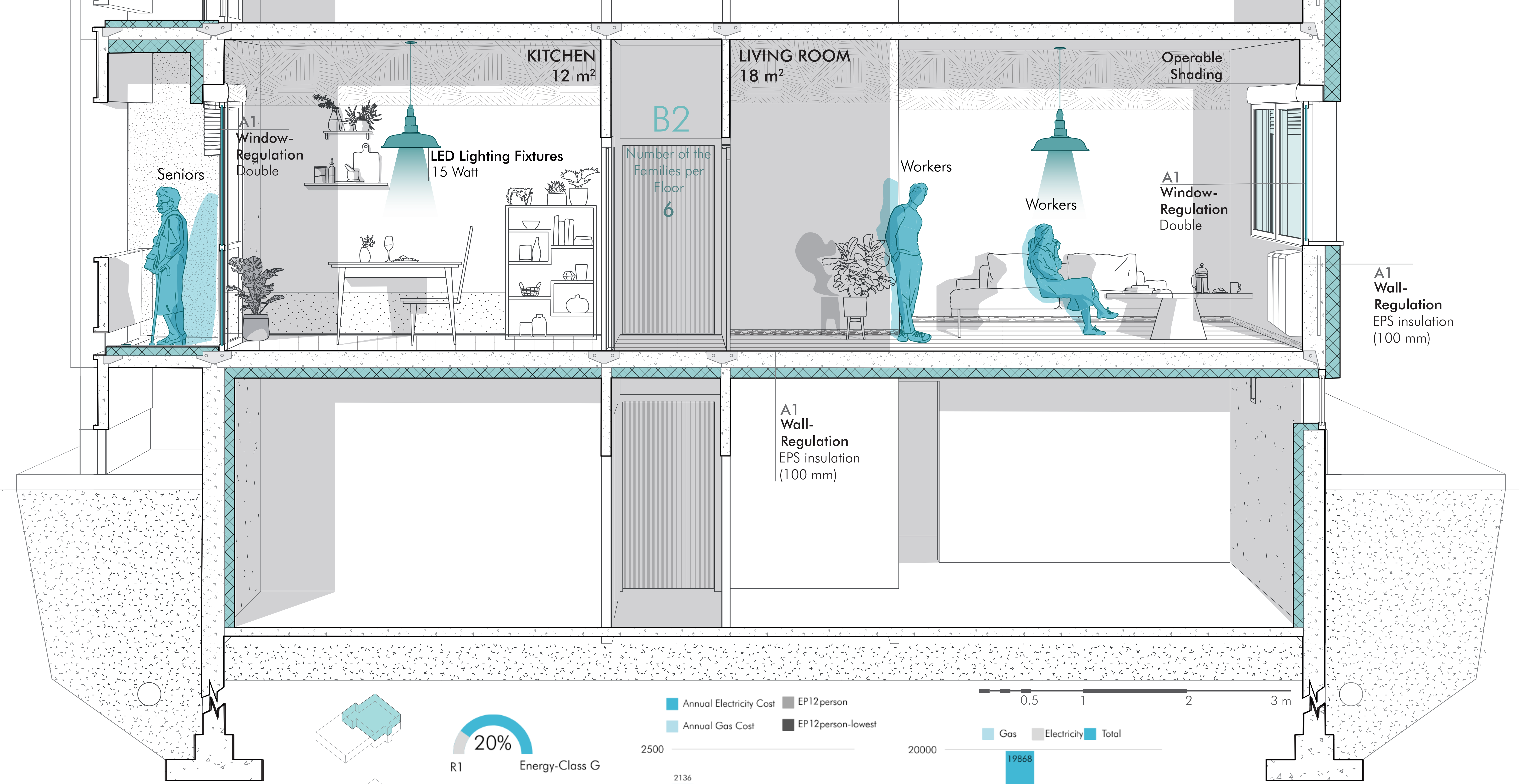
Energy Consumption

With this scenario, residents are the actors. Covering the balconies are surprisingly lowered the energy consumption. This effect is more prominent in the middle rooms.

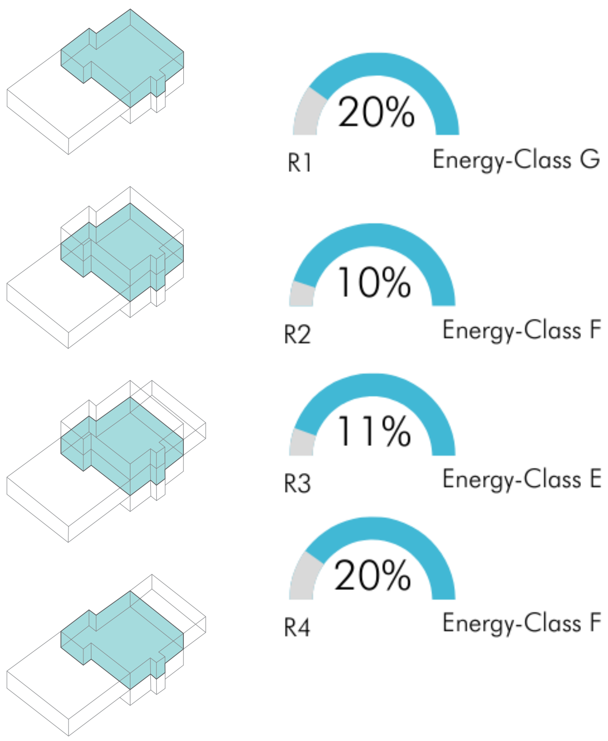
The energy class is not much improved. We can observe that residents with average income and lowest income who are living alone are struggling from the energy poverty greatly. If the income source is 2 people, middle rooms are under the energy poverty limit.

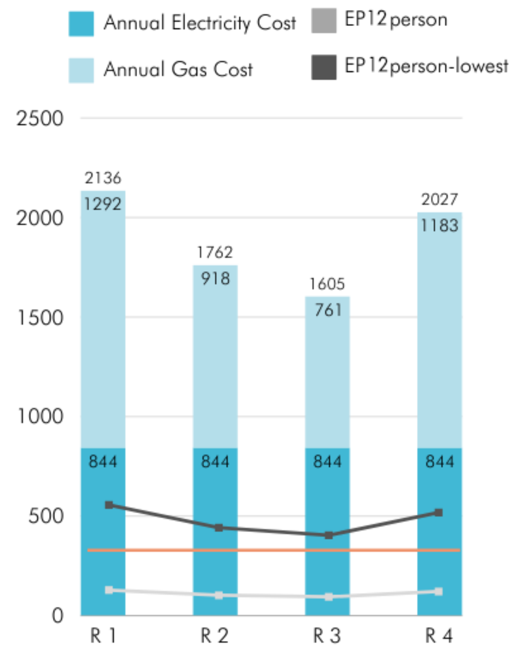
SC2 5.1.2 **PUBLIC** FUNDING SCENARIO -LOW COST



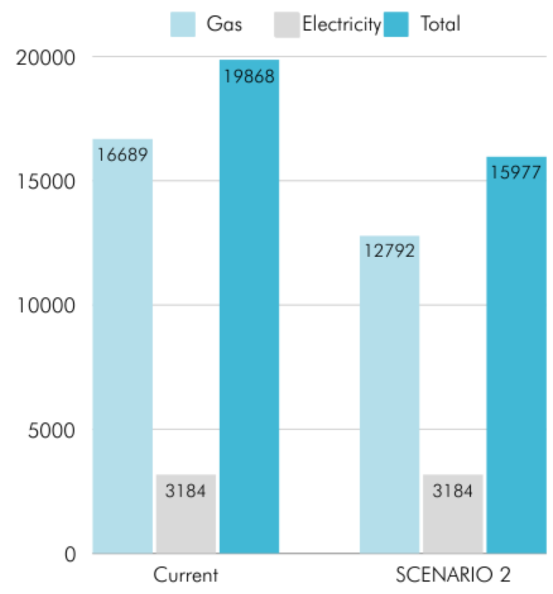


With this scenario, envelope reached to the regulation values. Covering envelope and changing glazing effects more rooms which have one surface adjacent to an unheated space.





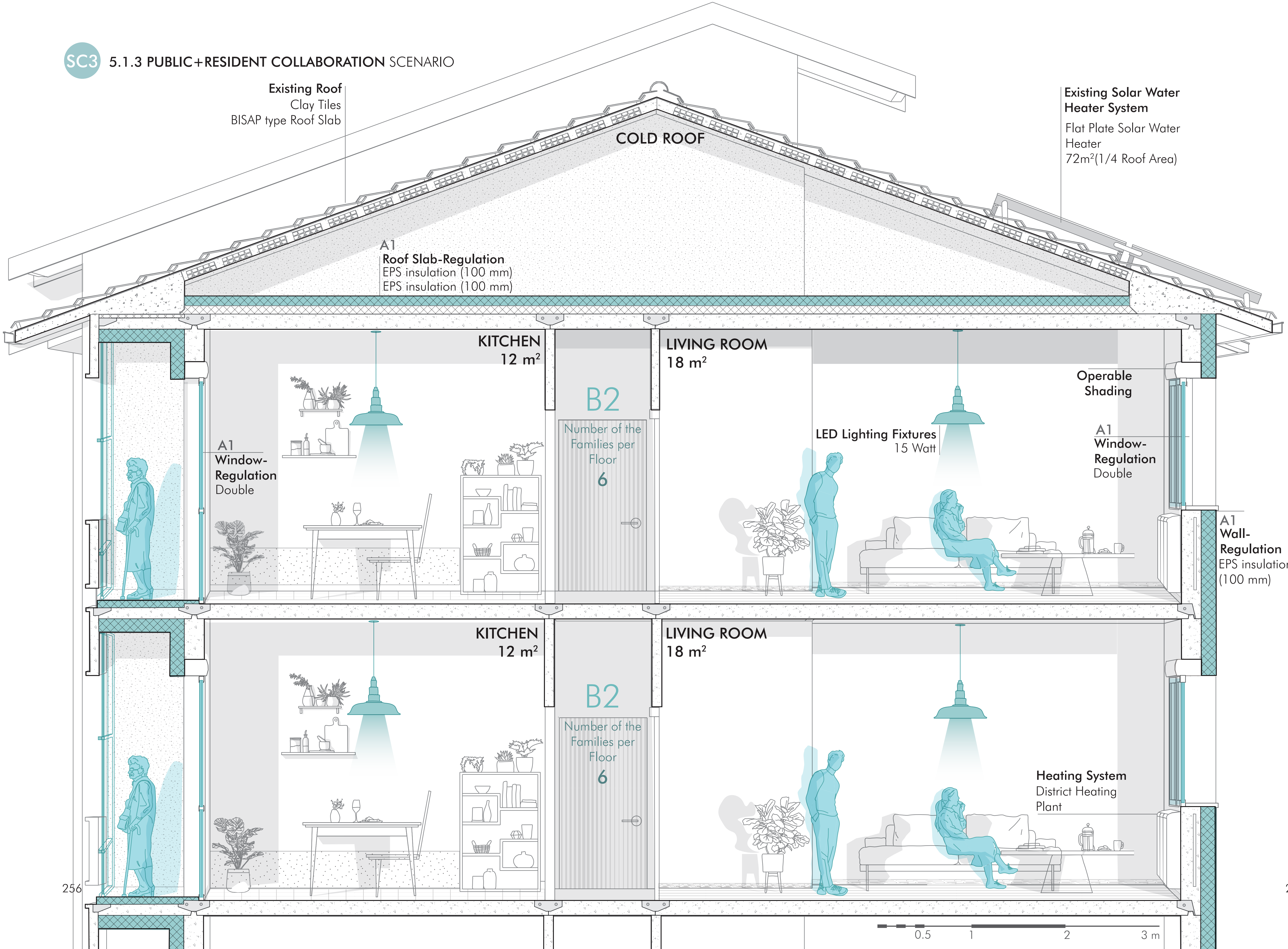
Annual Costs & Energy Poverty According to Number of people

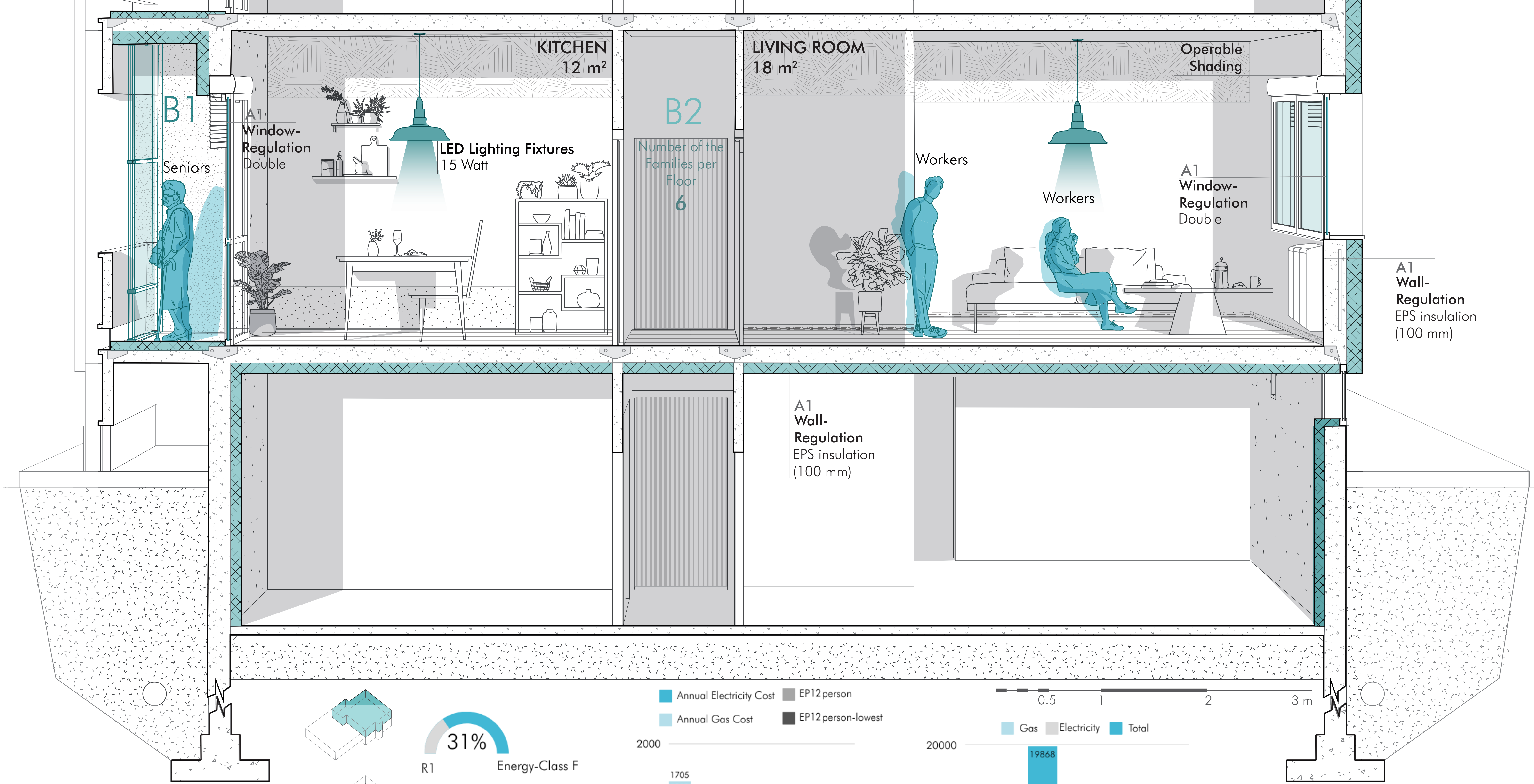


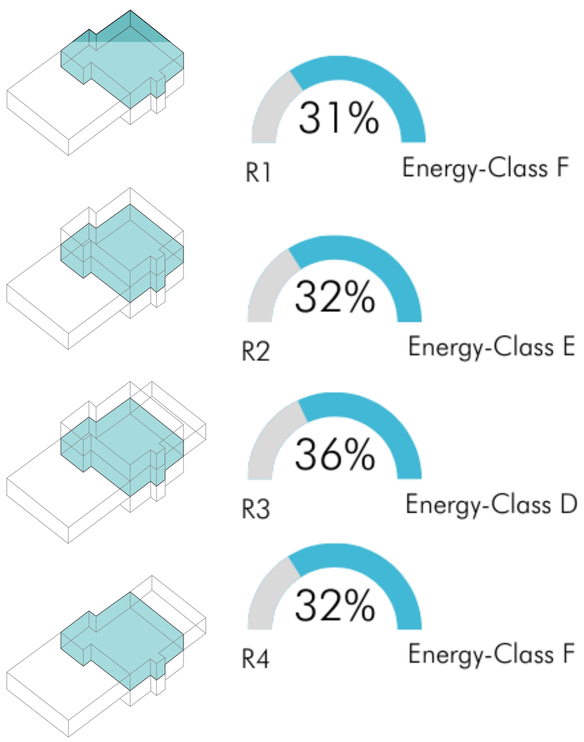
Energy Consumption

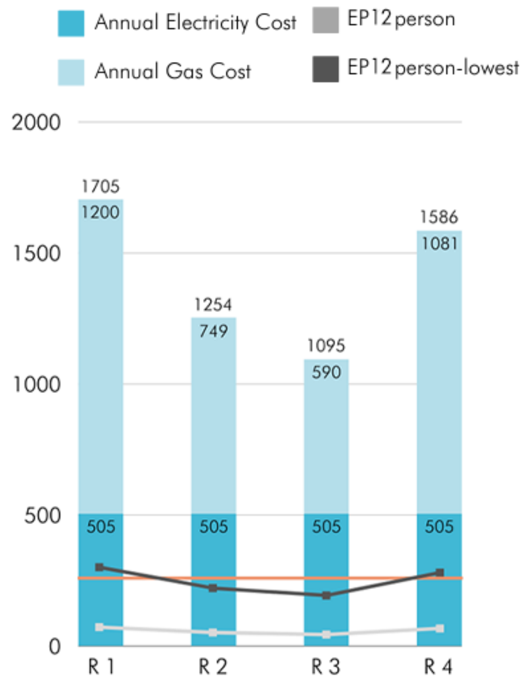
The energy class is improved higher in the corner rooms while mid rooms are not affected greatly. We can observe that residents that are in average income are not in energy poverty but lowest income groups are still at the risk of energy poverty.

SC3 5.1.3 PUBLIC+RESIDENT COLLABORATION SCENARIO

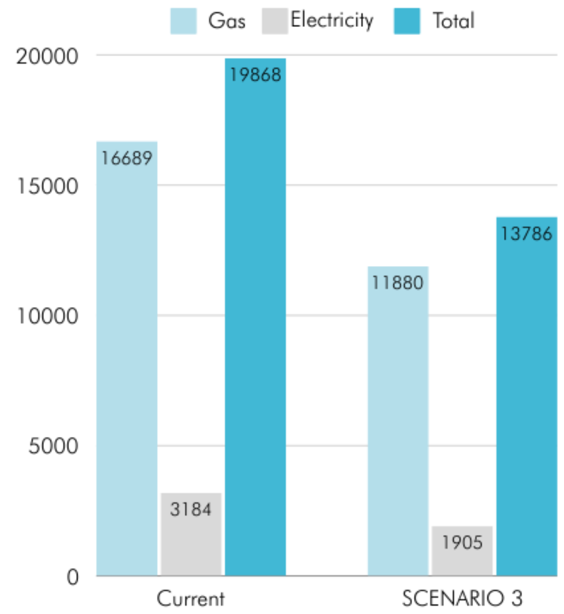








Annual Costs & Energy Poverty
According to Number of people

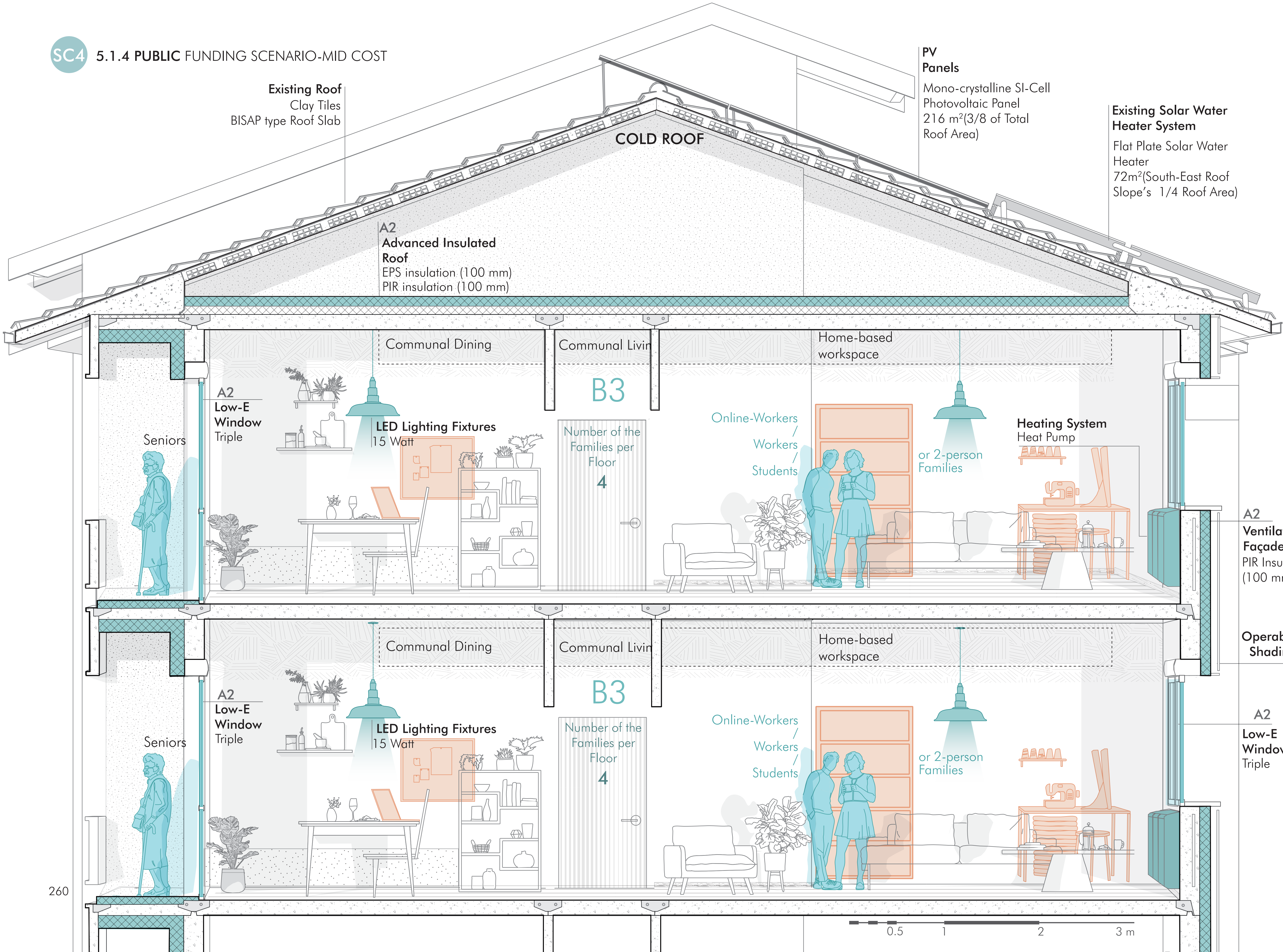


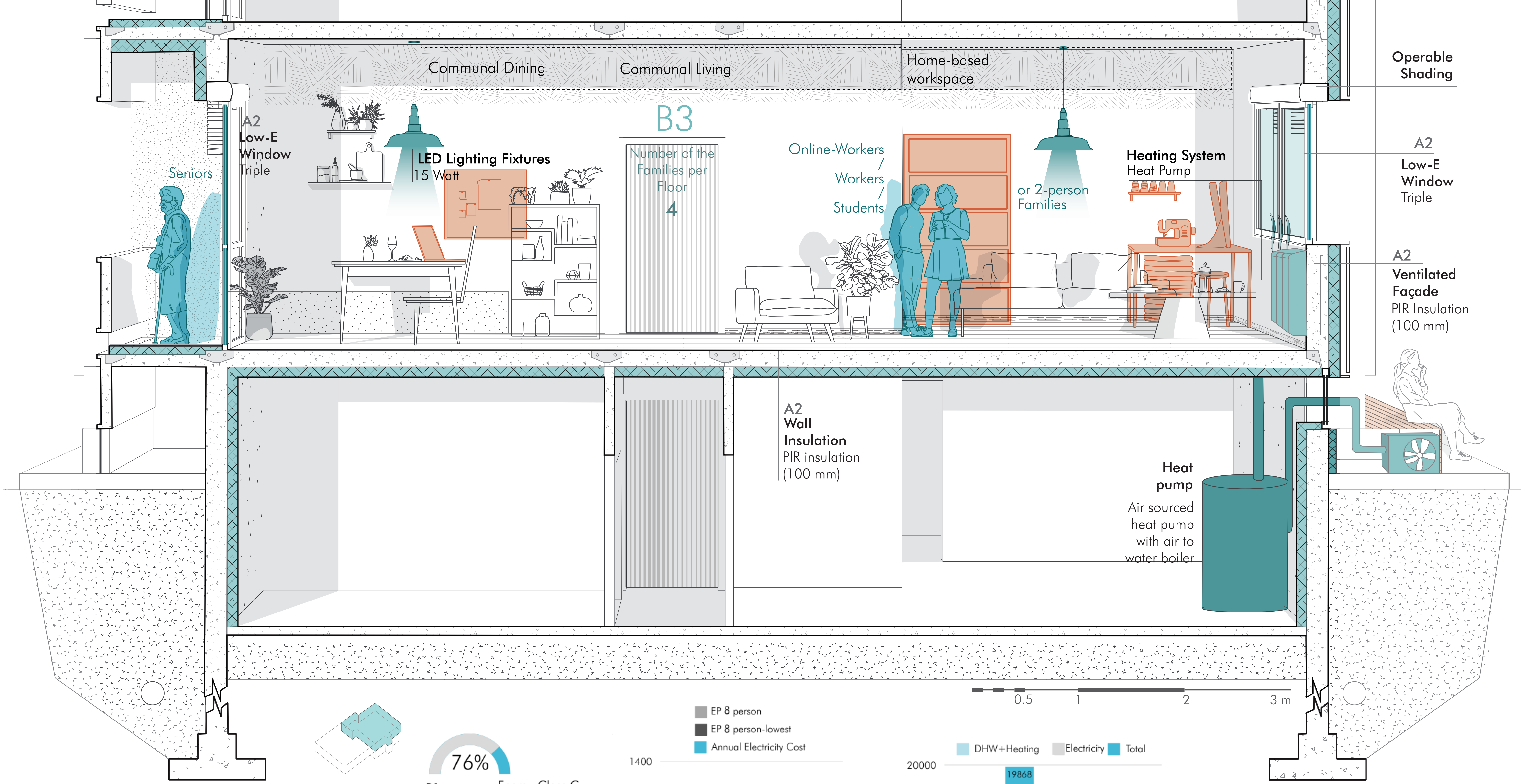
Energy Consumption

With the combination of two actors we can achieve a great result as high as 30% without high economical refurbishment cost.

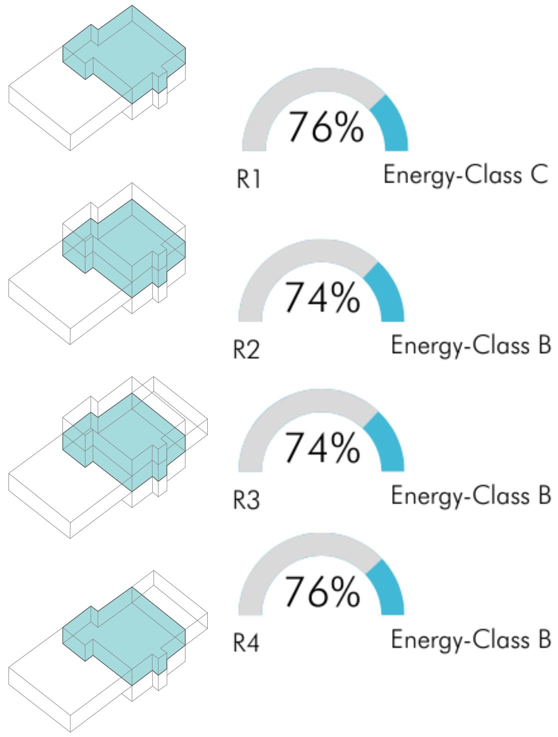
The energy class is improved higher compared to the intervention scope. We can observe that residents are highly likely to not considered in energy poverty as indicated with orange line.

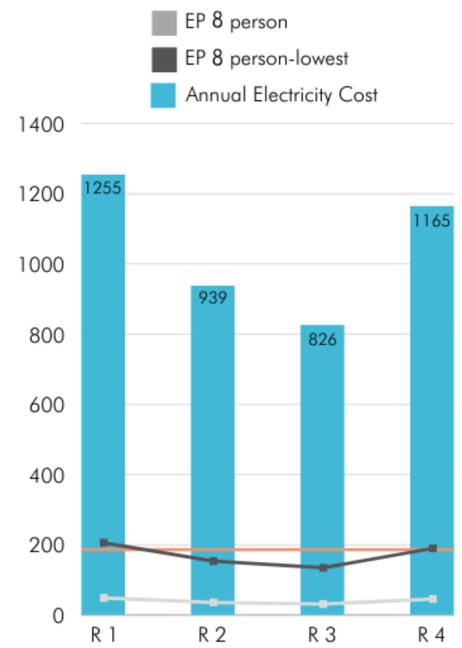
SC4 5.1.4 **PUBLIC** FUNDING SCENARIO-MID COST



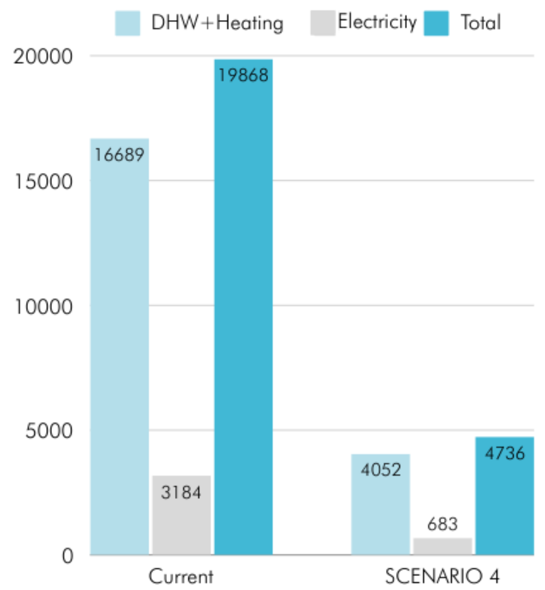


Around 70% energy is saved with this scenario. Using a heat pump and adding PV panels have effected the results greatly.





Annual Costs & Energy Poverty According to Number of people

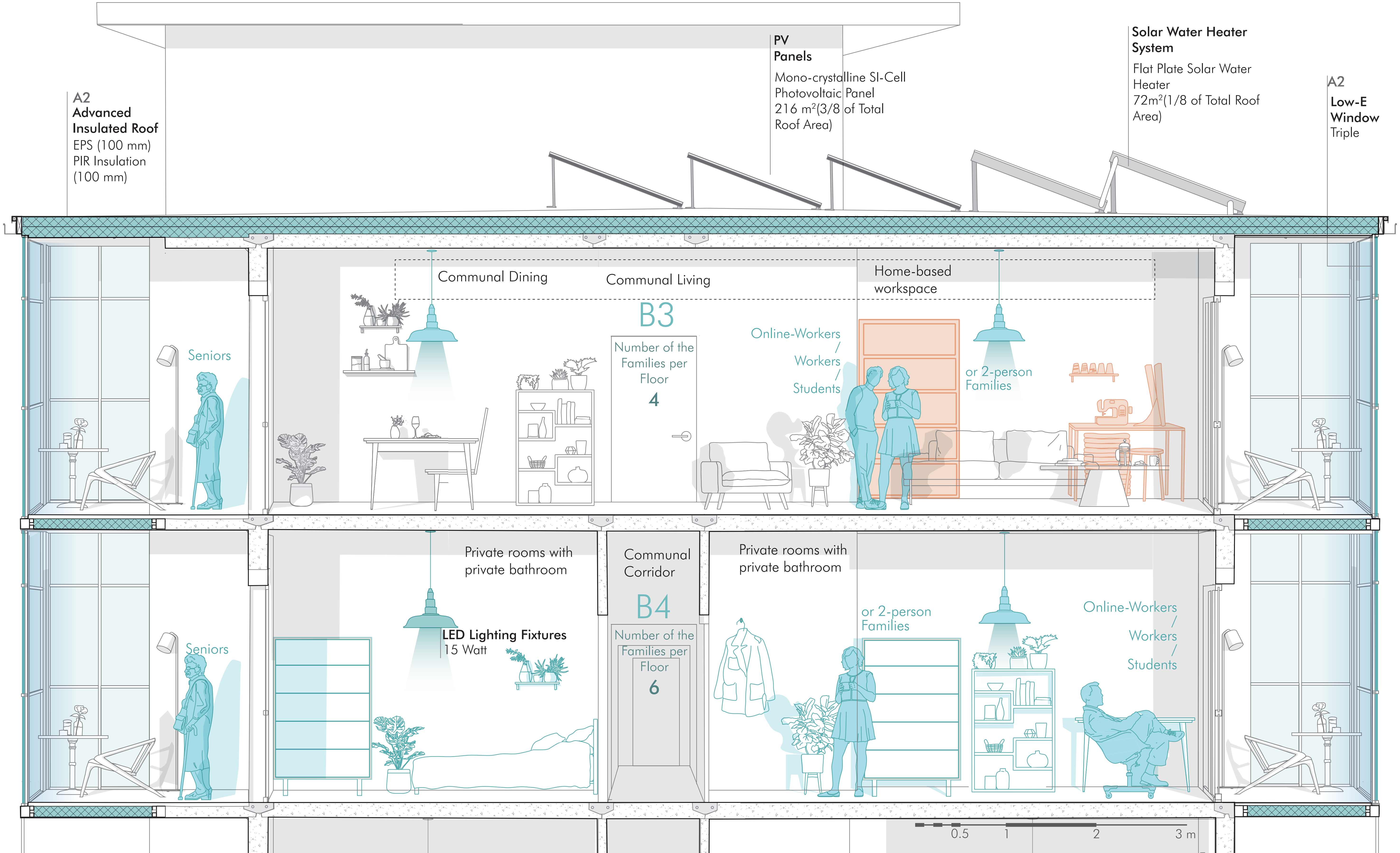


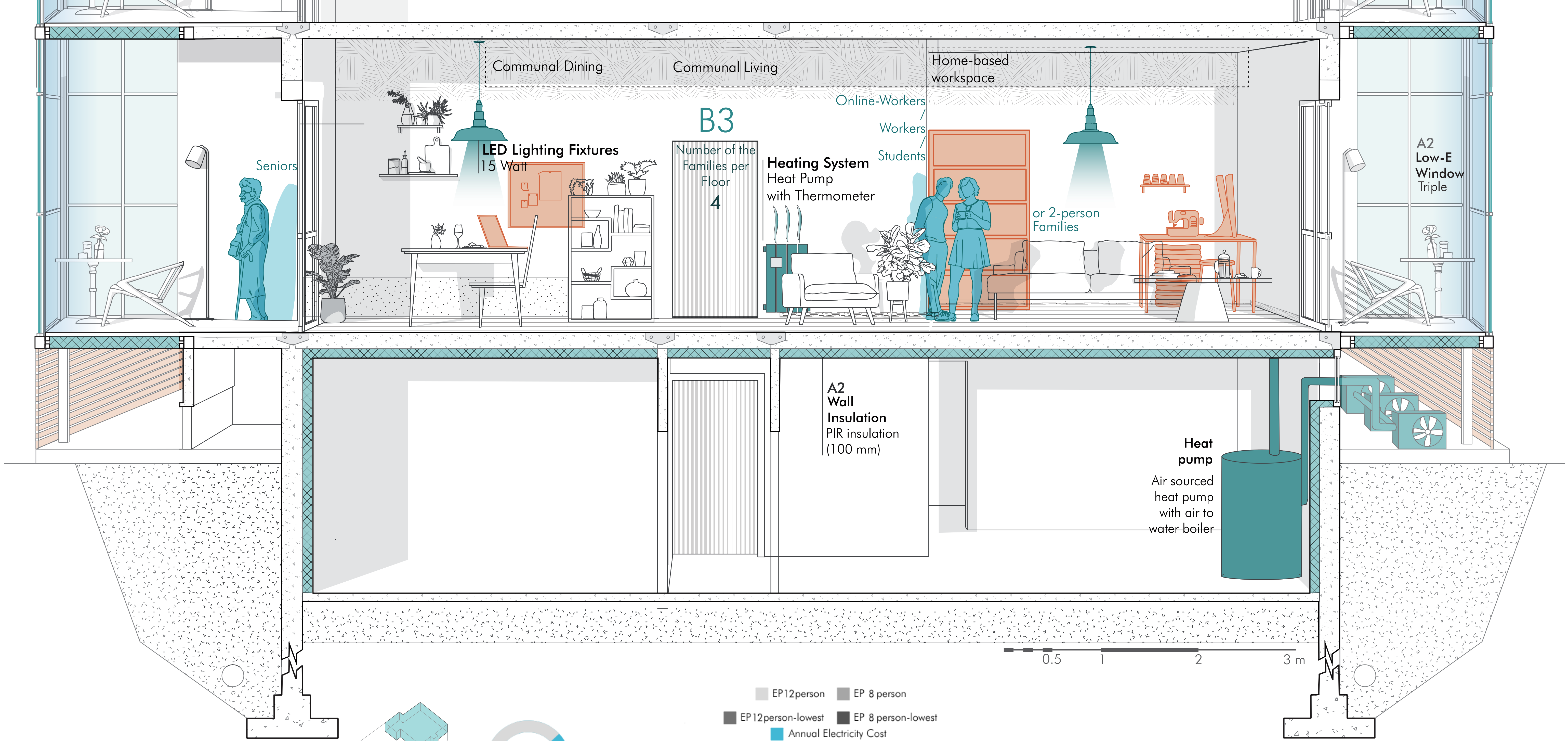
Energy Consumption

The energy class is highly improved in this scenario. We can observe that with the lowest income, residents are highly likely to not considered in energy poverty as indicated with orange line.

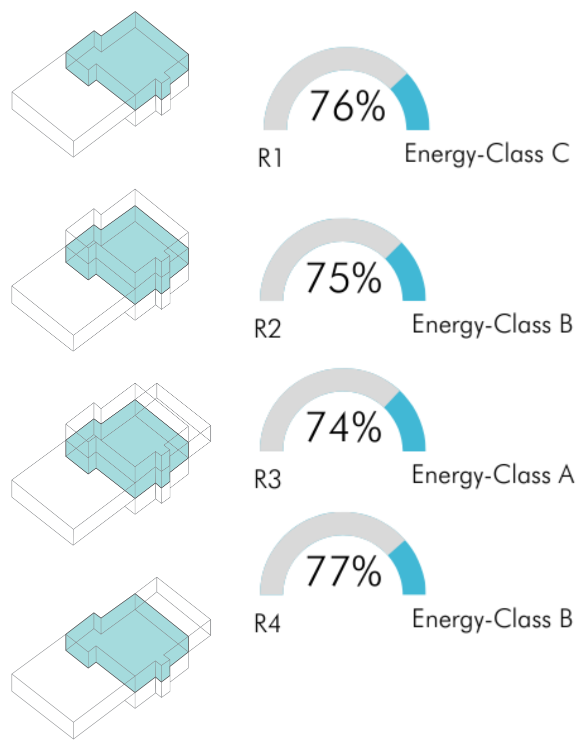
SC5 5.1.5 **PUBLIC** FUNDING SCENARIO-HIGH COST

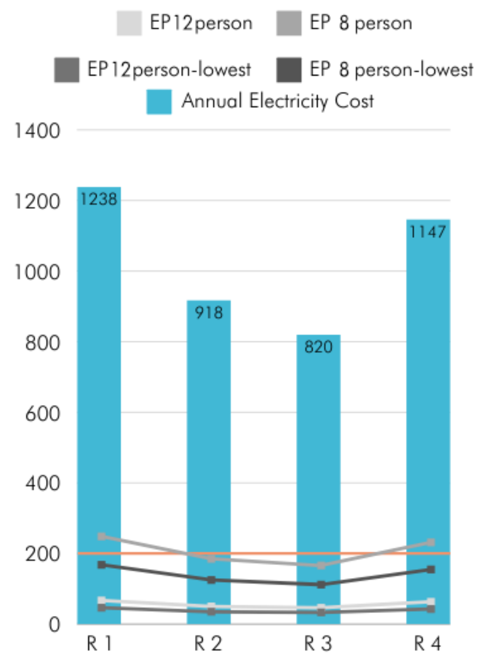
In each 2 floor communal floor is used to reach the housing demand. However it would be ideal to use the communal living quarters could be turned into different functions by the residents.



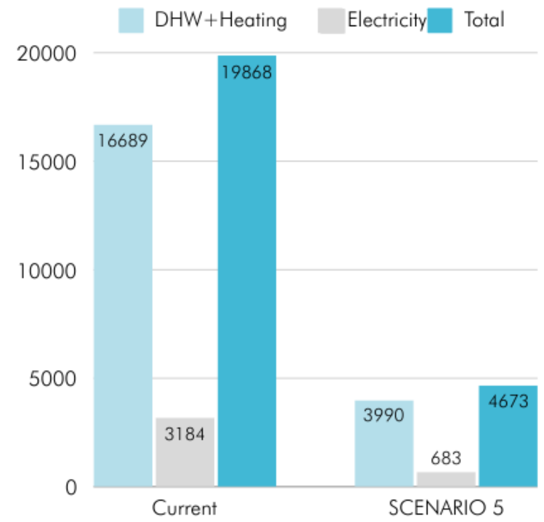


Similar to the Scenario 4, 70% energy is saved with this scenario. Accommodating the residents and improvements in spatial conditions is a key factor in this scenario. Using a heat pump and adding Pv panels have effected the results greatly.





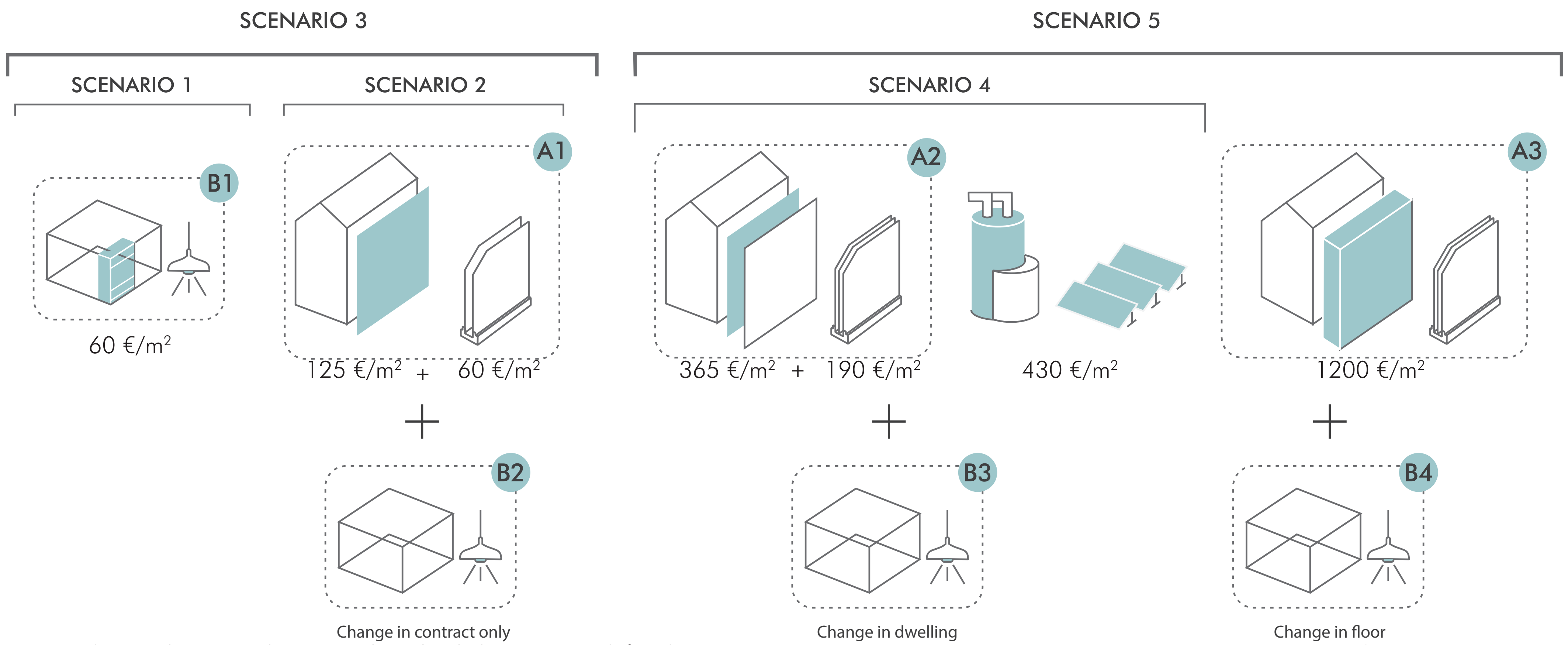
Annual Costs & Energy Poverty
According to Number of people



Energy Consumption

This scenario has the highest energy performance. One of the dwelling types even reach to the energy Class-A. We can observe that with the lowest income, residents are highly likely to not considered in energy poverty as indicated with orange line.

5.1.6 Socio-economic Comparison



To summarize, the simulation results are combined with the unit costs defined in Chapter 2. According to the opaque and transparent envelope areas present in the building, the unit costs are multiplied by the refurbished area. For Scenario 1, only the balconies are covered with double-glazing units. Therefore, the related area is multiplied by 63 €/m2. For Scenario 2, glazing units are changed, and the envelope is insulated. The average double-glazing unit cost of 63 €/m2 and the average cost of the basic intervention on the envelope, 190 €/m2, are multiplied by the related area. For Scenario 3, these two parametric costs are used to summarize the last cost of the scenario. For Scenario 4, triple glazing units are used, and their unit cost is decided at 190 €/m2. This cost is multiplied by the area of the glazing that is refurbished. In this scenario, the building envelope is refurbished with a ventilated façade; thus, the area is multiplied by 365 €/m2.

Scenario	Window Area (m^2)	Unit Cost of Glazing (€/m^2)	Elvelope Area (m^2)	Unit Cost of Envelope (€/m^2)	Total Cost for 1 dwelling (€)	Total Cost for the building(€)
1	27x10	63	3444	x	1601	68.040
2	16.8x10	63	3444	190	x	644.944
3	43.8x10	63	3444	190	x	681954
4	16.8x10	190	3444	365	x	1.288.980

Scenario	Total Area (m^2)	Unit Cost of Double Façade (€/m^2)	Total Cost for the building(€)
5	4032	1200	4.838.400

For Scenario 5, as a double façade, the total area is calculated by adding the exposed extended area of the intervention and the insulated building façade area. They are counted as the whole intervention action, which is derived as 1200 €/m2.

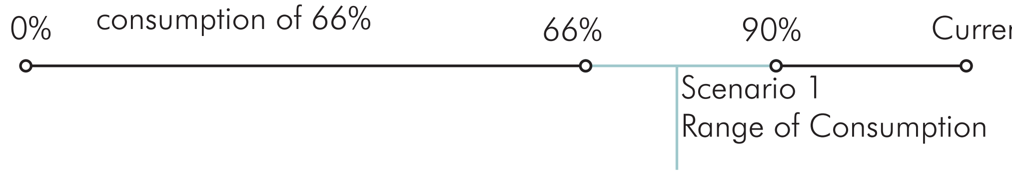
As a result, the total costs are given in the tables. These results are then combined with the energy-saving costs per year per dwelling. Energy cost savings by four different room types are averaged, and then this result is multiplied by 40(except for Scenario 1, which is used for one dwelling) to achieve the intervention payback period for the whole building with only counting envelope regeneration strategies and without accounting the logistical and infrastructural costs.

Scenario	Energy Bill Savings (Average)	Payback Year
1	500	3
2	250	66
3	750	23
4	1100	29
5	1100	110

SC1 has the shortest payback period of 3 years with moderate savings of 500, making it the most efficient option regarding the return on investment. SC2 has a much more extended payback period of 66 years and offers less cost reduction. SC3 achieves with a payback period of 23 years. SC4 and SC5 provide the highest savings of 1100; however, SC4 requires 29 years for payback, while SC5 has the longest payback period of 110 years due to extensive regeneration.

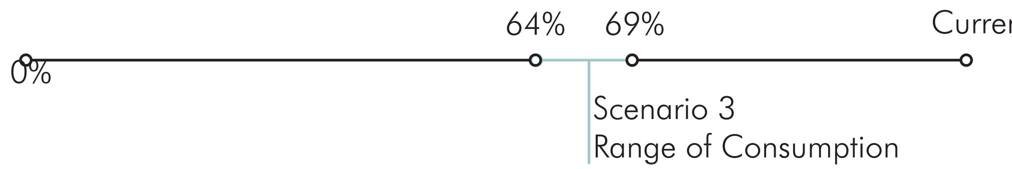
The holistic comparison consists of energy consumptions, refurbishment costs and energy poverty rates.To set the graph of the comparison, the fact of the energy poverty rate is different in each dwelling type R1,R2,R3,R4. For the indication of the different room types, a range of change is defined for the rooms. As from the simulation results we can conclude the energy consumption from the energy savings:

In the Scenario 1, the highest and lowest consumption of the rooms are R1 by 90% energy consumption from the current while R3 has an energy consumption of 66%



In the Scenario 2, the highest and lowest consumption of the rooms are R2 by 90% while R1&R4 has an energy consumption of 80%

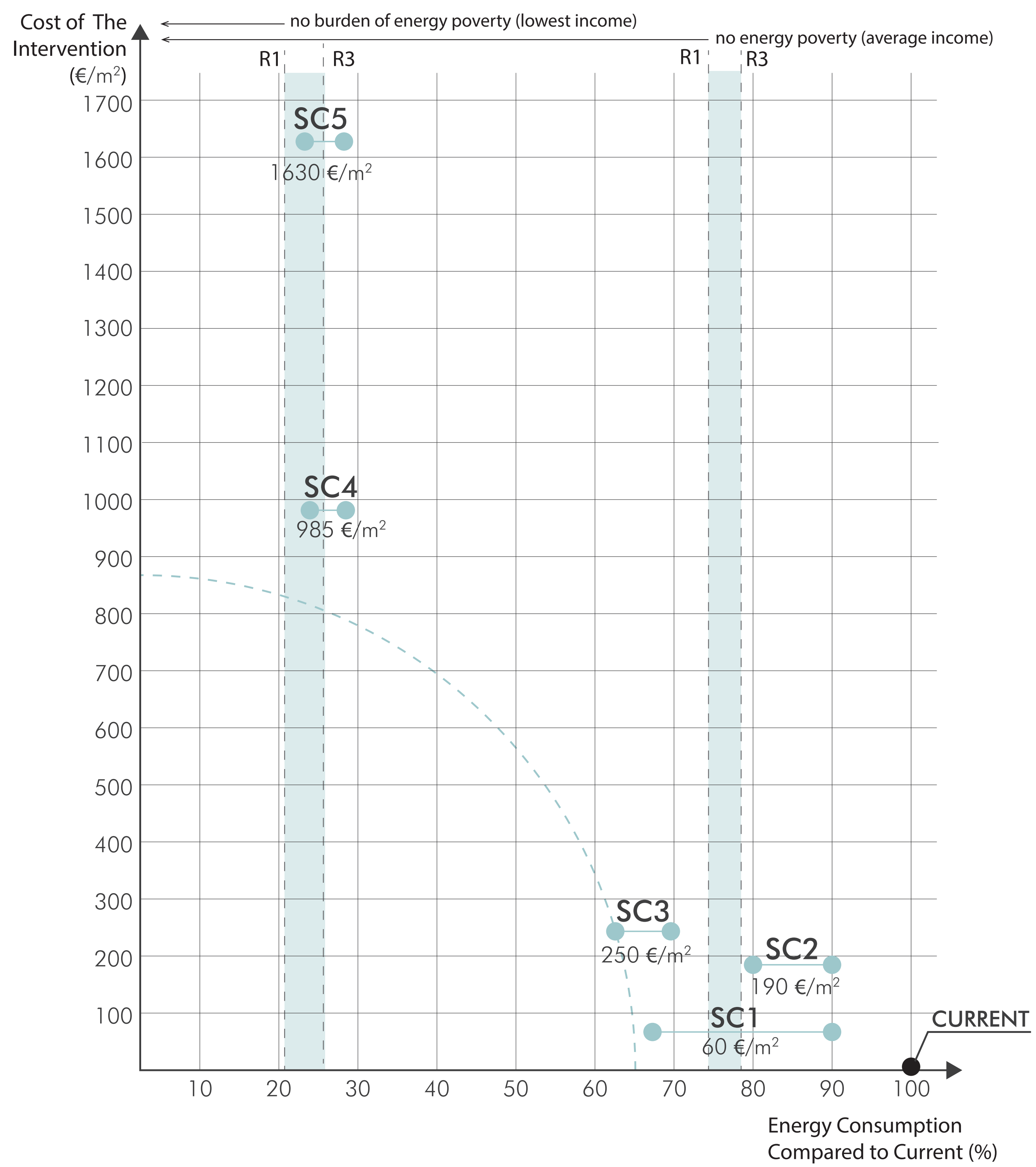
In the Scenario 3, the highest and lowest consumption of the rooms are R1 by 69% while R3 has an energy consumption of 64%



In the Scenario 4, the highest and lowest consumption of the rooms are R2&3 by 26% while R1&R4 has an energy consumption of 24%

In the Scenario 5, the highest and lowest consumption of the rooms are R2& by 26% while R1&R4 has an energy consumption of 23%

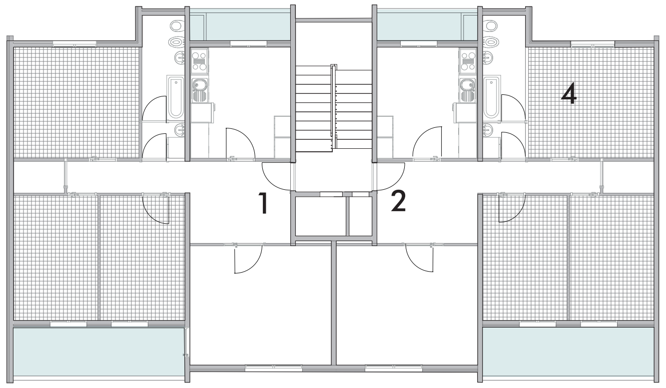
As for energy poverty, according to the incomes, the energy consumption needs to be 74% of the current energy consumption for R4-type rooms and 78% for the R1-type rooms as thresholds of both maximum and negative values. For the lowest income families, the energy consumption per family needs to be as low as 22% for R3 type rooms and 26% for R1 compared to current energy bills. Thus, if the scenario limits are on the left side of the energy poverty lines, it is highly likely that the families are not burdened by energy poverty.



A scenario which is close to the origin is the most cost-effective option. If a curve is drawn centering the origin from the closest point, it collides with the Scenario 3. Therefore, the most cost efficient scenario is the Scenario 3. Even though it has a high energy performance, it works even better than the Scenario 4 compared to the cost-efficiency. Since it requires minimum intervention costs Scenario 3 seems the most ideal one if the residents and ATC decided to collaborate. However when we consider best performing building, we can observe that the scenario 5 is better. It is also the best in terms of the energy poverty. If the public bodies have the enough funds to support, the result would be the optimal for both energy performance wise as well as the socially flexible option.

5.1.7 Socio-demographic Comparison

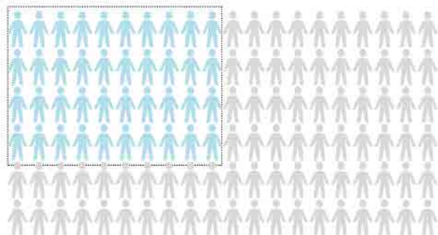
SCENARIO 1



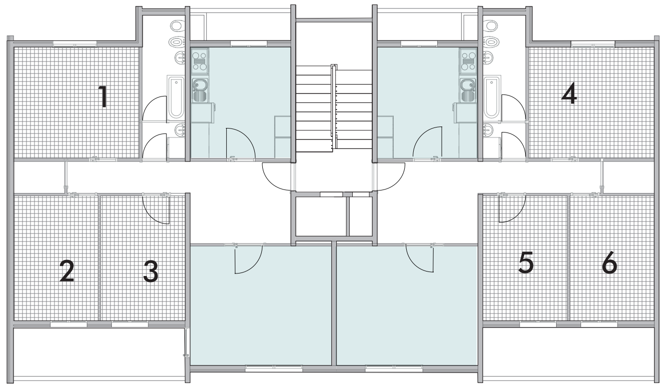
The scenario is acted only with the residents, therefore the number of people allocated is the same. Therefore it does not respond to the housing needs. Additionally the rooms are divided according to the strict programs, thus the different user groups can not be satisfied. However semi-open area which is already desired by current residents.

Resident numbers according to the whole building

Number of Families: 40
Maximum People: 120



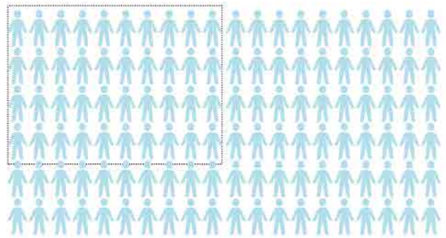
SCENARIO 2



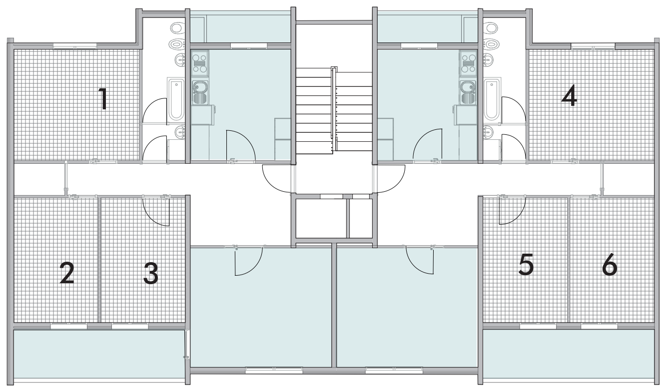
The scenario is acted by the ATC, therefore the contracts could be changed to increase the number of families. Additionally, this intervention does not require to relocate the residents. However it does not change the facilities or the organization, thus the different user groups can not be satisfied.

Resident numbers according to the whole building

Number of Families: 120
Maximum People: 120



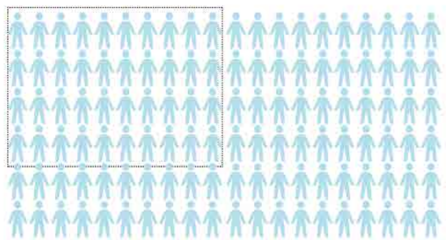
SCENARIO 3



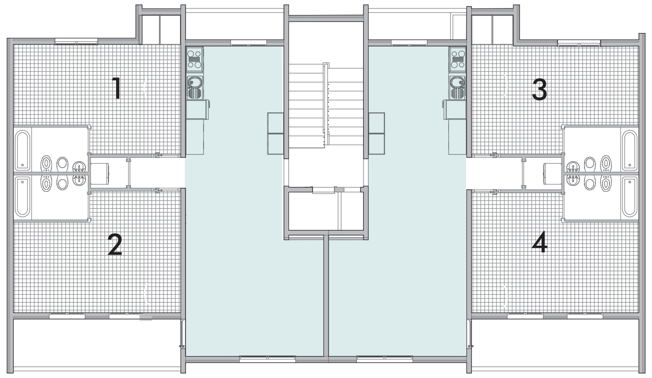
The scenario is acted both by the ATC & residents, therefore the scenario both benefits from the Scenario 1 and Scenario 2's advantages. Additionally, this intervention does not require to relocate the residents. Similar to the SC2, it does not change the facilities or the organization, thus the different user groups can not be satisfied.

Resident numbers according to the whole building

Number of Families: 120
Maximum People: 120



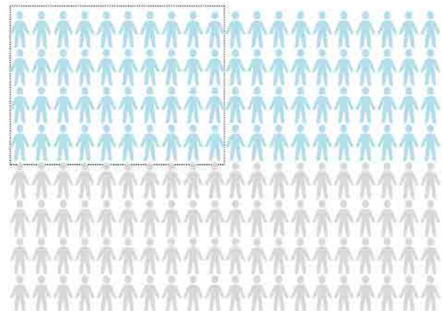
SCENARIO 4



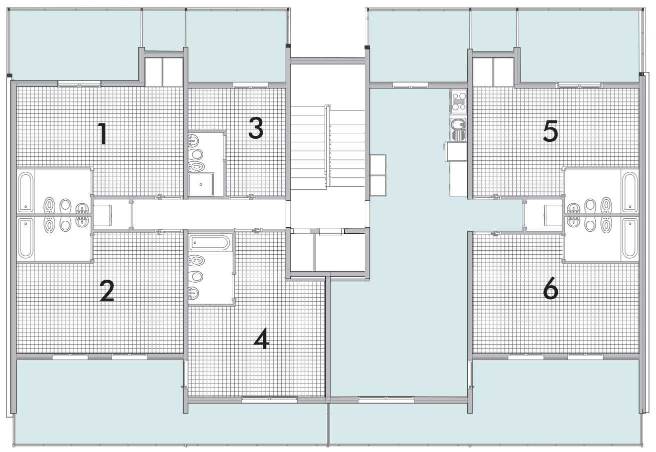
The scenario is acted by the ATC , therefore the new contracts are created to respond to the housing needs. Compared to the SC2, the floor has less families. However, flexible common places and individual facilities are created to respond to various user groups. The communal area is also adaptable to the needs of the home-based working individuals. As a downside, residents needs to relocate while the interior partitions are created. To construct the process, residents from the ground floor needs to be relocated to somewhere else by the ATC. After the ground floor, residents can be moved to the floors that are completed without moving from the building.

Resident numbers according to the whole building

Number of Families: 80
Maximum People: 160



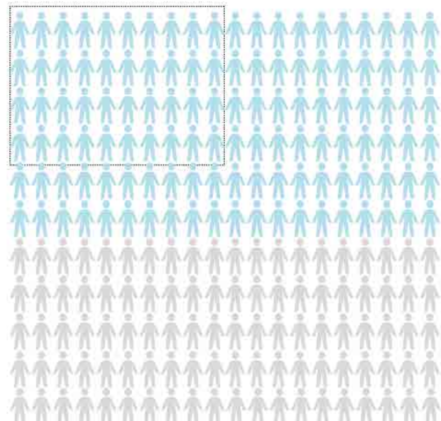
SCENARIO 5



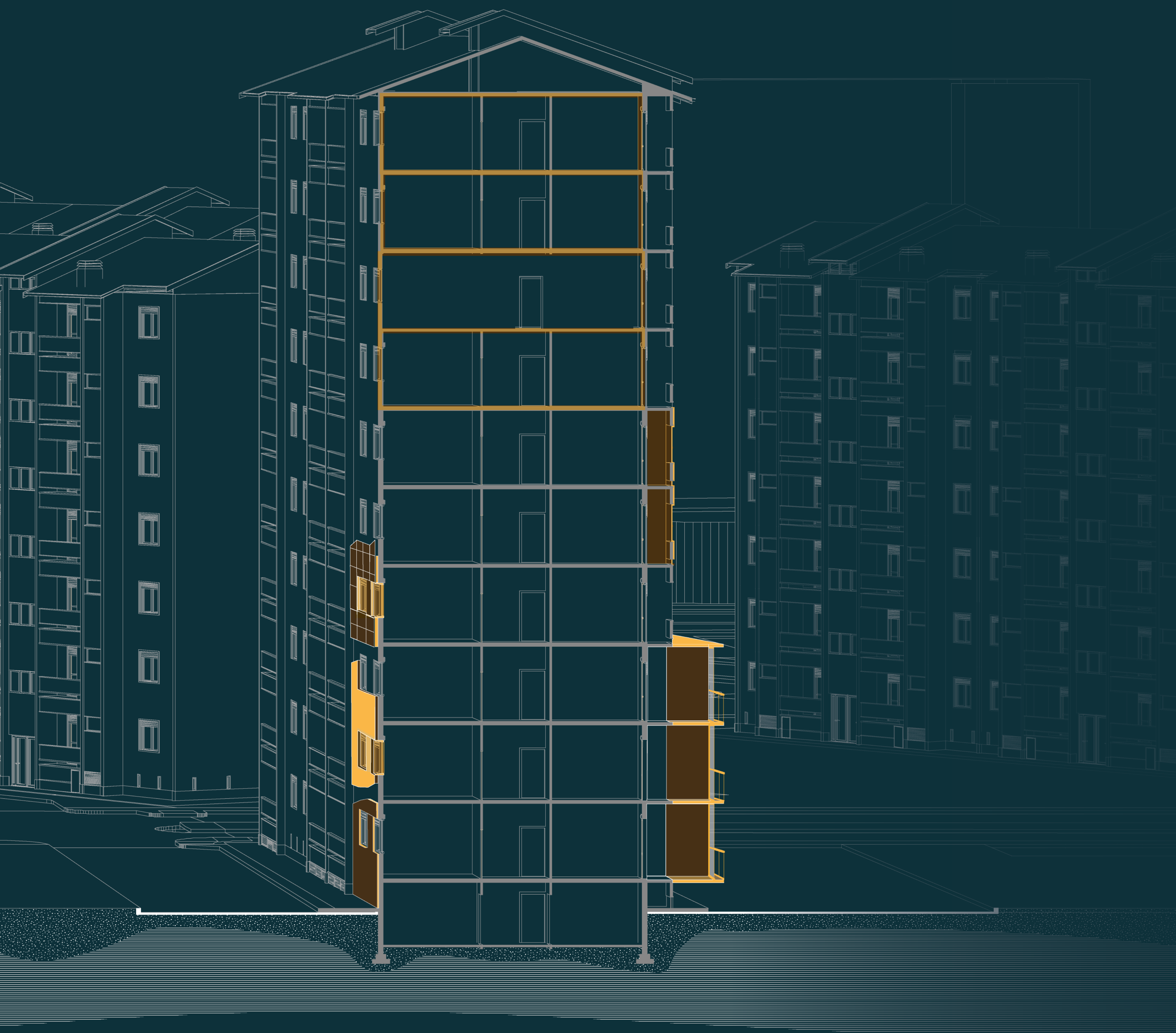
The scenario is acted by the ATC , so the new contracts are created to respond to the housing needs. Compared to the SC4, the floor has more families. Flexible common areas and individual facilities are created in the whole floor to respond to various user groups. Additionally, common balconies are created for interaction among the residents which is a necessary aspect of the co-living. As a downside similar to the SC4, residents needs to relocate while the interior partitions are created. Residents from the ground floor needs to be relocated to somewhere else by the ATC. After the ground floor, residents can be moved to the new floors without moving from the building.

Resident numbers according to the whole building

Number of Families: 80
Maximum People: 160



FINAL REMARKS



This thesis explored the intersection of social housing renovation strategies, energy poverty mitigation, and addressing housing crises through a parametric approach applied to public rental housing in Corso Taranto, Turin. The research utilized five scenarios to simulate and evaluate the effectiveness of different interventions, assessing their cost efficiency, payback periods, energy performance, and capacity to meet immediate and future housing needs.

Scenario 1, funded by residents, emerged as the most cost-effective solution regarding intervention costs. The payback period is three years, offering significant savings in energy costs and reducing annual energy expenses by 500€ per dwelling. However, its limited intervention is ineffective in comprehensively addressing energy poverty and does not respond to the housing crisis.

Scenario 2, low-cost funded by the public, even though it followed regulations, could have been more efficient in enhancing energy performance. Because of the low-energy performance improvement, its payback period was extended to 66 years. However, while it addressed the housing crisis by significantly increasing resident capacity, it fell short in mitigating energy poverty. It lacked sufficient private facilities, limiting its appeal to diverse user groups, including families and work-live arrangements.

Scenario 3, a balanced approach funded by both residents and public bodies, emerged as a practical and cost-efficient solution. It not only improved energy performance and increased housing capacity but also effectively addressed energy poverty and the housing crisis. It has a reasonable payback period, this scenario is a reassuring choice for projects with financial constraints, offering a feasible and effective solution with the collaboration of residents and public.

Scenario 4, a medium-cost funded by the public, prioritized energy performance while maintaining essential communal and private facilities. While it did not significantly increase resident numbers, it catered to a diverse range of user groups, making it a valuable and inclusive option for addressing energy poverty.

Finally, Scenario 5, the highest-cost public-funded scenario, achieved the best outcomes concerning energy efficiency, housing flexibility, and adaptability to changing user needs. It provided a comprehensive solution to energy poverty and housing needs by increasing the capacity of residents and making them resilient to future challenges. However, due to its 110 year payback period it is unfeasible as an economical investment, but valuable as a long-term social and environmental sustainability strategy.

In summary, Scenario 5 is the best strategy for addressing the problems of energy poverty and housing shortages in a comprehensive manner. It achieves the highest energy performance, ensures long-term adaptability, and meets future demands for social housing. However, for projects with financial limitations, Scenario 3 is the most practical solution, balancing energy performance and payback time while offering a meaningful response to energy poverty and housing shortages. Both cases highlight the importance of integrating social, economic, and environmental considerations, thus ensuring that our proposed strategies are comprehensive and holistic in addressing the regeneration of social housing building typologies.

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CHAPTER 1

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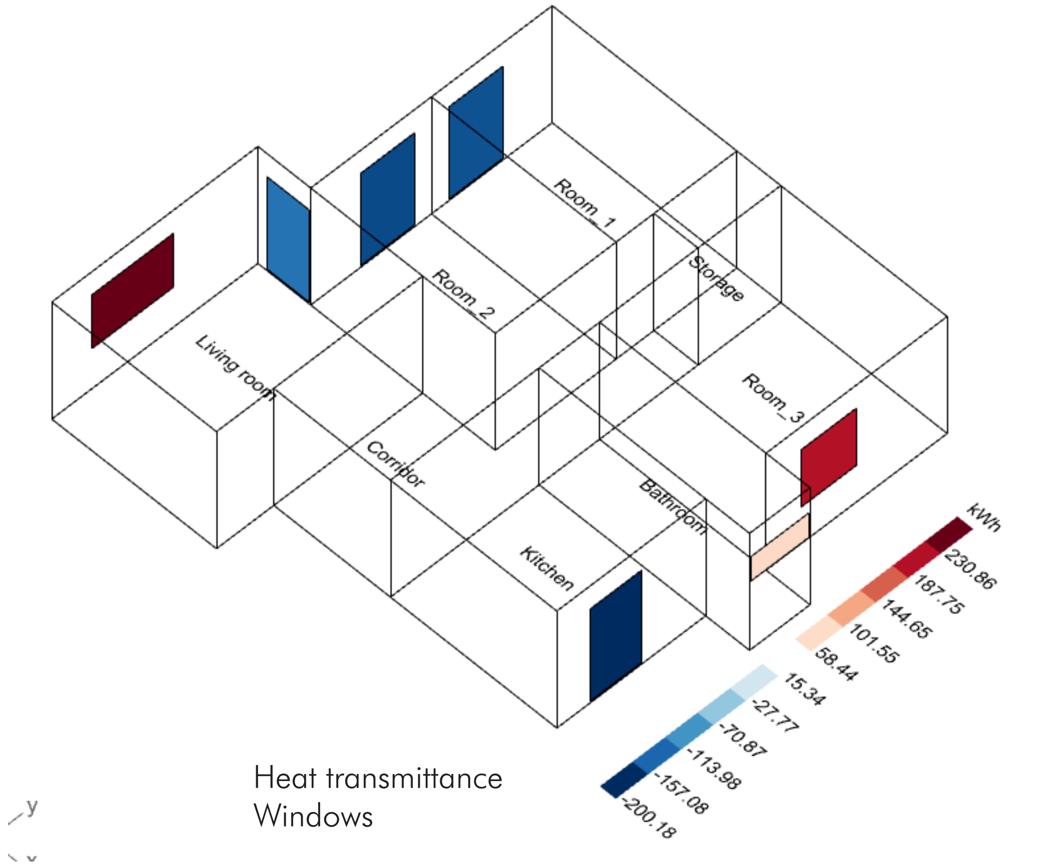
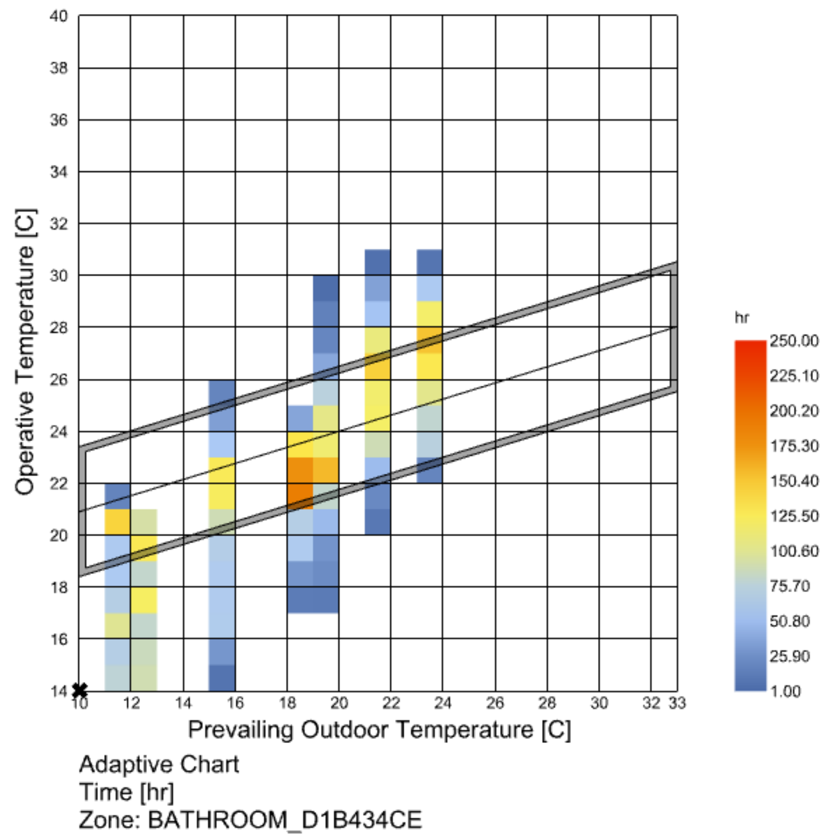
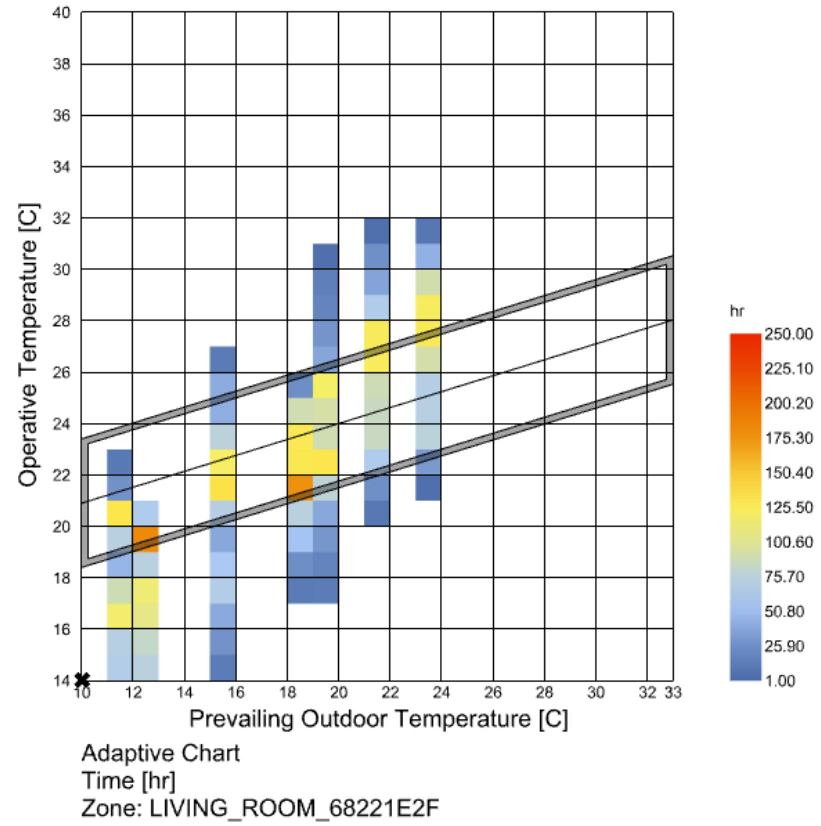
ANNEX

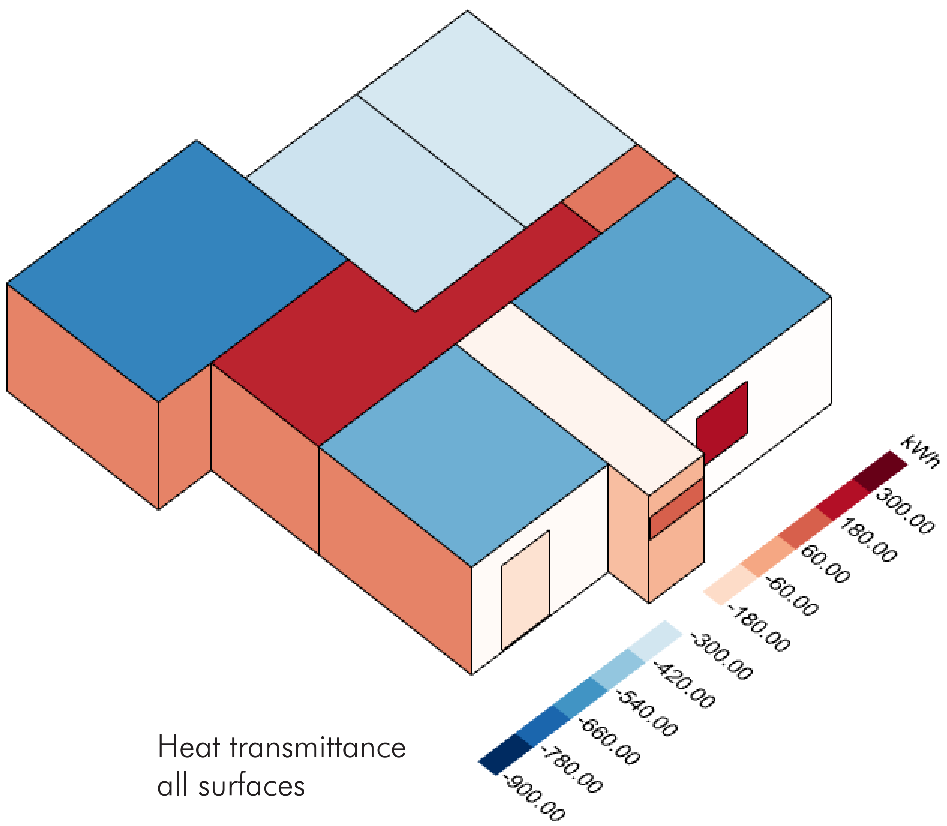
ROOM TYPE R1
Current corner type room graphs and simulation outputs derived from the grasshopper-ladybug



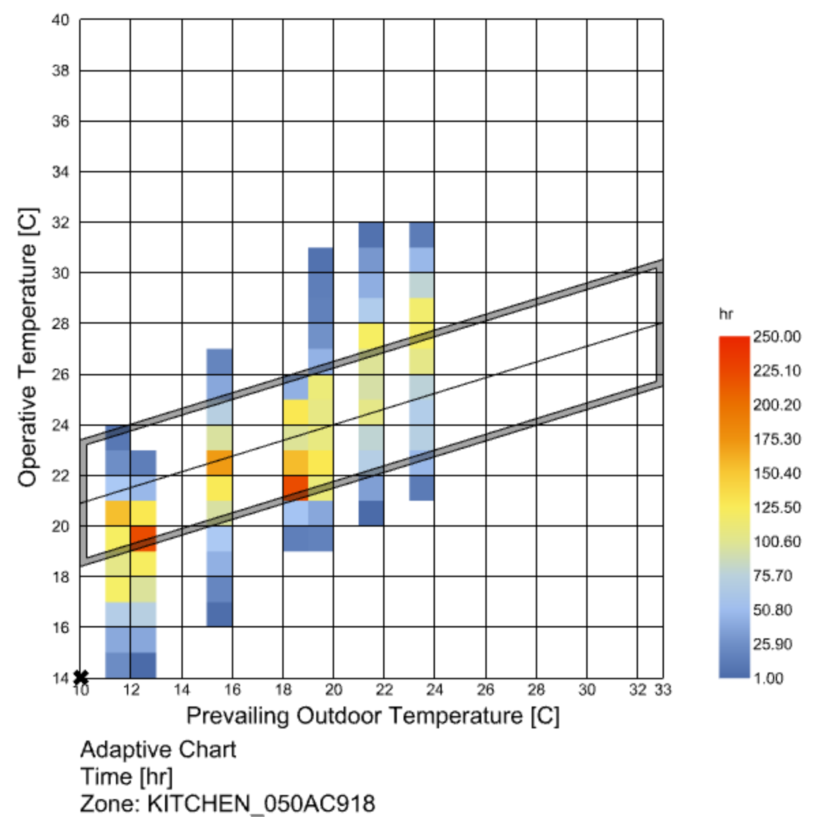
Heat transmittance
Windows

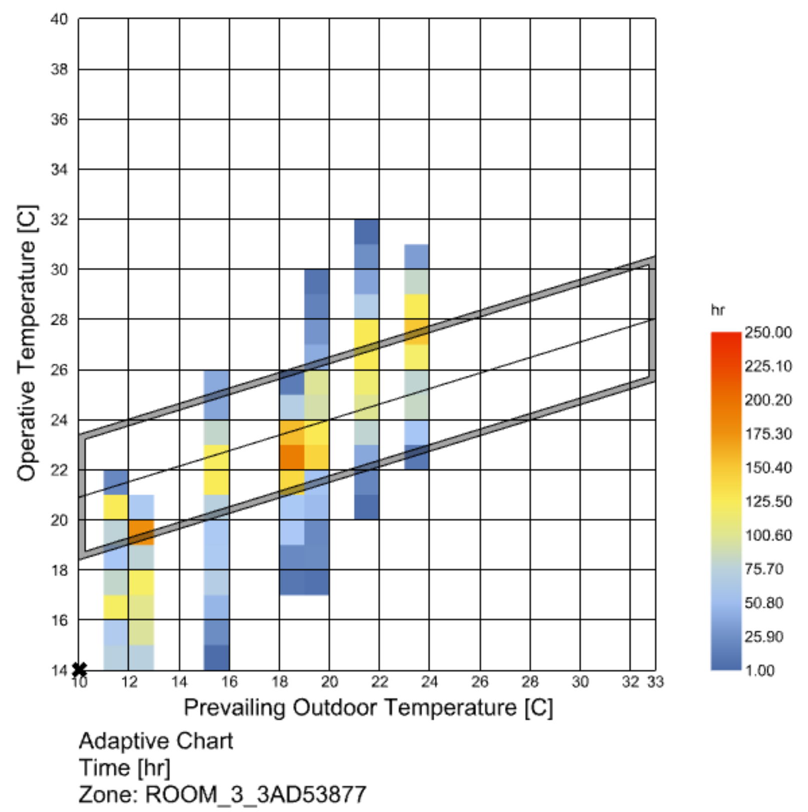






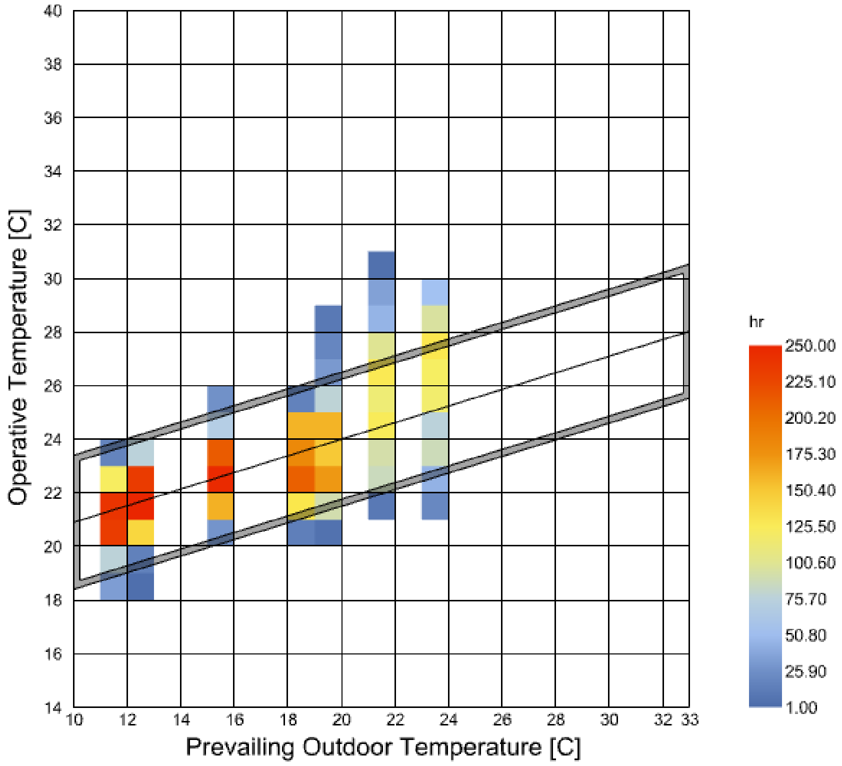
Heat transmittance
all surfaces



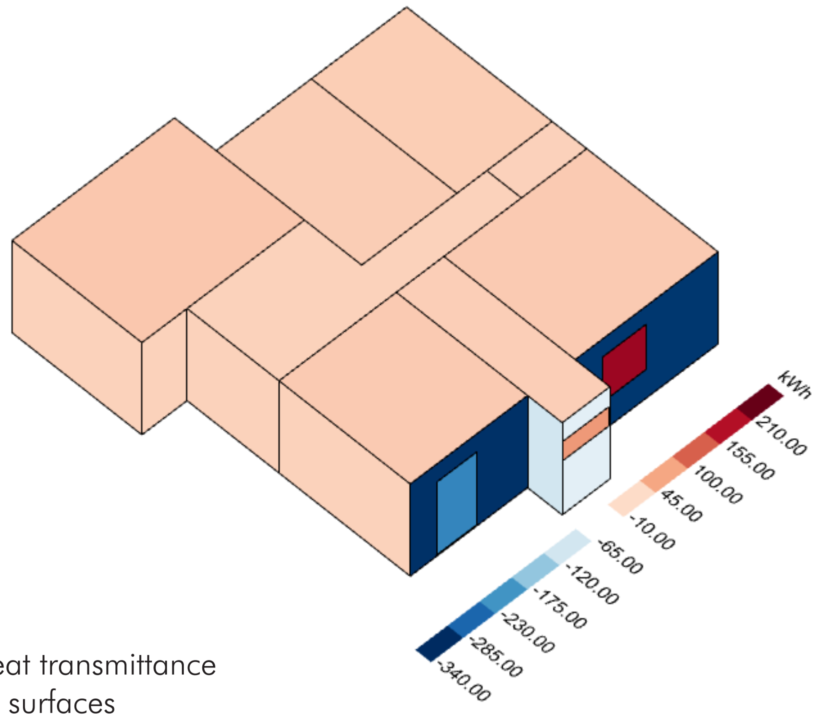


ROOM TYPE R2

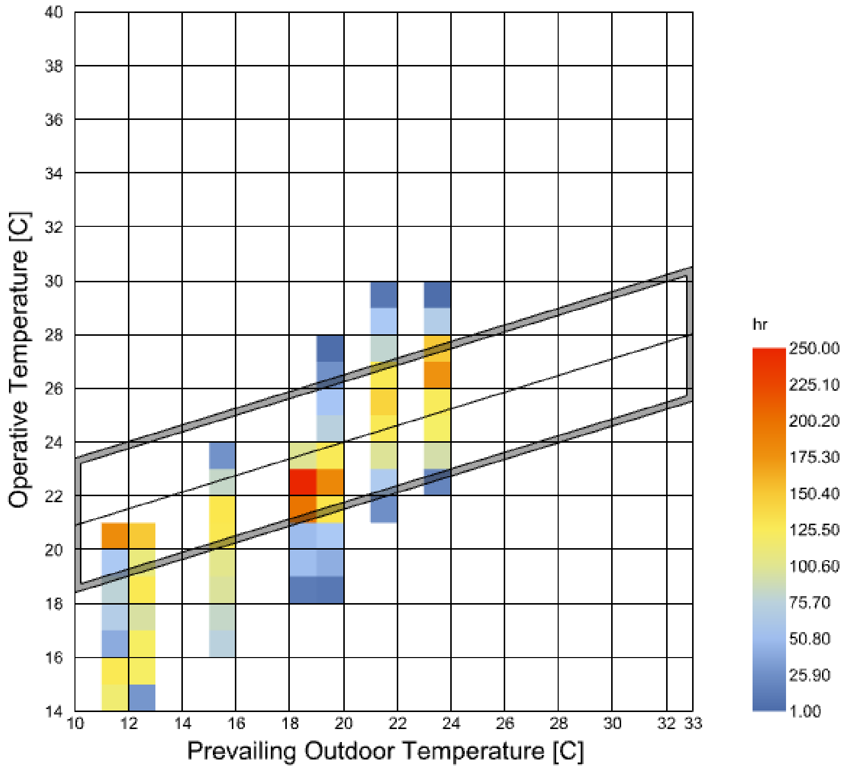
Current R2 type room graphs and simulation outputs derived from the grasshopper-ladybug



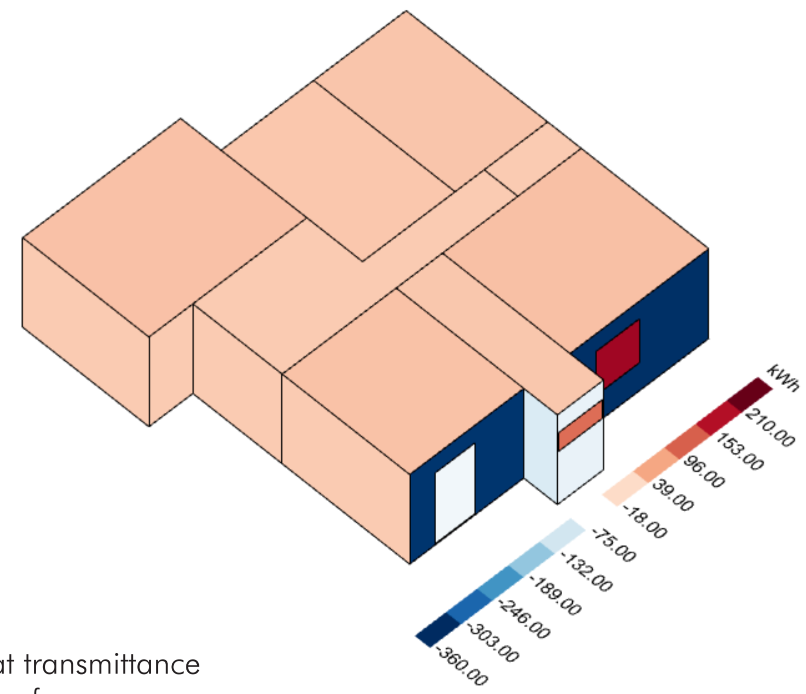
Adaptive Chart
Time [hr]
Zone: KITCHEN_C3302662



Heat transmittance
all surfaces



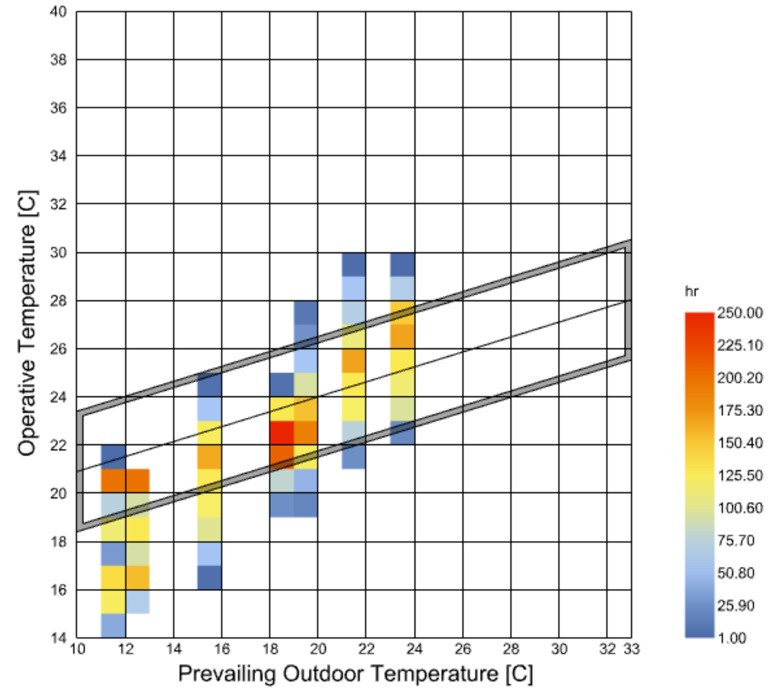
Adaptive Chart
Time [hr]
Zone: ROOM_3_97E86ABD



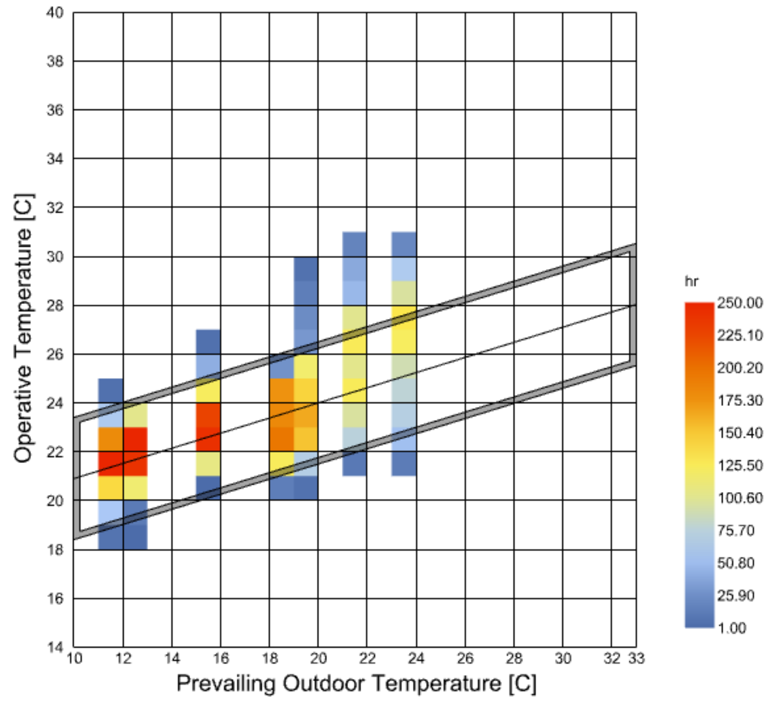
Heat transmittance
all surfaces

ROOM TYPE R3

Current R3 type room graphs and simulation outputs derived from the grasshopper-ladybug



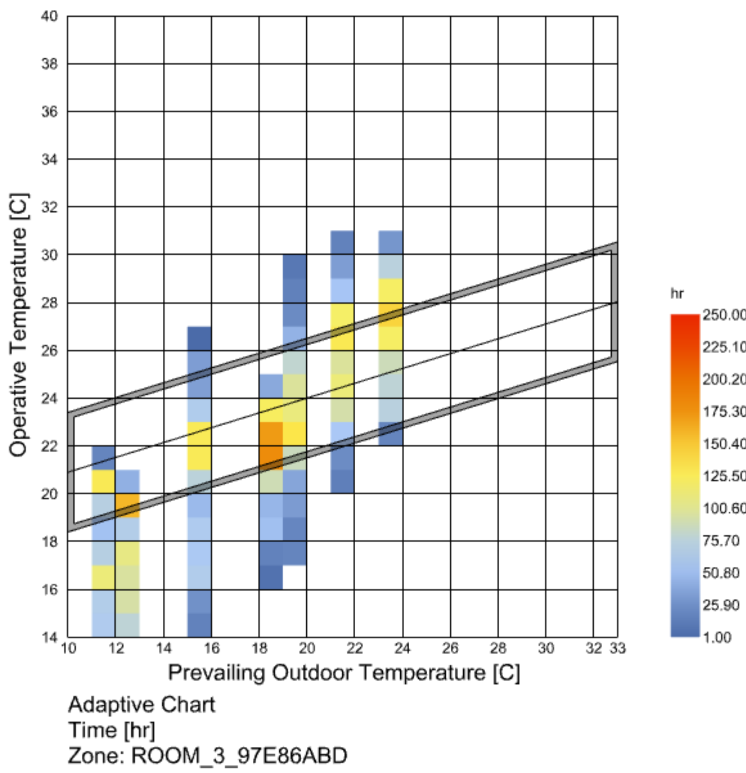
Adaptive Chart
Time [hr]
Zone: ROOM_3_97E86ABD

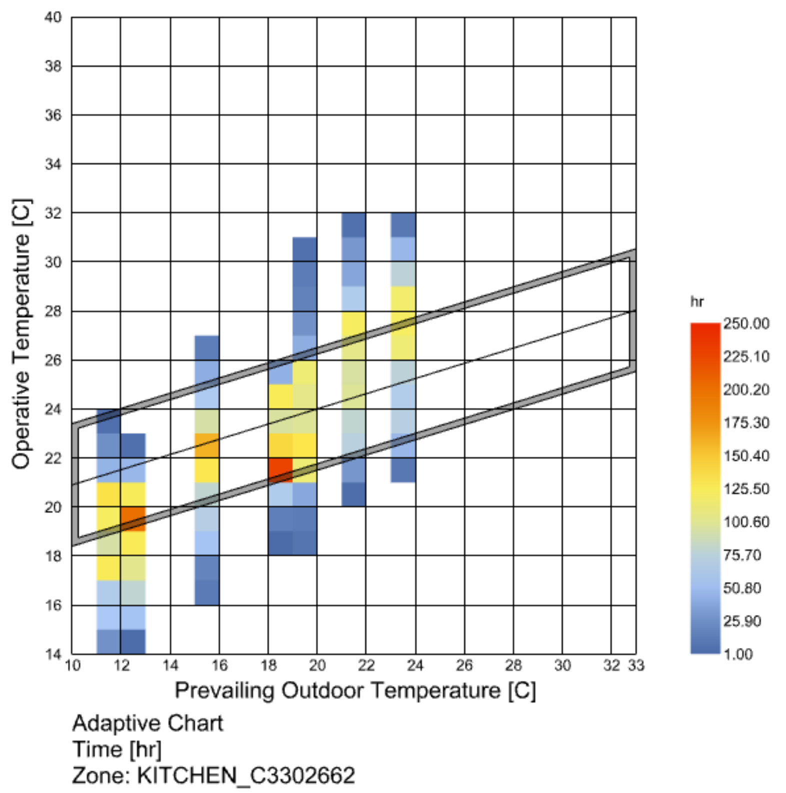


Adaptive Chart
Time [hr]
Zone: KITCHEN_C3302662

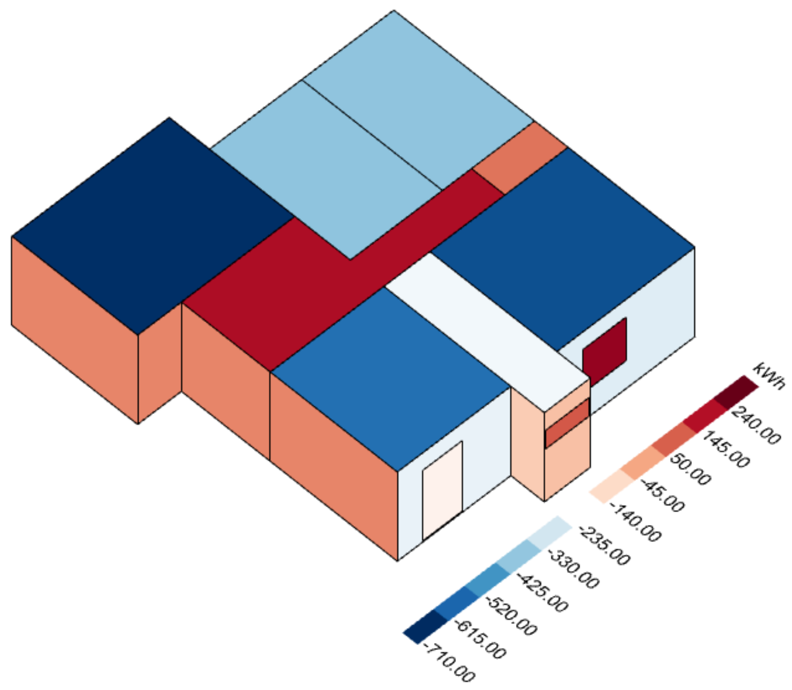
ROOM TYPE R4

Current R3 type room graphs and simulation outputs derived from the grasshopper-ladybug





Heat transmittance
all surfaces



SIMULATION RESULTS
R1&R2&R3&R4

Income (euro/year)2021	TYPEA-ROOM6	Annual Electricity Cost(Base Simulation)	Annual Gas Cost(Base Simulation)	EP-1 person	EP 2 person	EP-Lowest 1person	EP-Lowest 2 person
18762	R6-1	844	1676	13.4%	6.7%	52.9%	26.5%
4760	R6-2	844	1050	10.1%	5.0%	39.8%	19.9%
	R6-3	844	885	9.2%	4.6%	36.3%	18.2%
	R6-4	844	1554	12.8%	6.4%	50.4%	25.2%
	TYPEA-ROOM6	Annual Electricity Consumption	Annual Gas Consumption	Total Energy Consumption	Energy Class		
	R6-1	3183	16441	19624	G		
	R6-2	3183	10291	13474	E		
	R6-3	3183	8683	11866	E		
	R6-4	3183	15241	18424	F		

PAYBACK PERIOD CALCULATION

	Area	Unit Cost	Total		Total				
SC1	27	63	1701	for 1 dwelling	68040	for building			
	Window Area	Floor	Transparent Cost	Wall Area	Opaque Cost	OpaqueTot Euro	Transparent Tot Euro	Total without HP+PV	
SC2	16.8	10	63	3444	125	430500	10584	441084	for building
SC3	43.8	10	63	3444	125	430500	27594	458094	for building
SC4	16.8	10	190	3444	365	1257060	31920	1288980	for building
	Total Area	Unit Cost	Total without HP+PV						
SC5	4032	1200	4838400	for building					
	Scenario	Energy Cost F	PB-Years						
	SC1	500	3						
	SC2	250	44						
	SC3	750	15						
	SC4	1100	29						
	SC5	1100	110						

CURRENT WALL CONSTRUCTION

Type of component	External wall

Layers		d	ρ	μ	c	λ	R	opz.
(int-est)		[cm]	[kg/m³]	[-]	[J/kg°C]	[W/m°C]	[m²°C/W]	λ→R
Internal surface							0.13	
I	concrete	13.0	2200	69	840	1.480		☐
II	EPS	3.0	25	64	1250	0.042		☐
III	concrete	5.0	2200	69	840	1.480		☐
IV	EPS	5.0	25	64	1250	0.042		☐
V	External Paint	1.0	2000	24	1000	1.400		☐
VI								☐
VII								☐
VIII								☐
IX								☐
X								☐
External surface							0.04	

Parameter	Module	Time shift
Internal thermal admittance (Y_{ii})	5.752 W/(m²K)	1.37 h
External thermal admittance (Y_{ee})	1.714 W/(m²K)	3.96 h
Periodic thermal transmittance (Y_{ie})	0.048 W/(m²K)	-10.66 h
Internal areal heat capacity (κ_i)	79.8 kJ/(m²K)	
External areal heat capacity (κ_e)	24.1 kJ/(m²K)	
Thermal resistance (R)	2.204 (m²K)/W	
Thermal transmittance (U)	0.454 W/(m²K)	
Decrement factor (f)	0.105	

Thickness (s)	27.0 cm	
Areal mass (m)	418 kg/m²	
Time lag (φ)	10.66 h	

A1 WALL CONSTURCTION

Type of component	External wall

Layers		d	ρ	μ	c	λ	R	opz.
(int-est)		[cm]	[kg/m³]	[-]	[J/kg°C]	[W/m°C]	[m²°C/W]	λ→R
Internal surface							0.13	
I	concrete	13.0	2200	69	840	1.480		☐
II	EPS	3.0	25	64	1250	0.042		☐
III	concrete	5.0	2200	69	840	1.480		☐
IV	EPS	10.0	25	64	1250	0.030		☐
V	External Paint	1.0	2000	24	1000	1.400		☐
VI								☐
VII								☐
VIII								☐
IX								☐
X								☐
External surface							0.04	

Parameter	Module	Time shift
Internal thermal admittance (Y_{ii})	5.750 W/(m²K)	1.37 h
External thermal admittance (Y_{ee})	1.548 W/(m²K)	5.01 h
Periodic thermal transmittance (Y_{ie})	0.018 W/(m²K)	-11.33 h
Internal areal heat capacity (κ_i)	79.3 kJ/(m²K)	
External areal heat capacity (κ_e)	21.4 kJ/(m²K)	
Thermal resistance (R)	4.346 (m²K)/W	
Thermal transmittance (U)	0.230 W/(m²K)	
Decrement factor (f)	0.077	

Thickness (s)	32.0 cm	
Areal mass (m)	419 kg/m²	
Time lag (φ)	11.33 h	

A2 WALL CONSTURCTION

Type of component	External wall

Layers		d	ρ	μ	c	λ	R	opz.
(int-est)		[cm]	[kg/m³]	[-]	[J/kg°C]	[W/m°C]	[m²°C/W]	λ→R
Internal surface							0.13	
I	concrete	13.0	2200	69	840	1.480		☐
II	EPS	3.0	25	64	1250	0.042		☐
III	concrete	5.0	2200	69	840	1.480		☐
IV	PIR	10.0	25	64	1250	0.022		☐
V	Membrane	0.1	2000	24	1000	1.400		☐
VI	Air Gap	5.0	200	1	1000	0.026		☐
VII								☐
VIII								☐
IX								☐
X								☐
External surface							0.04	

Parameter	Module	Time shift
Internal thermal admittance (Y_{ii})	5.750 W/(m²K)	1.37 h
External thermal admittance (Y_{ee})	0.613 W/(m²K)	3.38 h
Periodic thermal transmittance (Y_{ie})	0.007 W/(m²K)	9.66 h
Internal areal heat capacity (κ_i)	79.1 kJ/(m²K)	
External areal heat capacity (κ_e)	8.4 kJ/(m²K)	
Thermal resistance (R)	7.475 (m²K)/W	
Thermal transmittance (U)	0.134 W/(m²K)	
Decrement factor (f)	0.056	

Thickness (s)	36.1 cm	
Areal mass (m)	411 kg/m²	
Time lag (φ)	14.34 h	

CURRENT FLOOR UNDER ROOF CONSTURCTION

Type of component	Floor on external space

Layers		d	ρ	μ	c	λ	R	opz.
(int-est)		[cm]	[kg/m³]	[-]	[J/kg°C]	[W/m°C]	[m²°C/W]	λ→R
Internal surface							0.17	
I	concrete	13.0	2200	69	840	1.480		☐
II	eps	8.0	25	64	1250	0.042		☐
III								☐
IV								☐
V								☐
VI								☐
VII								☐
VIII								☐
IX								☐
X								☐
External surface							0.04	

Parameter	Module	Time shift
Internal thermal admittance (Y_{ii})	4.776 W/(m²K)	1.12 h
External thermal admittance (Y_{ee})	0.512 W/(m²K)	0.56 h
Periodic thermal transmittance (Y_{ie})	0.136 W/(m²K)	-5.97 h
Internal areal heat capacity (κ_i)	66.2 kJ/(m²K)	
External areal heat capacity (κ_e)	7.5 kJ/(m²K)	
Thermal resistance (R)	2.203 (m²K)/W	
Thermal transmittance (U)	0.454 W/(m²K)	
Decrement factor (f)	0.300	

Thickness (s)	21.0 cm	
Areal mass (m)	288 kg/m²	
Time lag (φ)	5.97 h	

SIMULATION RESULTS
A1&A2&A3&B1

Income (euro/year)2021	Current	Annual Electricity Cost	Annual Gas Cost	A0 Tot	Gas Consumption	Electricity Consumption	Total Consumption	EP-1 person	EP 2 person	EP-Lowest 1person	EP-Lowest 2 person
18762	R6-1	844	1685	2529	16683.16832	3184.90566	19868.07398	13%	7%	53%	27%
4760	R6-2	844	1060	1904	10495.0495	3184.90566	13679.95517	10%	5%	40%	20%
	R6-3	844	899	1743	8900.990099	3184.90566	12085.89576	9%	5%	37%	18%
	R6-4	844	1563	2407	15475.24752	3184.90566	18660.15319	13%	6%	51%	25%
	B1	Annual Electricity Cost	Annual Gas Cost	B1 Tot	Gas Consumption	Electricity Consumption	Total Consumption	EP-1 person	EP 2 person	EP-Lowest 1person	EP-Lowest 2 person
	R6-1	505	1616	2121	16000	1906	17906	11%	6%	45%	22%
	R6-2	505	799	1304	7911	1906	9817	7%	3%	27%	14%
	R6-3	505	616	1121	6099	1906	8005	6%	3%	24%	12%
	R6-4	505	1481	1986	14663	1906	16569	11%	5%	42%	21%
	A1	Annual Electricity Cost	Annual Gas Cost	A1 total Cost	Gas Consumption	Electricity Consumption	Total Consumption	EP-1 person	EP 2 person	EP-Lowest 1person	EP-Lowest 2 person
	R6-1	844	1292	1812	12792	3185	15977	11%	6%	45%	22%
	R6-2	844	918	1438	9089	3185	12274	9%	5%	37%	19%
	R6-3	844	761	1281	7535	3185	10720	9%	4%	34%	17%
	R6-4	844	1183	1703	11713	3185	14898	11%	5%	43%	21%
	A2	Annual Electricity Cost	Annual Gas Cost	A2 total Cost	Gas Consumption	Electricity Consumption	Total Consumption	EP-1 person	EP 2 person	EP-Lowest 1person	EP-Lowest 2 person
	R6-1	844	1228	2072	12158	3185	15343	11%	6%	44%	22%
	R6-2	844	867	1711	8584	3185	11769	9%	5%	36%	18%
	R6-3	844	738	1582	7307	3185	10492	8%	4%	33%	17%
	R6-4	844	1125	1969	11139	3185	14324	10%	5%	41%	21%
	A3	Annual Electricity Cost	Annual Gas Cost	A3 total Cost	Gas Consumption	Electricity Consumption	Total Consumption	EP-1 person	EP 2 person	EP-Lowest 1person	EP-Lowest 2 person
	R6-1	505	1209	1714	11970.29703	3185	4673.117878	9%	5%	36%	18%
	R6-2	505	843	1348	8346.534653	3185	3465.197086	7%	4%	28%	14%
	R6-3	505	731	1236	7237.623762	3185	3095.560122	7%	3%	26%	13%
	R6-4	505	1105	1610	10940.59406	3185	4329.883554	9%	4%	34%	17%

SIMULATION RESULTS
SC1&SC2&SC3&SC4&SC5

			SC1	Gas Consumption	Electricity Consumption	Total Consumption	EP-1 person	EP 2 person	EP-Lowest 1person	EP-Lowest 2 person	energyclass	
				16000	1905.660377	17905.66038	11%	6%	45%	22%	G	
				7910.891089	1905.660377	9816.551466	7%	3%	27%	14%	F	
				6099.009901	1905.660377	8004.670278	6%	3%	24%	12%	E	
				14663.36634	1905.660377	16569.02671	11%	5%	42%	21%	G	
			SC2	Gas Consumption	Electricity Consumption	Total Consumption	Tot cost per floor	EP-6 person	EP-Lowest 6person	energyclass		
				12792	3185	15977	4272	4%	15%	G		
				9089	3185	12274	3524	3%	12%	F		
				7535	3185	10720	3210	3%	11%	E		
				11713	3185	14898	4054	4%	14%	F		
			SC3	Gas Consumption	Electricity Consumption	Total Consumption	Tot cost per floor	EP-6 person	EP-Lowest 6person	energyclass		
				11881.18812	1905.660377	13786.8485	3410	3%	12%	F		
				7415.841584	1905.660377	9321.501962	2508	2%	9%	E		
				5841.584158	1905.660377	7747.244536	2190	2%	8%	D		
				10702.9703	1905.660377	12608.63067	3172	3%	11%	F		
SC4	PV Saving Costs	Heatpump Electricity Cost	Heatpump consumption	A3-HEATPUMP PV	Light Consumption	Total Consumption	Tot cost per floor	EP-4 person	EP-Lowest 4person	energyclass		
	324	1073.993399	4052.805281	1254.993399	683.0188679	4735.824148	2509.986799	3%	13%	C		
	324	758.2673267	2861.386139	939.2673267	683.0188679	3544.405007	1878.534653	3%	10%	B		
	324	645.4455446	2435.643564	826.4455446	683.0188679	3118.662432	1652.891089	2%	9%	B		
	324	983.9108911	3712.871287	1164.910891	683.0188679	4395.890155	2329.821782	3%	12%	B		
SC5	PV Saving Costs	Heatpump Electricity Cost	Heatpump consumption	A4-HEATPUMP PV	Light Consumption	Total Consumption	Tot cost per floor	EP-4 person	EP-Lowest 4person	EP-6 person	EP-Lowest 6person	energyclass
	324	1057.376238	3990.09901	1238.376238	683.0188679	4673.117878	2476.752475	3%	13%	2%	9%	C
	324	737.2772277	2782.178218	918.2772277	683.0188679	3465.197086	1836.554455	2%	10%	2%	6%	B
	324	639.3234323	2412.541254	820.3234323	683.0188679	3095.560122	1640.646865	2%	9%	1%	6%	A
	324	966.4191419	3646.864686	1147.419142	683.0188679	4329.883554	2294.838284	3%	12%	2%	8%	B

APE CERTIFICATES
ROOM TYPE 6 EXAMPLES

Codice A.P.E.	B_TYPE	DWELLING	Piano	E_Class	Energia elettrica	Solare termico	Teleriscaldamento
2019 113184 0064	C	6	0	G	48	813	20848
2021 313821 0087	B	6	0	F	92	796	20610
2019 113184 0049	B	6	0	G	61	774	20058
2018 113184 0176	C	6	0	F	59	811	19273
2017 113184 0150	B	6	0	E	62	803	19031
2018 113184 0163	A	6	0	G	57	771	17248
2022 112419 0041	A	6	0	E	82	788	17224
2022 112419 0040	A	6	0	E	81	789	16438
2017 103636 0007	B	6	0	E	71	769	15865
2021 313821 0098	A	6	9	E	76	765	12250
2019 113184 0053	B	6	9	E	52	802	11968
2017 102351 0115	B	6	9	D	52	803	11848
2018 102351 0007	B	6	9	D	52	803	11848
2016 103636 0005	A	6	9	D	45	779	11682
2018 102351 0008	B	6	9	D	52	803	11642
2015 201195 0071	A	6	2	G	2848.6499	1018.25	11215.79
2015 201195 0100	A	6	2	G	2861.6499	1300.14	11061.1299
2022 313821 0117	A	6	4	E	74	788	10520
2022 313821 0090	A	6	9	D	98	781	10456
2018 102351 0006	A	6	9	D	48	771	10386
2017 113184 0149	A	6	9	D	48	771	10386
2022 313821 0043	B	6	8	E	78	818	10192
2018 113184 0174	A	6	9	E	48	771	10127
2022 313821 0089	A	6	4	E	73	789	9802
2022 112419 0042	A	6	4	D	73	789	9782
2022 313821 0088	A	6	7	E	73	789	9708
2024 113181 0009	A	6	8	D	73	785	9699
2019 113184 0050	B	6	2	E	48	802	9356
2019 113184 0052	B	6	7	E	48	802	9356
2019 113184 0058	B	6	1	E	48	802	9356
2019 113184 0059	B	6	7	E	48	802	9356
2021 313821 0088	B	6	1	E	77	796	9309
2018 113184 0169	C	6	5	E	46	807	9279
2019 113184 0057	B	6	4	E	48	803	9153
2019 113184 0060	B	6	4	E	48	803	9153
2016 103636 0004	A	6	5	D	41	779	8767
2019 113184 0061	A	6	4	E	45	771	8725
2018 113184 0002	B	6	2	D	48	803	8649
2018 113184 0003	B	6	3	D	48	803	8649
2017 113184 0147	B	6	2	D	48	803	8649
2019 113184 0062	A	6	1	E	45	771	8599
2019 113184 0048	A	6	6	E	45	771	8595
2018 113184 0173	B	6	5	E	48	802	8502
2017 102351 0117	B	6	8	D	48	803	8446
2016 103636 0002	A	6	5	D	40	779	8320
2018 113184 0184	B	6	5	E	48	802	8303
2018 113184 0179	B	6	8	E	48	802	8303
2018 113184 0004	A	6	5	D	45	771	8159
2018 113184 0005	A	6	6	D	45	771	8159
2018 113184 0160	A	6	1	E	45	771	8024
2022 313821 0103	B	6	4	D	75	811	7994
2021 313821 0085	B	6	1	D	75	796	7900
2019 113184 0063	A	6	7	E	44	771	7695
2018 113184 0186	A	6	3	E	44	771	7595
2018 113184 0164	A	6	3	E	44	771	7595
2018 113184 0165	A	6	8	E	44	771	7595
2016 103636 0313	A	6	9	D	47	745	7589
2016 103636 0136	A	6	4	C	45	779	7249
2018 113184 0175	A	6	6	E	47	762	7237
2017 103636 0006	B	6	6	C	57	769	6618