THE CROSSDOCK

AA E+E · MSc/MArch Sustainable Environmental Design · 2011/12 · Architectural Association School of Architecture
Term 2 Project | Isle of Dogs | Danah Dib · Ignacio Medina · Sandra Mayumi Morikawa · Filippo Weber

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"I certify that this piece of work is entirely my/our own and that any quotation or paraphrase from the published or unpublished work of others is duly acknowledged."

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CONTENTS

Introduction

This Term's design project, The Cross Dock, is a continuation of our Refurbishing the City research agenda introduced in the first term. Its purpose was to build on the findings of last term's case studies, providing a vehicle for design explorations that make use of the principles and tools introduced by the taught programme. The design proposal explores future visions of the city, following from the London 2020 Design Charrette, the Term 1 lectures and project fieldwork, and this Term's study trip. The Project brief suggested a reflection on urban morphology, transportation, built form and environmental design focusing on housing and home-work environments.

The Project team drew upon the results of last term's fieldwork and simulation studies to set design priorities and establish formal, typological, functional, programmatic and environmental design criteria. Design proposal aim to contribute to environmental sustainability and quality of life in cities. Occupant thermal and visual comfort are achieved without recourse to non-renewable energy sources based on the application of passive techniques and adaptive architecturing. The Project team addressed the remaining energy end-uses in buildings through the application of renewable technologies. Lifestyle trends, developments in the technology of domestic appliances and climate change scenario were reviewed to establish the likely impact of the proposal in the future on people's comfort and energy use. Finally, the proposal took account of the embodied energy and environmental impact of the proposal.

Key objects that lead to the team proposal

Improve environmental conditions and the quality of life in cities
In order to improve the current scenario of Isle of Dogs, made out of poor relationship between buildings and the urban context - residual unused open spaces, poor pedestrian activities and neglected canals that lead to the social deprivation of the island - a broader solution was proposed: the Crossdock. Organically incorporating the opportunities and constrain of the site with the surroundings, it aims for a further development of the urban context. The proposal seeks for a symbiosis between the buildings and their surroundings, making use of the environmental potential of the area offered by the canals.

On the selected site, the development of the Crossdock takes shape by following the larger scale strategies. The sought symbiosis is created by an organic environment that, by melting together built and outdoor spaces, promotes the use of the latter through the design of comfortable outdoor spaces and, at the same time, reducing the building's impact on the city, creating better micro-climates. This result is obtained by rearranging the layers of the city - the open, the built and the green - creating a fluid landscaped ground floor which integrates commercial facilities and natural environment, linking together the canal and its surrounding. Reinforcing the wanted mutual interactions between the different components of the city, the passive solar residential buildings are elevated, leaving the public space free from obstruction, to move towards the Sun and eliminate the space heating systems. (see Chapter 2.5).

Achieve independence from non-renewable energy sources
In order to achieve independence from non-renewable energy sources, the group took advantage of the multiple benefits coming from approaching the design as a generative process that tries to reach a beneficial symbiotic integration between different part of the design program.
Developing further the residential use, as suggested by the guide brief and on the line of the goals of the team's brief of moving away from the traditional definition of comfort to engage the inhabitant in the process of seeking his/her personal definition of what is comfortable, space heating systems were eliminated to be substituted by bioclimatic passive solar techniques. In fact, avoiding systems is to the group's mind the key point to decrease energy consumption in buildings, since "buildings don't use energy: people do" (Janda, 2009). Since the largest source of domestic energy consumption in UK is taken down, water heating and residual energy loads was addressed making use of the solar energy.

Develop the architecture of sustainable environmental design
To develop the architecture of sustainable environmental design, the conditions that make the inhabitant engaged in the process of seeking his/her personal definition of what is comfortable, has to be developed. In order to take distance from the previous conventional concept of providing the comfortable environment through the design of building services and to make the inhabitant appreciate the possibility of achieving comfort through sustainable means, the project aims to achieve what Nick Baker (2004) defined as "natural ambience" which is the package of environmental stimuli created by direct contact with the natural context. The symbiosis was assembled by a generative process that analysed requirements, challenges and impact of the active role of users, functional complexity, environmental quality and specificity of the climate and the location.
The ground floor, mixing together the environmental potential of a park and the sheltering advantages of a trench, creates a diverse landscape that provides the user with a variety of different environmental outdoor qualities - that also benefits the indoor spaces.
By elevating the residential building from the ground floor landscape, the apartments are flooded by the valuable sun presence, meant as a tangible mean for appreciating environmental sustainability in London thanks to the positive stimuli that it generates. The mutualism between indoor and outdoor spaces is also addressed by the creation of an elevated garden that creates a buffer zone towards the north from which the users benefit both socially and environmentally, increasing the spacial complexity of the residential units.

Demonstrate transparency in the process as well as the outcome of design
Transparency in the process as well as the outcome of design is demonstrated by the architectural process which was shaped by environmental strategies. The report will be informed by the sources of information that defined the different design hypothesis and it will show the evidences that lead to the outcome of the proposal.
The report's structure will be balanced between architectural research and the environmental considerations and studies that informed every fundamental step of the design process. It adopts the environmental design criteria that were asked to be addressed in the guides brief.

The following main topic were addressed by the design proposal and are further explained in referenced chapter of the report.

Strategies for refurbishing the city
The urban intervention: "Cross Dock" (see Urban strategies proposal, chapter 1.3)
The symbiosis between buildings and the urban-natural context and in between the different parts of the building (see Design concept, chapter 2.4)
see also:
Creating the symbiosis,chapter 3.1

Specific functional and environmental improvements over built precedents and current benchmarks
Promoting the active role of the user to achieve him/her comfort (see Providing opportunities, chapter 4.1)
Moving away from conventional space heating system (see Environmental Criteria, chapter 4.4)

Bioclimatic techniques for space heating, ventilation, cooling, lighting
They were based on an intense use of the opportunities given by the energy of the "sun" (see pre-design studies and strategies, chapter 2.3, Environmental criteria, chapter 4.4)
see also:
Daylight factor analysis, appendix 4.2.1

Adaptive opportunities for occupant thermal and visual comfort
it has been provided through internal flexibility, envelop adaptability and through offering spaces of different environmental qualities (see creating the symbiosis, chapter 3.1, Providing opportunities, chapter 4.1, private spaces, chapter 4.2)

Use of renewable energy sources to cover residual loads
Starting from reducing the use of energy by removing the heating systems, the residual loads were covered using solar strategies (see Energy and waste, Chapter 4.6)

Adaptation to changes in occupancy and outdoor climate
They were met through flexible units and making use of the potential of the northern buffer (see Changes, chapter 4.5)

Choice of materials and finishes
They were driven by completing the strategies of passive solar design, promoting the awareness of the inhabitant and the embodied carbon and energy (see Materiality, chapter 4.3)

I _ REFURBISHING ISLE OF DOGS

1.1_SITE SELECTION

As part of the definition of **our brief**, the site selection presented itself as a key aspect for the development of our project.

The **selection criteria** followed the Term 2 Project's brief of **Refurbishing the City** as it focused in an urban environment that would allow us to intervene in the hopes of increasing complexity.

The site should be allocated within an **existing urban fabric in need of diversification, urban activities and social interaction**. Alongside, the **proximity to the city centre** was very important, as well as the possibility to **explore the urban complexity**.

Within the Areas of Opportunity defined by the The London Plan, **Isle of Dogs** called the group's attention for presenting all the characteristics previously established (see Figs. 1.1.1 and 1.1.2).

Furthermore, when selecting the site, an area under current redevelopment called the group's attention. In the transition between the Financial District and the residential area of Isle of Dogs, the site by the **Millwall Inner Dock** offered the unique opportunity of combining the **urban scenario** with a **waterfront** (see Fig. 1.1.3).

SELECTION CRITERIA

1. EXISTING URBAN FABRIC IN NEED OF DIVERSIFICATION;
2. IN NEED OF URBAN ACTIVITIES AND SOCIAL INTERACTION;
3. PROXIMITY TO THE CITY CENTRE;
4. URBAN COMPLEXITY.

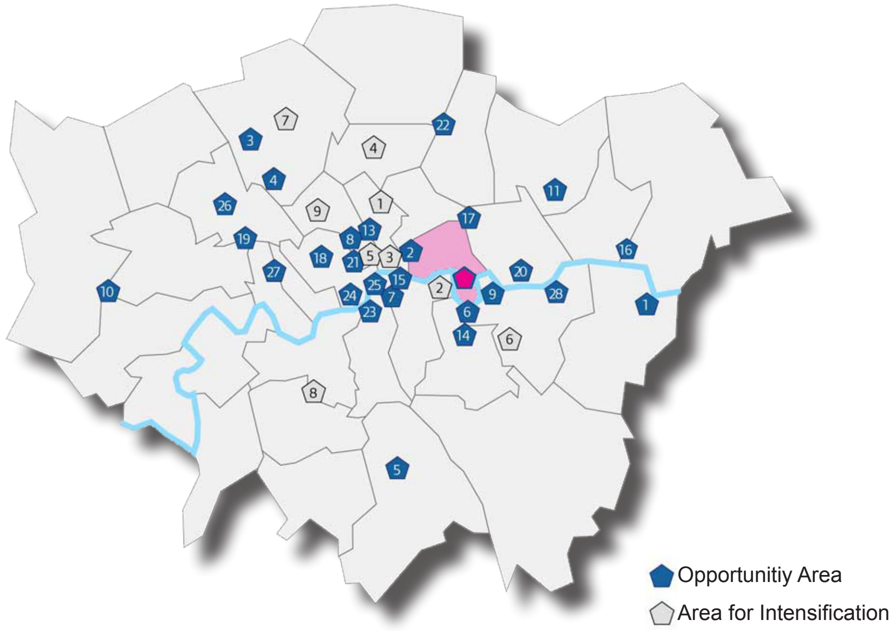


Figure 1.1.1 Opportunities Areas and Areas for Intensification. The London Plan. Source: After GLA (2011).

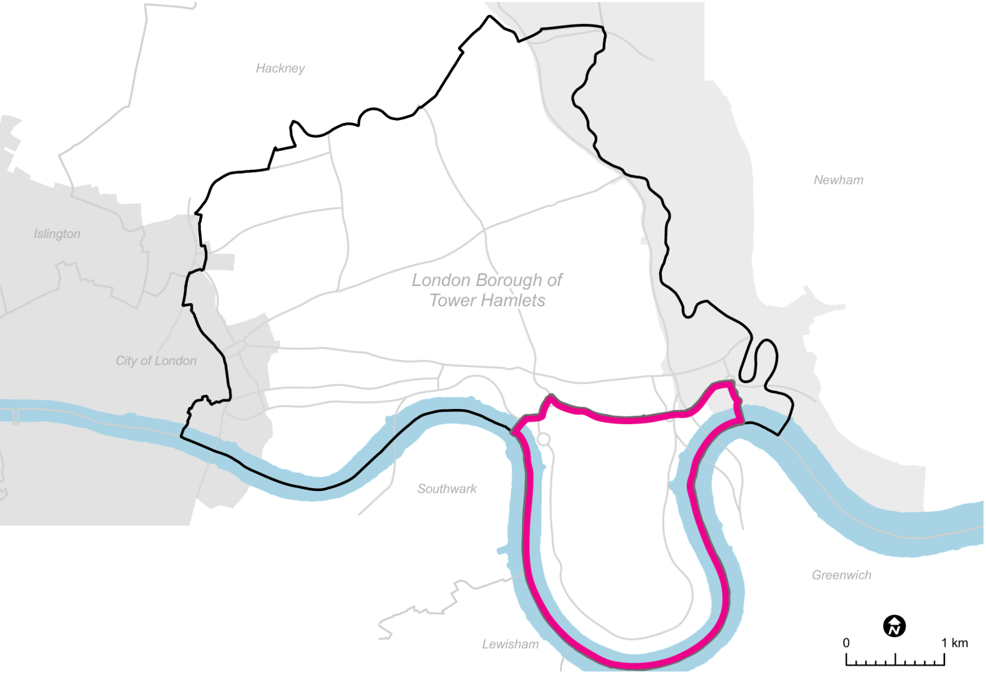


Figure 1.1.2 Isle of Dogs. Source: After Isle of Dogs Action Plan (2007).

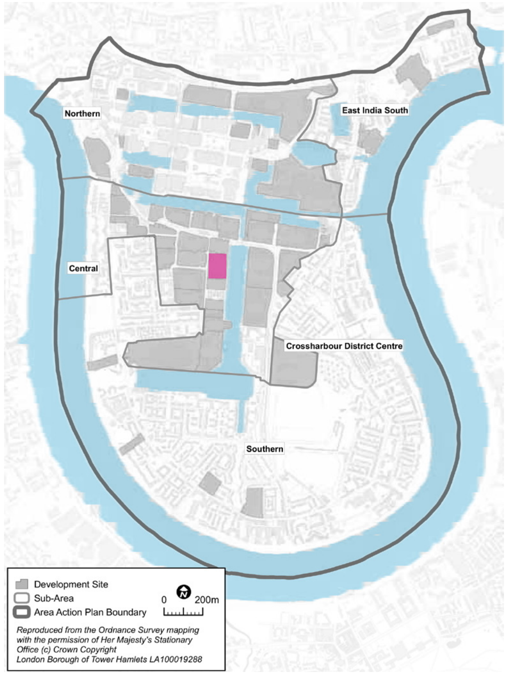


Figure 1.1.3 Development Sites. Source: After Isle of Dogs Action Plan (2007).

1.2_Urban Context

With its main activity being pastureland until the 1800s, Isle of Dogs began its urbanization after West India merchants petitioned Parliament for permission to build enclosed docks, due to an overflow of ships in London - starting defining the specificity of the Isle of Dogs given by the canals. The West India Docks opened in 1802, on the northern part of Isle of Dogs. Due to the increased activity, Isle of Dogs grew in population, with skilled workers and labourers. Streets and villas were built in order to accommodate them and, by the 1860s, the Island had a population of 14.000 inhabitants. As the shipbuilding industry decreased, industry flourished and the "Island" continued to grow, with a settled working-class community.Damaged during World War II, the reconstruction of the Island led the local authority towards building new connections and housing. This reconstruction was directed not only to the previous residents but also new population from other parts of London.

The Island prospered with increased internal connections, but due to poor bus services, car-ownership was higher than elsewhere in the Borough and the end of the 1960s, the Island was also known as "the forgotten island". By the 1970s, industry began to move away from the Island, towards other parts of London and with the closing of the West India and Millwall Docks, Isle of Dogs began its decay.In order to move away the area from its decadence, the London Dockland Development Corporation was created From the Greater London Development Plan (1967) in 1981. While the West India Docks was developed towards office buildings - Canary Wharf, the remaining part of the Island was developed mainly for housing. With 4.000 new homes built by 1997, Isle of Dogs presented itself as an opportunity of lower price houses located close to the City of London. Within the occupation redevelopment, the question of transportation was raised and major planning in this area took place. The DLR line was opened, increasing connections to and from the Island, which were - up to that point - mainly by bus. Moreover, the Jubilee Line tube extension played an important role in the redevelopment's success, opened in 1999. The London City Airport and River services are also connectivity features of the area, which also expects to receive the Crossrail station by 2017.

In 2000, the Millennium Quarter Masterplan was developed (MQMP 2000), establishing the ongoing redevelopment which surrounds our project's site. It is mainly focused in attracting new residents from Canary Wharf's influence. It is visible the expansion of the financial district's model, with an offer of smaller units with a high end-price.

It is true that many improvements can be seen from the deprivation scenario from the 1970s to today, but it is also important to raise the difference from Canary Wharf to the inner part of Isle of Dogs. In fact, from the working residents of Tower Hamlets, approximately 5% work inside the Borough, representing around 7% of the Borough's workers (GLA 2010). This indicates that although the financial district offers job opportunities, lower skilled previous residents have not been addressed as a main focus. The Borough suffers from a low employment rate, with 35 per cent of its inhabitants being economically inactive - the highest average in the UK. Contradictory, Tower Hamlets has also the 4th highest density of jobs. Being 72.5 % of those jobs in finance, banking and insurance, it is safe to say that the density rate should be accredited to Canary Wharf. (see Table 1.3.1).

With a population of 55% non British and 110 spoken languages, the cultural diversity aspect should be seen as an important opportunity for the Borough to prosper. Current population is also expected to grow in the next decades, exceeding the average growth in London and UK. From that, the already existing deficit in housing is only expected to grow bigger. Together with thirty per cent of households in the Borough falling into the category of overcrowded environments, those aspects reinforce the fact that the Borough is the third most deprived in London.

CULTURAL DIVERSITY	**55% not British** **110** languages
POPULATION	**40%** estimated population growth by 2025 **35%** of young people residents (most likely under 19s)
HOUSING	**25%** of unsuitable housing (2004) **30% of households registered as overcrowded** **low** housing affordability **43.000** new homes by 2025
SOCIAL DEPRIVATION	**3rd most deprived Borough in London** **75%** of children from low income families
EMPLOYMENT	**60%_lowest employment rate in London** **35%_highest proportion of economically innactive residents in the UK.** **4th highest density of jobs of all the London Boroughs** **72.5%** jobs in Finance and Banking and Insurance

Table 1.3.1 Profile of Tower Hamlets, section 2 - Socio-Economic. Source: After Tower Hamlets Conservation Strategy (2010).

References LDDC Monographs
The Island History Trust

1.3 _ Urban strategies proposal

Whereas it is true that transportation connections have been greatly improved in Isle of Dogs since the 1980s, it can still be called an Island (see Fig. 1.3.1). In fact, with the Thames and Canary Wharf as physical barriers, increased transport connections are not strong enough to break also the **psychological aspect of isolation**. Isle of Dogs is in need of a redevelopment that would bring a high social outcome. The incentive for employment with the same levels of qualification of its residents, and also stategies that would increasing it, is of great importance.

Canary Wharf (see Fig. 1.3.2) seems to be the focus of attention of the recent developments within the area, taking little consideration of the existing local residents. While it is true that the financial district should be considered as an ally because of the potential day-time visitors and future new residents, a conscious plan should consider integrating these two different worlds.

As reference, both cases The High Line, NY and Passeo del Turia, Valencia (see Fig. 1.3.7 and 1.3.8) took advantage of an existing physical and historical context and transformed them into vibrant public spaces. As a rock thrown into still water, the reverberating waves progressively affect its surroundings, promoting regeneration. Giving the main focus into public spaces, increasing pedestrian activity, they achieve - indirectly - economic growth for the area. In that sense, residents can profit not only from the enhanced quality of life, but also from its attractiveness to visitors and increased job-related opportunities.

With the potential from the existing canals (see Fig.1.3.3), Isle of Dogs has an unique urban configuration which could play an important role in today's redevelopment efforts. By providing unique open public spaces and a diversity in use for the waterfront, embracing and advertising the qualities of the existing canals, the heritage can rescue not only the identity of the island, but also attractiveness.

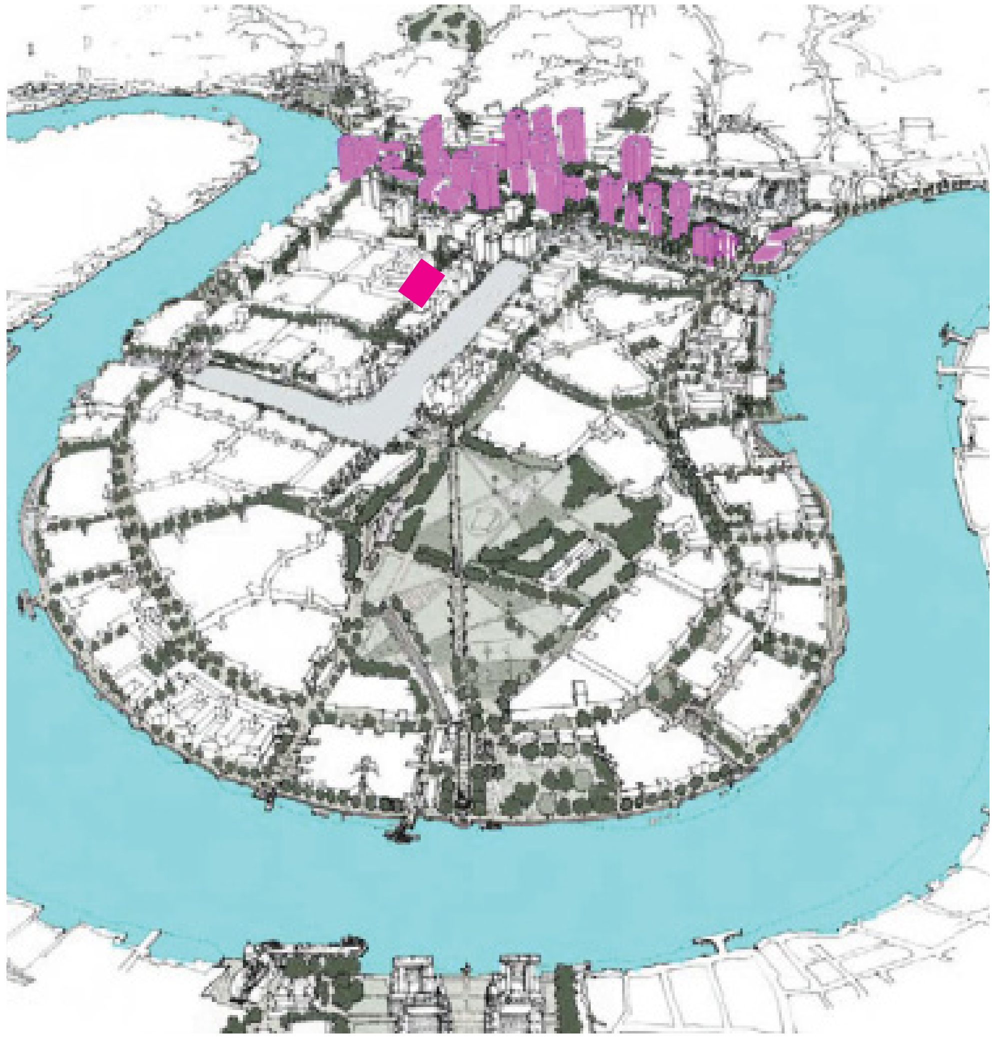


Figure 1.3.1 Isle of Dogs
Source: After Millharbour Quarter Design and Access Statement (2009)

What can be seen today is the appearance of new developments of mixed-use with a public ground floor for retail use (see Fig. 1.3.4). The formula is correct, but it is not unusual to find scattered residual open spaces, with low connectivity between each other, the urban fabric and the existing canals (see Fig. 1.3.5). This fact has lead to a disconnection between the different components of the urban context and mainly between buildings and the open spaces.
Furthermore, Isle of Dogs, in many occasions, has a poor pedestrian street level with very low commercial activity (see Fig. 1.3.5). As two 'functions' which complement each other, the success of a thiving community will depend on the new developments's design.

In the attempt of maximizing built area, many of the open public spaces area treated as **residual areas**, with poor solar access. Put together with the already un elcoming streets, pedestrians rush home, making community nearly inexistent.

> "You can neither lie to a neighbourhood park, nor reason with it. 'Artist's conceptions' and persuasive renderings can put pictures of life into proposed neighbourhood parks or park malls, and verbal rationalizations can conjure up users who ought to appreciate them, but in real life only diverse surroundings have the practical power of inducing a natural, continuing flow of life and use."
>
> Jacobs, J. (1961). The Death and Life of Great American Cities. Random House.

As addressed by Jane Jacobs, the social integration may be represented in the renderings of new developments and referenced in the Boroughs leaflefts, but it is evident that pedestrians are pushed away from streets if not designed with care.

The canals, instead of being treated as jewels from the History of the Island, are detached from their surrounding context. Without any interaction with the adjacent built environment, the canals have their opportunity backwards, sometimes increasing the aspect of abandonment.

Figure 1.3.2 Canary Wharf influence

Figure 1.3.3 Neglected Canals

Figure 1.3.4 New Redevelopment

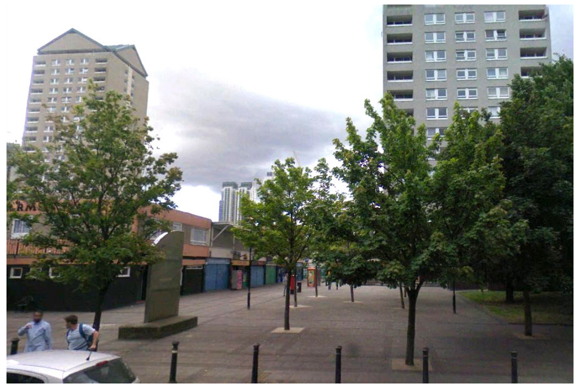


Figure 1.3.5 Residual Public Spaces
Source: google street view

Figure 1.3.5 Poor Pedestrian Activity
Source: google street view

The Crossdock

=

identity

regeneration of the canals

+

connectivity

complexity through connections

After analysing the site's past and current scenario, the group drew strategies for a better future outcome, addressing both issues and opportunities of Isle of Dogs.

The **Crossdock** which is the team's proposed urban scheme (see Fig. 1.3.8) reinforces the **identity** of the area by the **regeneration of the canals** to restore their original glory. This regeneration is achieved by the connection and improvements of the existing open spaces. These were once neglected and residual but by creating a connecting network, that links them together through naturals corridors along the canals, their potentials are promoted and it improves the pedestrian life.

Moreover, the proposal aims to re-qualify the environmental conditions and life in Isle of Dogs by promoting **the symbiosis between buildings and the natural-urban environment** which it wasn't appreciated in the existing urban context. By making use of the environmental potentials of the "cross dock", the strategy can lead to a improvement environmental qualities of both the indoor and outdoor.

By connecting the "Island" with the city and vice versa, the Crossdock creates **psychological and physical connectivity**, increasing the level of **complexity** of the island and forming a regenerative engine to deliver **social growth**, as it happened for the precedents of the High Line Park in New York and for the Paseo del Turia in Valencia.

More and more, cities are looking inwards and understanding where can they do better. In the future urban context scenario, the Crossdock is the mean for Isle of Dogs to leapfrog into a new generation of urban connections, much more focused in a sustainable growth of goods, infrastructure and, specially, people.

In this sense the Isle of Dogs can make use of the transportation potentials offered by the water bodies and the surrounding river Thames that connects the city from east to west, crossing all the main north south transportation axis.

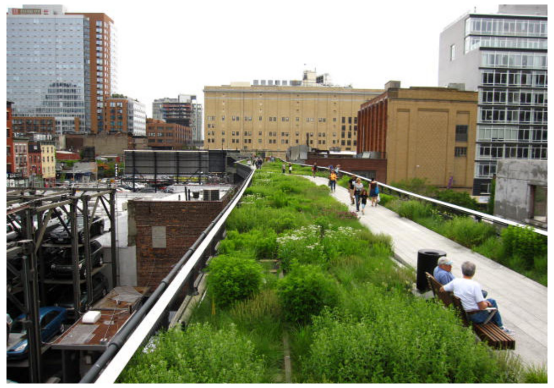


Figure 1.3.6 The High Line, NY
Source: www.metropolismag.com

Figure 1.3.7 Passeo del Turia, Valencia
Source: www.feetuphostelsblog.com

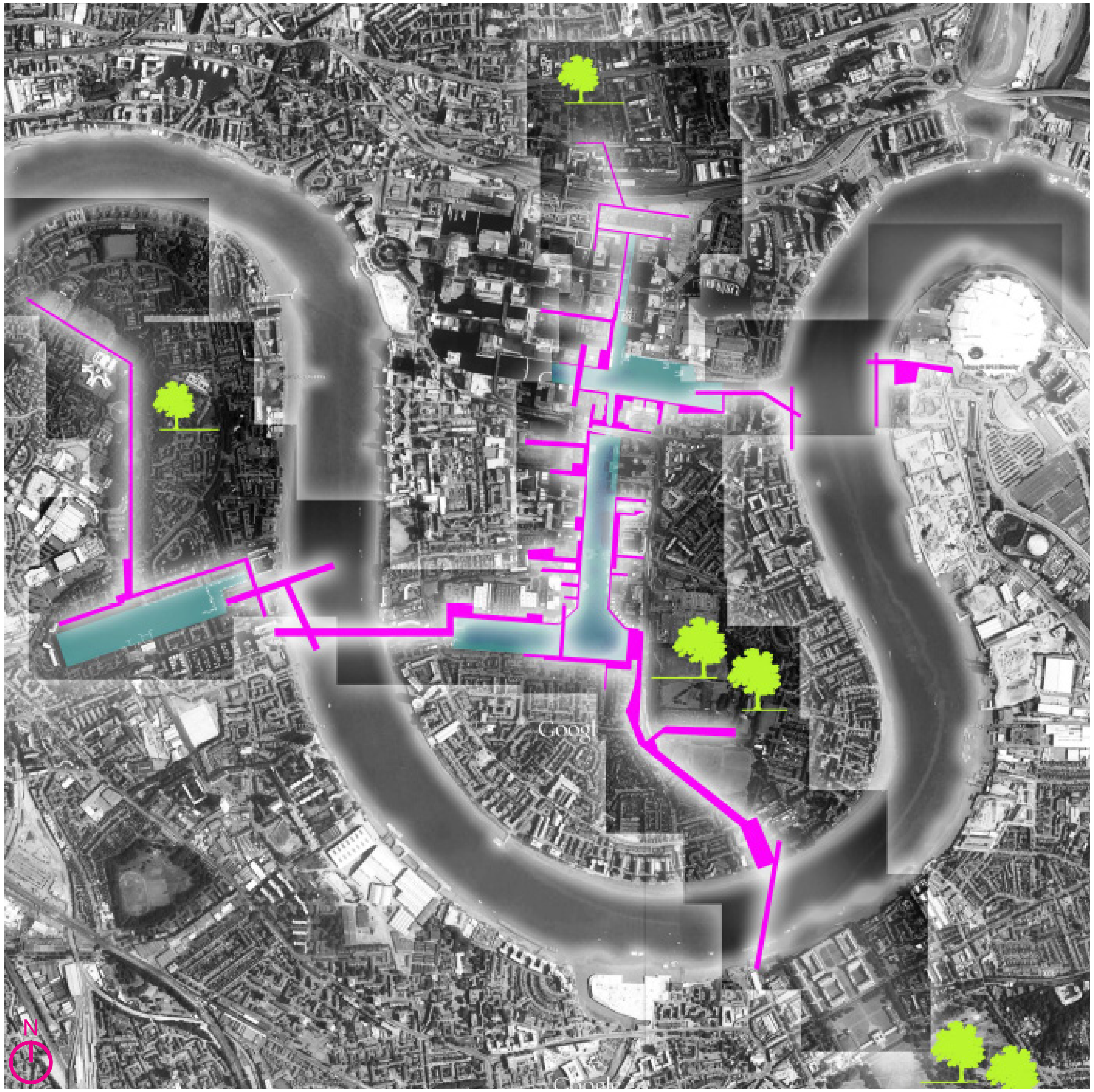
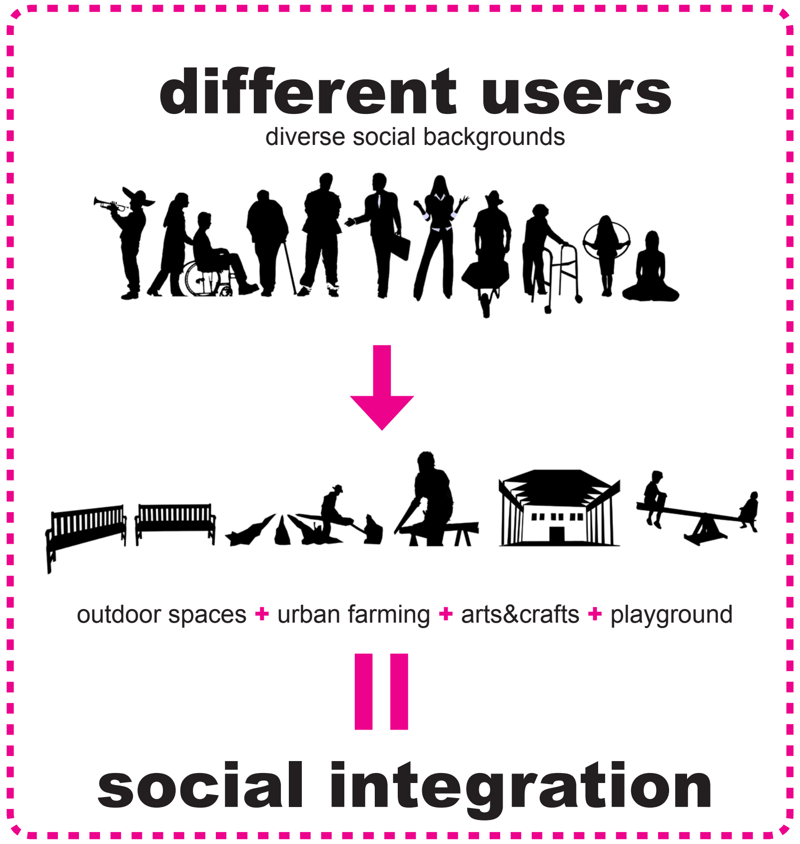


Figure 1.3.8 Crossdock

II_ ARCHITECTURAL INTERPRETATION OF SUSTAINABLE ENVIRONMENTAL DESIGN

Non-residential



different users

diverse social backgrounds

outdoor spaces + urban farming + arts&crafts + playground

=

social integration

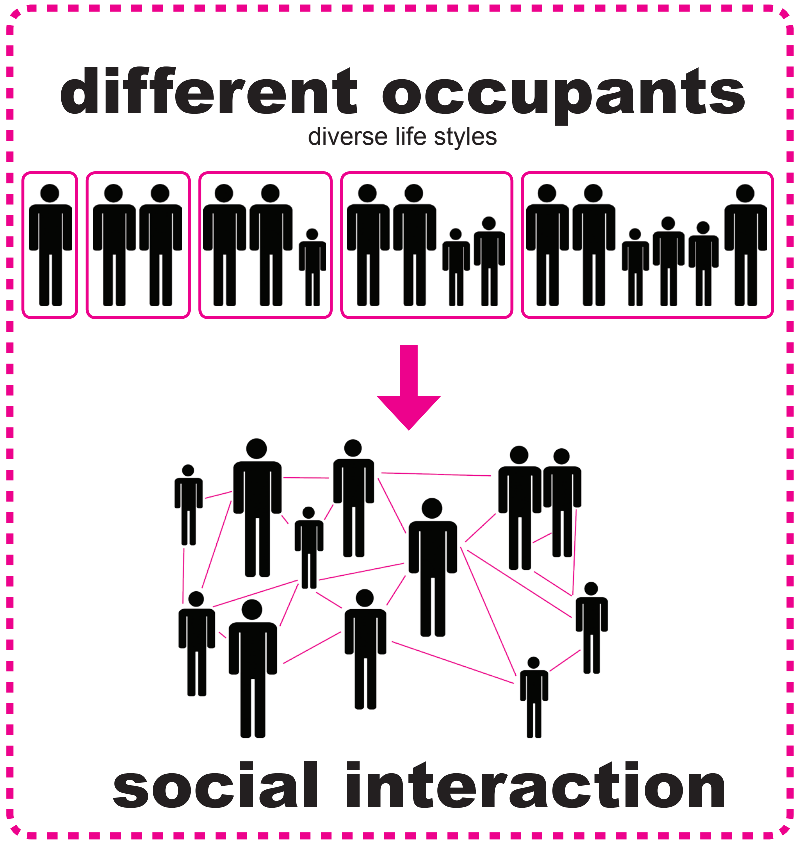
OFFICES - **WORKSHOPS**

LOCAL FARMING **MARKET**

LIFE BY THE **CANAL**

DIVERSE **PUBLIC** SPACES

Residential



different occupants

diverse life styles

social interaction

LIVING ROOM-KITCHEN

LAUNDRY

Figure 2.1.1 Plot Program Strategies

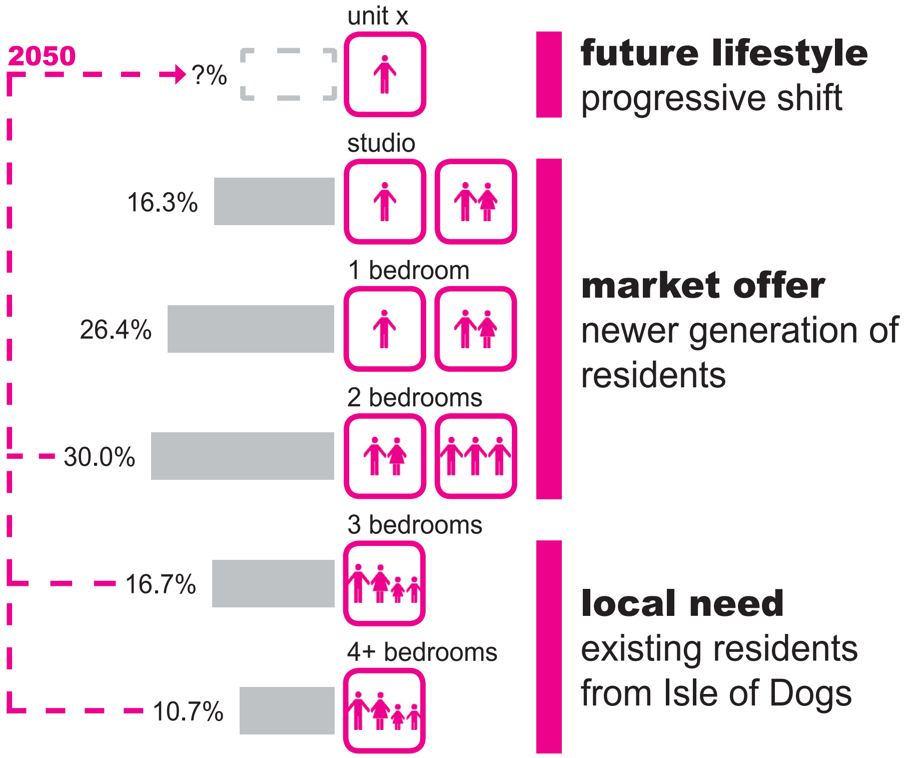


Figure 2.1.2 Unit type mix

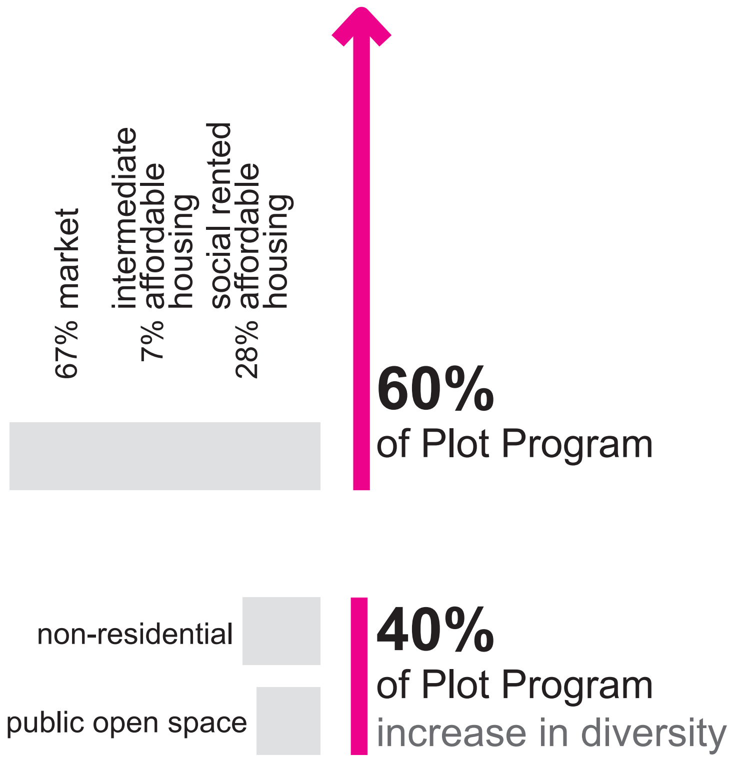


Figure 2.1.3 Plot Program

2.1_Team's project brief

The choice of site was driven by aiming to give an example of the concepts introduced in the "Cross dock" urban strategies (see Fig. 2.1.1). The site has a direct relation with the canal and offers the opportunity to make use of the environmental potential from the water environment, creating a **symbiosis between the new proposal and the existing surrounding**, made of residual open spaces and scattered retail on the ground floor.
Since the site is in a transitional area between Canary Wharf and the poor urban context of the "Island", it can attract both the neglected local residents and the professionals of the Financial District. The proposal targets both the users in order to encourage and promote social interactions between different parts of the existing society.

The proportion between residential and nonresidential proposed by the project brief modifies the Borough's standards, increasing the nonresidential uses to guarantee that enough stress is made in public and semi-public spaces, where social interactions most occur. In addition, it increases the local economic growth, addressing local unemployment and raising attractiveness of the area.
The percentage of nonresidential was increased of 10% until covering 40% of the program (see Fig. 2.1.3). This percentage include the pedestrian connections between the "Cross dock" on the canal and the residual spaces of the surrounding. Along them the open spaces and the ground floor facilities will be set: these are mainly shared workshops that can be used by the multicultural inactive existing society to start new activities.
The idea lies on the fact that the multicultural users of these facilities create diverse goods and products that make the "informal" markets attractive for the daily users. The nonresidential uses are complemented by a diverse green open space and offices that follow the same strategy of creating complexity through their interaction.

In fact being by the "Cross dock" this new **environmental array of opportunities** is part of the Brief's goal of increasing the attractiveness of the area, inviting not only local dwellers, but also workers from Canary Wharf and other visitors for lunch, dinner, bike ride or a stroll in a unique scenario where the resident's multiculturalism enriches and emphasizes the diversity offered.

Residential covers the remaining 60% of the plot: since the brief aims to increase social interaction between different parts of the existing society, a mix between social houses and market house is needed. The percentages that the Tower of Hamlet proposed for this area were thought to satisfy the project brief dividing the units between social and market in a good balance: 35% for first group and 65% for the second (see Fig. 2.1.2). Even though income levels between the two targeted groups are very distant, a common characteristic can be easily spotted: both are mainly not British and come from very different cultural backgrounds, often without a local social network. So, the proposal addresses social integration, creating the sense of familiarity, community and belonging through the provision of semi-private shared spaces within the residential building. The design makes use of the existing trend for smaller units in London (GLA 2006), minimizes the private and offers a range of semi-private spaces as shared facilities to the residents. Those areas, not only complement the choice of designing small private units, but also reinforce the idea of social integration and promote spatial variety.

The design proposal and its built form aim to create an enclosed and outdoor environment, private and semiprivate spaces that engage the inhabitant in the process of seeking his/hers personal definition of what is comfortable. This idea changes the role that the design proposal of the building should have for the inhabitant, **from providing a fixed definition of comfort achieved by building services, to offering the adaptive measures and opportunities**, making the **inhabitants active users in controlling the natural elements in order to achieve their comfort**. To take distance from the previous conventional concept of providing the comfortable environment through the design of building services and to make the inhabitant appreciate the possibility of achieving comfort through sustainable means, the brief aims to achieve what Nick Baker (2004) defined as **natural ambience** which is the **package of environmental stimuli** created by direct contact with the natural environment. In fact, this contact creates the diverse environmental conditions that field work has proven to be more preferable by the inhabitant. To his question if the kind of stimuli that the man needs in order to respond to them has to be natural, artificial or synthetic, the brief suggested a research towards the natural ones, individualizing between all the elements **the sun as the most valuable stimulus** for the inhabitant in London and to reach comfort through **bioclimatic passive techniques**.

Since the project's objective is to create a dialogue between the built and the natural environment mediated by the active role of the inhabitant, the scenario in which this natural environment would **change** has to be taken into consideration and analysed. In other words it must be assured that climate change, new life style and appliances efficiency will not affect the balance of this relationship and the indoor environment can be still maintained within a range that is acceptable. Moreover the internal environment of the units should provide the flexibility to be modified to meet the requirement of a working environment since the predicted trend is people working more from home.

2.2_Physical and climatic analysis

In the transition between the financial district (distance 500 metres) and the residential area of Isle of Dogs, the site is located in the Northern part of the Island, close to the South Quay DLR station (distance 100 metres), in an area called the Millenium Quarter. Currently under a redevelopment plan (MQMP 2000), the surroundings already follow the new plan for Isle of Dogs (see Fig. 2.2.1 and 2.2.2).

The North boundary comprises a hotel with two towers of 130m height, serving travellers from Canary Wharf (see Fig. 2.2.3). To the West (see Fig. 2.2.4), four future commercial buildings are expected to be built, the closest of them, of 100m tall. To the South, a residential building with a main body of 35m height and two towers of 65m, which poses the main challenges for solar access in winter (see Figs. 2.2.5, 2.2.10, 2.2.11 and 2.2.11). On the Southwest, a hotel with ground floor commercial facilities 100m height is planned to be built. Due to the importance that the future building will have on the site, they were also considered during simulations. The existing buildings do not have a commercial ground floor, whereas the future proposed projects will contain public spaces and commercial uses.

Having the East boundary to the Millwall canal as the only ‘open’ boundary of the site accentuates the close connection with the “Crossdock” (see Fig. 2.2.6). On he site a two storey building pre-exists and already partially demolished. The structural features do not show any particular environmental or architectural value to be addressed.

Figure 2.2.1 Project Site and Context

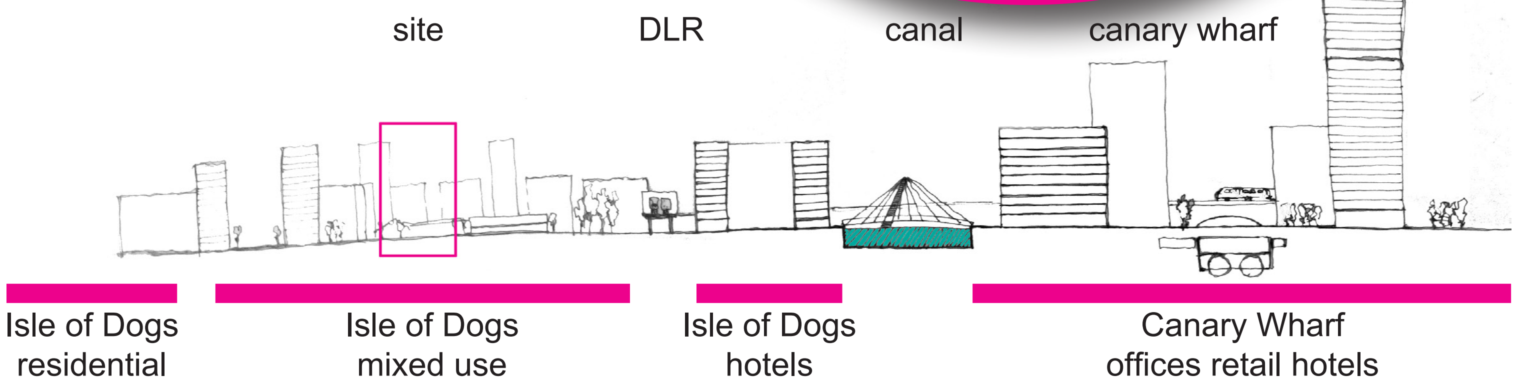


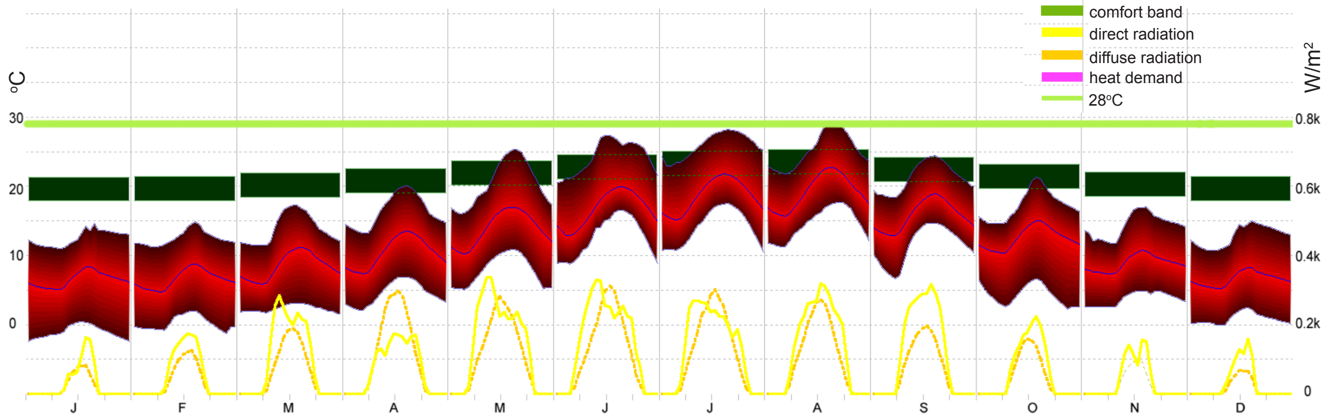
Figure 2.2.2 N-S section

Figure 2.2.3 NORTH boundary high-rise hotel towers

Figure 2.2.4 WEST boundary future commercial development

Figure 2.2.5 SOUTH boundary residential building

Figure 2.2.6 EAST boundary Millwall Canal



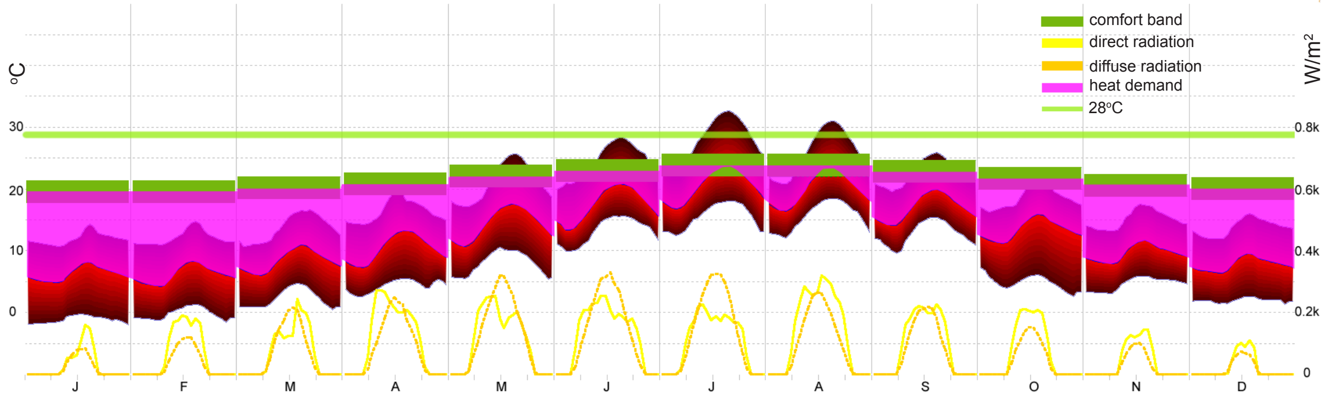


Figure 2.2.7 (above) Climate analysis for 2015
Source: after Tower Hamlets Weather File 1996-2005 [Meteonorm 6.1]

Figure 2.2.8 (below) Climate analysis for 2050
Source: after Tower Hamlets Weather File 2050 projections [Meteonorm 6.1]

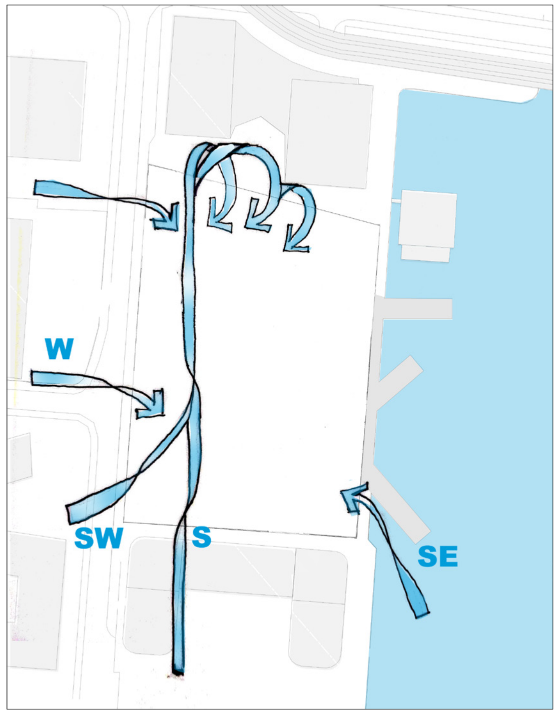


Figure 2.2.9 Plot's prevailing winds

By analysing the weather data of Tower Hamlets obtained from Meteonorm 6.1, for both a representative typical year and 2050 projection, it emerges that the heating period in both cases is the main issue to address. This can be seen in Figures 2.7.7 and 2.7.8, which illustrates plotted graphs of the weather data. The shaded magenta area drawn between the average daily outdoor temperature and the adaptive comfort band it represents the heat demand. Furthermore, taking into consideration a medium to high greenhouse gas emissions scenario based on a study for climate change (CIBSE 2005), the average temperature rise in summer is expected to be of 2K. Nevertheless, this average rise in temperature could be seen of not great threat, because the projection of external temperature only exceeds the upper limit of the acceptable temperature of 28°C - the green line in the graph - for less than 1% of the hours of the year. However, the future main concern relies in the possibility of more frequent heat waves which is addressed in the design proposal (see Chapter 4.6).

Zooming in to the scale of the chosen site, the high-rise neighbours of the plot result in greatly overshadowing the ground level in winter as illustrated in Figures 2.2.10, 2.2.11 and 2.2.11. And despite of the east boundary of the plot being unobstructed, the short sunpath during Winter is still obstructed by the residential building to the South of the plot. This obstruction is perceived until a height of approximately +25.00m, as the two stereographic graphs illustrate (see Figs. 2.2.13 and 2.2.14). The east boundary 'openness' by the Millwall canal may not have a big influence on solar access in Winter, but together with the other enclosing high-rise boundaries, creates high and unpredictable wind draughts. Furthermore, Because wind patterns are highly modified by the urban context, several CFD analysis were undertaken to understand the impact that the surrounding has on different directions of the prevailing wind. Figure 2.2.9 illustrates a schematic summary of this modification. Starting with the most frequent wind direction in both winter and summer which is from the south-west arc (see Appendix 2.2.1), it has been noticed that when the wind blows from the south and south west the towers on the north create a strong down draught that redirects the wind towards the south again, while the west wind arrives to the site through the canyons between the high rise buildings to the west and is redirected northeast on the north part of the site. Also the southeast wind was taken into consideration since the eastern boundary of the site is open towards the free space of the canal. In the eastern arc the southeast is the most frequent direction. This wind flow arrives to the site unobstructed without any noticeable pattern modification. Another important aspect to highlight is that, even if the sky variable conditions make the presence of the sun not always apparent in London during the long winter, the average global solar radiation on a horizontal plane during these months is between 500 W/m^2 and 1000W/m^2 . This fact makes the solar radiation an important mean to be used as a passive bioclimatic technique to rise the indoor temperature during the long winter. Moreover, due to its rare presence it becomes an element to appreciate as value for the psychological effect on people and an important source of external heat gain.

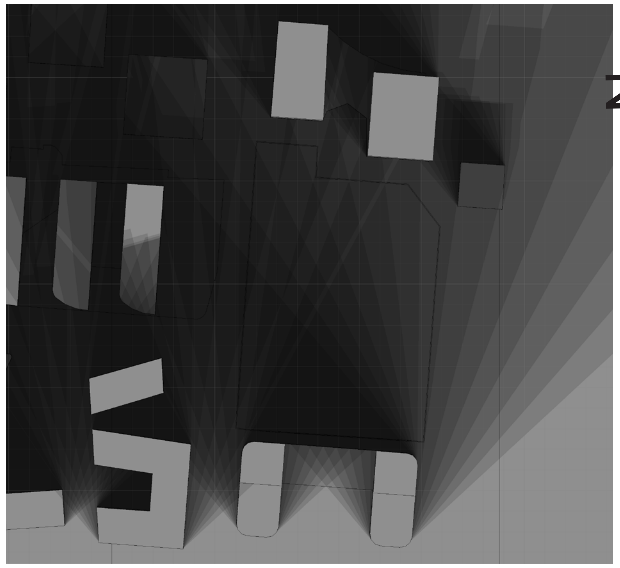


Figure 2.2.10 Plot's shadow overcast December

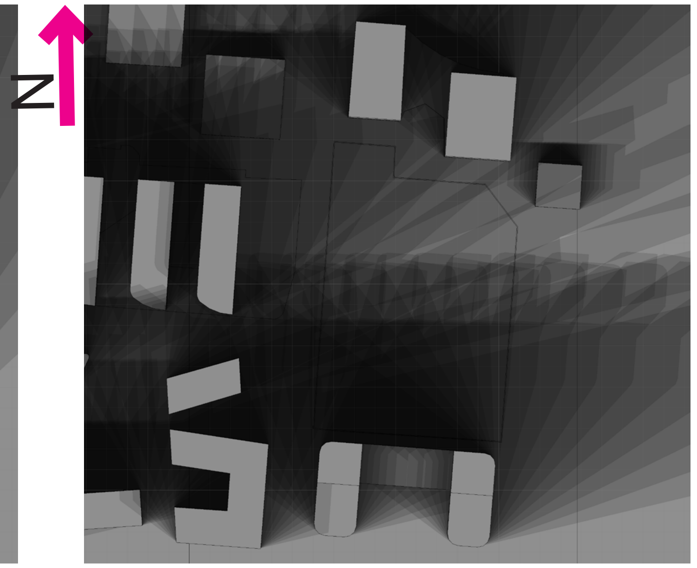


Figure 2.2.11 Plot's shadow overcast March

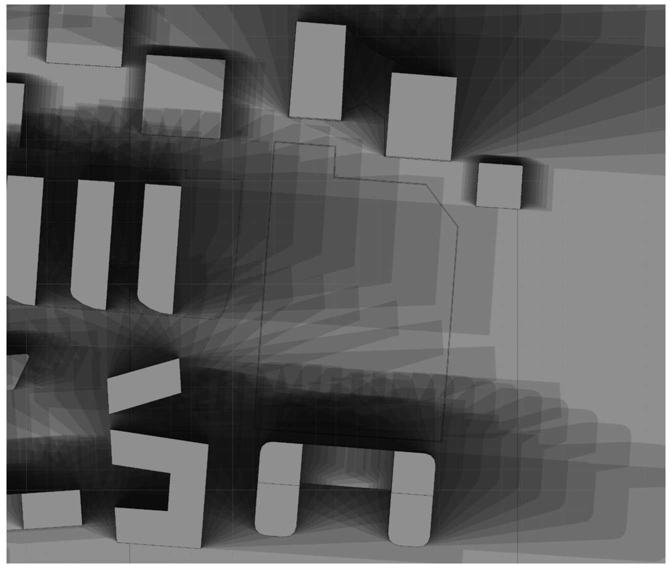


Figure 2.2.12 Plot's shadow overcast June

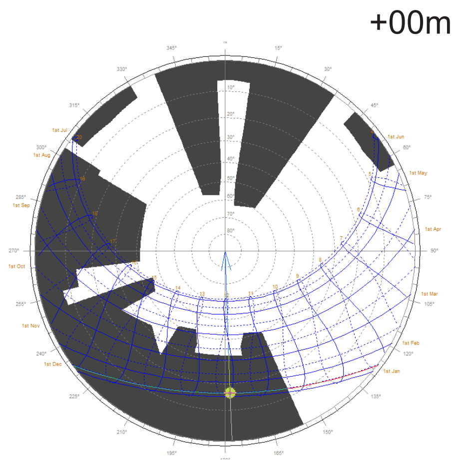


Figure 2.2.13 Stereographic Diagram for Center of the Plot +00.0m [Ecotect]

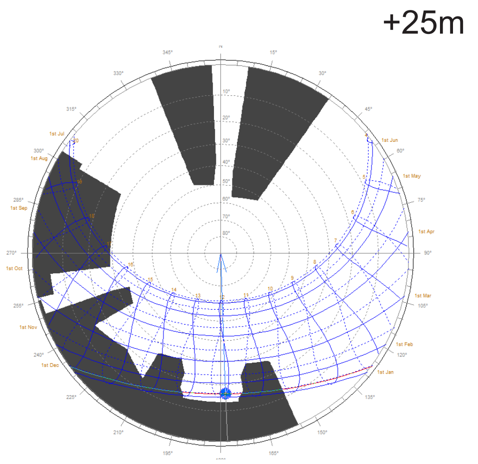


Figure 2.2.14 Stereographic Diagram for Center of the Plot +30m [Ecotect]

2.3_Pre-design studies and strategies

Public and Commercial Spaces

The Public and Commercial Spaces design took into consideration lessons learned from St Pancras Station and One New Change Building case studies. Both studies analysed retail and semi-open spaces, its requirements and behavioural-based effects on energy consumption, performance and comfort.

From St Pancras case study it has been learnt that commercial spaces do not need external sources of heat in winter due to the high internal heat gain. For Winter, the study proposed a change in behaviour, allowing the shop doors to be kept closed. In order to avoid heat dispersion during nighttime, double glazing and insulated shutters should be considered.
During the summer the strategy of coupling with the outside through leaving the doors open, is sufficient to remove the internal heat gain and keep the temperature within comfortable limits -due to the mild summer temperatures.

Lighting plays a major role in energy consumption when considering commercial spaces. From last term's cycle of lectures, contrast appeared as the key for decreasing energy consumption. Shop displays have to increase their lighting levels in order to have enough contrast for the goods to be seen from outside. By lowering lighting levels on the outside, displays can also lower their lighting levels and, therefore, decrease energy consumption.

For Offices and Workshops, much from the lessons learned could also be applied, since they present high internal heat gain comparable to commercial and they are too sensitive to lighting levels. It is important to stress that glare should be avoided in both cases.

Given that some of the nonresidential uses could be benefited from low solar direct radiation, the shaded ground floor (see figs. 2.2.10-12) presents itself as a suitable host for the above activities.
If in one hand, placing commercial uses in the ground floor is beneficial for internal performance, on the other hand, for colder seasons, outdoor comfort would not be able to improved by solar access. Taking the overshadowing of the ground floor of our site into consideration, the strategy for increasing outdoor comfort in winter is sheltering from the wind and, therefore, improving the physiological equivalent temperature (PET) of the users.

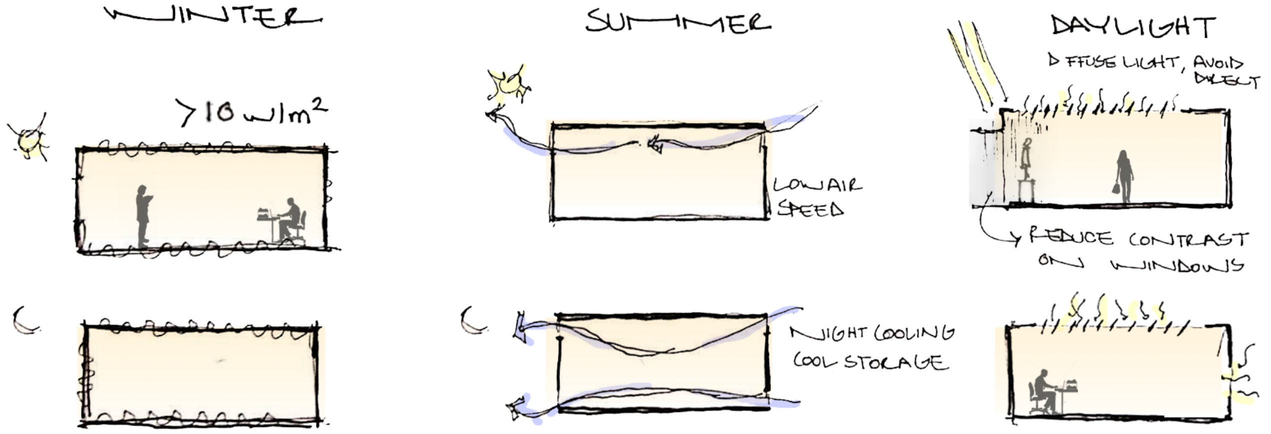
During Summer, when the site can be benefited by the presence of the sun, creating spaces with different solar access levels as a strategy, provides the user with the opportunity of choosing the most suitable environment according to his/her preference.

Another lesson learned from One New Change is how expectancy of colder/warmer temperatures, whenever in outdoors or semi-outdoors, can improve the psychological effect of comfort as indicated also by Baker (2001). Therefore, the main goal is only to provide shelter from extreme weather conditions.

As part of the Refurbishing the City agenda, introducing greenery into the site and reducing absorptive and reflective surfaces are valid strategies into the mitigation of Heat Island Effect.

high internal heat gain

Possibility of coupling offices and commercial



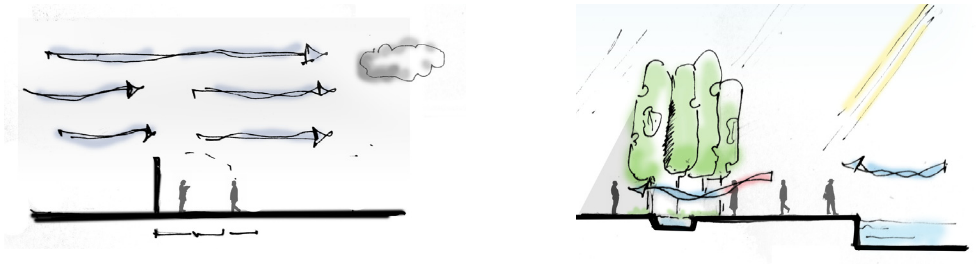
Containing the Heat Gain
Night insulation

Heat removing though cross ventilation
Low air speed
Night cooling and "cool" storage

Diffuse light
Commercial - general lighting with diffuse daylight
Reduce coontrast on windows

Figure 2.3.1 Offices and commercial strategies

Figure 2.3.2 Outdoor strategies



variety of environmental quality of outdoor spaces

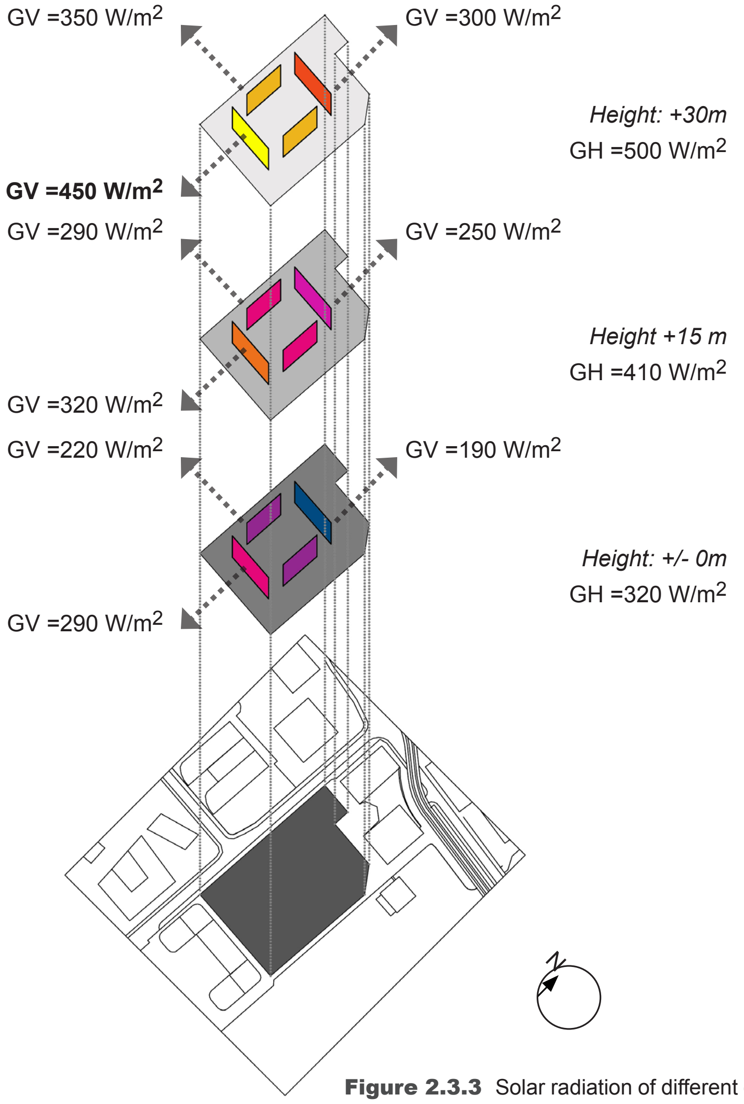
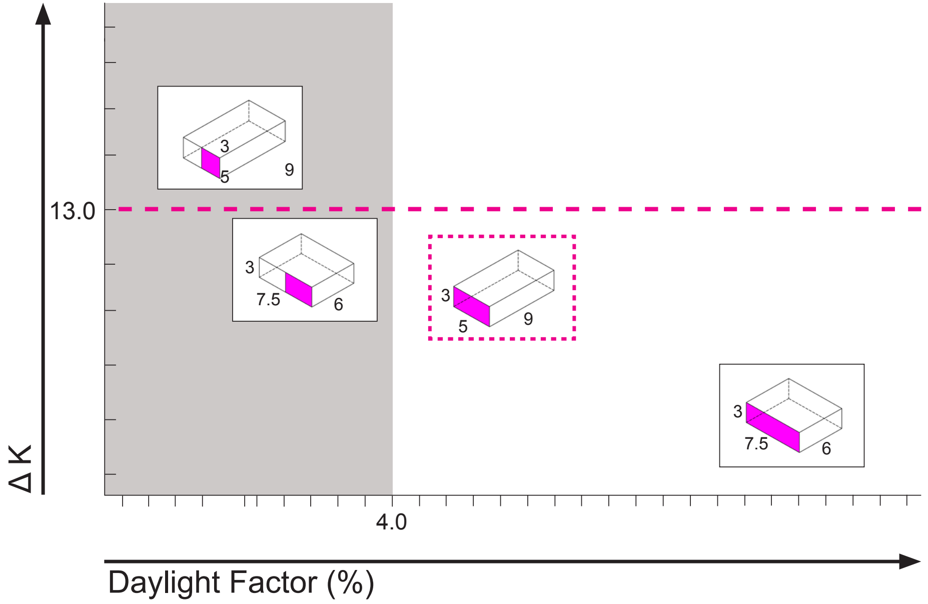


Figure 2.3.3 Solar radiation of different orientation at different heights

Typology: **1 bedroom apartment**



Typology: **2 bedroom apartment**

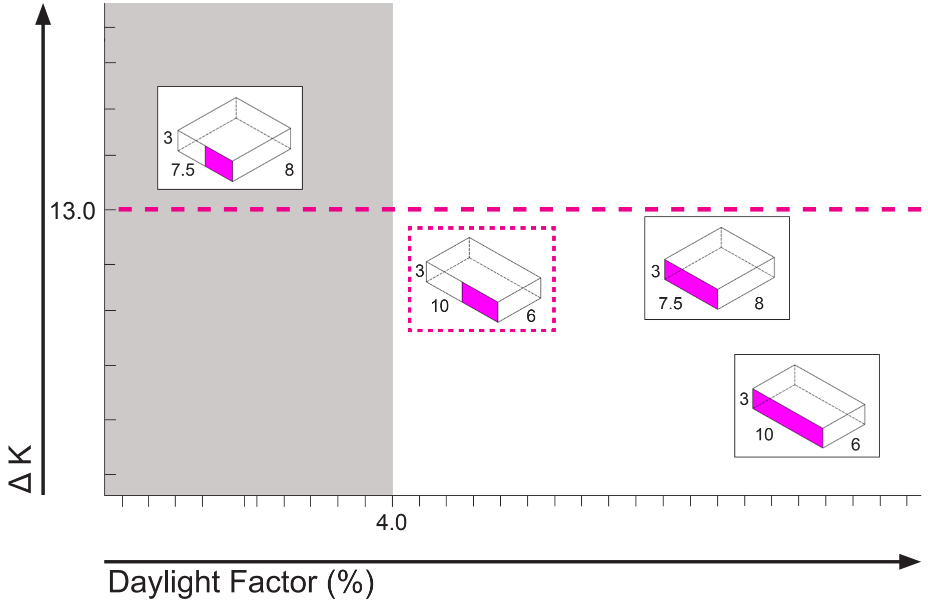
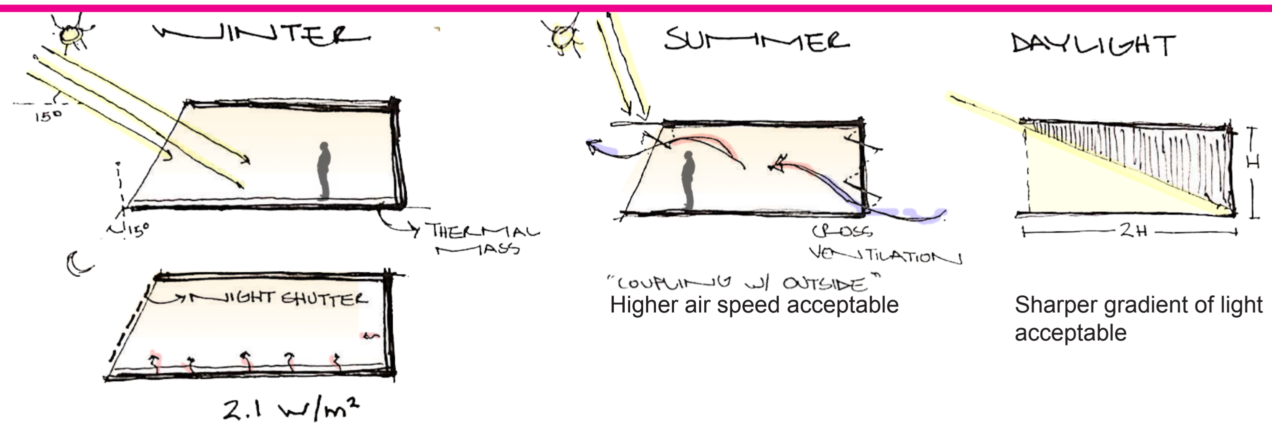


Figure 2.3.4 Mean Indoor temperature results



Solar heat source needed
Retain of the heat gain trough thermal mass and night insulation

Higher air speed acceptable

Sharper gradient of light acceptable

low internal heat gain

Figure 2.3.5 Apartments strategies

Private and semi-private spaces

For Residential Spaces, previous case studies were also taken in consideration, Central St. Giles and Fortune Green. Both studies analysed recent residential developments in London, which followed recent buildings regulation with high insulation levels and low infiltration rates.
From both cases, it can be seen that a 8K difference from the external temperature was easily reached during Winter, into apartments located in the middle of the building due to the internal heat gains and the low heat losses from the little exposed walls and windows. Windows can be both a source of heat losses or heat gain depending on the dimensions of the openings, their orientation and the property of the glass. Therefore, an arbitrary design of the opening in terms of dimension and aperture mechanism can influence their benefit as a thermal regulator of the internal temperature.

Through the Mean Indoor Temperature spreadsheet and the gross formula for calculating daylight factor (see appendix 2.3.2), the proportion between width, height and depth of the units and window to floor ratios was firstly defined. Several cases were studied by varying solar radiation magnitudes according to solar studies undertaken on different horizontal levels (see appendix 2.3.1) then those values were corrected for the different orientations on the vertical planes based on the climpro Solar availability plot surface chart that shows the irradiation relative to the total horizontal. The cases showed that higher magnitudes of solar radiation (more than 500 W/m^2 that are found on the higher levels of the plot) are needed in order to rise the temperature within the apartments to values that are averagely into the comfort zone. It also showed that a value of around 25% windows to floor ratio was beneficial for both daylight and solar gain. And finally, a south exposure was preferred in order to maximise solar gains in winter.
From the pre-studies and from the analysis of the precedents the team decided to **adopt passive solar design strategies as the main bioclimatic techniques for space heating and lighting**.
Since the team decided that effort had to be made in order to do passive solar design in a high rise buildings urban context, the units have to be displayed on higher level and oriented towards the southern arc. Moreover, because of the preferred exposure towards the south and because of the variability of the weather in London, the skin of the building has to be provided with **adaptive measures that can control the internal environment**. Operable Windows, shutter and shading devices become fundamental measures under the control of an active responsible inhabitant. Furthermore, because of the small size units that the team chose to design, the choice of different internal environmental conditions from space to another are limited, therefore in order to **re-create** this **spatial diversity the apartments** should be provided with flexibility that allow internal modifications according to different activities. Also this flexibility can allow the transformation of the units from a living space to a working environment meeting the requirements and the future projection of more people working from home.
Building materials and finishing of the apartments have to take into consideration properties that allow the **storage of the solar and heat gains** during the day to be released during the night. The thermal mass proprieties of these material become important also in the thermal regulation during the warmer hours of the summer, especially in the prevision of the more frequent heat waves in 2050, when the strategy of coupling the internal environment with the outside is not beneficial due to the fact that the external temperature can go above the comfort zone.
Since the summer is mild in London, as shown in the climatic analysis, the strategy is coupling with outside -since there are not environmental pollutants in the area. Apertures on both sides of the apartments should be provided to allow cross ventilation that not only will remove the internal heat gain but also increase the air movement within the apartment resulting in a better perception of indoor comfort- in fact the air movement creates a pleasant sensation on the skin due to the increase heat removal effect from skin transpiration.
Another important aspect to highlight is that because of the minimal dimension of the apartments, diverse spaces should be provided within the building which offer different thermal, light and spatial qualities also to encourage the interaction between the residence which has been suggested in the project's brief.

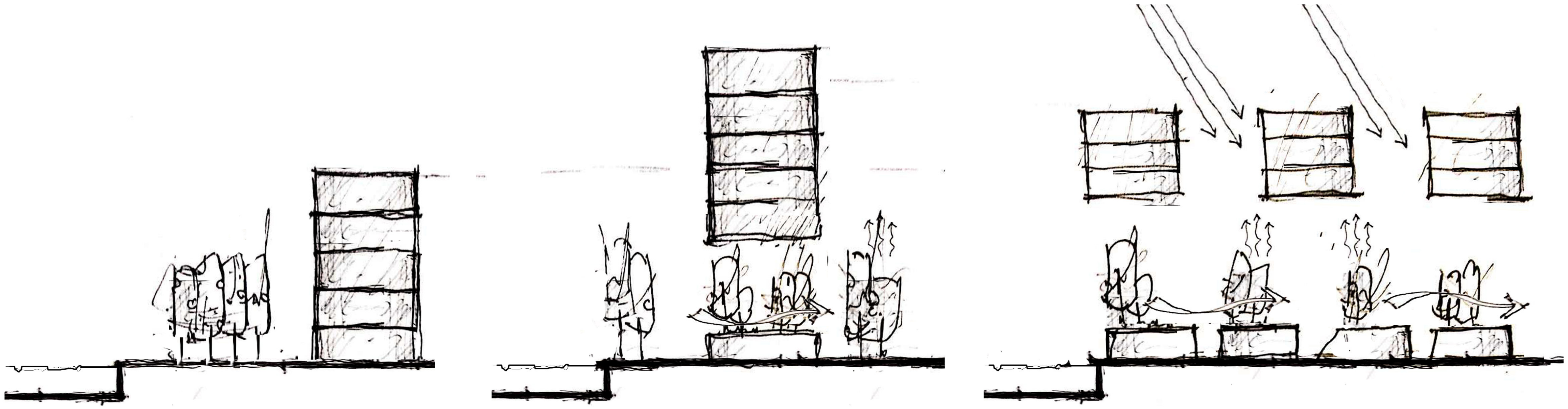


Figure 2.4.1 Design concept, changing the layer of the city

Refurbishing the city “the concept revises this conventional model of the city disassembling its layers and reorganizing them following the symbiotic relationship that building and the urban-natural environment could have.”

THE CONCEPT DEVELOPMENT

Figure 2.4.2 North-South section

Figure 2.4.3 View of the proposal from the north west corner towards the southeast

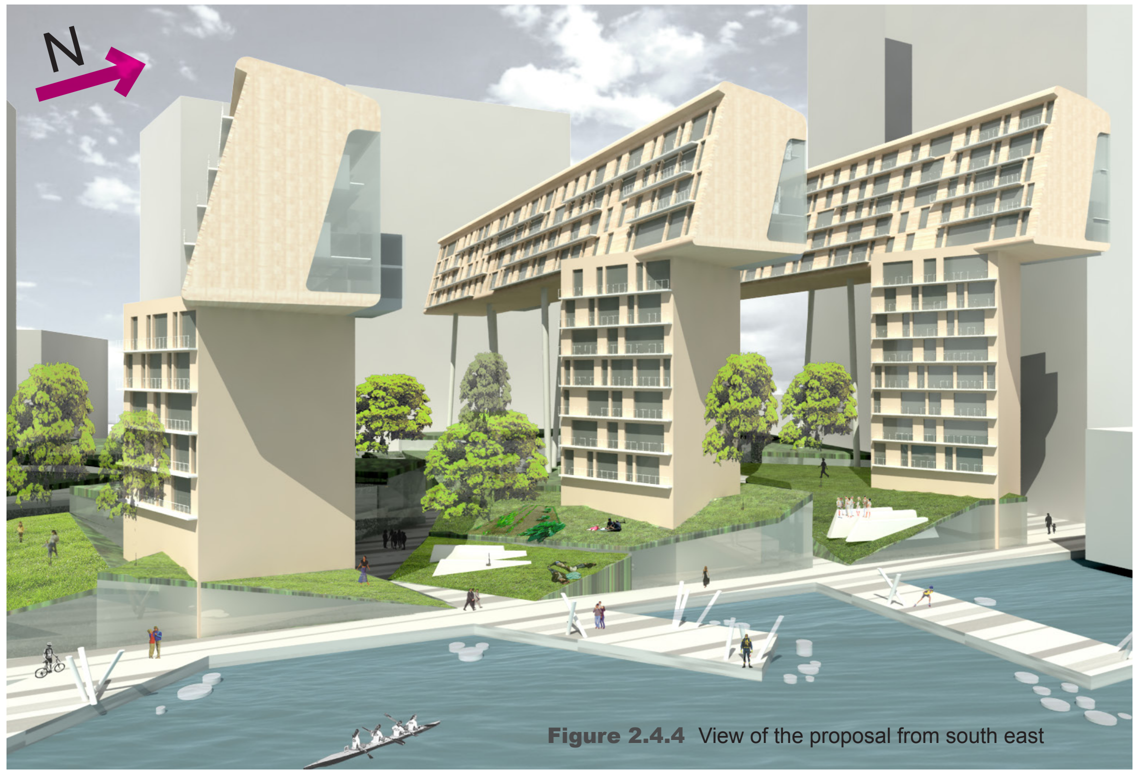


Figure 2.4.4 View of the proposal from south east

Figure 2.4.5 Roof plan

2.4_Design concept

The team’s **strategies to refurbish the city** started from seeking for the **symbiosis between buildings and the urban context** that is not found in cities and also in the isle of dogs. Traditionally in the city, the enclosed spaces of buildings are separated from the open, and the built is separated from the natural and it doesn’t explore the mutual potential benefit that each can have on the other, so often leading to a uncomfortable outdoor conditions and an excessive use of energy in buildings.
The concept revises this conventional model **disassembling its layers and reorganizing them following the positive relationship** that building and the urban-natural environment could have. Making use of the potentials and the constrains of the site emerged from the environmental physical and climatic analysis, the activity and the uses were placed according to their requirements defined in the strategies (see chapter 2.3) and shaped in a way that both indoor and outdoor can benefit from each others leading to sensible functional and environmental improvements over built precedents.

The public and semi-public activities -workshops, market, offices - are melted together in a fluid landscape that create the connection of cross dock with the existing area and define open diverse environment. The private and semiprivate uses are raised to leave the ground floor visually and physically free and meet the sun access as sustainable source of external energy and valuable element to appreciate sustainability in London. As it will be explained in the course of the report these are the main strategies that lead to a new definition of the architecture of sustainable environmental design.

Public and semi-public

The ground floor is conceived as a layer of earth created from the reuse of the soil removed for the foundation. It embraces both outdoor and indoor spaces on two-three levels. The outdoor spaces on the canal level are designed as canyons penetrating through this ‘earth’, creating public pathways with series of markets and fairs that link the front of the canal to the heart of the project and to the existing urban context (see figs 2.4.2 and 2.4.5). The canyons are bounded by workshops, commercial facilities and offices forming built areas that vary in height and as a green carpet, the public garden fluidly covers the complex ground floor beneath. The relationship between the public garden, the canyons, the workshops and the canal is allowed by an organic configuration where at times the green carpet descends towards the canyons, in order to create a direct physical connection with them, and at other times, ascends for increased visual connections with the canal. in this way, the design of the ground floor in its different layers creates a series of outdoor and indoor spaces of different qualities that, through mutual benefits, forms environments that promote informal social interactions. (see also chapter 3.1)

Private and semi-private

The elevated residential buildings are three horizontal blocks oriented towards the south to allow solar gain and sunlight penetration into the apartments and to avoid overshadowing from each other they were positioned according to solar geometry (see fig. 2.4.2). In fact, using the **free source of heating and lighting offered by the “Sun” was part of the bioclimatic strategies** in order to promote the “Sun” as valuable natural element to appreciate sustainable environmental design in London.
The units are minimal in dimensions and are provided with a number of adaptive measures both internally and externally in order to facilitate the inhabitant’s search for comfort. The units are also complemented by common facilities which appear like projecting boxes on the northern facade (fig. 2.4.3). The envelope of the blocks wraps together these spaces creating an internal garden that extends the use of the units through terraces and adds spatial and environmental options to the user in his/her search for comfort. Moreover the “garden-Buffer” helps in reducing the heat losses from the apartment playing a great role in maintaining the units temperature within a comfortable range for the most of the winter. (see also chapter 4.4.4)
The buffer garden with the semi-private common boxes promote social interaction between the different residents by providing space where different activities can take place, such as working and studying in addition to spaces for laundry and day-care. (see also chapter 4.1)

FORM GENERATIVE PROCESS

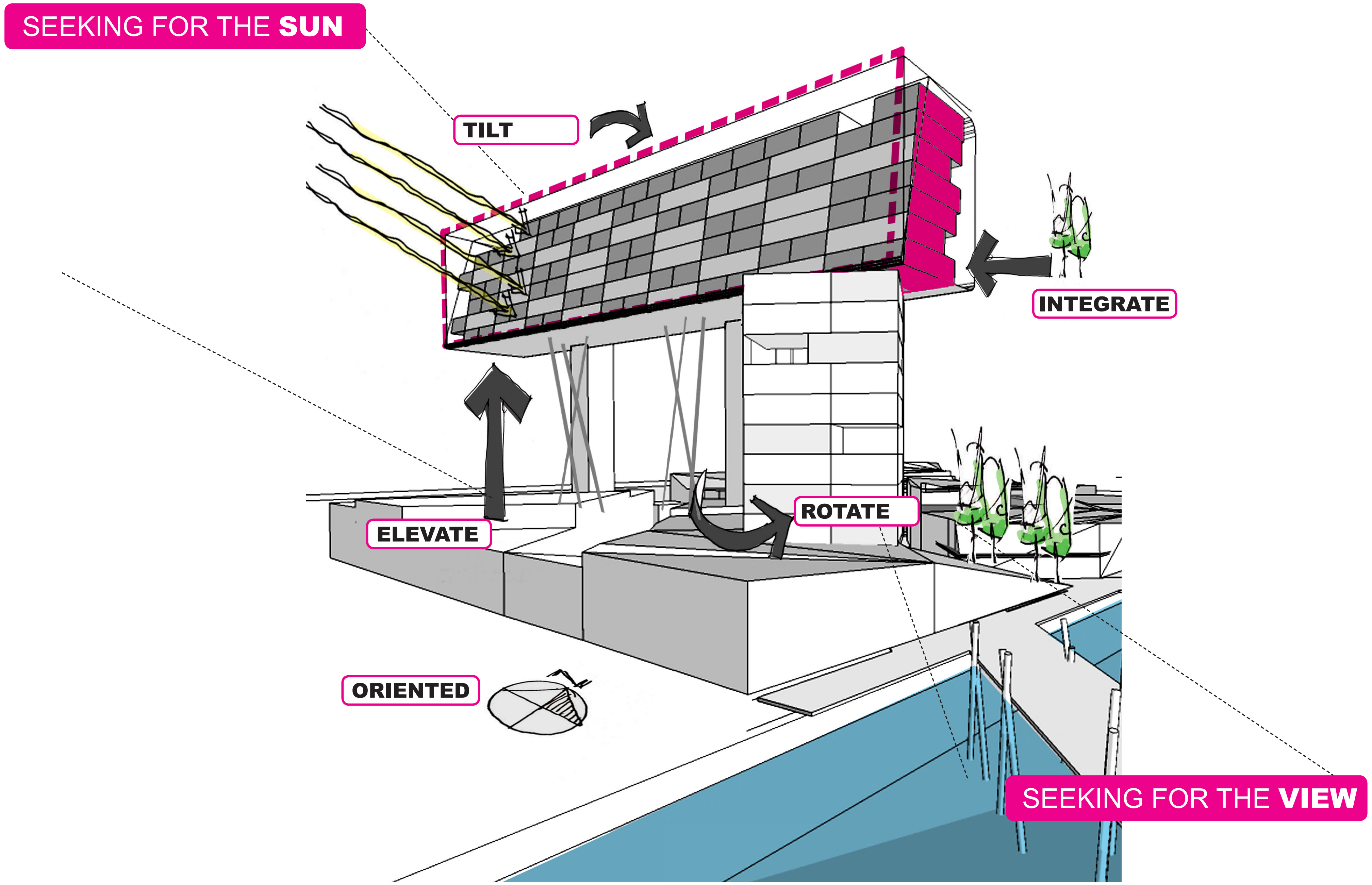


Figure 2.5.1 Scheme of the generative process

2.5_Form generative process

As a starting point, the free ground floor, the solar access and the sun benefits on the user drove the definition of the residential building shape . In fact, the suggested permeability of the ground floor supports the notion of having free visual connections across the city and to the canals. Moreover, the winter, as established in the climate analysis, is the main season to be addressed in London. So, in order to reach indoor comfort through passive bioclimatic techniques the solar access was identified as the main source of free heating as well as a valuable element to improve people's comfort in London.

The final shape of the residential buildings was generated by view - concerning the three vertical blocks - and by maximizing the solar exposure - the horizontal elements.

Due to the enclosure of the site by the high rise south building, and according to the solar study made on vertical surfaces in different orientations, the horizontal buildings were elevated until some 25 metres form the ground floor and 15 metres from the roof park of the public levels and oriented south (see figs 5.5.2 and 2.5.4). Even if the south east and south orientations present similar solar access, the final decision on the orientation was made to allow the beneficial presence of the sunlight for the longest period of time possible.
The south facade was then tilted in order to reduce the angle of incidence of the sun rays on the glass of the windows and increase the amount of solar radiation transmitted into the apartment. The angle of the facade from the vertical plane is 16 degrees and it was defined according with the solar geometry of the winter months. The Figure 2.5.3 show the benefits of the increased solar access when the plane is tilted.
The last movement of integrating (see fig. 2.5.5) was made in order to wrap the units in an envelope that creates the garden-buffer towards the north that will provide benefits both environmentally and socially (see chapter 4.4.4).
The vertical legs were rotated towards the south east with an angle of 30 degrees from the south to implement both views and solar access in the first hours of winter days (see Appendix 2.5.2).
Figure (2.5.6) show the benefit of the direct solar access on the shoebox - the first simple model of the units to do sensitive studies. in fact this case compared with the one that doesn't have direct solar access, reduces the hours in which the modules has temperature below the comfort of a half (see Appendix 2.5.1).

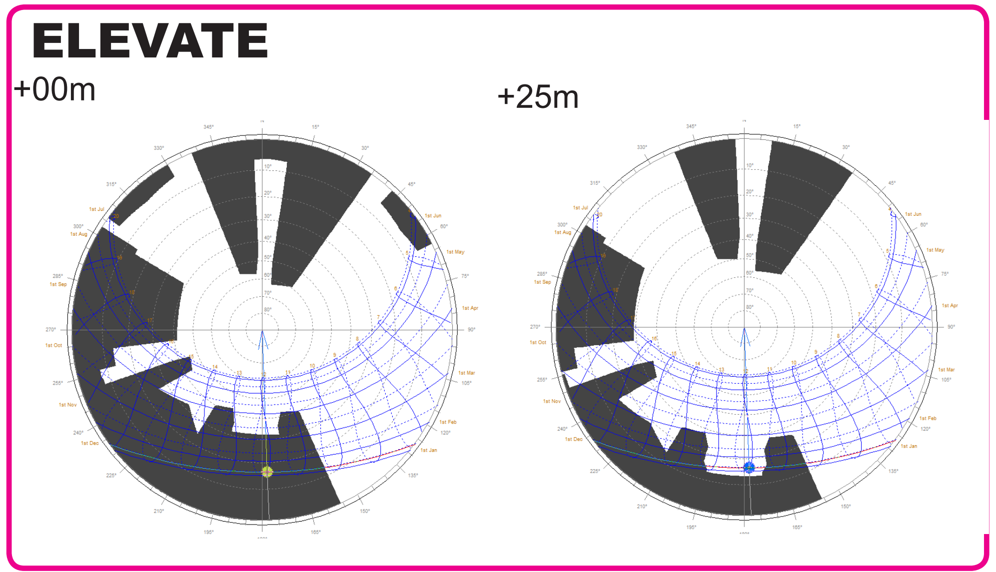


Figure 2.5.2 Stereographic Diagram for Center of the Plot [Ecotect]

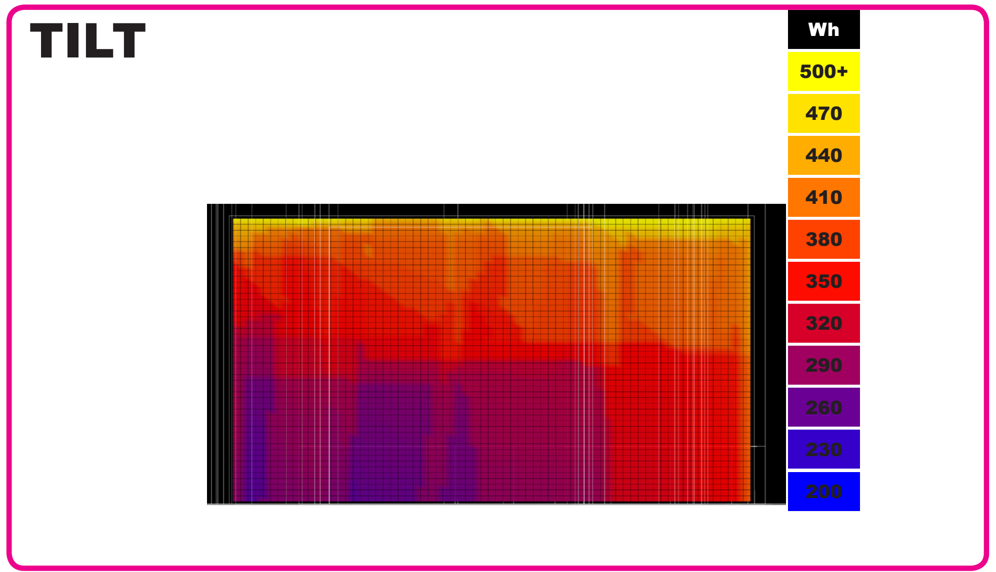


Figure 2.5.3 Solar access on a south oriented tilted surface as average daily solar radiation in December. tilt angle 16 degrees from the vertical axis [Ecotect]

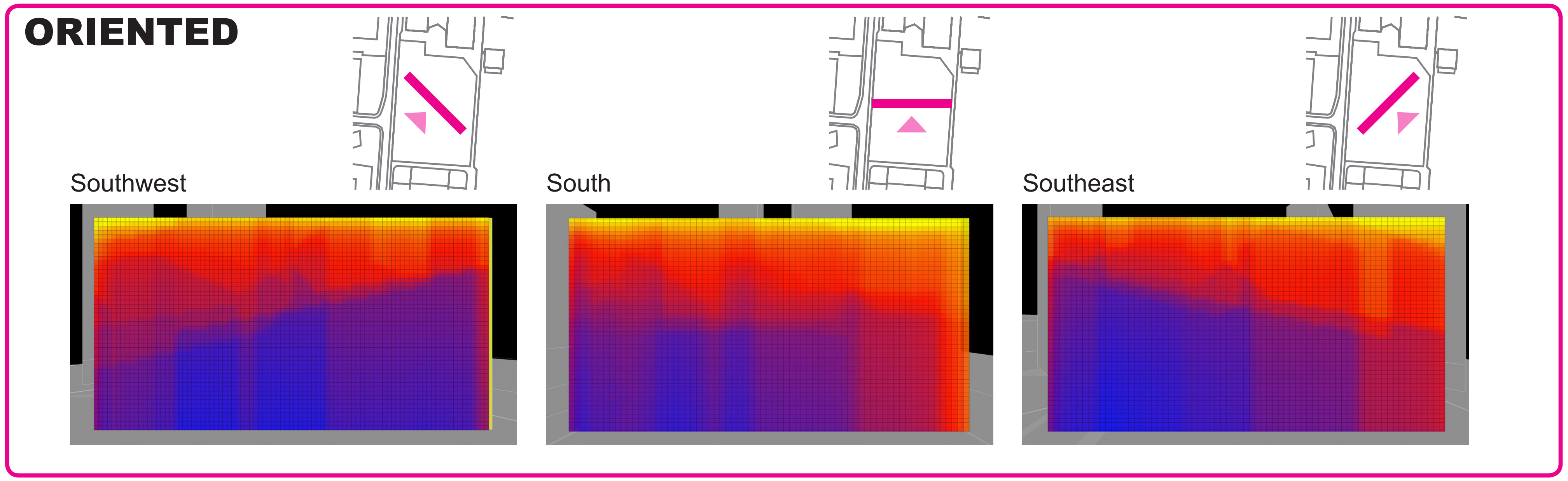


Figure 2.5.4 Solar access on verticals surface according to different orientations expressed as as average daily solar radiation in December [Ecotect]

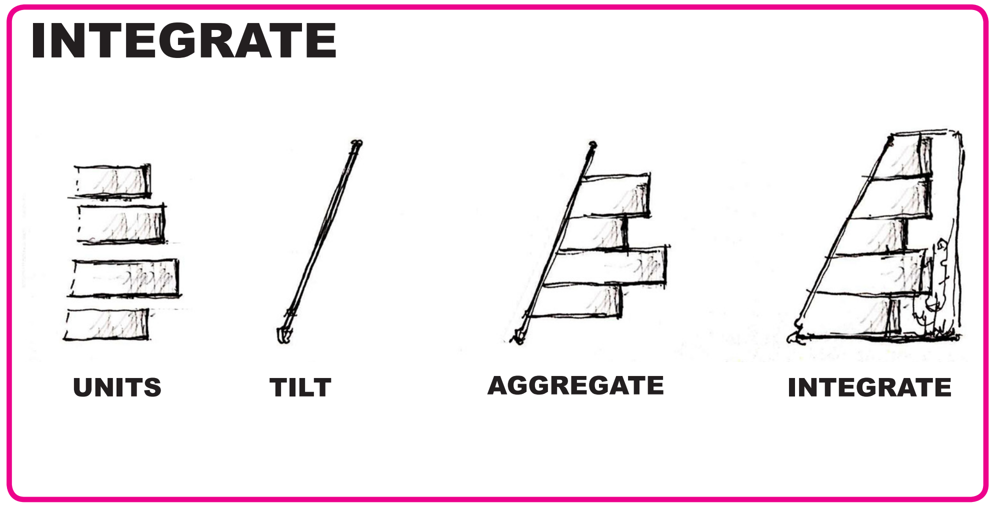


Figure 2.5.5 Concept of the generative process of the section of the residential buildings

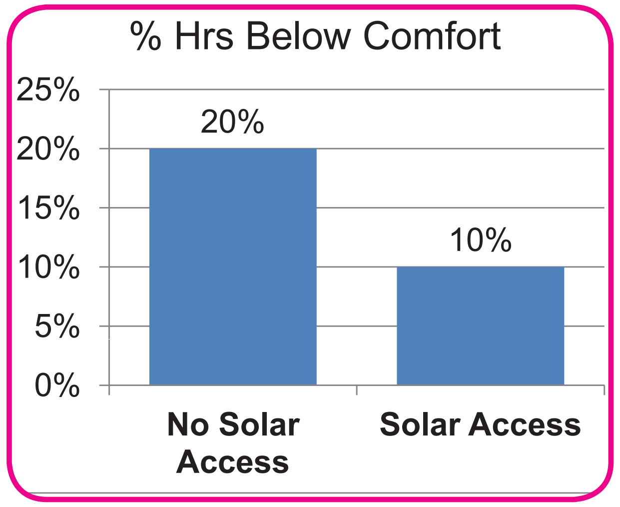


Figure 2.5.6 Comparison that shows the benefit of having solar access in the units

III _ GROUND FLOOR

PUBLIC AND SEMI-PUBLIC

Figure 3.1.1 groundfloor ¦ illustrated view from the canal

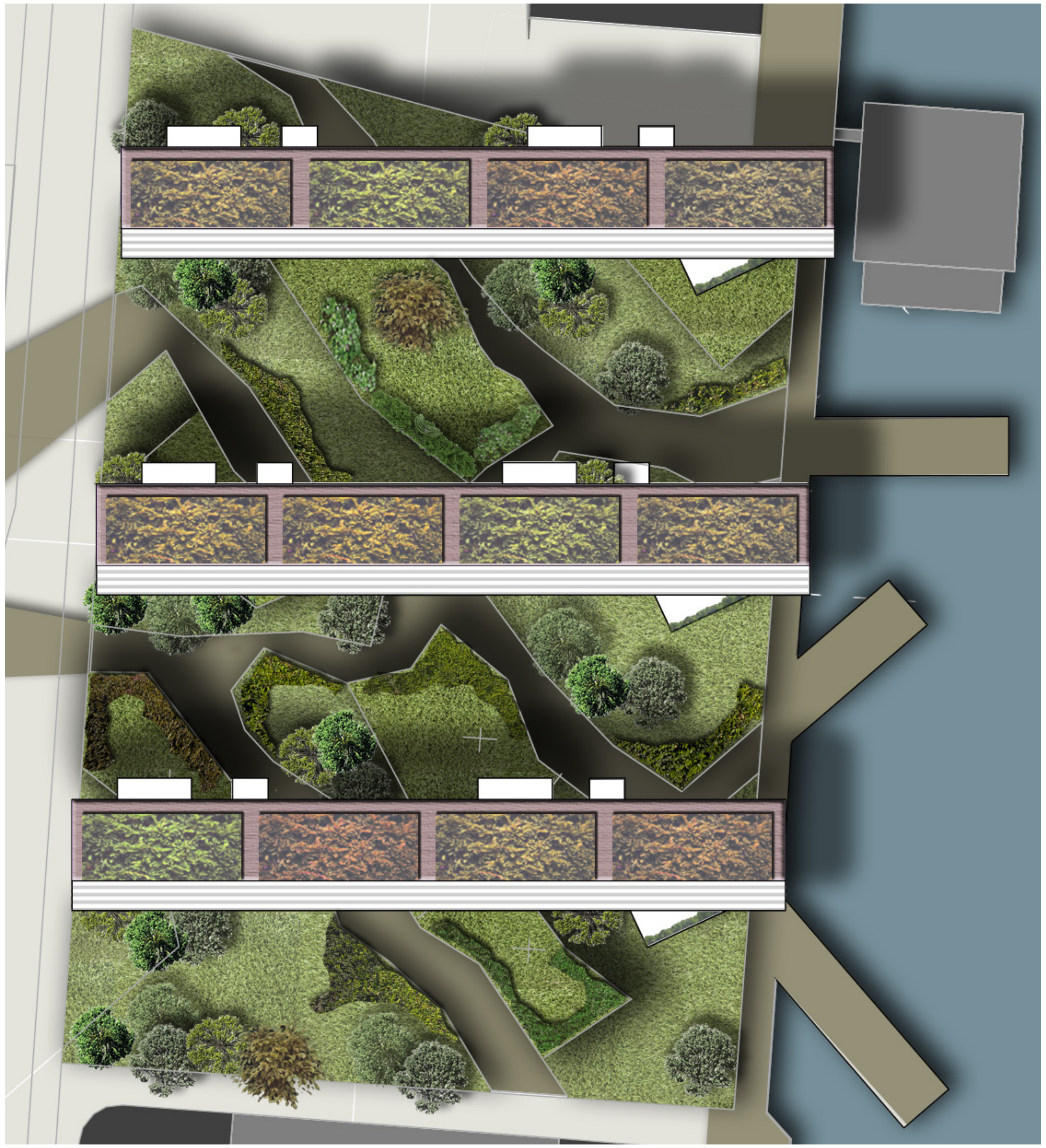


Figure 3.1.2 proposal ¦ illustrated top view

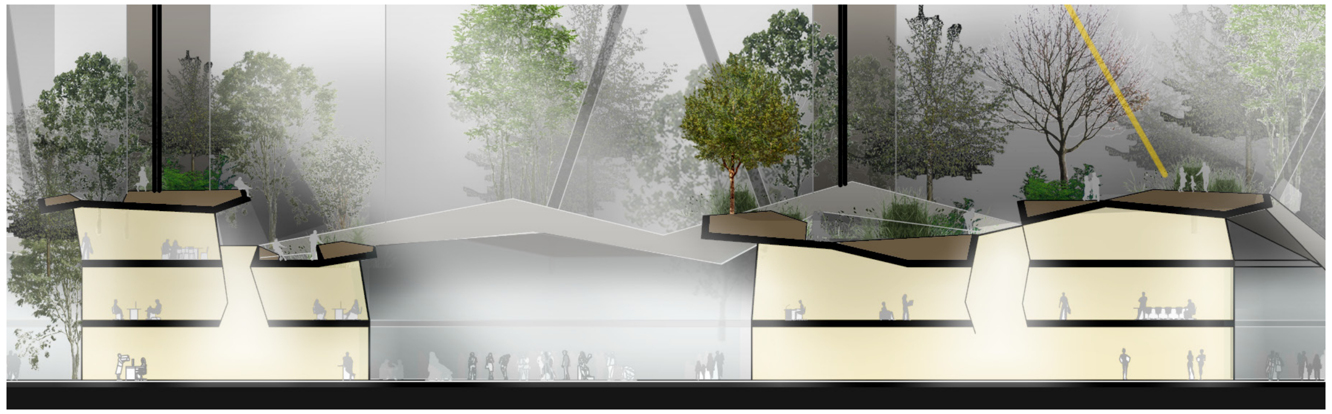


Figure 3.1.3 groundfloor ¦ N-S section of the landscape. see also picture 3.4.1

3.1 _ Creating the symbiosis

The public and semi-public spaces within the project are designed to host social activities, local markets, workshops, offices and street fairs throughout the year. The design of these spaces is accompanied with environmental strategies in order to create comfortable conditions for the various activities and suitable settings that will enforce the reciprocal benefits. Furthermore, creating spaces of **different environmental qualities** both indoor and outdoor **provides the user with the opportunity of choice**, according to the type of activity, the season of the year and the time of the day.

The indoor activities -**workshop, offices, and shops** - that were placed on the ground level to create the **symbiosis** between the inclose public spaces and the natural environment, suggested in the brief, **benefit from the specificity of the site and from the concept of rearranging the layer of the city.** In fact the pre-analysis have shown that direct solar access should be avoided both thermally and visually: so during winter they profit from the absence of direct solar radiation in the lower levels of the plot , as shown in the climatic studies, and during summer from the green carpet that naturally filters the direct sun light, creating this symbiosis and **promoting a new definition of sustainable architecture in cities**, see fig. 3.1.3. Moreover the canyons, that the organic landscape creates, work as pedestrian connections on the ground floor which are sheltered from the wind by the informal disposition of the built form, improving the outdoor comfort in winter since it can not be achieved by solar radiation. The canyons also allow diversity, together with the landscape, especially during the summer when the disposition of the buildings and the greenery creates areas with different solar access. Moreover the green carpet reducing the absorbed solar radiation by the surfaces of the plot and through the evapotranspiration of the greenery helps in dispersion the heat island effect (See Figs 3.1.1, 3.1.2 and 3.1.3).

Since providing simply an architectural space that can embrace those activities does not guarantee their happening and since micro climatic planning of **outdoor spaces can highly increase the use and the inhabitation** of those spaces (Nikolopoulpou 2004), the team tuned the potential of the proposal developing environmental strategies addressing the different seasons of the year to improve outdoor comfort.

Comfort outdoor strategies

First term's undertaken case studies, St. Pancras station (2011) and One New Change building (2011), have shed the light on such issues, highlighting that in a climate such as London's, where in warmer seasons, the outdoor temperature is mostly within comfortable limits or outdoor comfort can be achieved by minor physiological or physical alterations, winter is the most problematic season when it comes to designing outdoor and semi-outdoor spaces. Outdoor comfort is affected by a composition of climatic factors which influence thermal sensation - dry bulb temperature, mean radiant temperature, wind velocity and solar radiation. But, in terms of the specificity of the selected site, the lack of solar radiation on the ground floor in winter - caused by the overshadowing of the surrounding buildings - has put forward the strategy of sheltering from the prevailing wind as the main environmental strategy applied in the "attunement" of the canyons. Whereas, for the summer and mid-season the main strategy is to provide spaces of different environmental qualities such as, spaces that are sunny, shadowed, by the canal, within the canyons or the green carpet. Since the user expects to be colder/warmer whenever in outdoors or semi-outdoors spaces than in indoor, the main goal is only to provide shelter from extreme weather conditions especially in winter. The results are discussed in the next two chapters

3.2_Public outdoor spaces

Winter Strategy

As discussed earlier, the proposal's main winter strategy for outdoors spaces is sheltering from the wind. As in can be seen from the preliminary CFD studies (see Appendix 3.2.1), the pattern (wind directions and velocity) of the prevailing wind in winter - southwest arc - is highly modified and affected by the urban fabric surrounding the plot, generating a down draught acceleration that redirects the wind towards the south. In addition, since the eastern boundary of the site is open towards the free space of the canal, the wind direction from the south east was tested to refine the proposal.
The initial design of the canyons - orientation and width-to-height ratio (see Appendix 3.2.1) - was set taking into consideration the direction of the prevailing winds in winter and the pattern caused by down draught and the network needed to connect the canals with the surroundings. Moreover the configuration of the built elements was varied in height and disposition in order to reduce the momentum of the wind flows, since the wind direction is actually unpredictable. Figures 3.2.1 and 3.2.2 illustrate a diagrammatic process of the design, starting with the idea of the pathways, followed by informing their configuration according to the discussed patterns. Finally, tuning the proposal to the other wind directions adaptable elements such as movable gates to the North, the South and the West were designed to avoid wind in the entrance of the canyon. These movable gates can be kept more closed in winter but totally open in summer to allow the breeze into the canyons.

Figures 3.2.4 and 3.2.5 illustrates a CFD simulation of the final proposal with two wind directions, West wind and Southeastern wind which is from the unobstructed boundary of the site - the canal-. In both cases it can be seen from the simulations that the wind velocity is reduced to below 0.5 m/s almost through all of the proposed canyons.

Finally, further sheltering could be attained by increasing the roughness of the surfaces within the canyons, that in fact are discontinuous and by the use of high canopy trees - such as the one proposed on the upper level of the garden - that even if in winter they don't have the leaves provide a decrease in wind velocity dispersing the wind flows and so reducing its momentum.

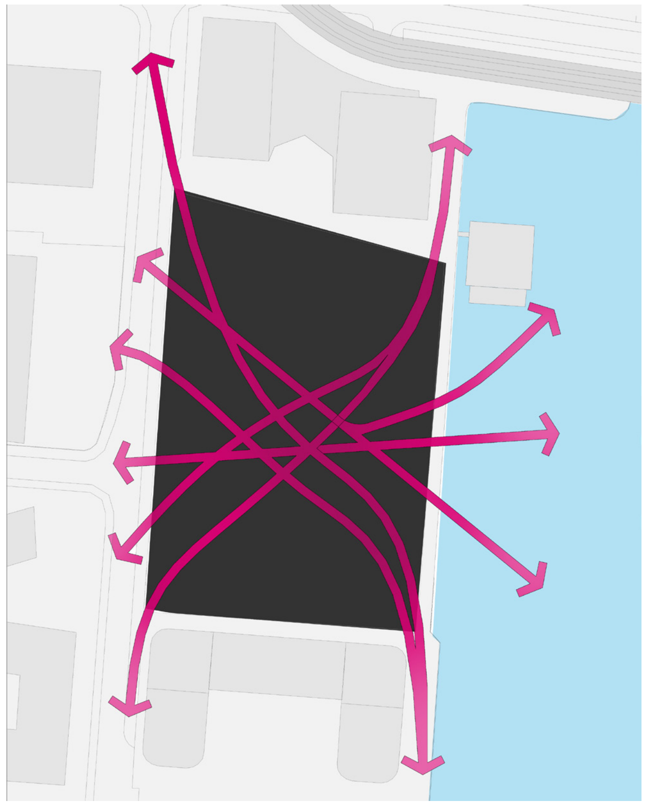


Figure 3.2.1 ground floor ¦ conceptual connections

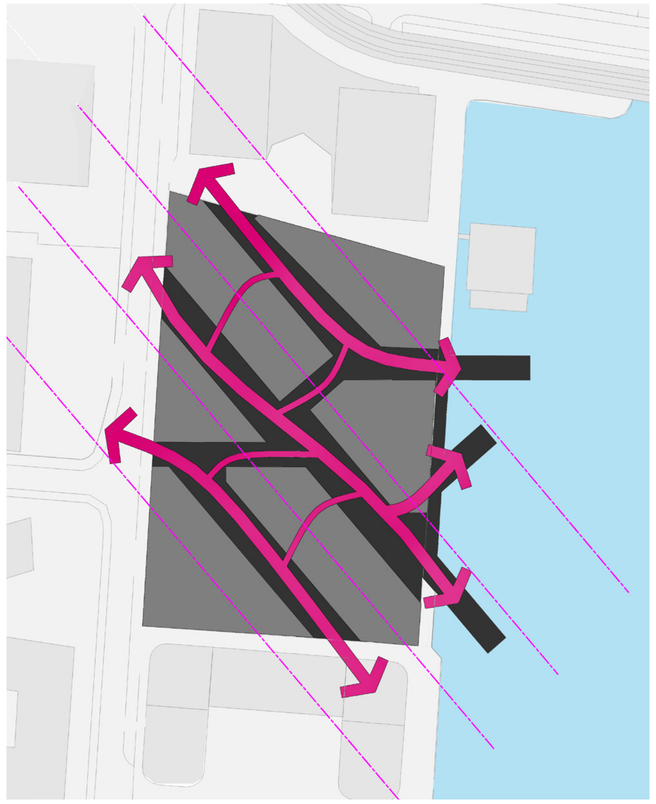


Figure 3.2.2 ground floor ¦ circulation paths and patterns proposal

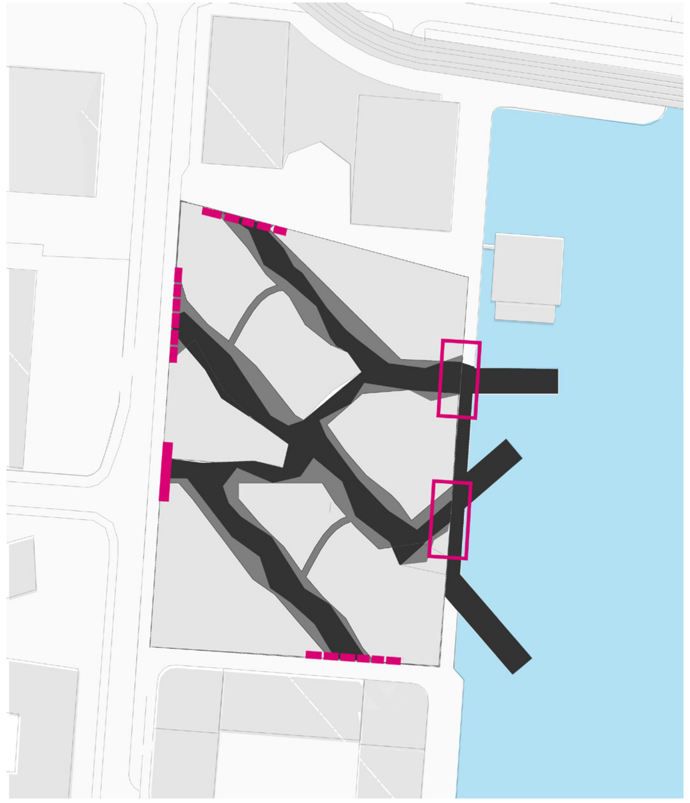


Figure 3.2.3 groundfloor ¦ finals attunement of the proposal

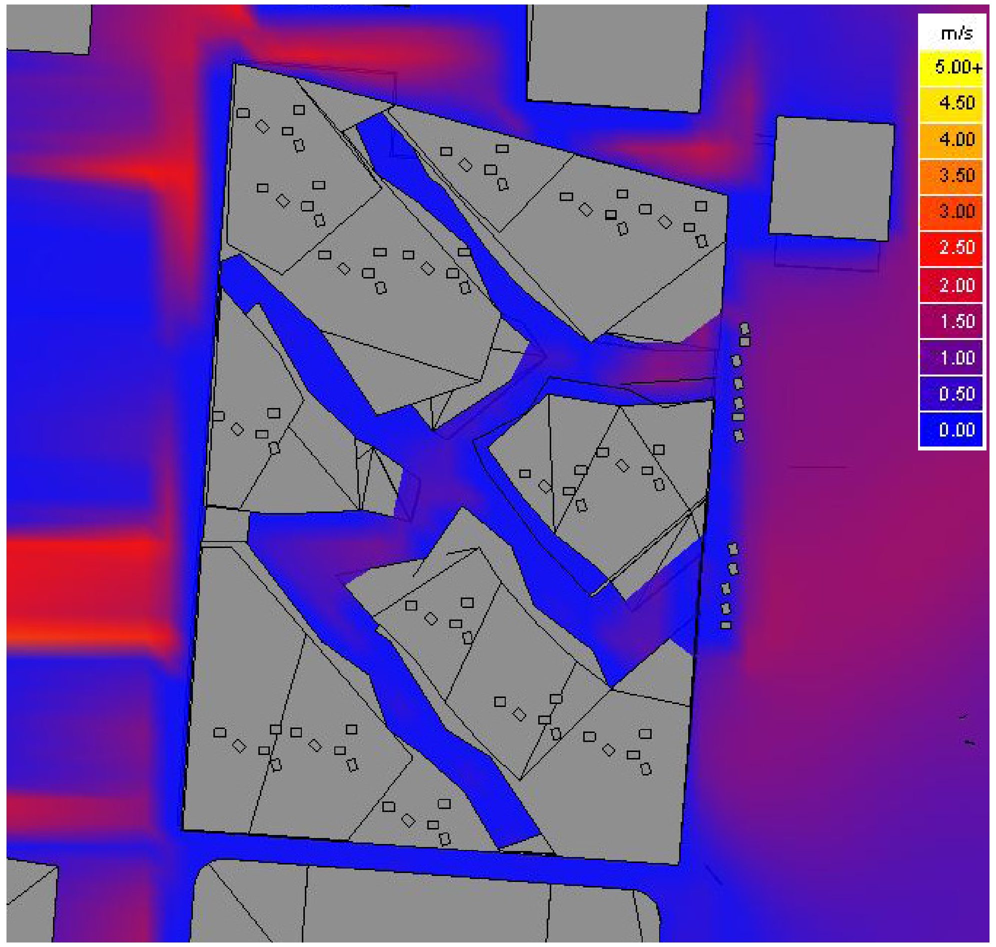


Figure 3.2.4 groundfloor ¦ proposal CFD analysis ¦ prevailing wind from West [Ecotect Winair]

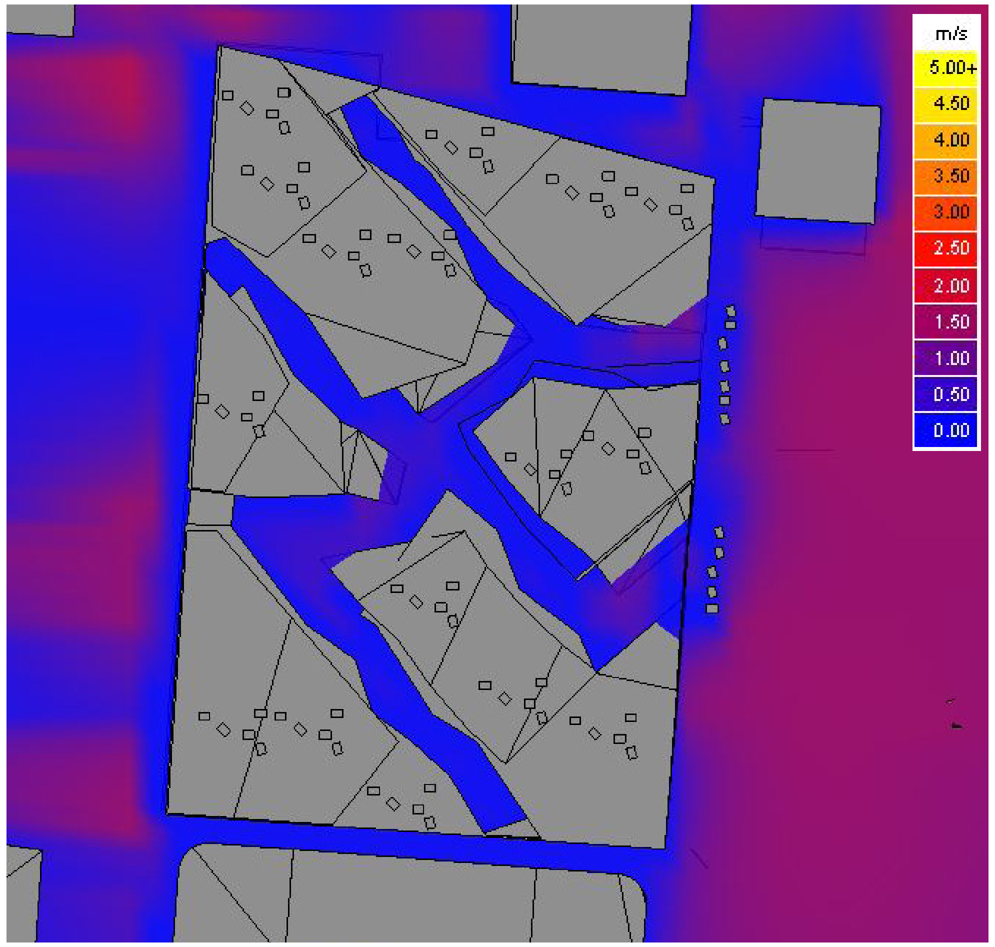


Figure 3.2.5 groundfloor ¦ proposal CFD analysis ¦ prevailing wind from Southeast [Ecotect Winair]

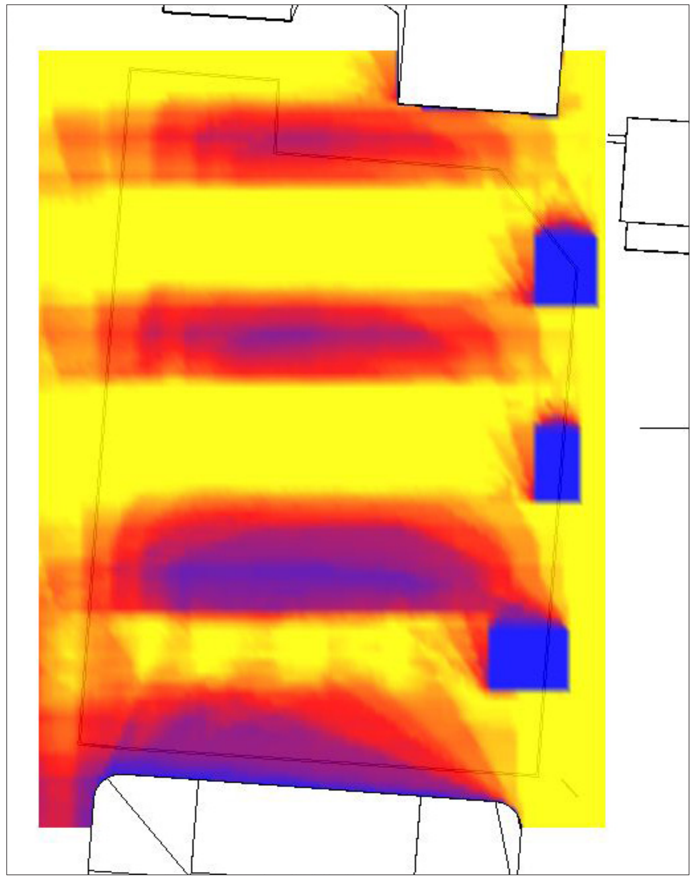


Figure 3.2.6 +6.00m from groundfloor ¦ proposal analysis
total direct radiation ¦ Summer
[Ecotect]

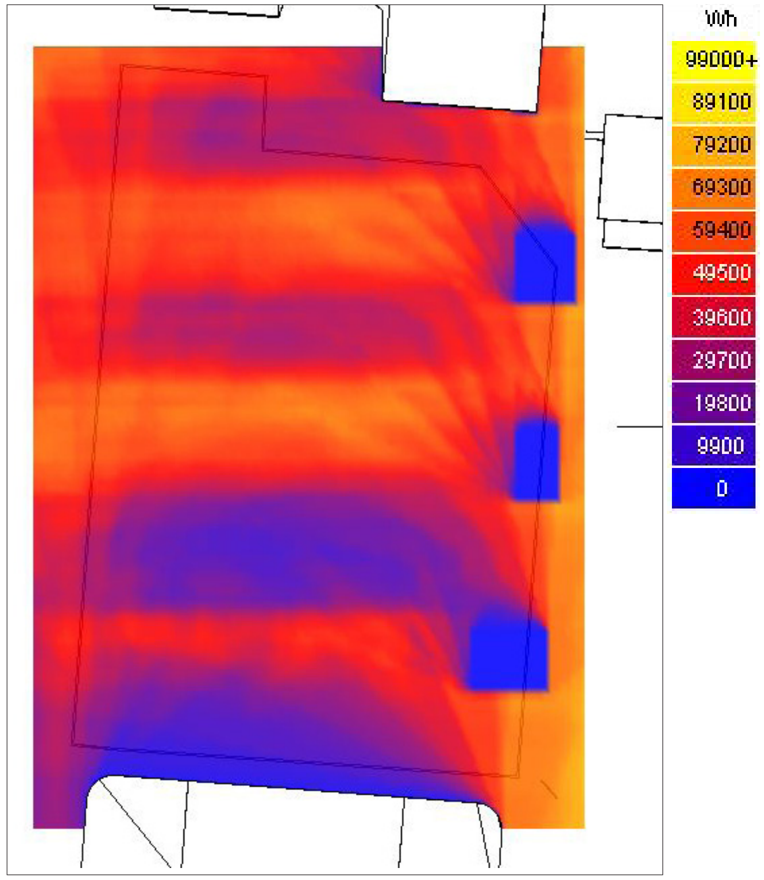


Figure 3.2.7 +6.00m from groundfloor ¦ proposal analysis
total direct radiation ¦ Summer
[Ecotect]

Summer and Mid-seasons Strategies

While in winter the strategies was sheltering from the extremes of the climate, in summer and mid-seasons the comfort strategy is to provide the user with the opportunity to choose between different environmental settings: the canyons or the green landscape.

The organic configuration of the “green carpet” offers a variety of open and semi-open spaces both upwards and downwards, which creates gradients of exposed or sheltered areas form the wind, insolated or shadowed spaces, offering the users the opportunity of choosing the different spatial qualities accordingly to his/her preference.

When analysing total direct radiation in Summer and Spring (see Figs. 3.2.6 and 3.2.7), it can be seen that the elevated buildings cast a pattern of shadows on the garden level, resulting in spaces which receive less direct solar radiation. So in order to expand the shadowed areas without reducing the exposed ones, the the vegetation was distributed on the boundaries of the shadowed areas. Increasing vegetation in some areas influences not only the provision of shaded areas during summer, but also increases roughness for wind control during winter whether those trees are evergreen or deciduous (see Fig 3.2.8).
In addition to the “green carpet” the canyons creates on the street level different option of solar access (see Appendix 3.2.2) enlarging the range of possibilities offered by the organic configuration of the public spaces.

Figure 3.2.8 proposal illustration
shaded areas ¦ tree plantation

Figure 3.2.9 proposal illustration
sunbath gardens ¦ shadowed summer gardens

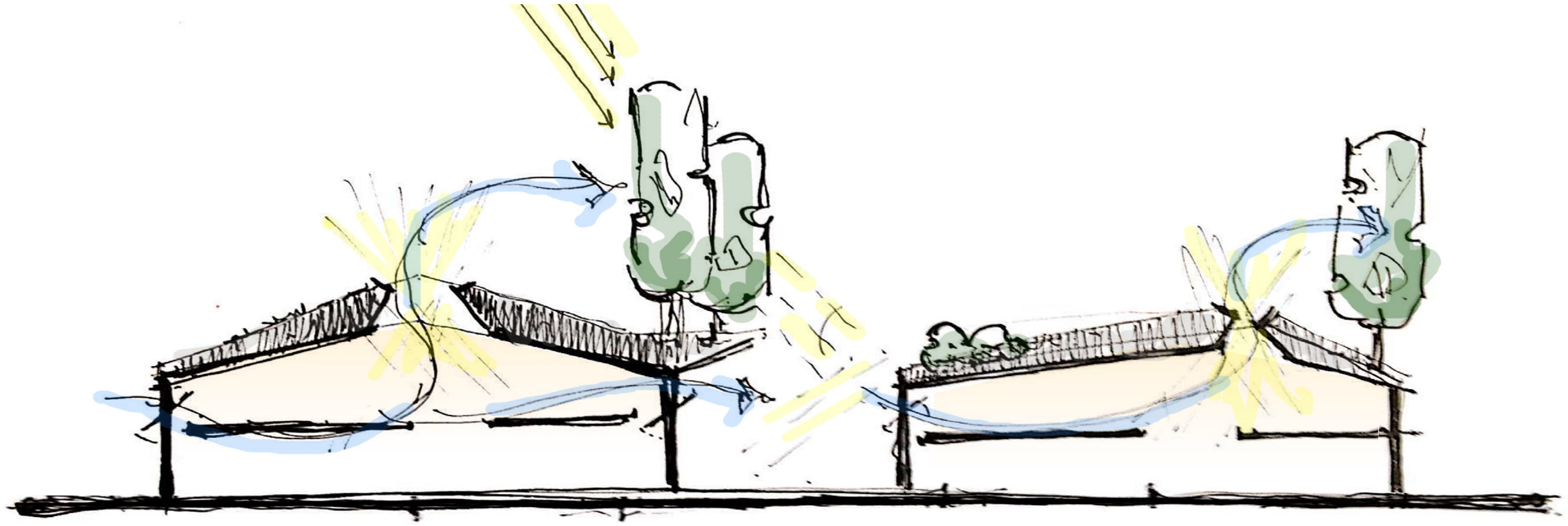


Figure 3.2.10 ground floor ¦ Interpretative scheme of the strategies for workshop and offices use.

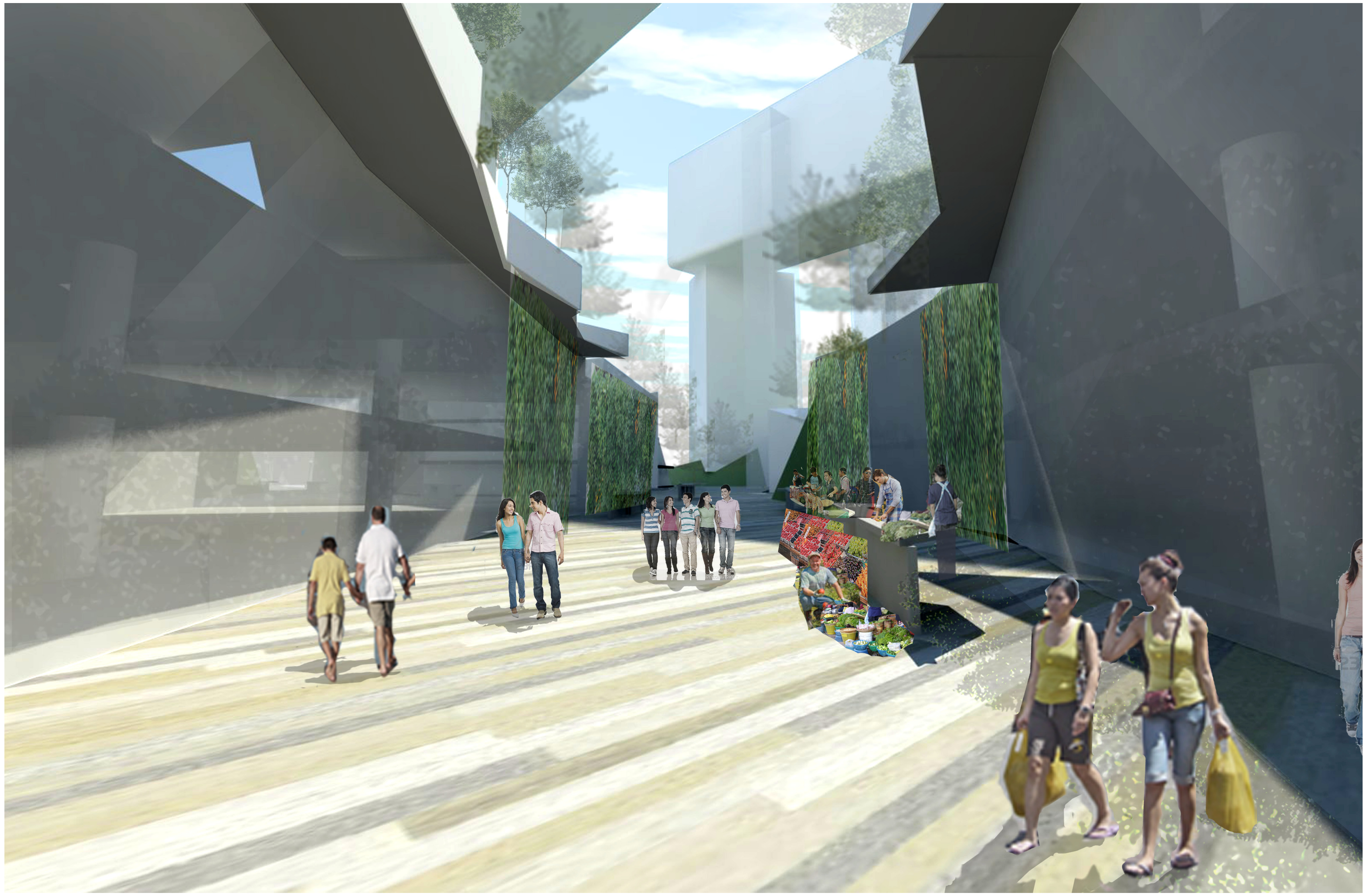


Figure 3.2.11groundfloor ¦ illustrated view from canyon

IV _ RESIDENTIAL

PRIVATE AND SEMI-PRIVATE

Figure 4.1.1 Internal view from the Buffer Garden

Figure 4.1.2 Internal view from the Buffer Garden South terrace

Figure 4.1.3 Internal view of the one bedroom unit

Figure 4.1.4 Illustrated plan

4.1 _ Providing opportunities

The residential buildings host the private and semi-private uses of the project. The definition of its architecture was shaped to allow the access of solar radiation, as mentioned in Chapter 2.5, and driven by the idea introduced in the team's project brief. That was in order to **take distance from the previous conventional concept of providing the comfortable environment through the design of building services and to make the inhabitant appreciate the possibility of achieving comfort through sustainable means**. In this way the proposal aspires to promote the engagement of the inhabitant in the process of seeking his/her personal definition of what is comfortable.

Therefore the building has to be equipped with the adaptive measures that allow the inhabitant to modify the private space of the units according to the outdoor environmental conditions and his/her preference. The **adaptive measures** at the scale of the apartments provide the flexibility that allows the **creation of different internal layouts and spatial definitions** and enable the user to **mediate between the indoor and outdoor** environment through the use of movable shutter-shading devices, operable windows (tilting and sliding) and habitable balconies towards the south and the north garden. The units will be discussed further in the Chapter 4.2. Furthermore the **buffer-garden**, that encloses the social boxes (see fig. 4.1.2, 4.1.5 and 4.1.6), plays a vital role in the scheme: it is a reminder of the sought natural ambience introduced in the brief and e**xpands the inhabitant array of choices out of the units** offering a complementary space to them. While the apartments are looking south, the buffer garden creates an envelope that aggregate towards the north the different depth of the units creating a sequence of private terraces and semi-private areas. The space of the garden is filled with diffuse norther light that together with the green and the rammed earth chosen for the back walls of the apartments, create a natural protected environment that develops a symbiotic relationship with the apartments and their users. In fact it represents both the **natural stimuli that evokes the response of the user to the building** and the **mean to reduce the heat losses from the northern/back walls of the apartments**. The environmental options that the garden promote extend to protected terraces towards the south (see fig. 4.1.1 and 4.1.2) and to different enclosed spaces attached to the north facade (see figs. 4.1.5 and 4.1.6). The garden is thought to be a sheltered space that can be lived in different way according to the different seasons. In winter sunny days for example, the internal terraces towards the south can be enjoyed even if the temperature of the garden is low since the penetration of the solar radiation contribute to the thermal sensation within that place. While the other spaces in the garden are thought to be more transitional in winter and to be lived when the outdoor temperature, and so the garden's, is higher from March to October. While in summer it offers cool environment protected from the direct solar radiation since the apertures in the garden are kept open. Morover, the Multifunctional social boxes are designed to be closed spaces in winter and open in summer and thought to be flexible spaces that can be modified during the day. In the same space different events can happen: from work to cook and from a living space to a day-care room. They are directly connected with the garden, physically and visually, and they are thought to extend the private dimension of the house giving both environmental diversity and social dynamism of interaction between the users of different background as defined in the brief (see Chapter 2.1).

The proposal was tuned through analytic work and due to the generative process followed and the benefits obtained by the buffer zone of the north garden the temperatures were kept within the comfort zone for most of the time relying only on passive strategies. Since the **hours below the comfort zone were below the 3-5% of the year**, it was possible to eliminate the use of heating systems and **therefore reduce the dependance on nonrenewable energy of the building**. The process will be shown in two parts: firstly the improvement made on the envelop of the north garden and then the final performance of the apartments during the typical winter and summer weeks.

Figure 4.1.5 Illustrated section 1 - social terrace towards the south

Figure 4.1.6 Illustrated section 2 - Facilities on North facade - the boxes and balconies towards the north of the apartments.

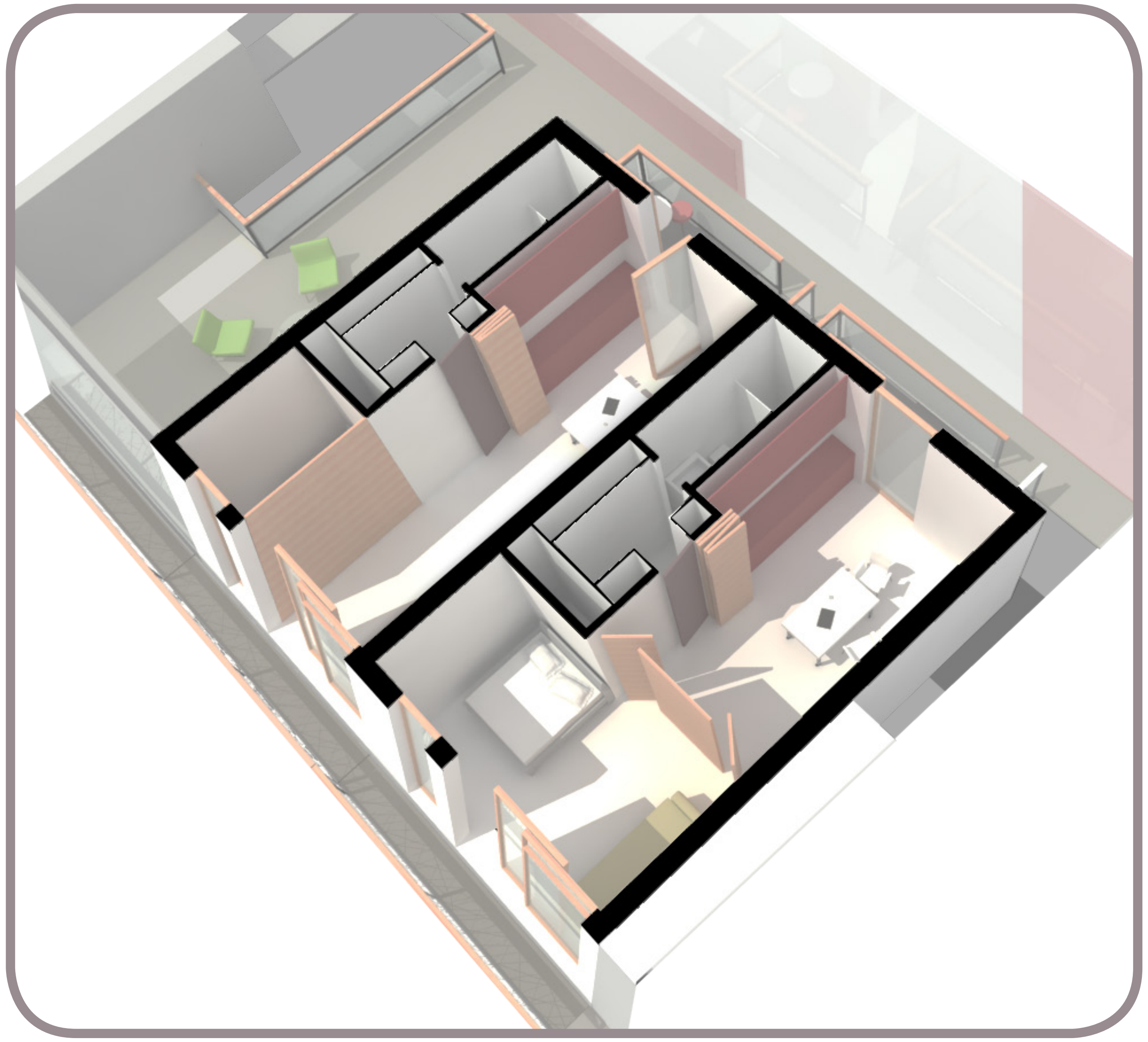


Figure 4.2.1 Illustrated internal view - 1 bedroom apartment

Figure 4.2.2 1 bedroom typology: plan and different spatial configurations schemes

Figure 4.2.3 2 bedroom typology: plan and different spatial configuration schemes

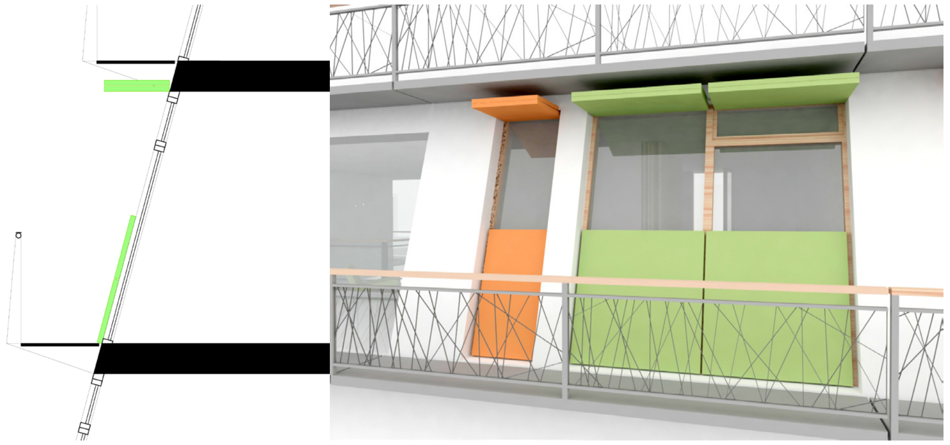


Figure 4.2.4 Illustration - Shutters - Typical winter cloudy day option

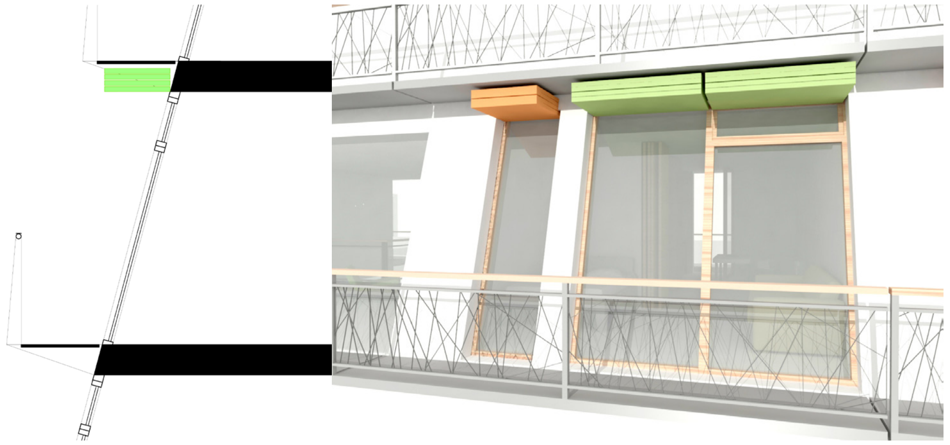


Figure 4.2.6 Illustration - Shutters - typical winter sunny day option

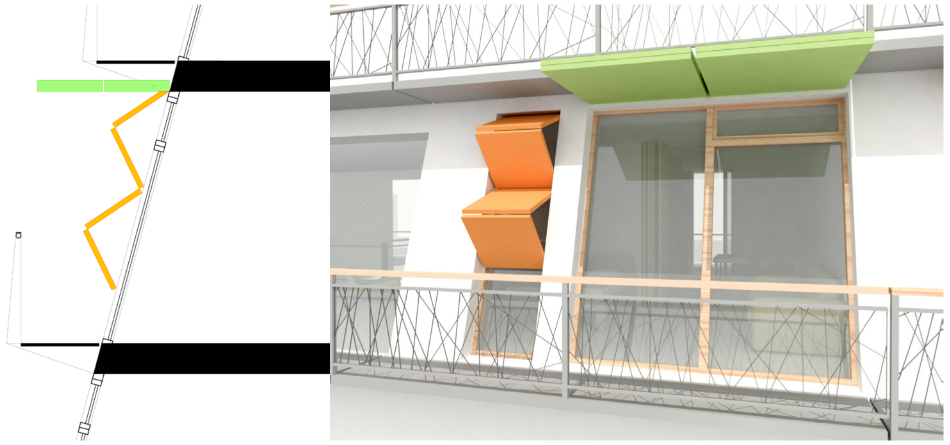


Figure 4.2.5 Illustration - Shading device - Typical summer sunny day option

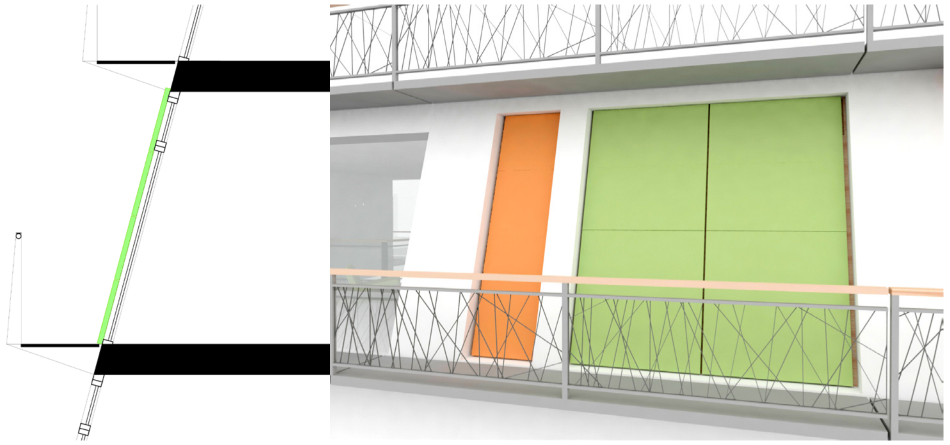


Figure 4.2.7 Illustration - Shutters - Typical winter night configuration

4.2 _ Private spaces

As mentioned earlier, the residential units offer adaptive measures and opportunities, making the inhabitants active users in controlling the natural elements in order to achieve their comfort.

The opportunities to respond to the different outdoor conditions are given by two different mechanisms. The first is he **flexibility of** the internal layout given by the **movable walls**. This way, the spatial configuration can be adjusted according to user's preference. for example, if the users are in the living room watching a movie and the indoor temperature is too cold for them, the partitions can be adjusted in order to reduce the space improving the sense of cosiness and containing the heat gain produced at that moment. Or if they are having a dinner with some friends the living room and the kitchen can be connected in order to disperse the heat gain. Moreover, these movable walls have the capacity to filter the daylight that penetrates deep into the apartment in winter, achieving the desired lighting conditions if the home is used also as working space (see Chapter 4.7, Fig. 4.7.8, see Appendix 4.2.1). Flexibility is also achieved with the use of furniture that can be placed in different parts of the house.
The second mechanism consists on a **shutter system** placed on the windows that at time become **shading device**. The different configuration of the insulated shutters provide the user with a device to mediate the outdoor conditions in winter, while providing protection from direct solar radiation when displayed as overhang in summer (see Chapter 4.7). Since they are extremely flexible, they can be configured in all the intermediate positions according to the user preference.

As examples the two bedroom apartments and the one bedroom apartment are shown in figures, in the previous page.

1 bedroom apartment [45 m^2]:
the One bedroom typology is designed as one space where the user can define multiple spatial configurations by movable walls (see Figs. 4.2.2 and 4.2.3).

2 bedroom apartment [60 m^2]:
The two bedroom typology is based on a central living space with two adjacent bedrooms divided by movable walls, so that the spatial configuration and volume can vary, modifying the central space.

All the apartments are provided with two terraces, one to the south and the other to the north garden to extend the spatial perception of the apartments and adding spaces to the units that have different environmental qualities (for detailed units, see Appendix 4.2.2).

4.3_ Materiality

Since the residential buildings were elevated until 15 metres from the park beneath, lightness of the materials was considered, when possible, in the definition of the materiality of the building. In fact the choice of lightness will reduce the structure needed to elevate the buildings leading to a decrease of carbon emission foot print of the proposal.

In the case of the floor and ceiling, the need of completing the strategies of passive solar design drove the choice of materials that should have properties that allow the storage of the solar and heat gains during the day to be released during the night. The thermal mass proprieties of these material become important also in the thermal regulation during the warmer hours of the summer, especially in the prevision of the more frequent heat waves in 2050, when the strategy of coupling the internal environment with the outside, adopted for the units, is not beneficial due to the fact that the external temperature can go above the comfort zone. So a concrete precast slab was preferred and it was left exposed without finishing to promote the awareness of the users towards the lived environment.

Contrasting with its properties of heat storage, the concrete is perceived as a cold material because it is related with the coolness of stone. Since comfort is a state of mind, it has been though that choosing different materiality for the element with which the users will interact, can play a important role in the definition of their personal comfort. so the internal movable walls are made in wood that reminds the user of spaces such as sauna or a mountain chalet creating a sense of warmth and cosiness when they are kept closed. Also the other internal walls are in wood, but painted in white to increase the reverberation of the daylight into the apartment while recognizing its materiality.

Furthermore, as the strategy to reduce carbon footprint followed for the lightness of the building, the materials for the various building elements and their different layers were chosen according to their weight and their embodied carbon.
Figure 4.3.2 on the opposite page shows a comparison between traditional building elements and the chosen for the proposal.

Finally as explained in the chapter of the ground floor the soil moved from the foundation will be used to create the landscape of the park, consequently reducing the impact of its transportation away from the site. Moreover, the waste produced by the dismantle of the existing building is used to build new urban furniture such as benches and pavements, extending the life cycle of these materials.

Internal walls:

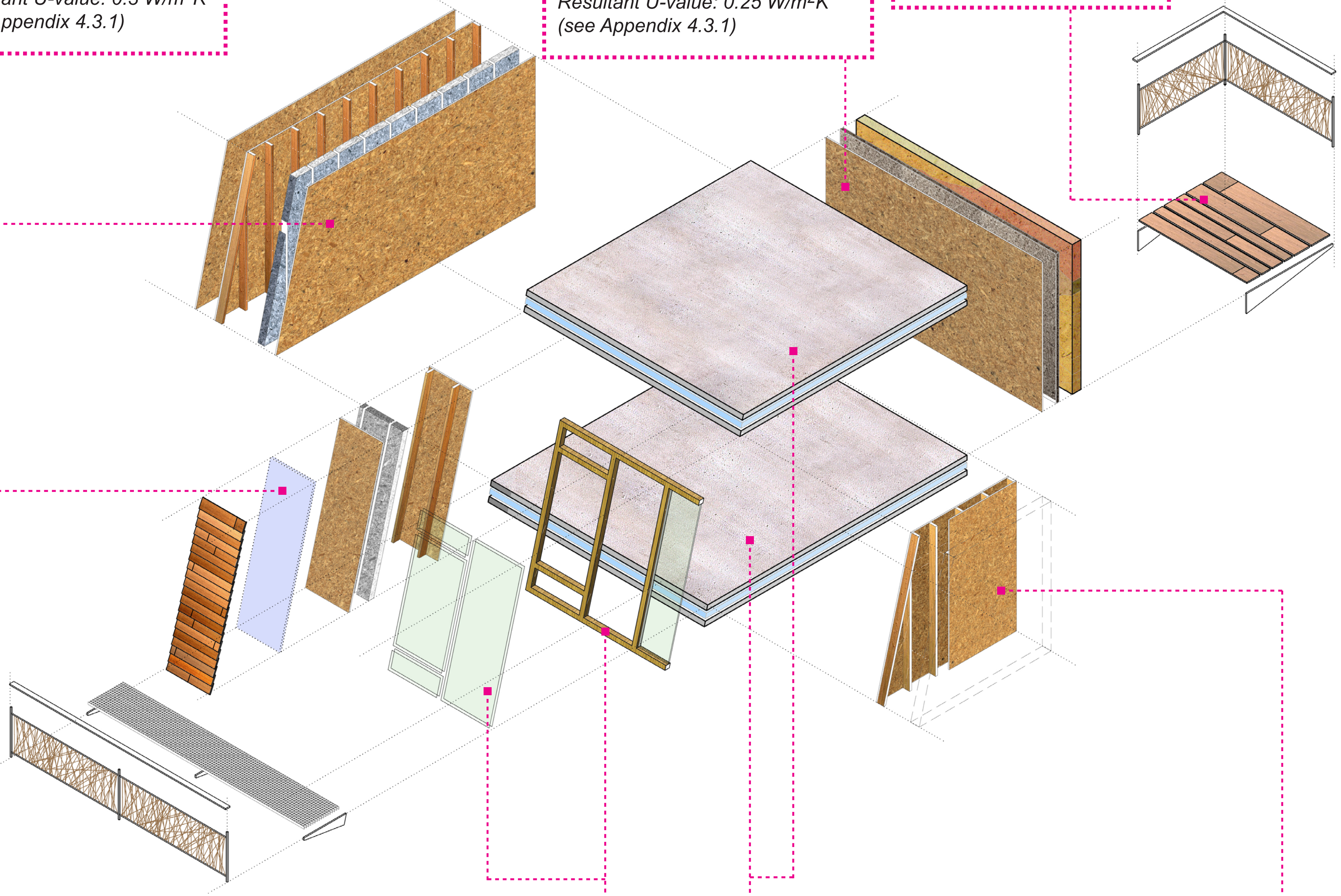
-Wood panel (25 mm)
-Cellulose insulation (80 mm)
-Wood panel (25 mm)
Resultant U-value: 0.3 W/m^{2}K
(see Appendix 4.3.1)

North Back Walls:

-Wood panel (25 mm)
-Cellulose insulation (130 mm)
-Rammed earth wall (200 mm)
Resultant U-value: 0.25 W/m^{2}K
(see Appendix 4.3.1)

Indoor North Terraces:

-Wooden pavement
-Wooden frame
-String parapet



External walls:

-Wood panel (25 mm)
-Cellulose insulation (120 mm)
-Wood panel (25 mm)
-Air cavity (400 mm)
-Wood finishing (150 mm)
Resultant U-value: 0.25 W/m^{2}K
(see Appendix 4.3.1)

Windows:

Double glazed window with wooden frames.
Resultant U-value: 2 W/m^{2}K
(see Appendix 4.3.1)

Floors and ceilings:

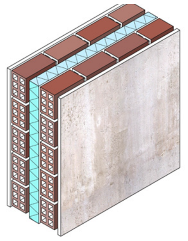
-Precast concrete (100 mm)
-Cellulose insulation (150 mm)
-Precast concrete (100 mm)
Resultant U-value: 0.25 W/m^{2}K
(not exposed), (see Appendix 4.3.1)

Internal partitions:

-Wood panel (25 mm)
-Wood lumber substructure
-Wood panel (25 mm)

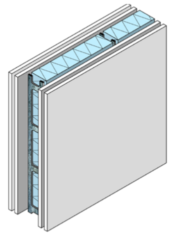
Figure 4.3.1 Materiality illustration

Brick wall:
326.5 kg/m^2



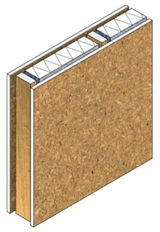
Plaster - 25 mm
Brick - 125 mm
Polyestyrene - 80 mm
Brick - 125 mm
Plaster - 25 mm

Drywall:
31.5 kg/m^2

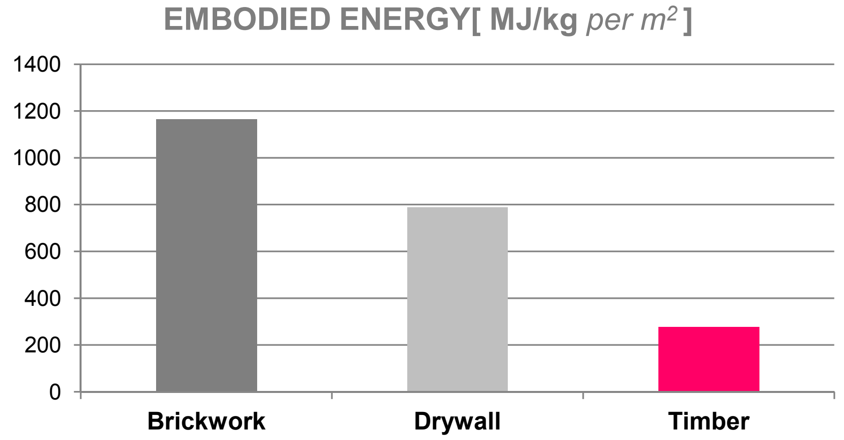


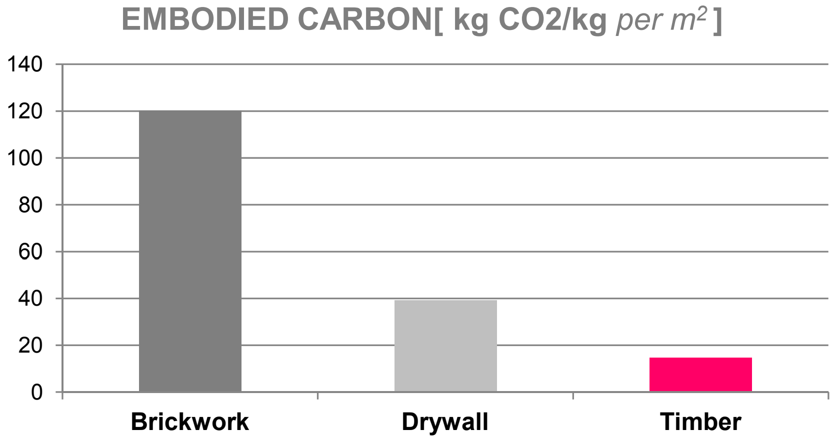
Plaster - 25 mm
Paperboard- 25 mm
Polyestyrene - 80 mm
Paperboard- 125 mm
Plaster - 25 mm

Timber wall:
33.0 kg/m^2

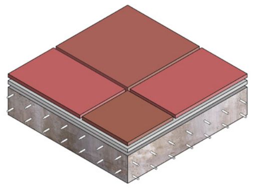


Chipboard - 25 mm
Cellulose - 80 mm
Chipboard - 25 mm



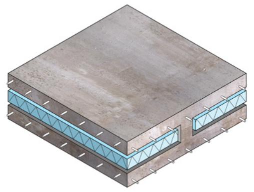


Concrete slab + clay tiles:
556.5 kg/m^2

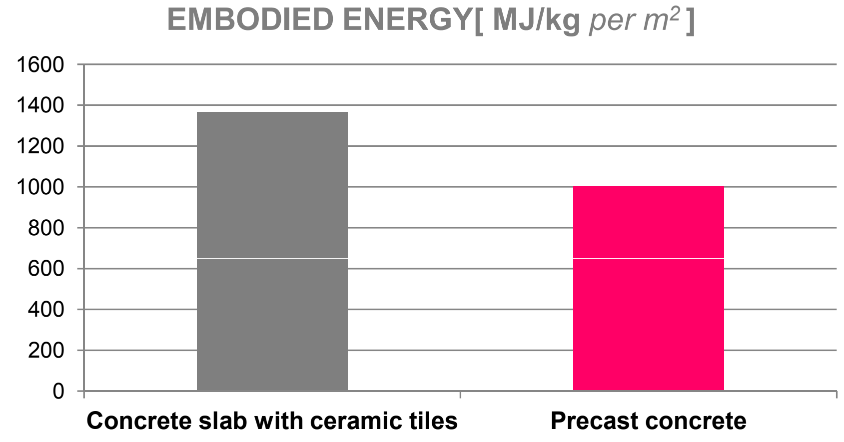


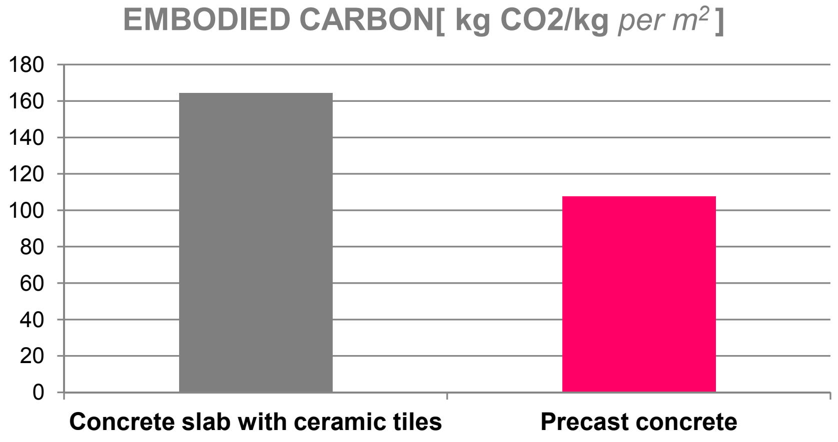
Clay tiles - 25 mm
Reinforced concrete -
200 mm

Precast concrete floor:
501.3 kg/m^2

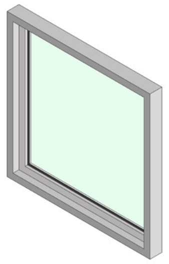


Precast concrete-100 mm
Cellulose - 80 mm
Precast concrete-100 mm



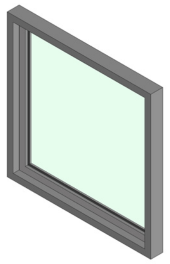


Double glazed window-aluminum framed:
1.2 x 1.2 m



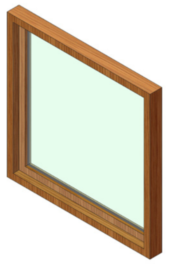
external
aluminum air insul plasterboard

Double glazed window-PVC framed:
1.2 x 1.2 m

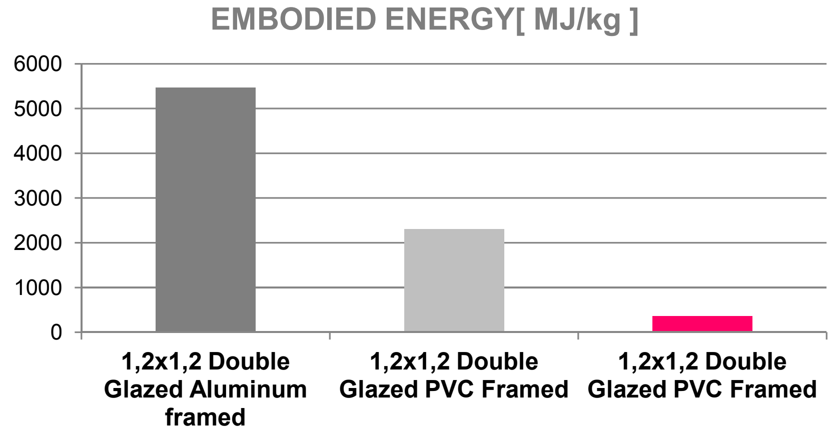


external
tails(st jails) air ins plasterboard

Double glazed window-timber framed:
1.2 x 1.2 m



external
our case



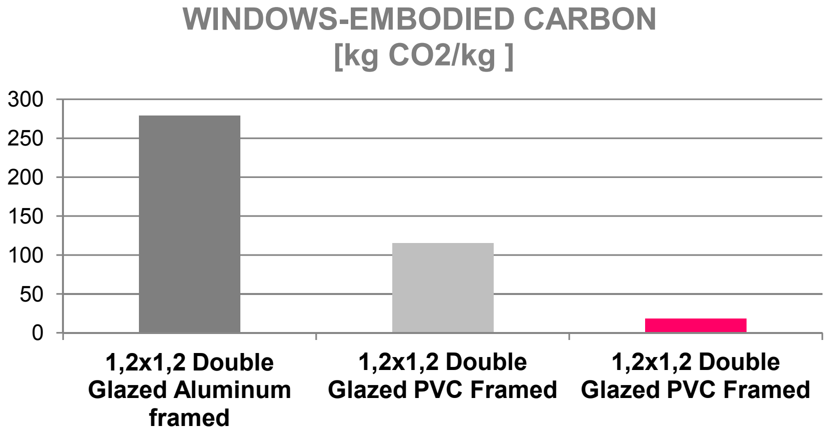


Figure 4.3.2 Materials by Embodied Carbon and Embodied Energy

References Hammond, G and C. Jones. 2006. “Inventory of Carbon and Energy.” University of Bath, Department of Mechanical Engineering.
Calkins, M. “Materials for Sustainable Sites”. New Jersey, 2009.
Fernandez, J. “Material Architecture”. Oxford, 2006.

4.4 _ Environmental design criteria

4.4.1 _ Internal Heat Gain Scenarios

In order to define the internal heat gain in the apartments, The Passive-on Project report on Internal heat gain scenarios was analysed. The report was made by eERG - the energy department of the Politecnico of Milan - based on PHI studies and field works on the energy consumption of 110 homes over an 18 month period in 2001-2002 around Italy. It proposes three levels of Internal Gains from Appliances and Lighting. Then through the analysis of the energy consumption and values of the PHI it defines appliance, lighting and occupancy schedules. See figures 4.4.1.2 and 4.4.1.3 and appendix 4.4.1.1 for the whole report.
The three scenarios, that the report sets, are:
high with 4W/m^2, standard with 3.4 W/m^2 and low with 2.1 W/m^2 - see figure (4.4.1.1).

To define the most appropriate scenario to be used in the simulations, the team took into consideration the change in internal heat gain due to difference life style, changes in occupancy and technological development in 2050 - as asked in the guide brief. The development in technology has been thought to be the factor that will play a major role in the change of the internal heat gain scenario in the future. In fact, in 2050 the number of appliances will reduce in number and increase efficiency: instead of having a cell phone, a laptop, a television, a DVD player etc. Probably only one device could cover the most of those functions. Another example that was considered is the great effort made in the recent years to develop new technologies for lighting. if today, LED technology is far from satisfying completely the light quality preferred - compared to a more traditional incandescent bulb - soon it will be possible to satisfy it. These considerations made the team think that it is more than possible that the standard heat gain scenario suggested by the passive-on report, will see a reduction of a 40-50 % in 2050.
For that reason the team decided to base the analytic work of the apartments using the pattern suggested by the Passive-on project study for a low heat gain scenario that is shown in fig. 4.4.1.2. The team called this pattern of internal heat gain as “design pattern” since it is an average of different real patterns. That means as it can be seen in the plot of the occupancy pattern of fig. 4.4.1.3 that the number of occupants is a percentage rather than a real number of people, covering a higher number of possible pattern combination. The fresh air required for the apartments was defined according to the “percentage” of occupants of the different units and taking in account that a person needs 30m^3 per hour of fresh air.

Even if the low scenario was chosen, the building was tested with all three of them to verify any problems of overheating due to the high difference in the magnitudes of the different scenarios. As it can be seen in figure 4.4.1.1 both the hours below and above comfort for the different scenario are lower than 3-5% of the whole hours of the year, which is consider to be in a range of acceptability according to the EN15251.

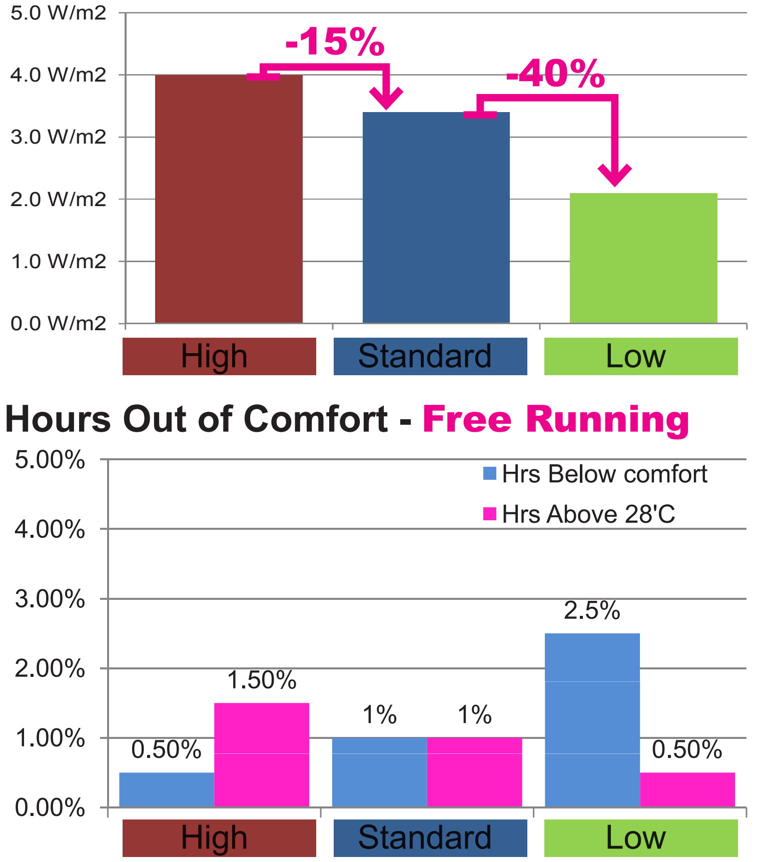


Figure 4.4.1.1 Above, Internal Heat Gains Scenarios. Below, comparison for hours below out of comfort

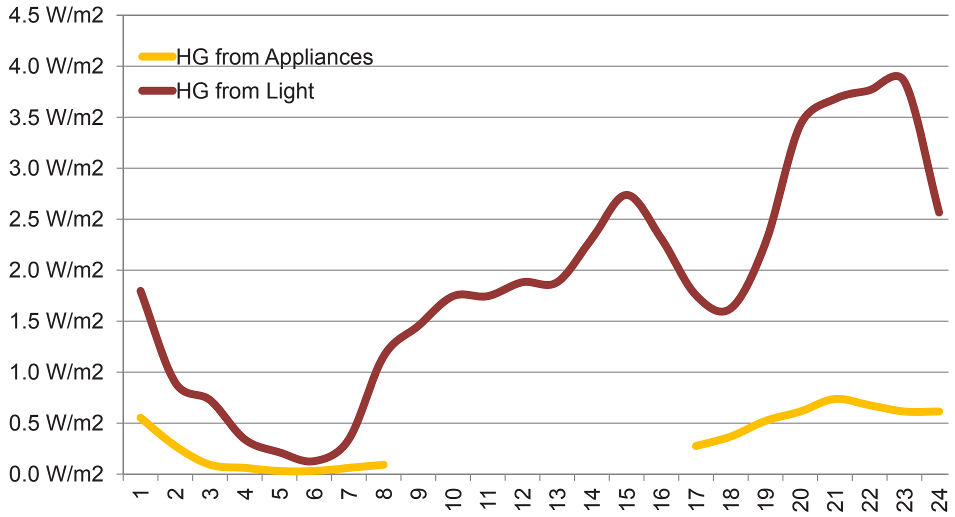


Figure 4.4.1.2 Appliances and Light Pattern

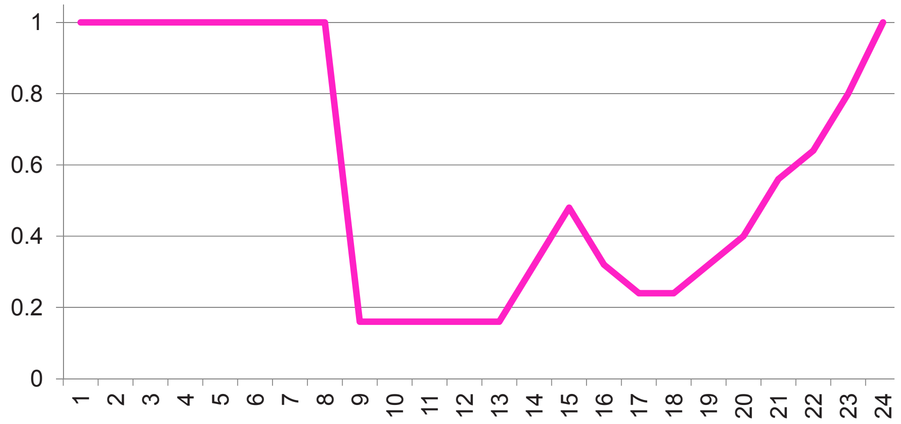


Figure 4.4.1.3 Occupancy Design Pattern

IF IN 2015 IS: ...

IN 2050 COULD BE: ...

Estimated reduction of Internal Heat Gain from appliances and light of 40-50% in 2050

⬇

Low Scenario 2015

=

Medium Scenario in 2050

Figure 4.4.1.4 Internal Heat Gains scenarios for 2015 and 2050

4.4.2 _ Thermal comfort

Since the team's challenge of approaching the design proposal suggests changing the definition of comfort from providing a fixed one, achieved by building services, to offering the adaptive measures and opportunities to make the inhabitants active users in controlling the natural elements in order to seek their personal satisfaction, the theory of adaptive comfort was revised.

Among the different theories of comfort and relative mathematical formulas, the de Dear equation was chosen to provide a reference for the user satisfaction with the indoor environment for the winter months. Whereas for summer, the equation suggested by the EN15251 was chosen. In fact, it has been thought that their combination provide a better reference to be compared with the results of our analytic studies. According to the de Dear theory people find comfortable a lower range of temperature from the one suggested by the EN15251. While the latter predicts a higher range in summer and more variable due to the consideration of mean running temperature in the formulation of the of the equation. This fact makes this model more appropriate to the variable climate of London. Figure 4.4.2.1. Either ways an addition upper limit of 28ºC was defined by the guide brief. 17ºC was set as the lower limit for the calculation of the hours below comfort, since it has been thought that the high range of adaptability provided will play a role in the forgiveness effect of the thermal environment during the extremely cold days of the winter (see materiality, chapter 4.3). Another aspect to be consider is that, since it has been used the "design pattern", that consider the presence of the user through all the day, the calculation of the hours out of the comfort limits was made on the 24 hours of the day.

Winter months

de Dear neutral temperature equation:

Tn=17.8 + 0.31 Tm

Tm = mean monthly temperature

Lower limit of comfort assumed **17ºC**

HOURS BELOW COMFORT 2.5%/a

Summer months

EN15251 neutral temperature equation

Tn=18.8 + 0.33 Trm

Trm = weighted running mean of the daily mean external temperature

Higher limit of comfort assumed **28ºC**

HOURS ABOVE COMFORT 0.5%/a

Figure 4.4.2.1 Comfort equations adopted according to the different seasons

4.4.3 _ Thermal Proprieties

Thermal proprieties of the materials respected the lower values suggested by the programme brief: U-values of 0.25 W/(m²K) were consider for the external Walls, equal to 2.00 W/(m²K) for the windows (glass + frame) and 0.20 W/(m²K) for the roof. The U value's properties of the north garden wall are 2.5 W/(m²K) for the glazed part and 0.3 W/(m²K) for the opaque parts.

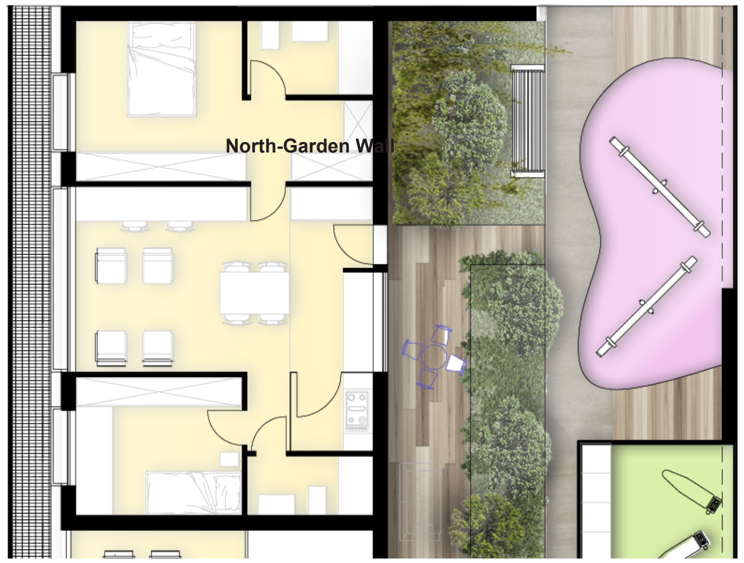
The infiltration rate in the apartments was establish as 0.2 ACH, according to the last specifications for new buildings.

The windows were considered to have a solar transmittance in the vicinity of 0.7 accordingly with the project brief and they were provided with insulated shutter on the external part: the composition glass + night shutter has a final U-value of 0.5 W/(m²K).

The fresh air supply was assumed as 30m³ per person per hour and scheduled accordingly with the user pattern described in the chapter before.

Finally the figures 4.4.2.2 and 4.4.2.3 show the Heat transfer coefficient (HTC) per m² occupied floor area for the one bedroom and two bedroom apartments.

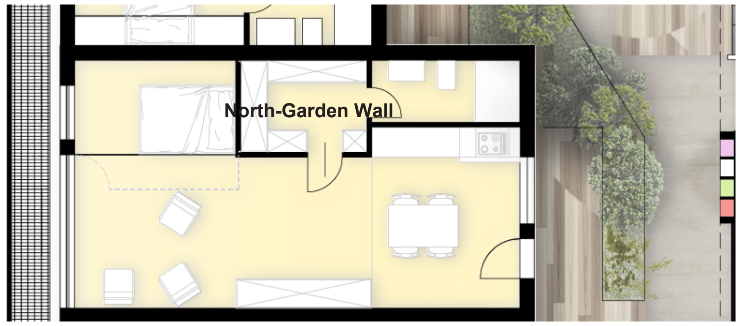
Apt Area	60	m^2 floor area
Apt Vol	180	m^3
External Wall		
U-value	0.25	W/m^{2}K
Surface	15.2	m^2
Windows		
U-value	2	W/m^{2}K
plus Shutter	0.5	W/m^{2}K
w/ shutter per 8hrs	1.5	W/m^{2}K
Surface	14.8	m^2
Infiltration	**0.2**	**ACH**
HTC from the south envelop	**0.63**	**W/m^{2}K of occupied area**



North-Garden Wall		
U-value	0.25	W/m^{2}K
Surface	27	m^2
Windows		
U-value	2	W/m^{2}K
plus Shutter	0.5	W/m^{2}K
w/ shutter per 12hrs	1.25	W/m^{2}K
Surface	3	m^2
Average hourly fresh air	**0.25**	**ACH**
HTC from the south envelop	**0.42**	**W/m^{2}K of occupied ai**

Figure 4.4.2.2 Thermal properties - Heat Transfer Coefficient related to the occupied floor area - two bedroom apartment

Apt Area	45	m^2 floor area
Apt Vol	135	m^3
External Wall		
U-value	0.25	W/m^{2}K
Surface	4.5	m^2
Windows		
U-value	2	W/m^{2}K
plus Shutter	0.5	W/m^{2}K
w/ shutter per 8hrs	1.5	W/m^{2}K
Surface	10.5	m^2
Infiltration	**0.2**	**ACH**
HTC from the south envelop	**0.57**	**W/m^{2}K of occupied area**



average hourly fresh air **0.21** **ACH**

North-Garden Wall		
U-value	0.25	W/m^{2}K
Surface	12	m^2
Windows		
U-value	2	W/m^{2}K
plus Shutter	0.5	W/m^{2}K
w/ shutter per 12hrs	1.25	W/m^{2}K
Surface	3	m^2
average hourly fresh air	**0.21**	**ACH**
HTC from the south envelop	**0.36**	**W/m^{2}K of occupied ai**

Figure 4.4.2.3 Thermal properties - Heat Transfer Coefficient related to the occupied floor area - one bedroom apartment

4.4.4 _ Results

The garden-buffer is placed on the north side of the residential blocks. It represents both the natural stimuli that evokes the response of the users to the building and the mean to reduce the heat losses from the north/back walls of the apartments in winter while providing a cool environment in summer. The idea of the garden came from the architectural necessity of creating a space at the levels of the apartments that can promote social interaction between the residents. At the same time it was thought that it could have an environmental role in the performance of the apartments, since Nick Backer in the book Energy and environment in architecture, define that an attached atrium, which has similar feature of the proposed garden, has a rise in temperature from the external playing a role in reducing the heat losses from the surrounding spaces even if there were not direct solar heat gains. Applying the same idea of creating a symbiotic relationship between buildings and the natural environments, it was thought that the same relationship could have been established between the apartments and the garden in a way that they can benefit from each other. So the idea was that the buffer could work not only as a mean to reduce heat losses from the apartments but also as a container from which the apartments can be provided with the required fresh air in winter.

The preliminary tests made with and without garden, showed the potential that the buffer could have when the air is taken from it. As it can be seen in the fig. 4.4.4.6 the reduction of the percentage of the hours of the year in which the temperature in the apartments is below the comfort, is 3% reaching a value of 5.5% which is closer to the acceptable percentage that is suggested by EN15251. Therefore it has been thought that by improving the envelop of the garden -which was all single glazing in the first test - less number of hours below the comfort could be reached.

To simulate in the thermal analysis simulator TAS what in reality is the user opening the windows towards the garden when the air is stuffy into the apartment, an Inter Zone Air Movement was created. The parameter of the ventilation within the internal condition of the apartments was set as zero and the ACH required were transformed into Kg/s to be applied to the IZAM. The air goes from the garden to the apartment and the same amount from the apartment to the garden. As it can be seen in the scheme of picture 4.4.4.8.
It has been verified that the 0.4 ACH of infiltration rate into the buffer satisfies the fresh air required for all the apartments. A thermostat of 18°C was set in the internal condition of the zones of the apartments that were not modelled in detailed. The thermostat setting was based on the lower temperatures reached in the preliminary studies of the apartments, in order to simulate the real heat exchange between the apartments and the garden. Since the heat losses through convection has a great impact on the performance of the units, it has been thought that reducing the ΔT between the indoor and the garden would have the heat losses caused by the fresh air required ventilation reduced. The delta T was reduced improving the envelop thermal proprieties of the buffer. The fig. 4.4.4.7 shows the increment in temperature of the garden in different steps until a 3K of the best case by using 40% of opaque insulated sandwich panels (U-value of 0.3 W/(m^{2}K)) and 60% double glazing (U-value of 2.5 W/(m^{2}K)). These improvements has lead to a further reduction of the percentage of hours below the comfort zone from 5.5% to 4% that is within a range of acceptability. Moreover those hours can be reduced if the frequency of the insulated shutter is increased during the coldest days as shown in the figure 4.4.4.6.

The plot of the indoor temperature of the apartments of an extreme winter week in different cases (fig. 4.4.4.7), show the benefit of taking the air from the buffer and the benefit of the adaptive opportunity provided. An additional run was made testing the possibility of preheating the fresh air required through a heat exchanger. The improvement reduces to minimal values the hours below the comfort. But the option wasn't explored further since **the strategies that driven the whole process was to avoid building services**. It is important to note that the study of the temperature in the apartment were made considering a Low Internal Heat gain scenario (2.1 W/m^2)

In the next pages the temperatures of the one bedroom apartments and two bedroom apartments during a typical week in winter and summer are plotted.

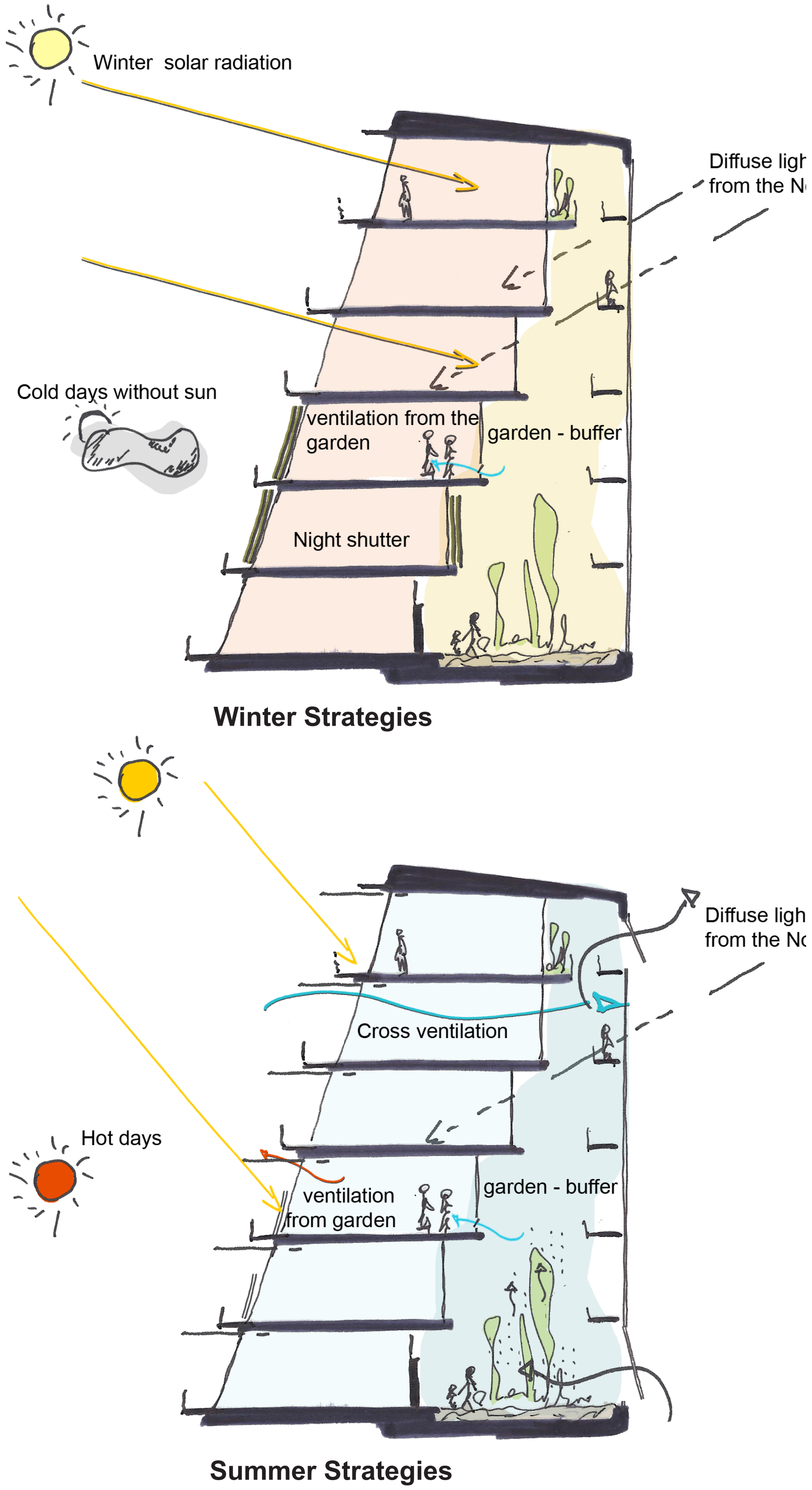


Figure 4.4.4.1 Buffer Garden Strategies for Winter and Summer

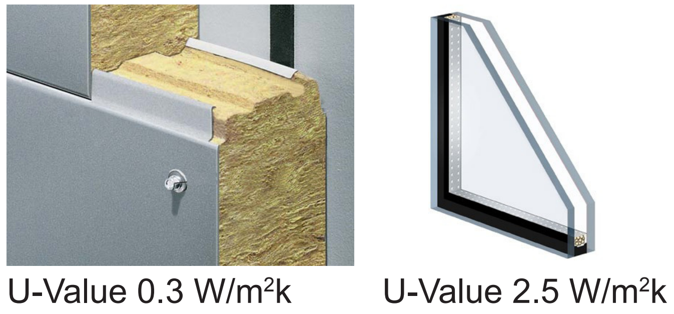


Figure 4.4.4.2 U-Values for Opaque and Double-glazed panel

Fresh Air Required for Apts =3481 m3 per day
Infiltration rate of the Garden 0.4ACH provides 6000 m3

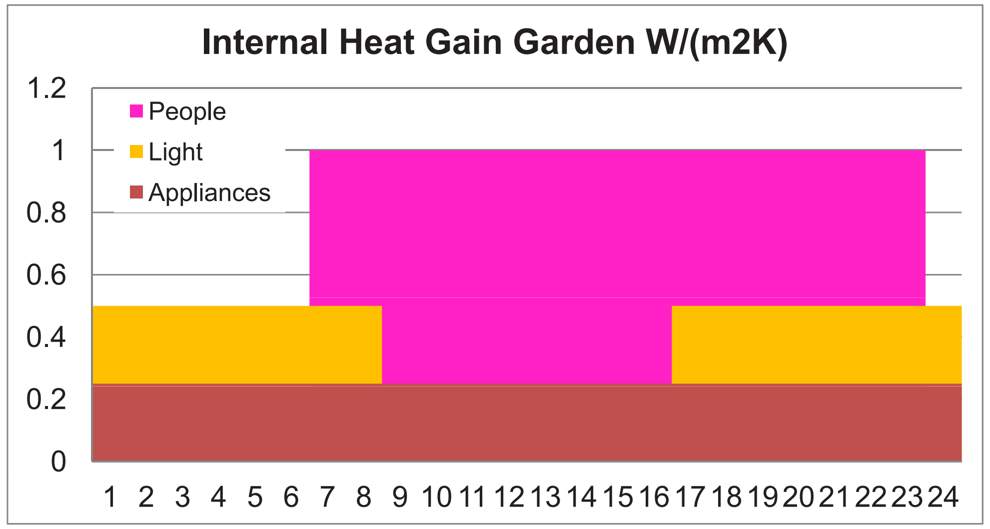


Figure 4.4.4.3 Internal Heat Gains for Buffer Garden and Infiltration rate calculations

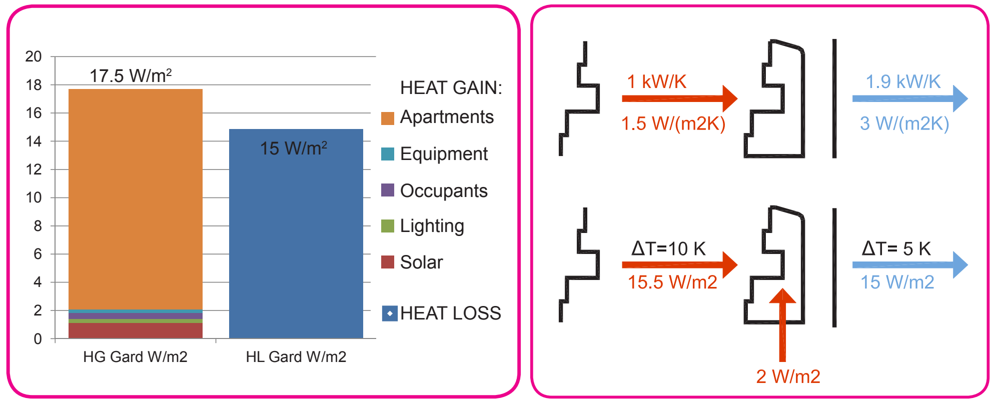


Figure 4.4.4.4 Buffer Garden - Heat Gains/Losses and HLC

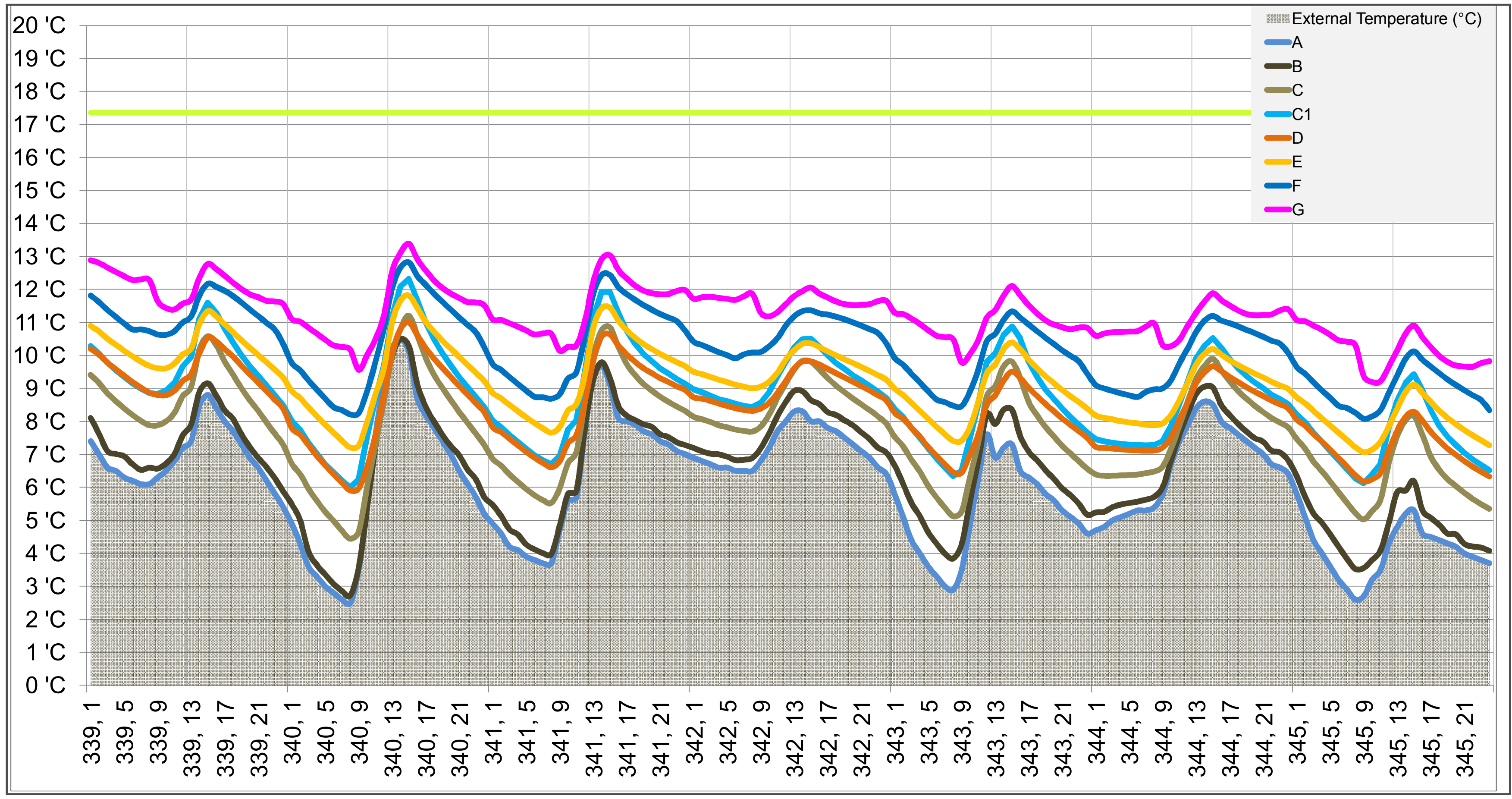
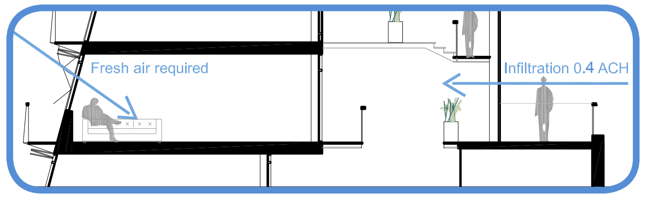
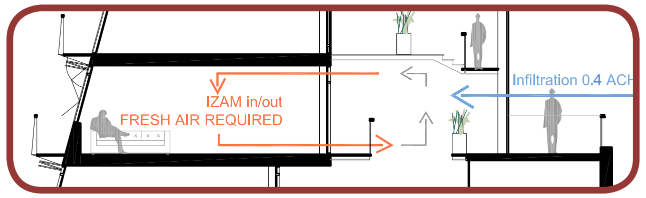


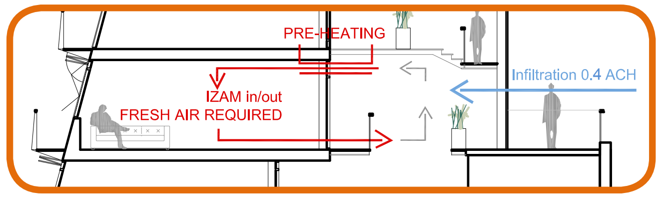
Figure 4.4.4.7 Dry bulb temperature of the garden buffer

A	NO GARDEN		
B	GARDEN	All Open	All Single Glasing
C	"	Close	All Single Glasing
C1	"	Close	All Double Glazing
D	"	Close	40% Opaque and 60% Single glazing
E	"	Close	40% Opaque and 60% Double Glazing
The next runs start from the case E:			
F	"	Close	+ Internal HG in the Garden
G	"	Close	+ Apt's fresh Air Required from the garden

Figure 4.4.4.5 Buffer Garden - Legend







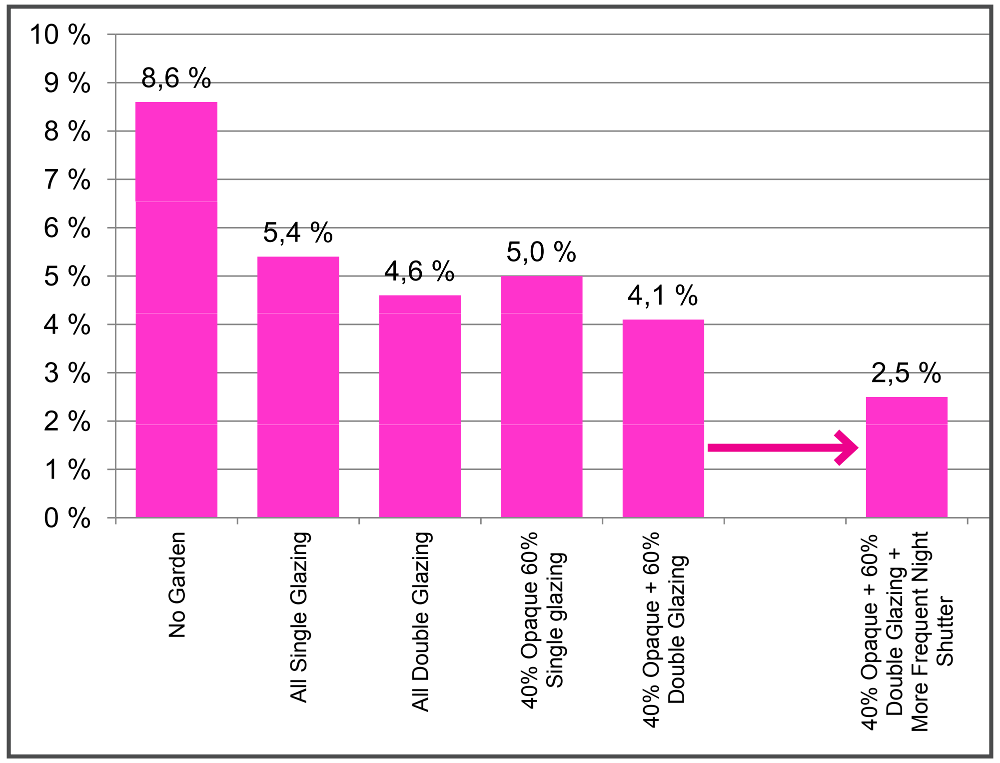


Figure 4.4.4.6 Resultant % of hours below 17°C in the one bedroom and two bedroom apartment according to the improvement made in the garden envelop. The low internal heat gain scenario was considered (2.1 W/m²) in the calculation

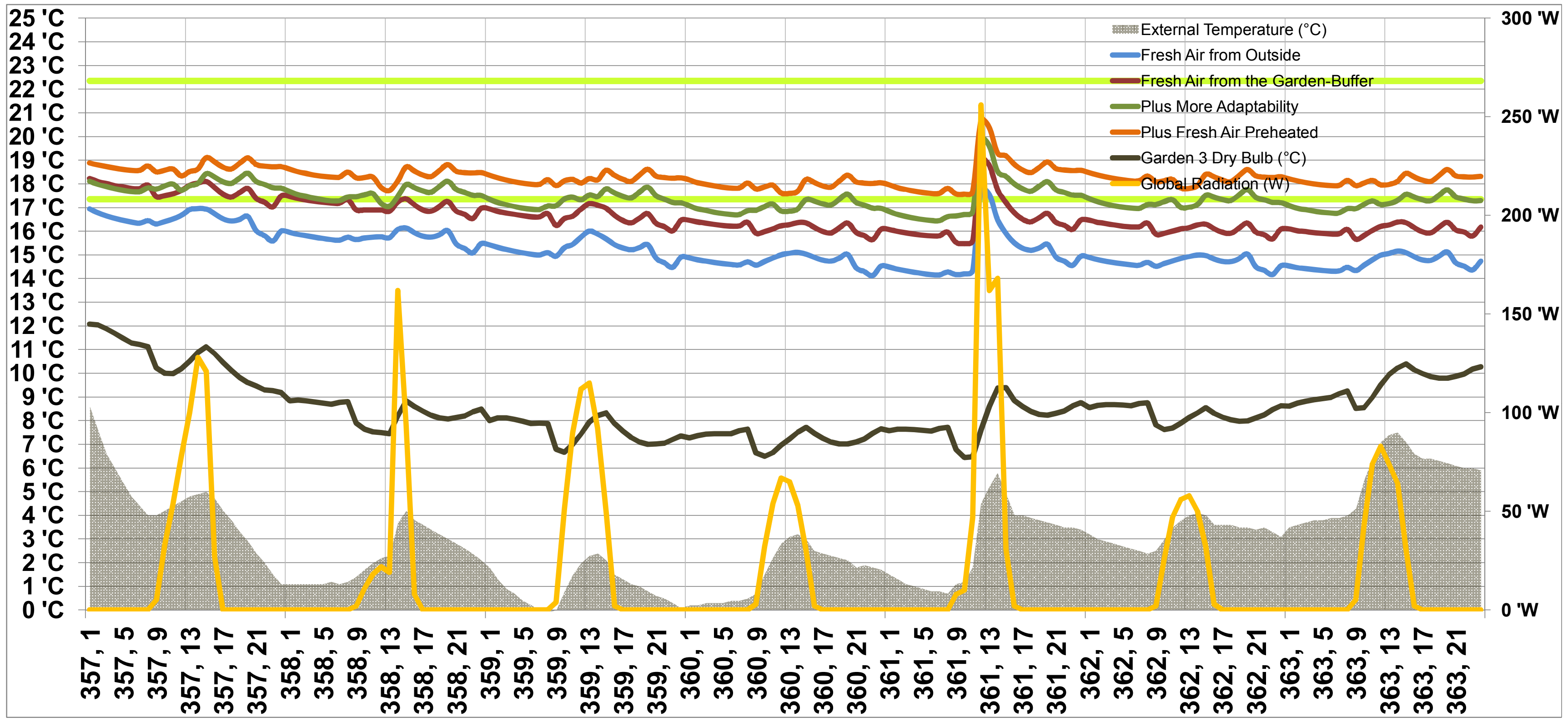


Figure 4.4.4.8 Resultant temperature comparison between extreme weeks.
The low internal heat gain scenario was considered (2.1 W/m²) in the calculation

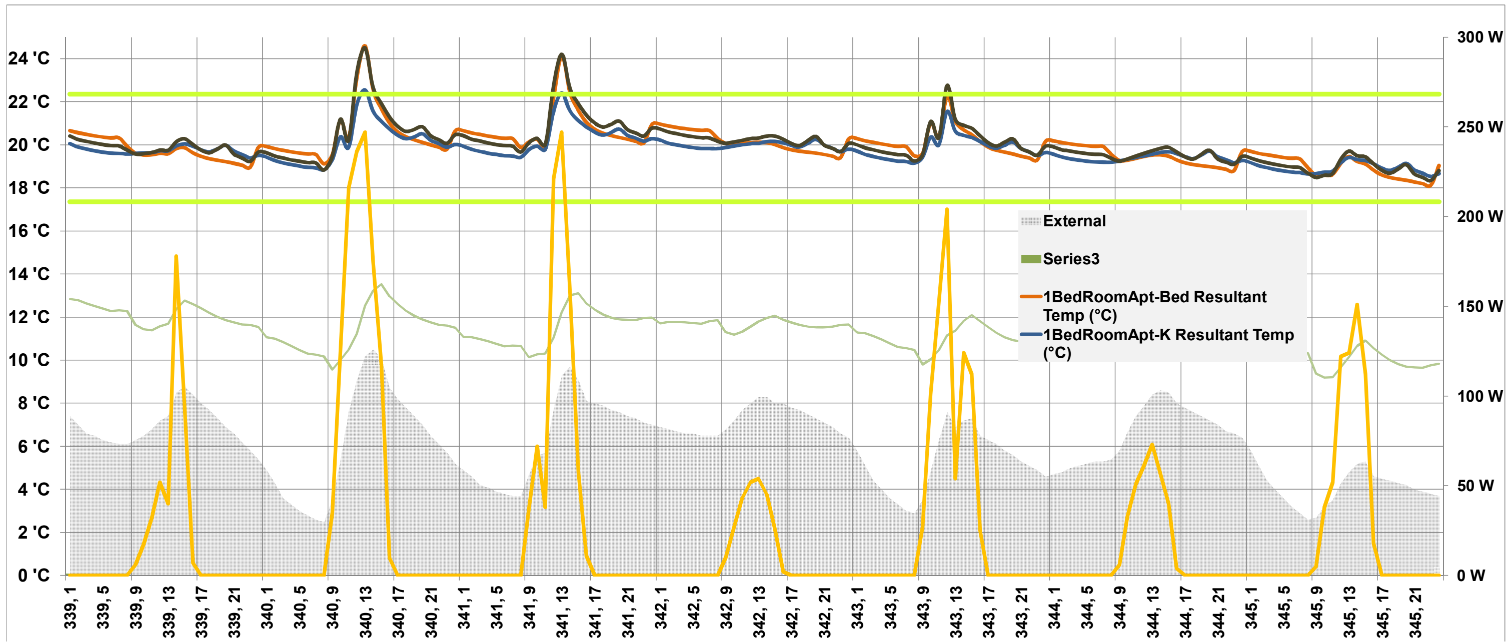


Figure 4.4.4.8 1 bedroom typology - Predicted indoor resultant temperature during a typical winter week

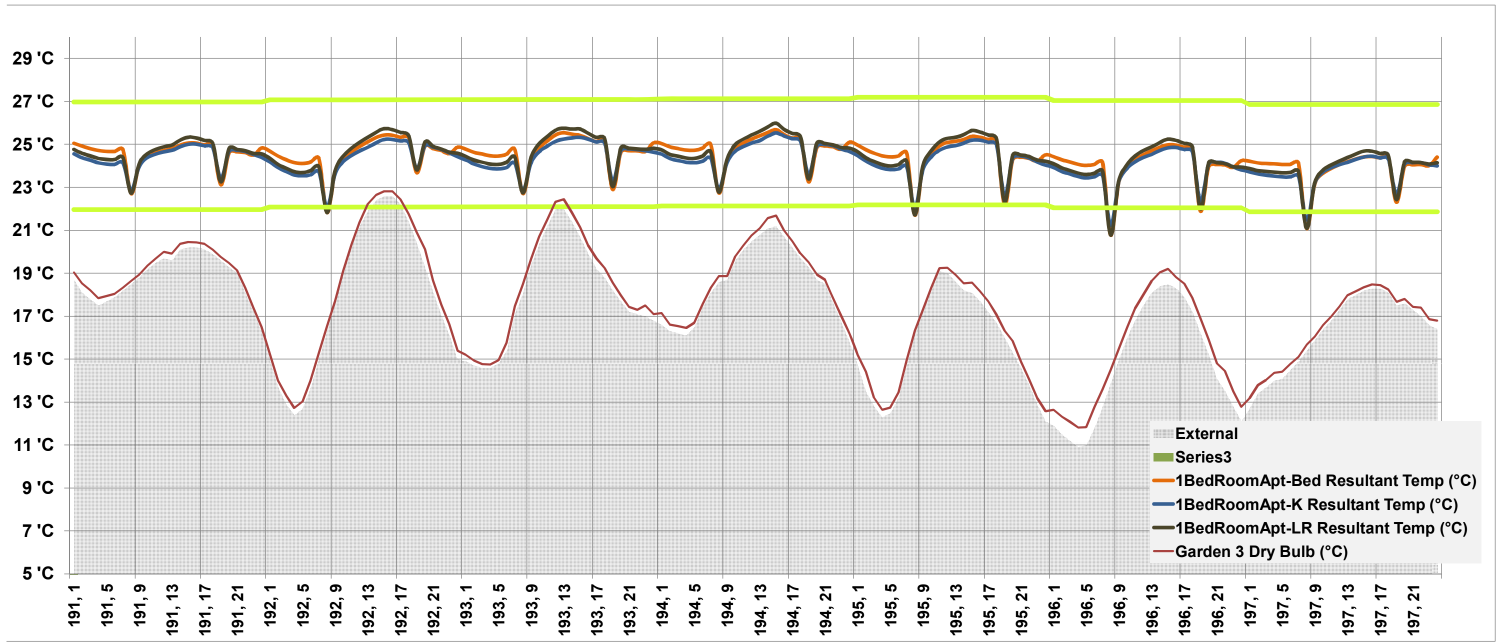


Figure 4.4.4.10 1 bedroom typology - Predicted indoor resultant temperature during a typical summer week

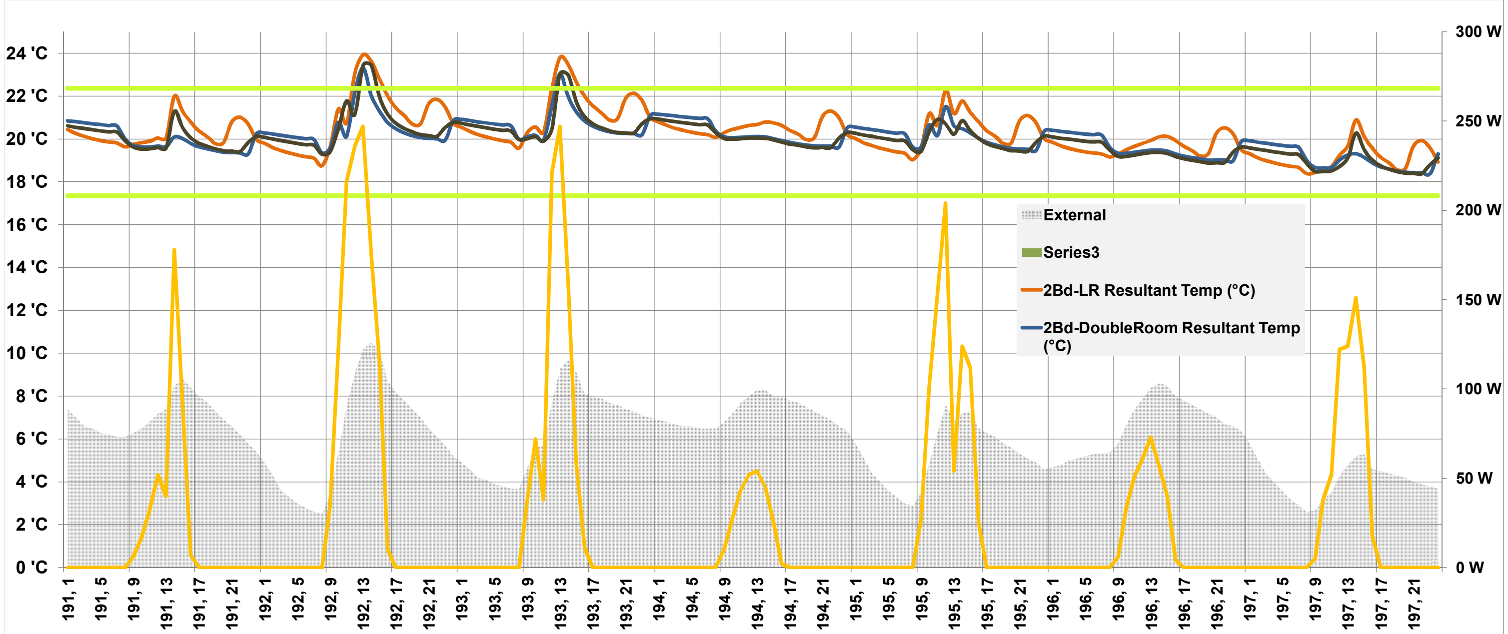


Figure 4.4.4.9 2 bedroom apartment typology - Predicted indoor resultant temperature during a winter week

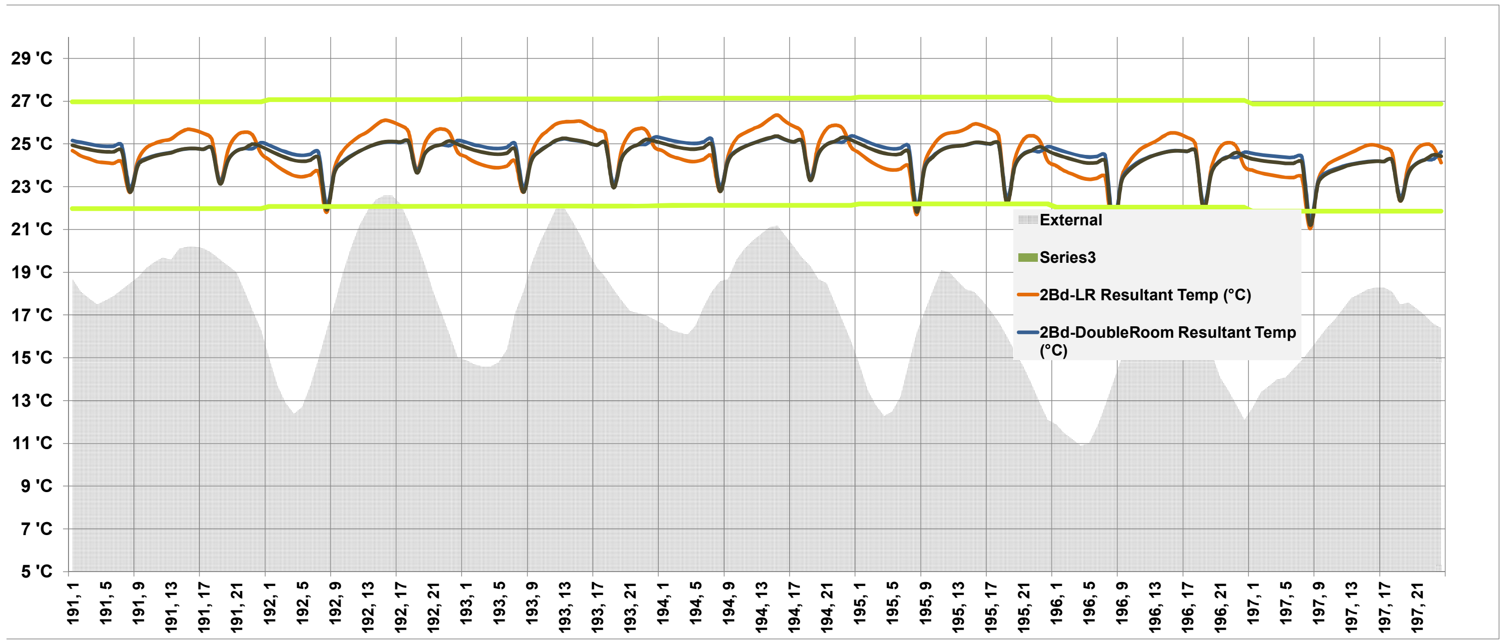


Figure 4.4.4.11 2 bedroom typology - Predicted indoor resultant temperature during a typical summer week

Fig. 4.4.4.8 and 4.4.4.9 show the predicted indoor temperature for the One Bedroom and Two Bedroom apartments, during a **typical winter week**. The space adaptation considered was limited to the users closing the shutters during sleep hours (11pm to 8am).

The fresh air required is thought to be taken by opening the windows towards the Garden, taking advantage of pre-heated air from the Buffer Garden. The temperature fluctuation is considerable during an extremely sunny day for winter, due to the strong South exposure of the apartment. While this fluctuation may be appreciated by the user when home, it can also be avoided by opening the tilting windows provided by the apartment's design, increasing ventilation. In case the user is not home, the fluctuation does not present itself as a critical point.

Fig. 4.4.4.10 and 4.4.4.11 show the predicted indoor temperature for the One Bedroom and Two Bedroom apartments, during a typical summer week. The space adaptation considered in the simulation, was limited to the users opening the sliding windows twice a day for 1h each at 8am and 6pm, but it is important to remind that the tilting windows provided can remain partially open throughout the day, allowing cross ventilation.

In fact, due to the mild temperatures for Summer in London, the outdoor temperature is typically below the comfort zone (see Chapter 2.2). Controlling the indoor temperature does not present itself as a challenge if the movable shutters are used as shading devices, avoiding heat gains from direct sun radiation.

The extreme weeks of the year are plotted in the appendix 4.4.4.1.

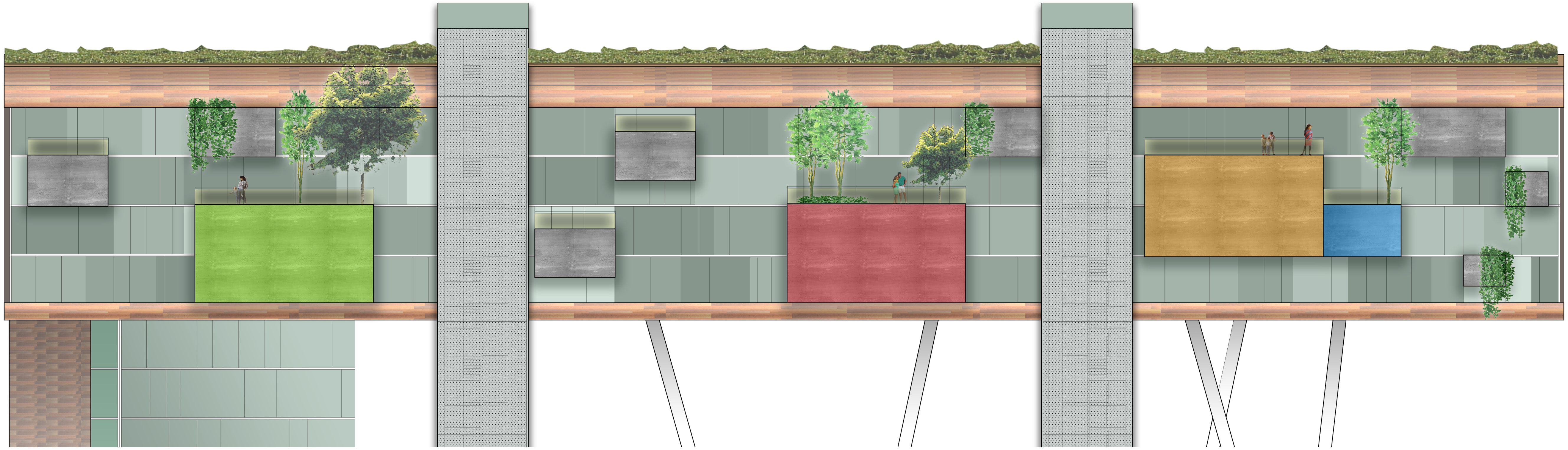


Figure 4.4.4.12 Illustrated Elevation - North Facade
(above)

Figure 4.4.4.13 Illustrated Plan
(below)

4.5 _Changes

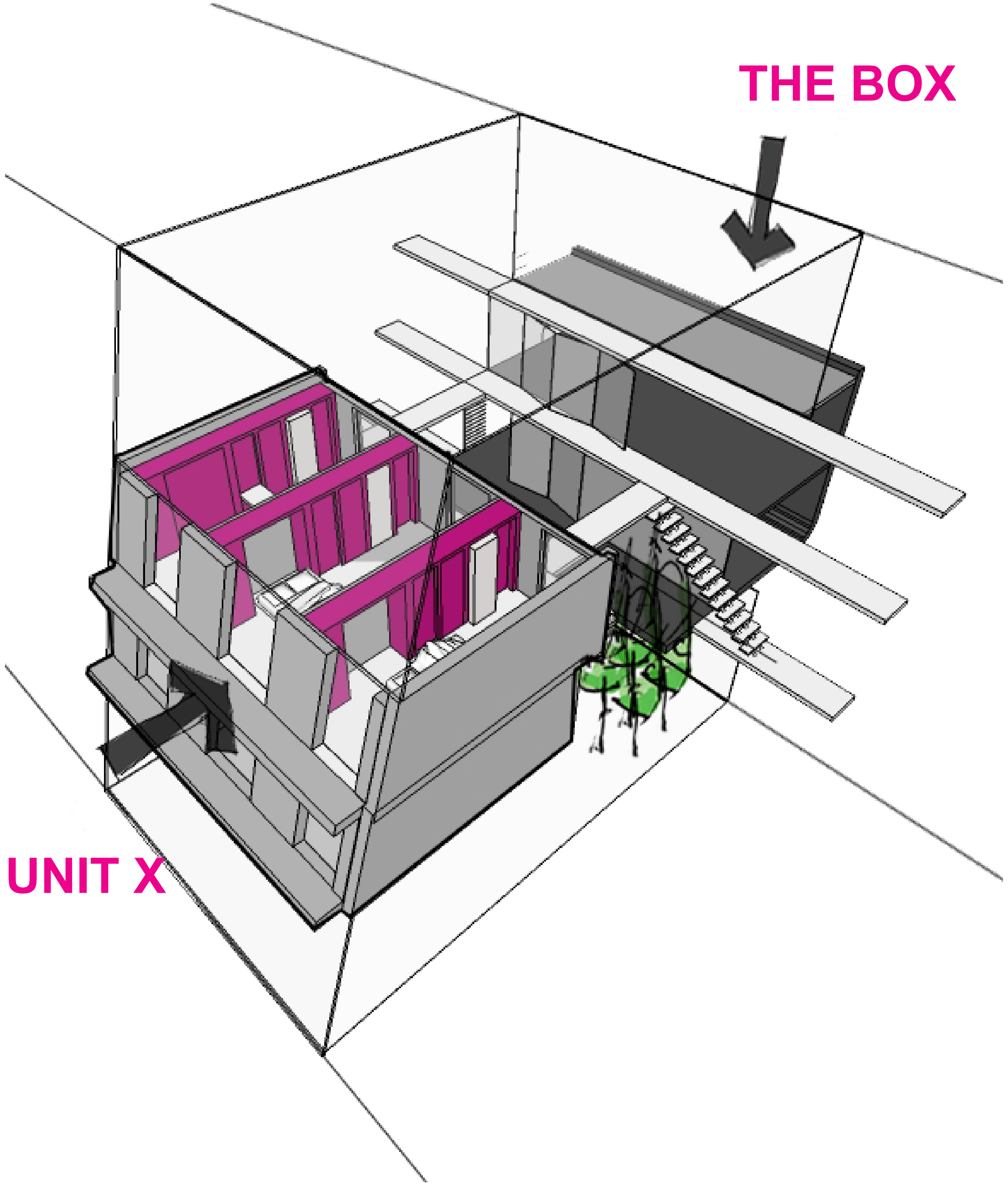
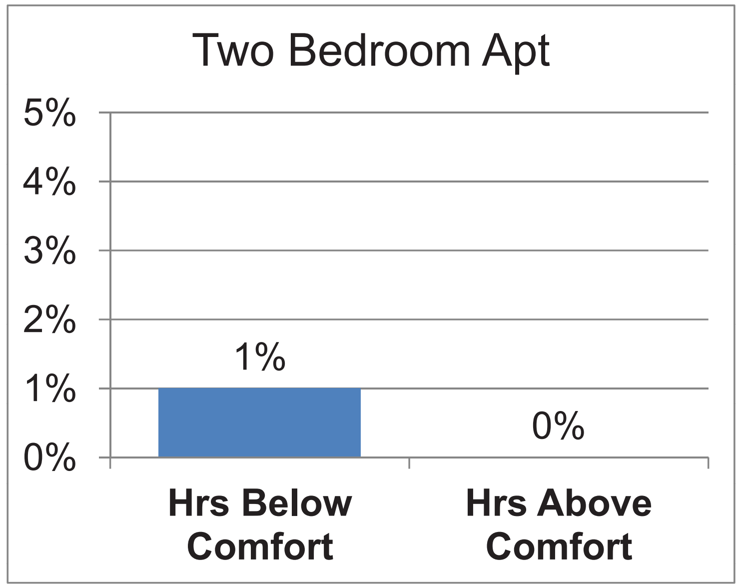


Figure 4.5.1.1 Connection between units X and communal facilities - the box-.

HOME SWEET HOME

FAMILY UNITS



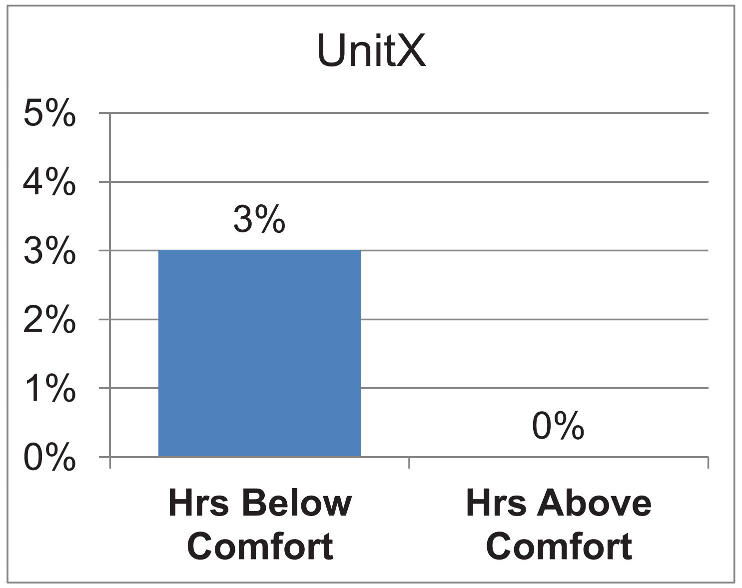
Internal Heat Gain **2.1 W/m^2**

Figure 4.5.1.2 Plan - 2 bedroom typology in 2015
(above)

Figure 4.5.1.3 2 bedroom typology - annual percentage of hours with temperatures out of a comfort range
(below)

HOME SHARED HOME

MINIMAL UNITS



Internal Heat Gain **1.7 W/m^2**

Figure 4.5.1.4 Plan - Unit X cluster in 2050
(above)

Figure 4.5.1.5 Unit 'X' - annual percentage of hours with temperatures out of a comfort range
(below)

4.5.1 _ Changes in occupancy

UNIT-X

`

The future scenario projects a trend of increase of the number of people working from their homes and a demand for smaller units.
the attempt to address the first term is through the spatial adaptability of the smaller units -studio and one bedroom. As it has been shown in the Chapter 4.2 through the description of the one bedroom apartment, these units can be configured as both a living space or a working environment only by moving the internal partitions.
The second trend implies that the spaces for social interaction that the building provides will be more valued as the trend can be interpreted that more people will be leaving individually. The shift can be conceptualized by a transformation of the idea of the home as a sweet environment to a home imagined as a shared space. The unit X which transforms the larger apartments (see Fig. 4.5.1.2) to minimal habitable units of 18 m^2 (see Fig. 4.5.1.4) in which different domestic and working activities can be developed. This module lives in symbiosis with "the box" which will be uses as an extension of the utilities of the minimal units (see Fig. 4.5.1.1). In fact the unit X is composed of a series of modular movable elements that can be arrange in an infinitive number of compositions where the only fixed modules are the sink, the shower and the toilette. The adaptability of the internal space balance the fact of the restricted dimension of the module providing the users of the adaptability that is preferred.
Since part of the utilities were moved into the box, the internal heat gain of the unit X will reduce. This reduction has been set as 1.7 W/m^2 which affect the internal performance in winter rising the percentage out of the comfort up to 3%, which is however still in a range of acceptability accordingly to EN15251 (see Fig. 4.5.1.5).

Figure 4.5.2.1 Buffer Garden - internal illustration

4.5.2 _ Climate Change

Since the project's objective is to create a dialogue between the built and the natural environment mediated by the active role of the inhabitant, the scenario in which this natural environment would change has to be taken into consideration and analysed. In other words it must be assured that climate change, new life style and appliances efficiency will not affect the balance of this relationship and the indoor environment can be still maintained within a range that is acceptable.

The previous climate analysis (see chapter 2.2) has shown that taking into consideration a medium to high greenhouse gas emissions scenario based on a study for climate change (CIBSE 2005), the winter will remain the main problem to be addressed in London. In fact the average rise in temperature in winter will be about 0.5K while in summer is expected to be of 2K. Nevertheless, this average rise in temperature could be seen of not great threat, because the projection of external temperature only exceeds the upper limit of the acceptable temperature of 28°C - the green line in the graph - for less than 1% of the hours of the year. However, the future main concern relies in the possibility of more frequent heat waves which is addressed in the design proposal.

The building can benefit from the presence of the garden-buffer that in these occasions will work as a chimney for the passive downdraught evaporative cooling system (PDEC). The potential of the application of this system where establish analysing the meteonorm for the extreme referment year. it has been shown that during the warmest days, when the temperature goes up to 35°C, the depression (difference between the dry bulb and the wet bulb) is between 7K and 12K. This difference is the range suggested to the applicability of the PDEC system.

The magenta line in Fig. 4.5.2.3 shows the temperature in the garden estimated using the gross formula shown above.

Fig. (4.5.2.1) represent a possible scene in the garden when this system is applied.

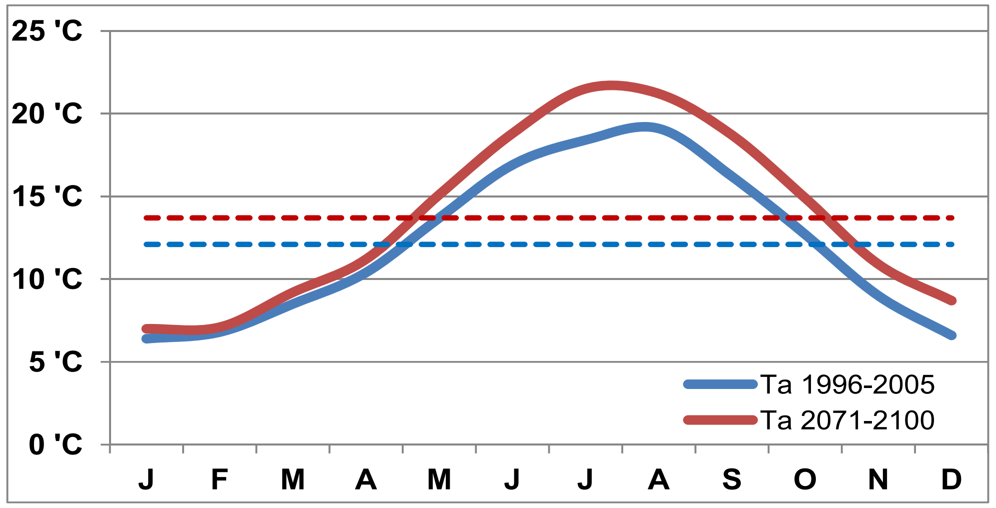


Figure 4.5.2.2 Temperature increase for mediow-high climate change scenario
Source: After CIBSE 2005

EVAPORATIVE COOLING IN THE ATRIUM/GARDEN

Extimated Temperature

Tt = Tdb – 0.8 (Tdb – Twb)

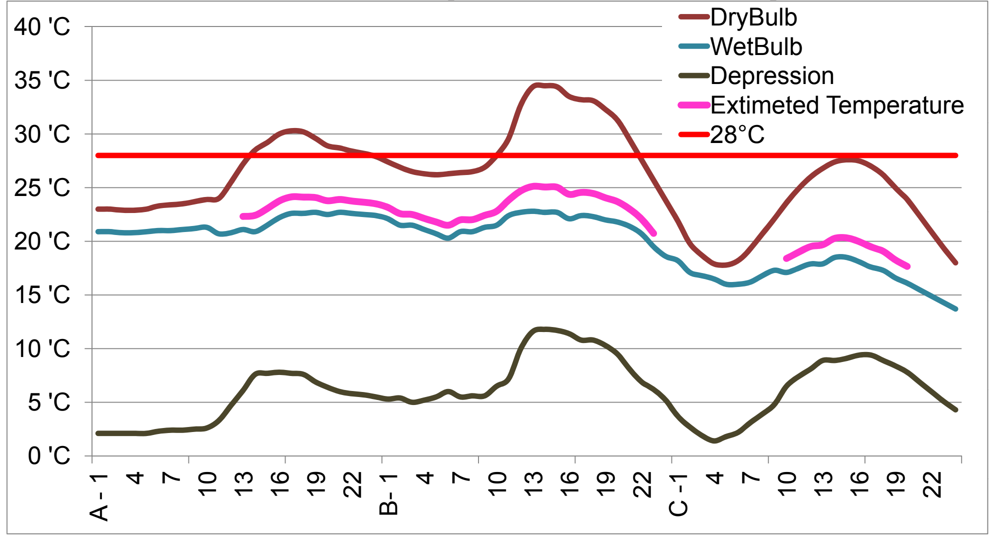


Figure 4.5.2.3 Estimated Temperatures for Buffer Garden with Passive downdraught cooling

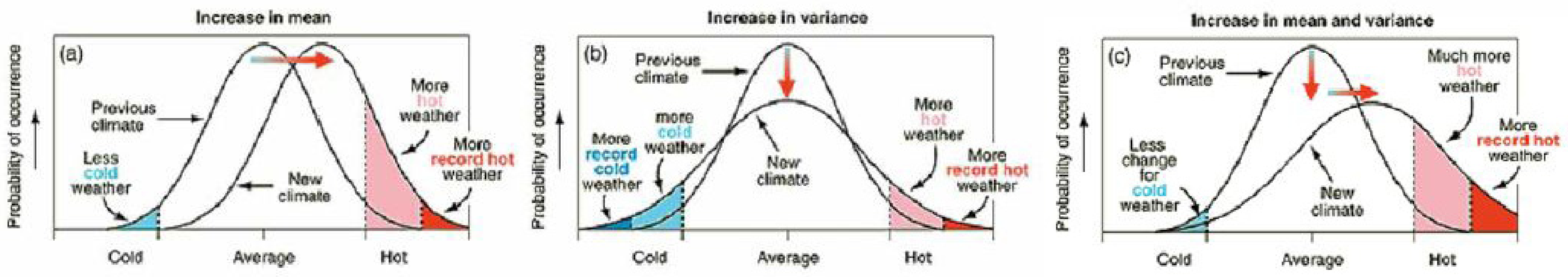


Figure 4.5.2.4 Climate Change effects
Source: Taylor, B. Microclimate lecture.

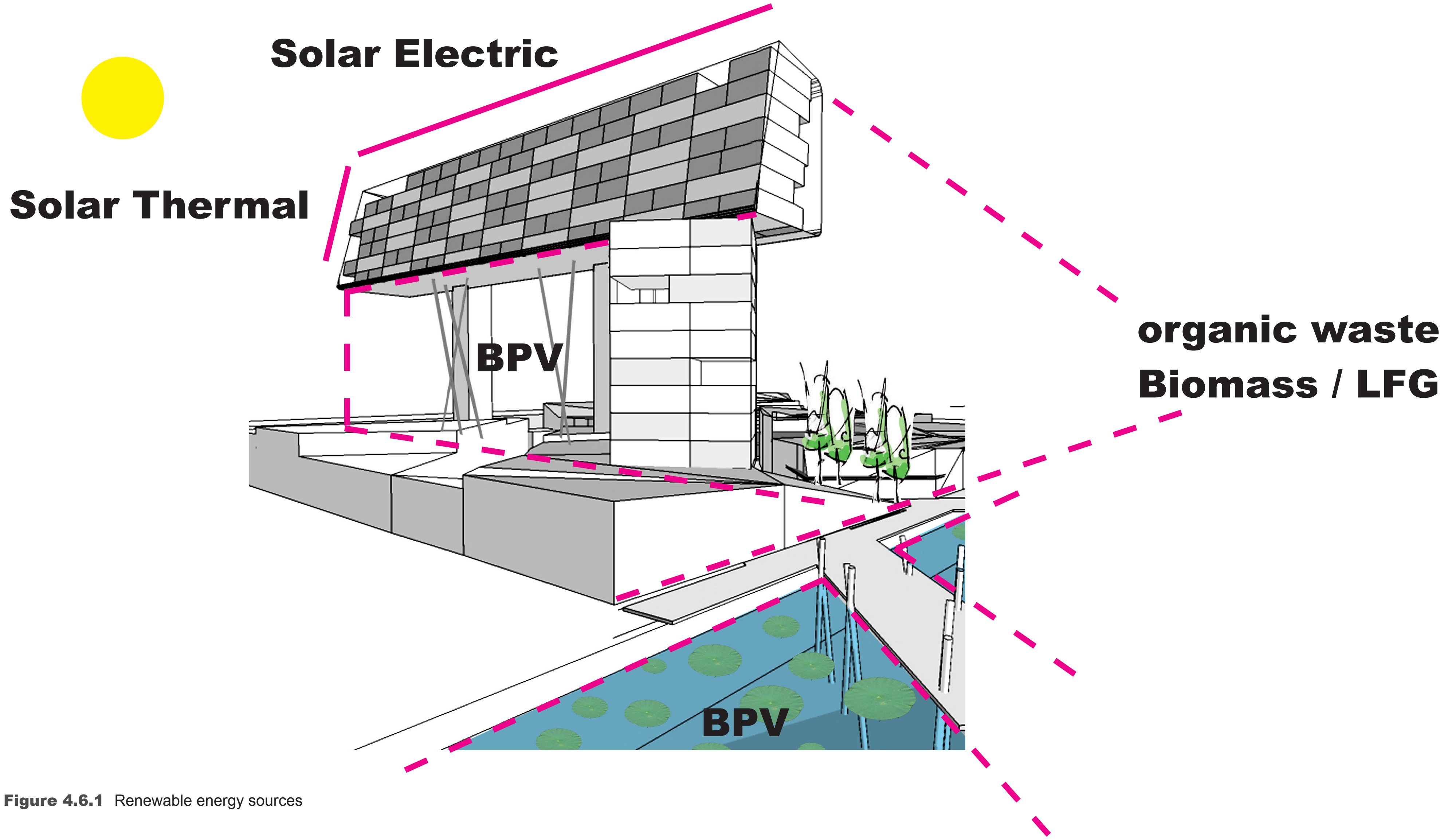


Figure 4.6.1 Renewable energy sources

… Meeting Residual Loads

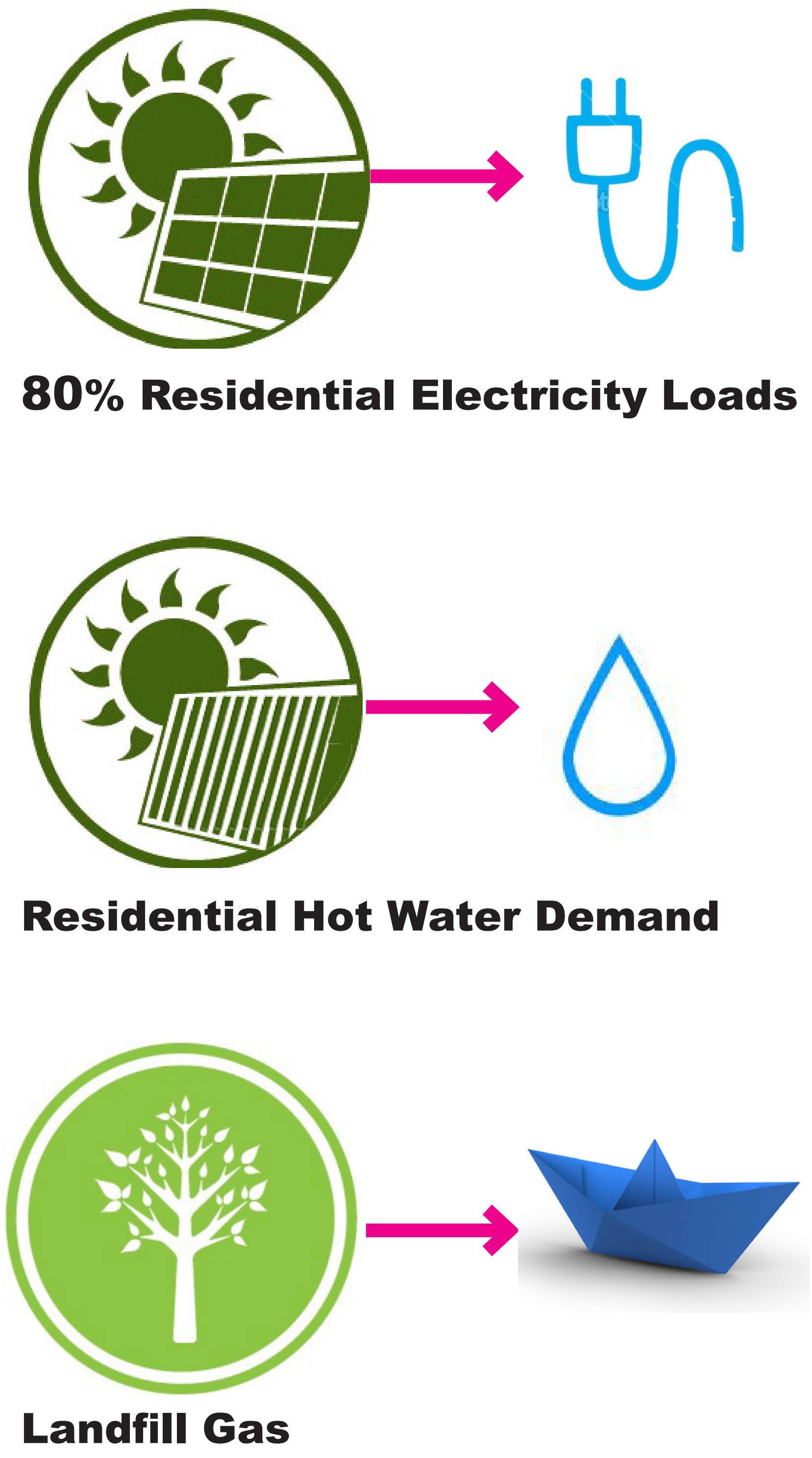


Figure 4.6.2 Renewable energy strategies

4.6_Energy and waste

Due to the group's design strategies of seeking for the sun and the results achieved in being able to eliminate buildings services for space heating the need of non-renewable energy was also reduced. Both facades and roofs of the Buildings are suitable for implementing solar-based systems do to the south orientation.

Eliminating the space heating demand, cause of the first domestic energy consumption in London, the Water Heating which is the second end use responsible for energy consumption in UK households (see Appendix 4.6.1), was addressed. A Solar Thermal system was integrated in the facades (see figures DD). In order to increase the system's efficiency, a combined Waste Water Heat Recycling system was also considered, making use of the surplus heat from the shower to preheat the incoming water.

For the residual loads of energy consumption, a Photovoltaic array was integrated in the top part of the roof. This system would generate approximately 150.00 kWh/a, meeting 60% of the residential annual energy consumption if the low energy consumption scenario is taken into account according to the concepts explained in the Chapter 4.4.1 regarding the internal heat gain scenario (see Appendix 4.6.3).

As part of the "cross dock's" goals of generating the interaction with the canals, the use of bio-photovoltaics in a early stage was also considered. BPVs are currently under development, but it is expected that panels should have competitive market prices - when compared to PVs - in a few years (2016-2021).
With the benefit of needing lower solar radiation than PVs, the Project has a great potential for being a testing field for prototypes, as it offers different levels of solar radiation and water bodies configuration, including the canal (see Appendix 4.6.4).

A part from decreasing energy demand and producing energy on site, other levels of the Building's interaction with the city were considered. One of the highest share's for London's carbon footprint comes from food (41%). Furthermore, within the food footprint, approximately 80% is accounted outside London and is added to the city's total emissions due to transportation (GLA 2003 and City Limits 2002).

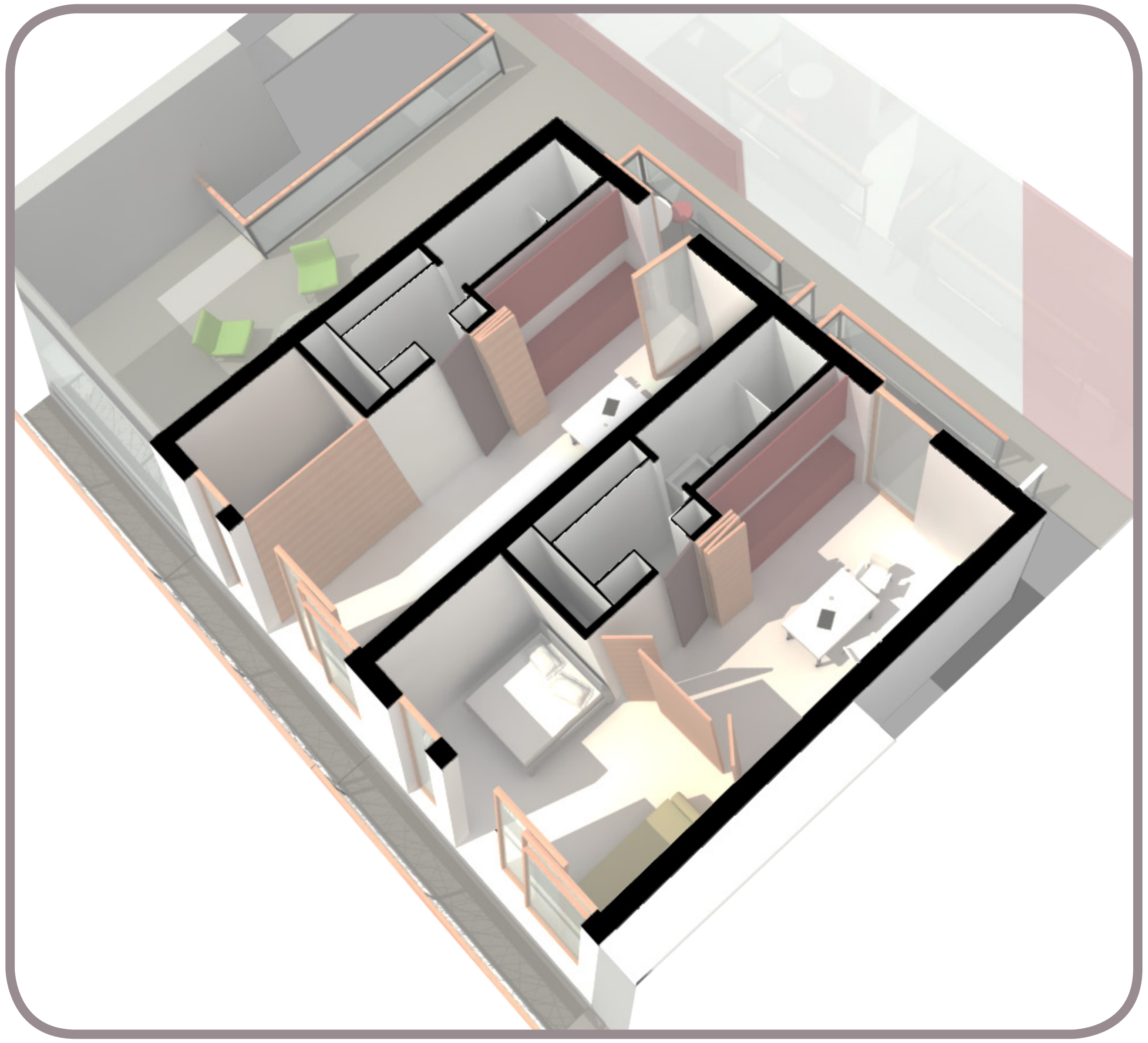
As a strategy to reduce carbon emissions due to food and waste, urban agriculture (see Appendix 4.6.2) is a considerable option if weighted not only transportation into the city, but also outside the city. As well as providing products to the city's dwellers, urban agriculture can also employ and make use of the residues after consumption.

As part of the Refurbishing the City agenda, taking advantage of the urban farming for composting the organic waste generated on site means reducing transportation emissions. Biomass energy generation was considered, but due to CO_2 emissions and fine particles residue, the excess organic waste is thought to be transported, by boat, along the Thames to the Tripcock Point Landfill and then transformed into LFC (landfill gas). In this case, although transporting the waste to an external location, reductions are still accounted by considering water transportation.

Another important aspect of the urban farming strategy and the landscape of the ground floor is the water management potential. The greenery aids in retaining water, important if considered the increase in flash-floods by the effects of climate change and, in addition, it can provide means for grey water biological treatment and also make use of blackwater after it is treated.

4.7 _Interacting with the Natural Ambiance

One Bedroom Apt - 45 m²



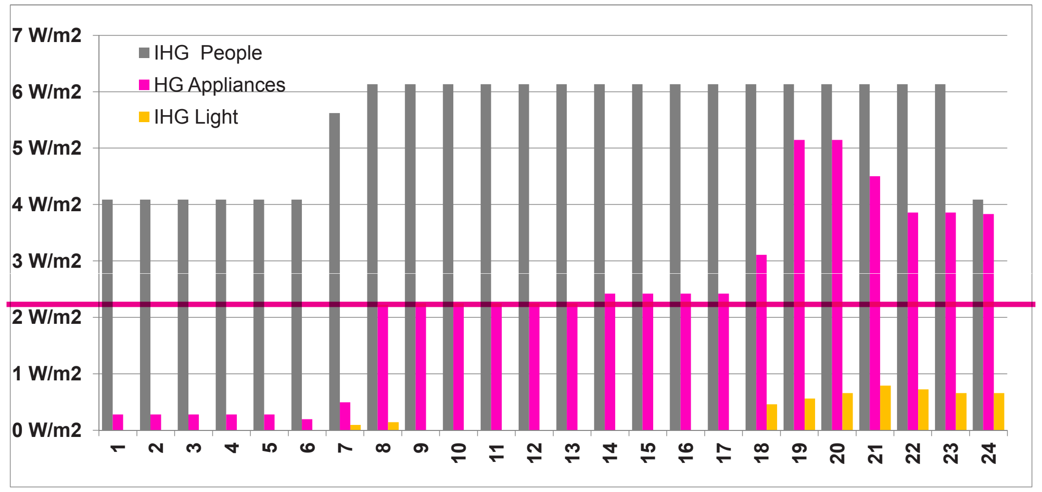


Figure 4.7.1 Internal Heat Gains and occupancy Schedule

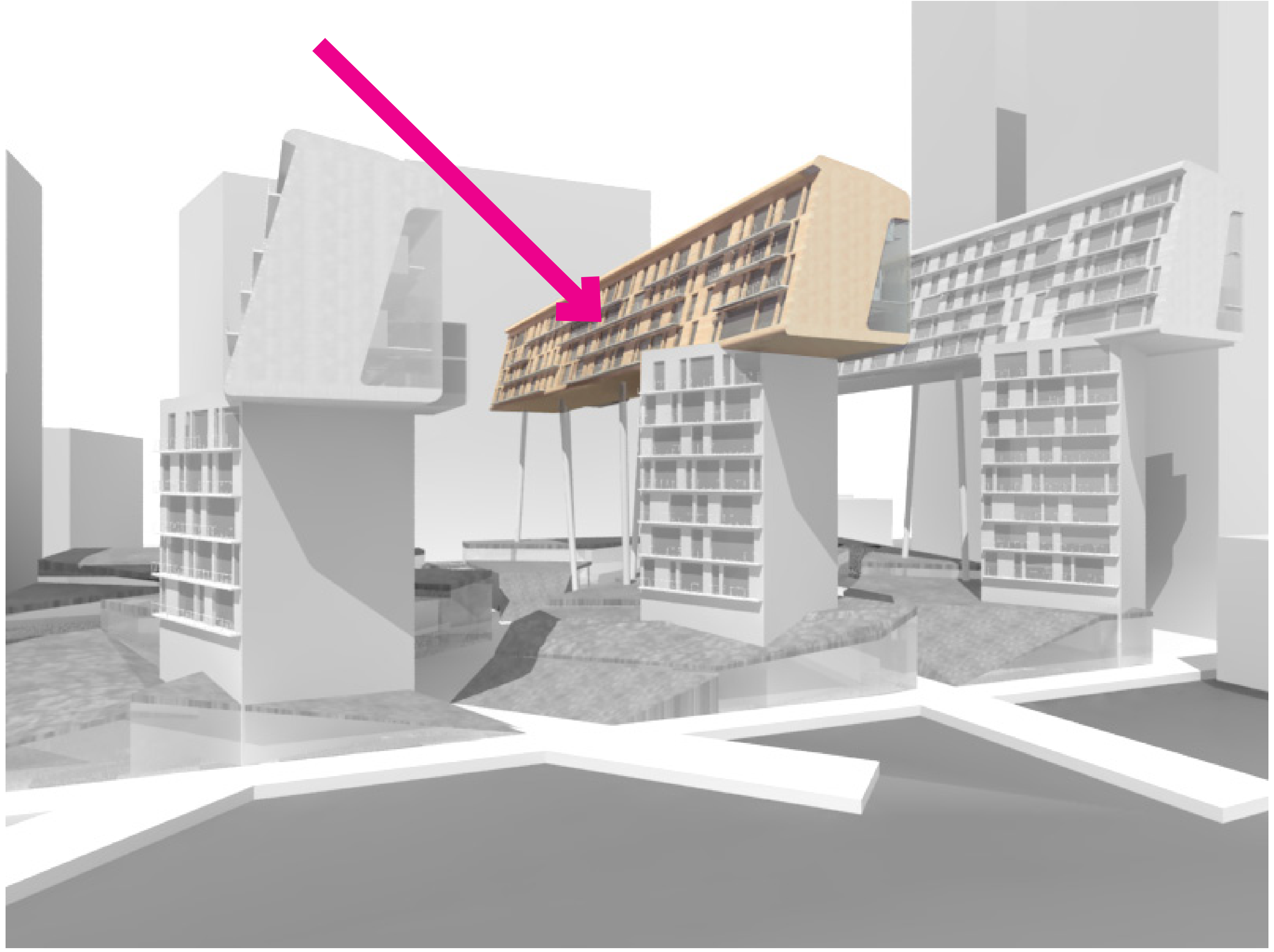


Figure 4.7.2 Analysed unit location

A post-occupancy visualization

The post occupancy visualization aims to show how the inhabitant could interact with the adaptability of the units and with the spaces of the residential block.
It analyse a One bedroom apartments occupied by a couple who spend the day in the apartment. The spaces will be shown from their point of view, predicting how they could live the building.
The figure 4.7.1 shows the pattern applied to the test made on different days of the year: typical winter sunny and cloudy day and typical summer sunny and cloudy day.

Typical winter sunny day

For a winter sunny day most of the shutters are kept opened, allowing solar gains raise the temperature inside (see Fig. 4.7.4), and letting the sunlight penetrate into the apartments (see Fig. 4.7.3).

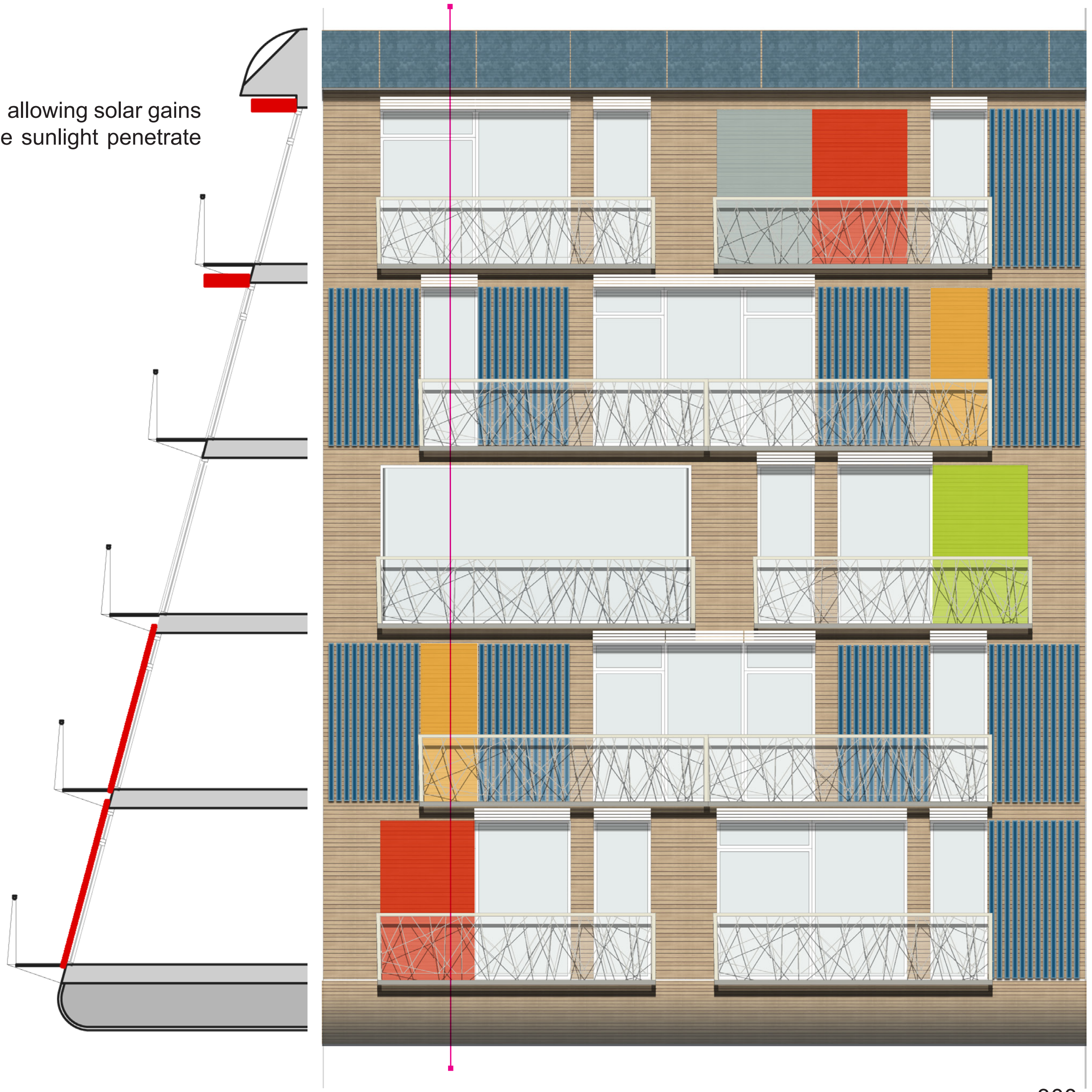


Figure 4.7.3

Winter Sunny Day
different South facade configurations

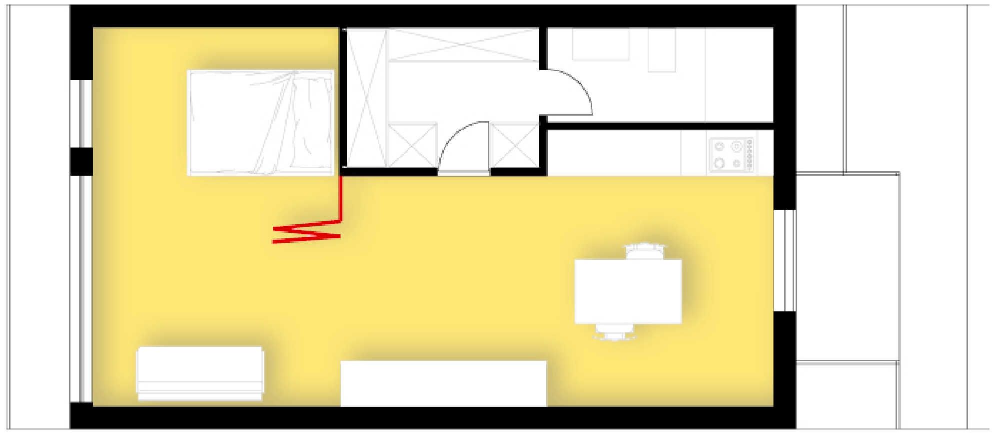


Figure 4.7.5 1 bedroom apartment plan
opened shutters · closed windows · opened internal partitions

Figure 4.7.6 Winter Sunny Day ¦ 9 am
Internal view

During a winter sunny day, the sun patch that penetrates deep into the apartment describes the benefits on the user perception of the space. Due to the south orientation of the apartments, the couple can have their breakfast in bed when they wake up, appreciating the positive value of its presence. (see Figs. 4.7.5 and 4.7.6).

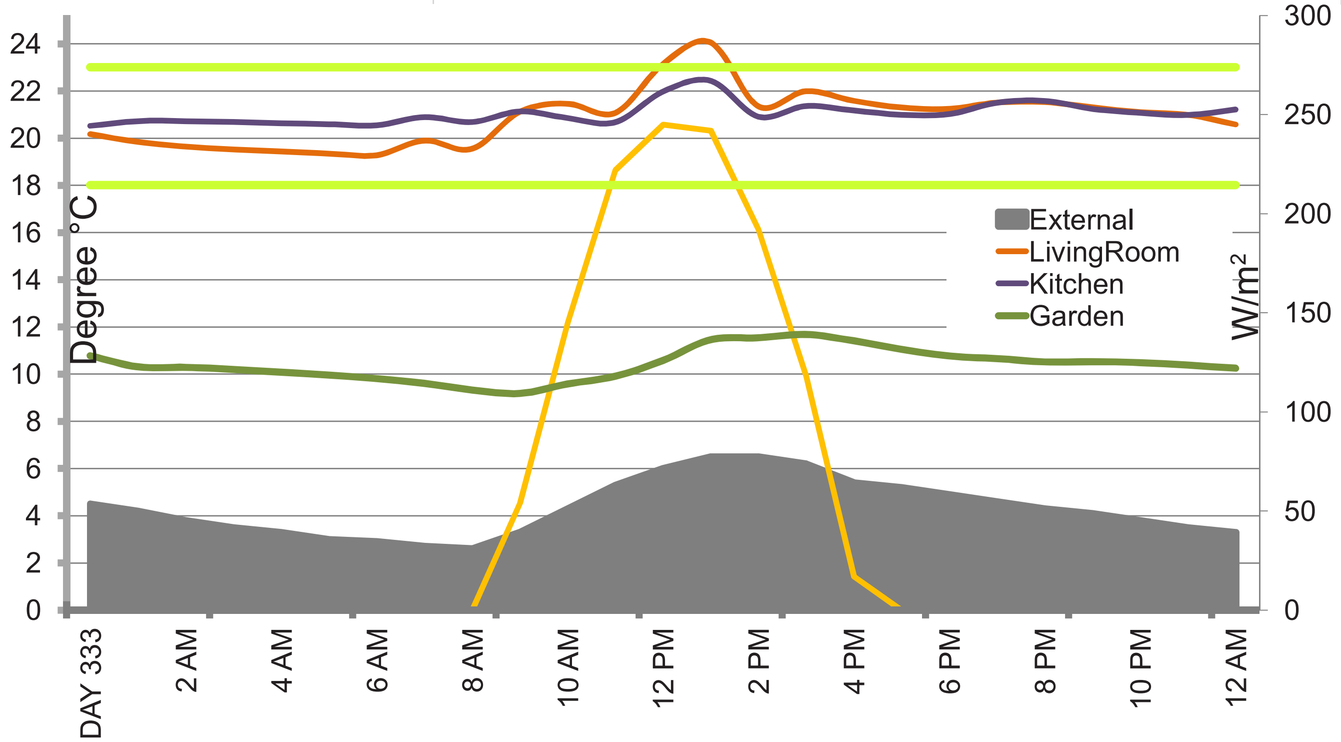


Figure 4.7.4

Winter Sunny Day
Plotted simulated temperatures [TAS]
global radiation and comfort zone

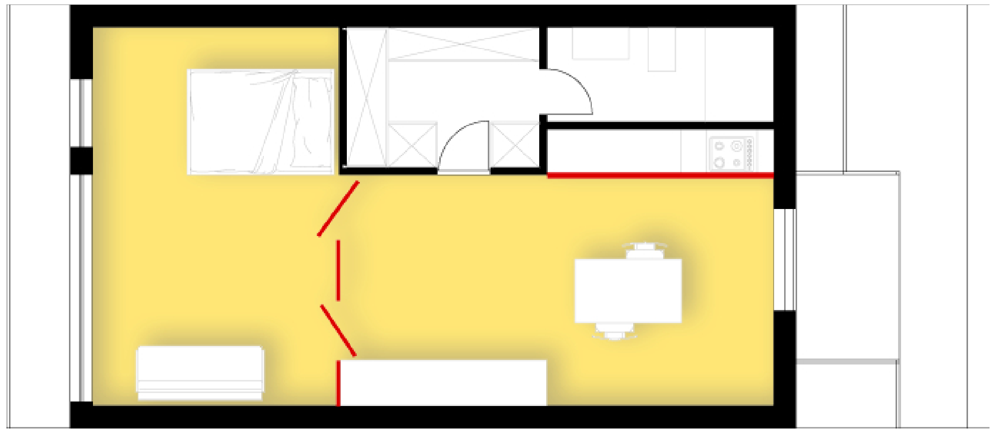


Figure 4.7.7 1 bedroom apartment plan
opened shutters · closed windows · semi-closed internal partitions

Figure 4.7.8 Winter Sunny Day ¦ 12 am
Internal view

At midday the temperature indoor is raised by the solar radiation and, if this increase is not preferred by the inhabitants at that moment, they can open the tilted windows towards the buffer garden. Due to the low solar angle in winter, the sunlight penetrates almost horizontally into the space so, if they have to work from their units, the movable walls can be displayed in a way that sieve the sun light in order to avoid glare and deliver the appropriate conditions for working in the north part of the space (see Figs. 4.7.7 and 4.7.8).

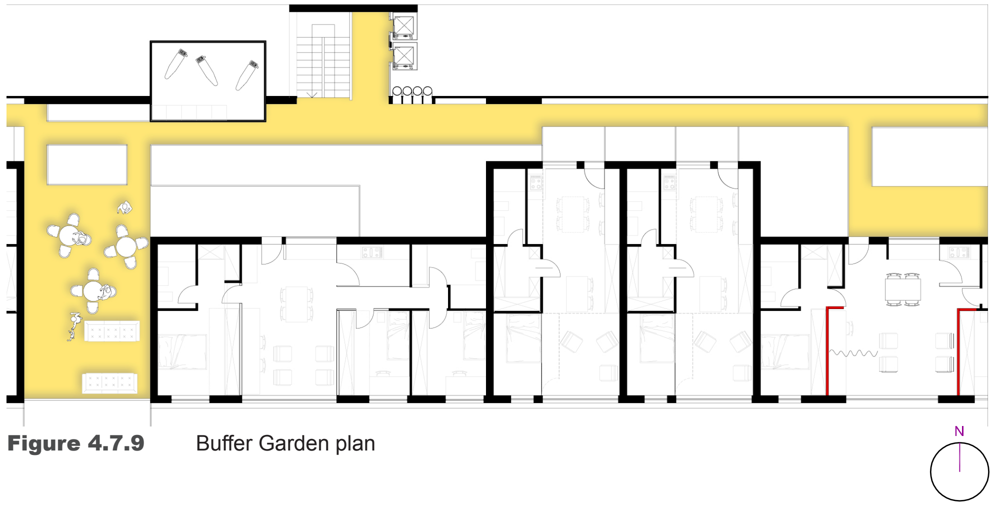


Figure 4.7.9 Buffer Garden plan

Figure 4.7.10 Winter Sunny Day ¦ 2 pm
Buffer Garden view

As described in the chapter 4.1, the garden provides enclosed terraces towards the south that expand the inhabitant array of choices out of their apartment within the building (see Fig. 4.7.10). Here the couple can spend the lunch time, socializing with the other residents in an atmosphere that is cold (around 12ºC) but it is made warmer by the intense solar radiation and the intense light.

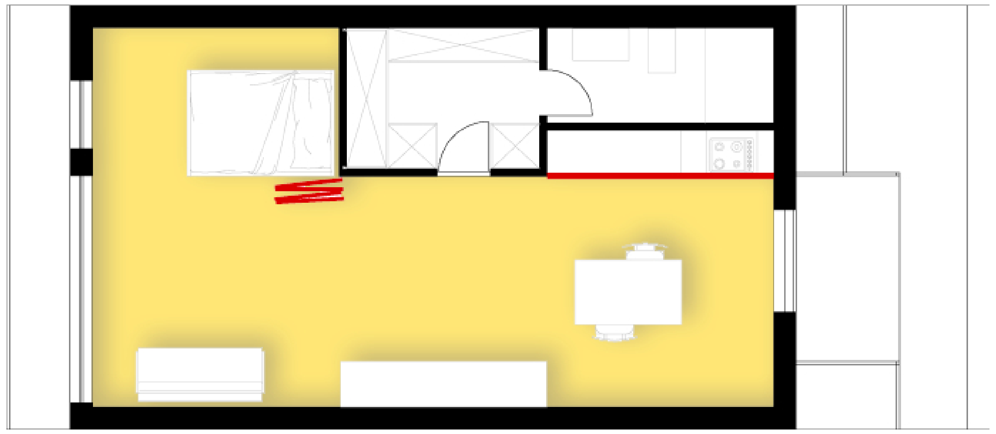


Figure 4.7.11 1 bedroom apartment plan
opened shutters · closed windows · opened internal partitions

Figure 4.7.12 Winter Sunny Day ¦ 3 pm
Internal view

During the afternoon of a sunny winter day, the direct sunlight is kept in the south part of the units due to its geometry. Therefore the movable walls can be kept open to enlarge the livable space physically and visually (see Figs. 4.7.11 and 4.7.12).

Typical winter cloudy day

For a typical winter cloudy day, shutters will be kept closed in the units that do not require daylight in order to avoid heat losses (see Fig. 4.7.14). In the case of units in which daylight is required, the shutters can be closed partially and allow the necessary daylight penetration (see Fig. 4.7.13).

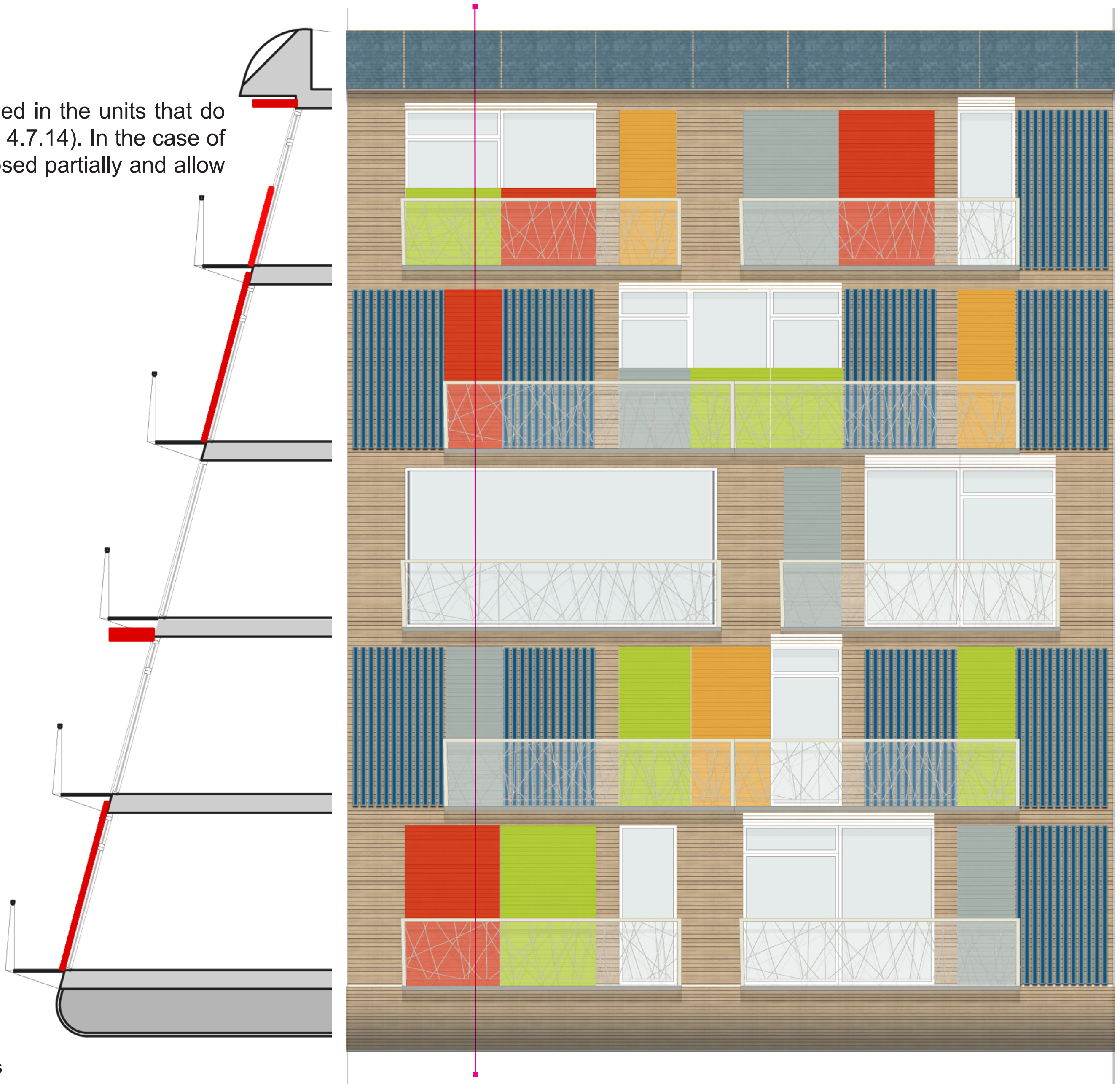


Figure 4.7.13

Winter Cloudy Day
Different South facade configurations

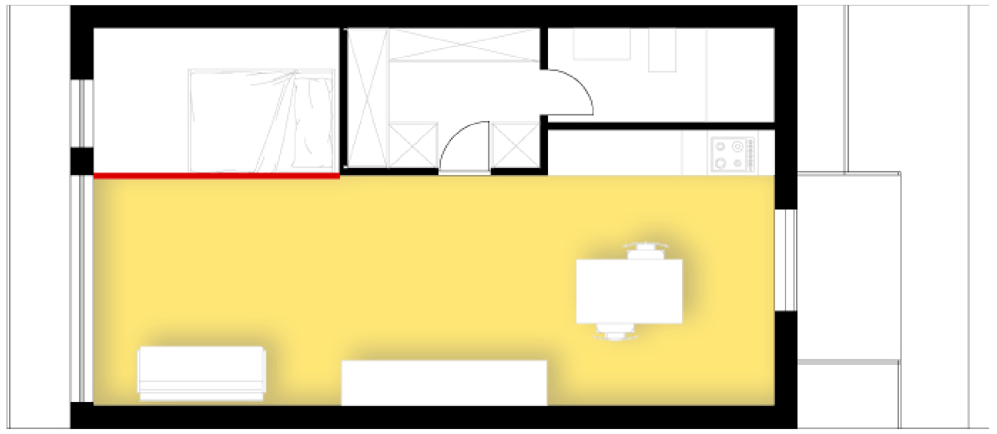


Figure 4.7.15 1 bedroom apartment plan
opened shutters · closed windows · closed internal partitions

Figure 4.7.16 Winter Cloudy Day ¦ 12 pm
Internal view

During a typical winter cloudy day, the furniture can be rearranged to move the table towards the south windows allowing the inhabitant to enjoy the view while having a better light even if intense. (see Figs. 4.7.15 and 4.7.16).

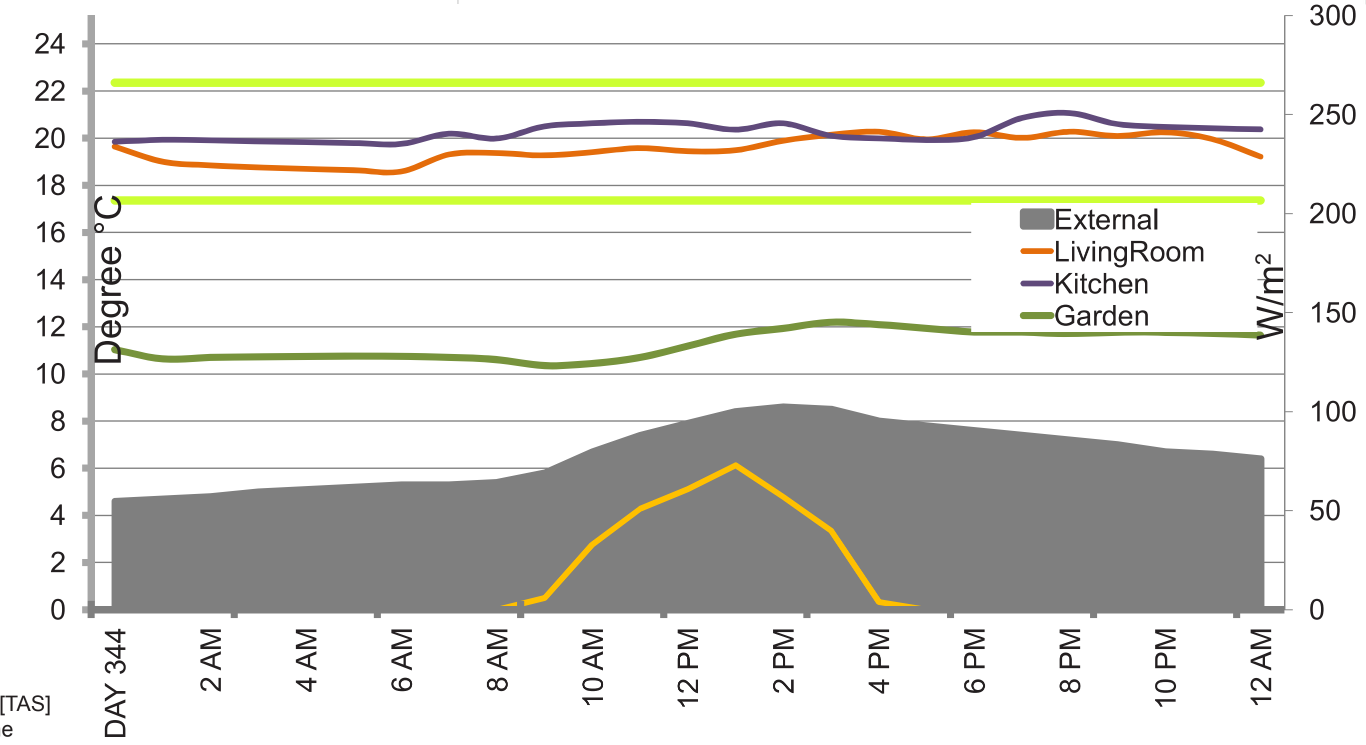


Figure 4.7.14

Winter Cloudy Day
Plotted simulated temperatures [TAS]
global radiation and comfort zone

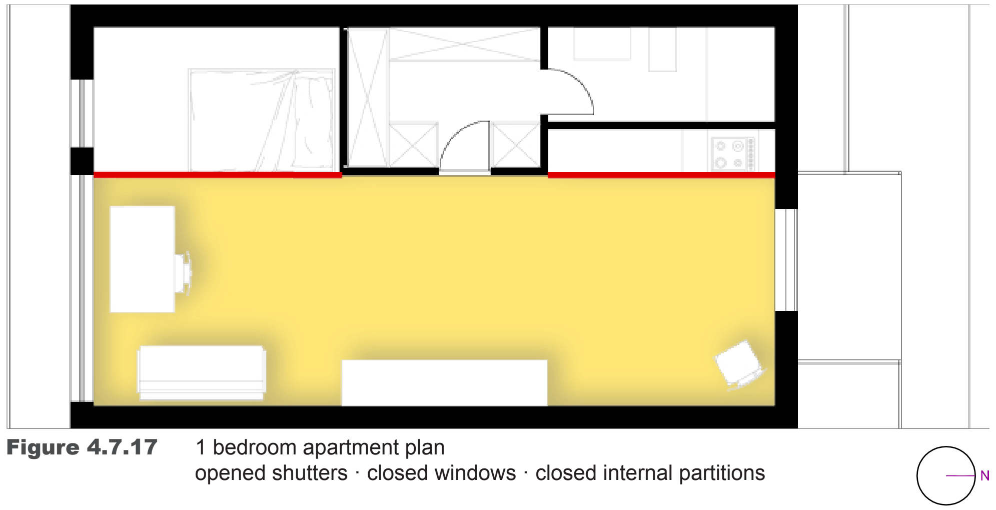


Figure 4.7.17 1 bedroom apartment plan
opened shutters · closed windows · closed internal partitions

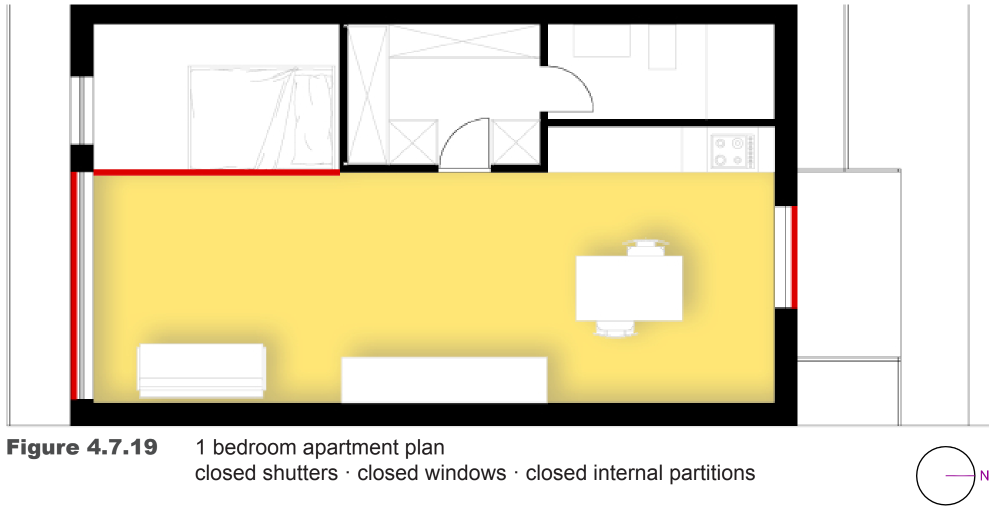


Figure 4.7.19 1 bedroom apartment plan
closed shutters · closed windows · closed internal partitions

Figure 4.7.18 Winter Cloudy Day ¦ 3 pm
Internal view

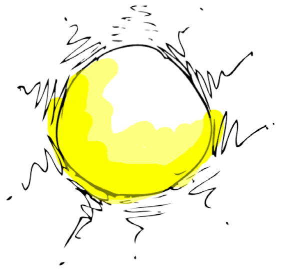
Figure 4.7.20 Winter Cloudy Day ¦ 9 pm
Internal view

In the afternoon, due to the lower diffuse light that enters the apartment, the furniture are displayed in their original layout to lay back on the sofa while reading a book. The movable walls of the bedroom is kept close to reduce the space an maximise the benefit of the low internal heat gain and to increase the sense of cosiness and warmth offered by the wood texture (see Figs. 4.7.17 and 4.7.18).

During the night, the night shutters can be partially closed avoiding heat losses from the apartment, while leaving some part of the window unobstructed to enjoy the views of the city. (see Figs. 4.7.19 and 4.7.20).

Typical summer sunny day

For a typical summer sunny day, (see Fig. 4.7.22). The shutters are configured as overhangs to avoid direct solar radiation penetration into the apartments or partially closed to filter the undesired sunlight. (see Fig. 4.7.21).



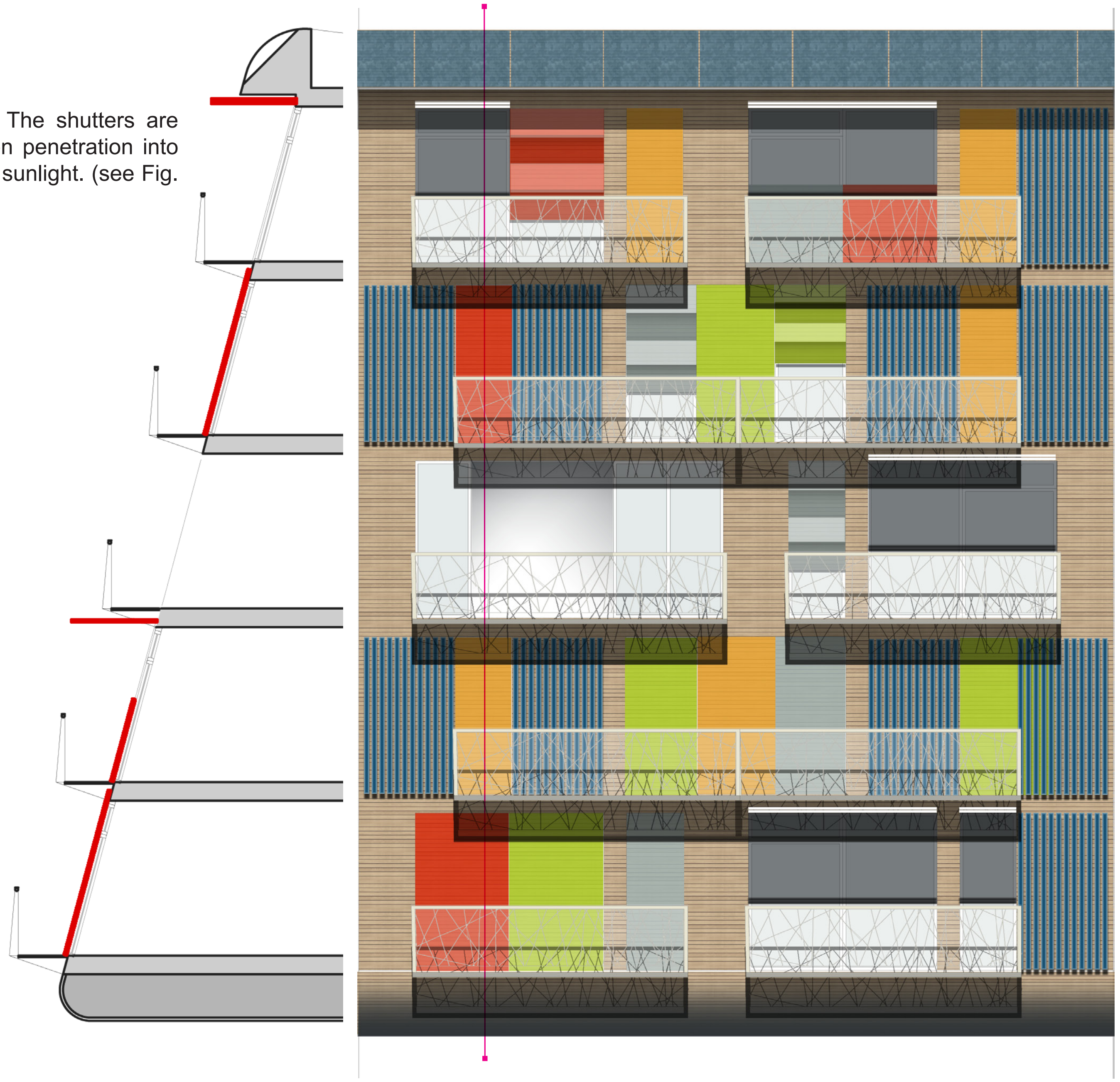


Figure 4.7.21

Summer Sunny Day
different South facade configurations

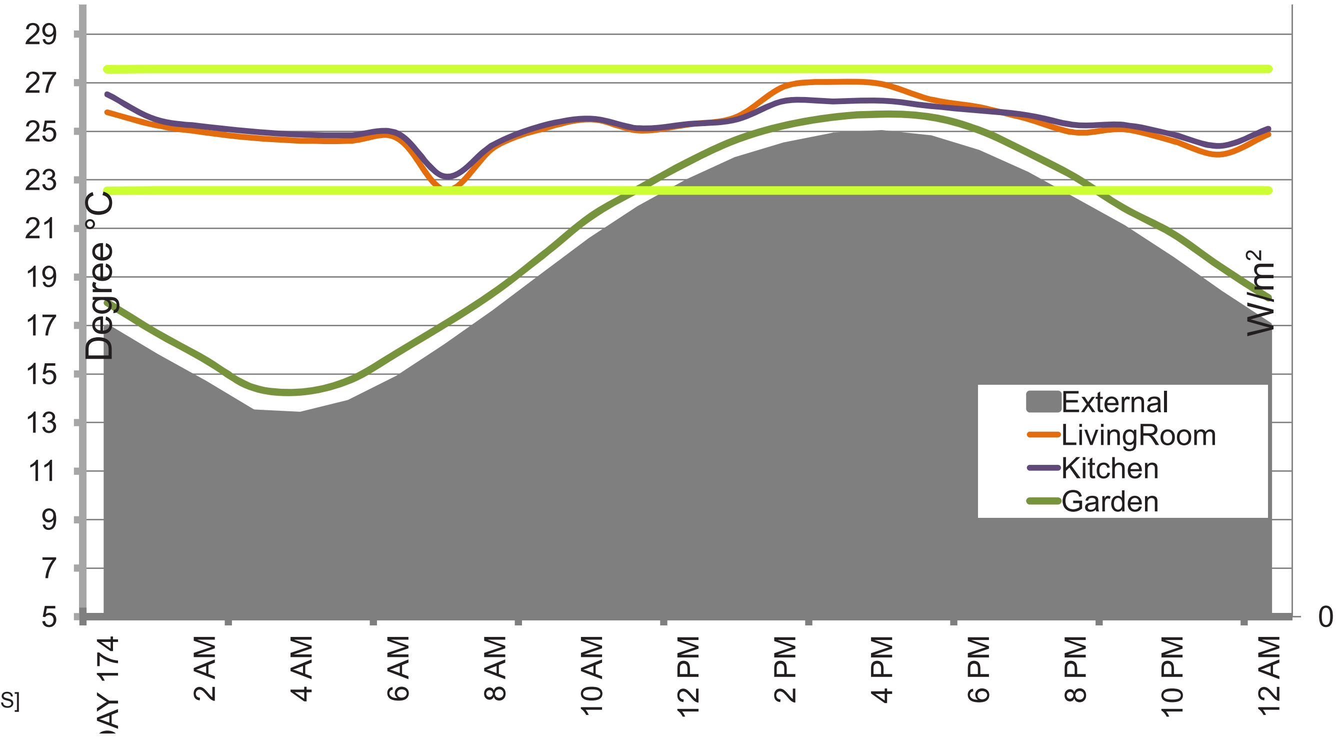


Figure 4.7.22

Summer Sunny Day
Plotted simmulated temperatures [TAS]
global radiation and comfort zone

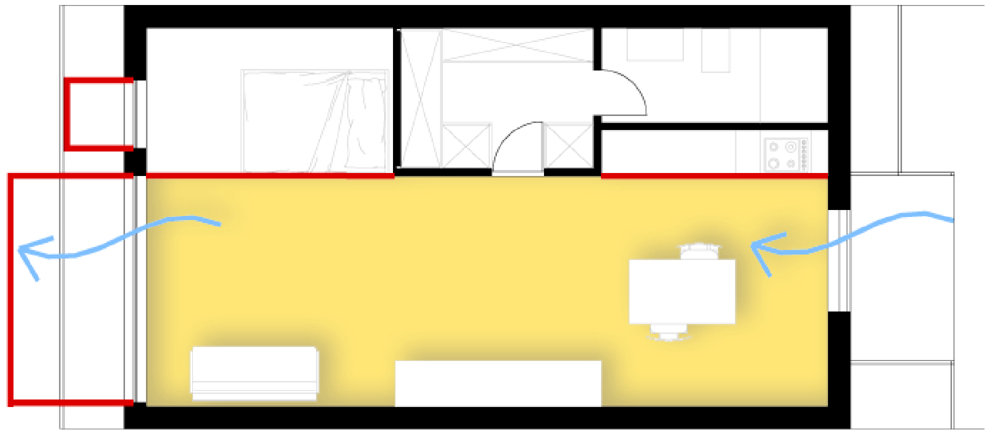


Figure 4.7.23 1 bedroom apartment plan
shutters as overhang · opened windows · closed internal partitions

Figure 4.7.24 Summer Sunny Day ¦ 12 pm
Internal view

During a typical summer sunny day the angle of the sun on the horizontal is higher so the display of the shutter as overhang keeps the direct sunlight out of the apartments creating an intense but uniform light in the space. If a lower temperature is preferred, the user can work in the kitchen are while enjoying the sensation of air movement due to the cross ventilation. (see Figs. 4.7.23 and 4.7.24).

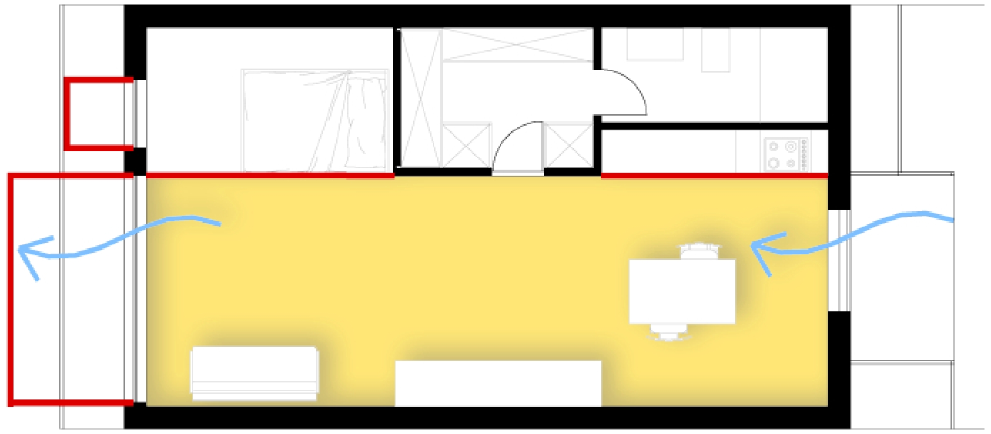


Figure 4.7.25 1 bedroom apartment plan
shutters as overhang · opened windows · closed internal partitions

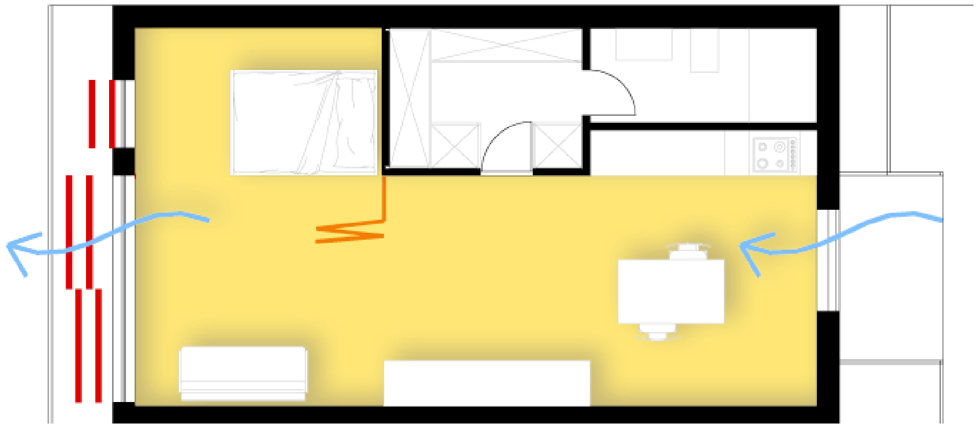


Figure 4.7.27 1 bedroom apartment plan
semi-opened shutters · opened windows · closed internal partitions

Figure 4.7.26 Summer Sunny Day ¦ 1 pm
terrace view

Figure 4.7.28 Summer Sunny Day ¦ 3 pm
Internal view

During such a day, the balconies towards the buffer garden can be used for having lunch in a semi outdoor space, protected from the direct sun making the inhabitant in close contact with the natural ambience of the garden. Moreover it can gives the opportunity of strengthening social relation with the resident passing by (see Figs. 4.7.25 and 4.7.26).

To take a nap in the warm summer day, the shutters can be displayed in order to darken the space creating a relaxing pattern of light, while enabling cross ventilation. (see Figs. 4.7.27 and 4.7.28).

Typical summer average day

For a typical summer cloudy day, the shutters can be kept partially closed to avoid strong diffuse solar radiation that would rise the indoor temperature (see Fig. 4.7.30), or totally closed if the units are not occupied (see Fig. 4.7.29).

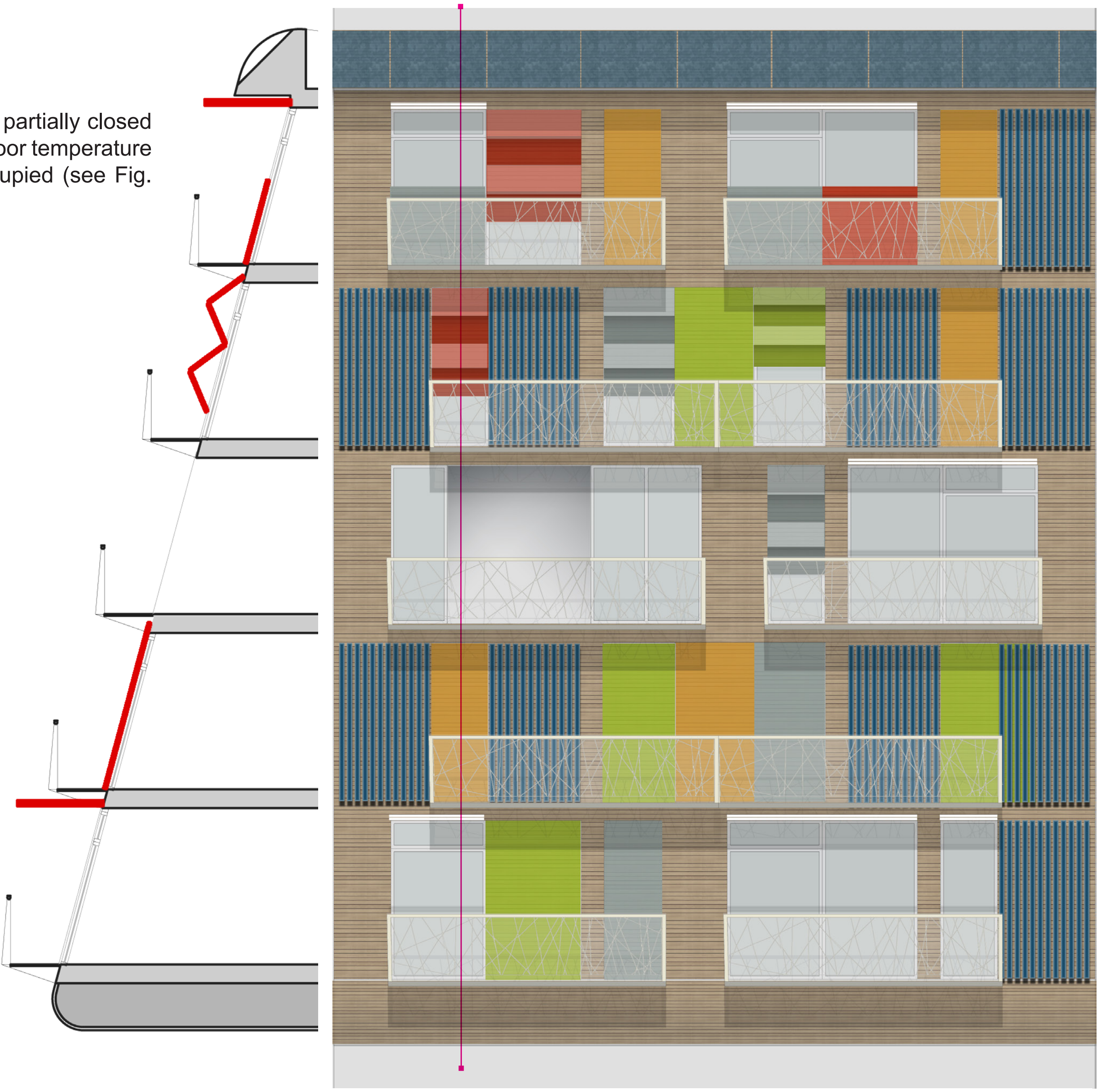


Figure 4.7.29

Summer Cloudy Day
different South facade configurations

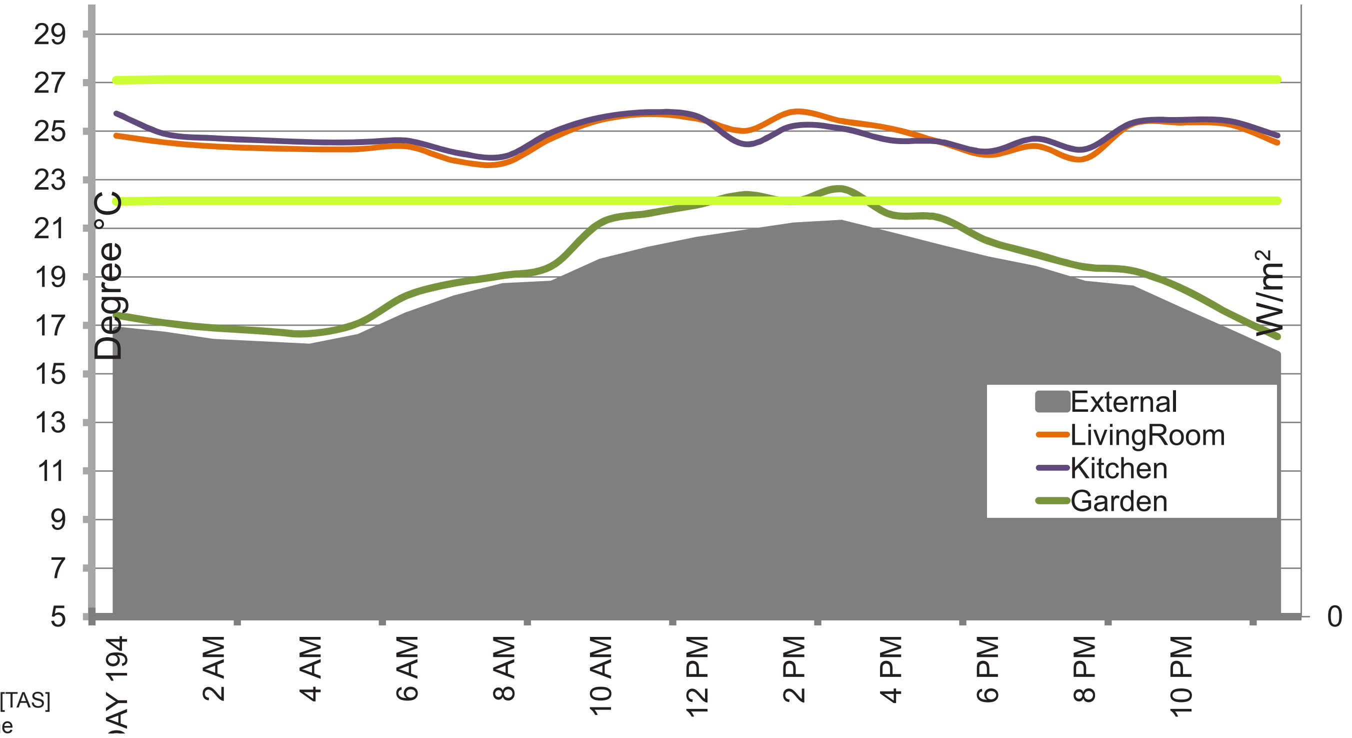


Figure 4.7.30

Summer Cloudy Day
Plotted simulated temperatures [TAS]
global radiation and comfort zone

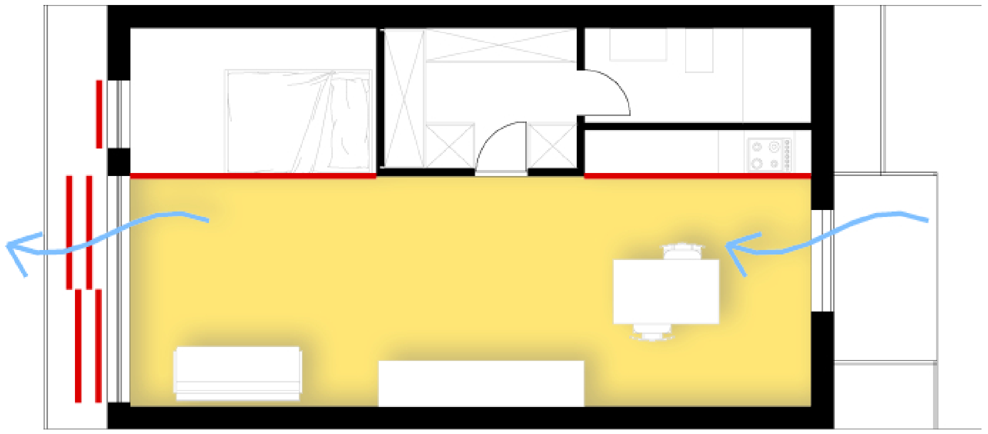


Figure 4.7.31 1 bedroom apartment plan
semi-closed shutters · opened windows · closed internal partitions

Figure 4.7.32 Summer Cloudy Day ¦ 9 am
Internal view

Since during a summer cloudy day the levels of solar diffuse radiation can be very high, the shutter can be pulled partially down to reduce heat gain. The north side present a good light environment due to the daylight that comes through north window of the apartment. in this are the user can sit if he has to work with a computer. (see Figs. 4.7.31 and 4.7.32).

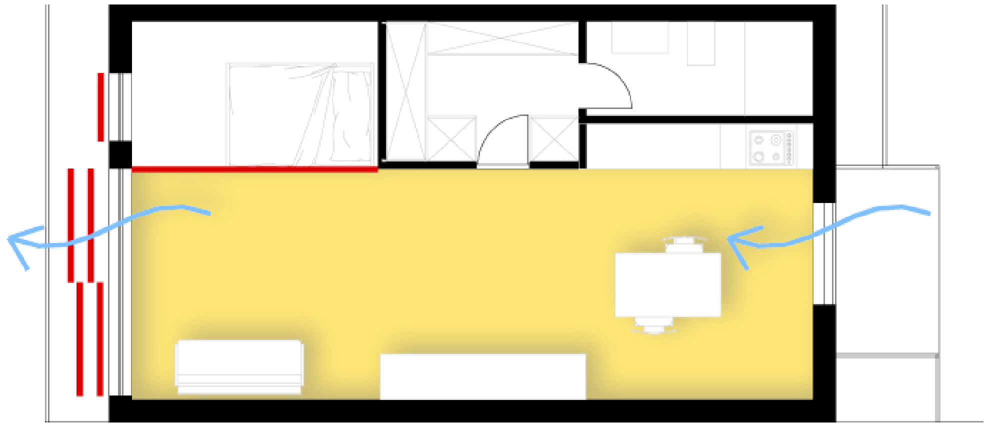


Figure 4.7.33 1 bedroom apartment plan
semi-closed shutters · opened windows · closed internal partitions

Figure 4.7.34 Summer Cloudy Day ¦ 12 am
Internal view

At lunch time, while in the summer sunny day they spent the lunch time in the garden, in a cloudy day the external temperature is lower than the comfort zone they might prefer staying home. Figures 4.7.33 and 4.7.34 illustrate an occupant while cooking in the apartment.

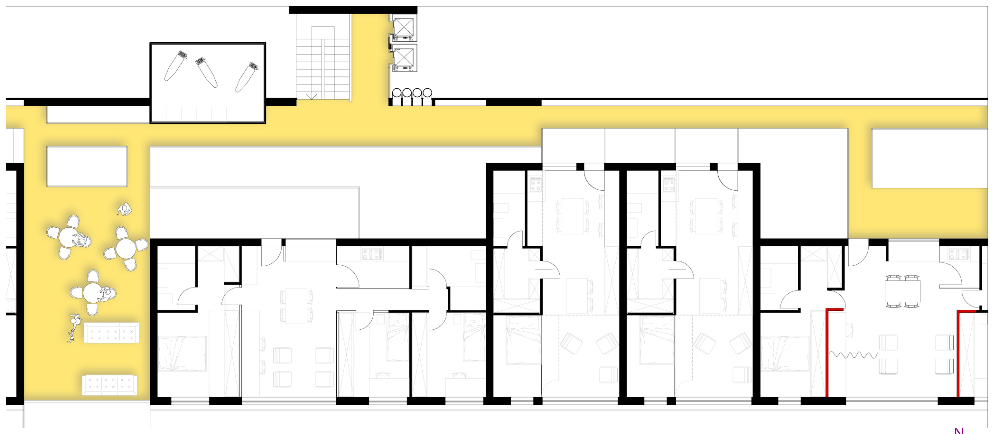


Figure 4.7.35 Buffer Garden plan

Figure 4.7.36 Summer Cloudy Day ¦ 2 pm
Buffer Garden view

the image above (see Figs. 4.7.35 and 4.7.36), shows how residents can live the different space of the building, such us the laundry, to encourage social relationship

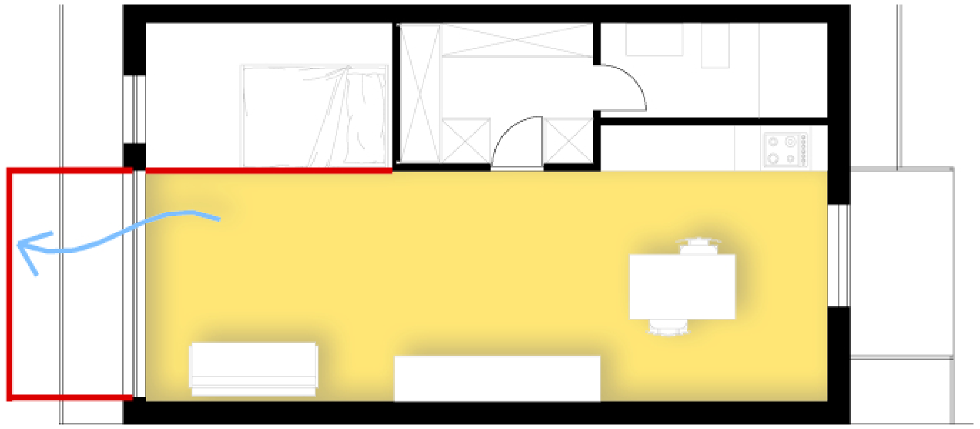


Figure 4.7.37 1 bedroom apartment plan
opened shutters · opened windows · closed internal partitions

Figure 4.7.38 Summer Cloudy Day ¦ 3 pm
Internal view

At night, the windows can be kept partially open accordingly to the user preference. Moreover, the movable internal walls enable the occupants to configure it as a projecting screen (see Figs. 4.7.37 and 4.7.38).

V _ CONCLUSIONS

V _Conclusions

The results achieved by the proposal have been met through the research of the symbiosis - as mean to improve environmental condition in cities - within buildings and the urban-natural environment which has been improved by the project itself. In fact the architectural generative process, that was informed by environmental pre-analysis, strategies and analytic work, leads to an holistic proposal in which its different parts benefit mutually from one another.

Since the guide brief set the residential as the main focus, the environmental studies for the ground floor were limited to the provision of comfort. For outdoor spaces the strategy, deduced from the term 1 teams' project, was limiting the effect of the extremes in both summer and winter. The symbiosis was obtained by placing the uses according to the specificity of the high obstructed site and their requirements. Then working on both the requirements of filtering the light in those spaces and the strategies to reduce the wind effect on the outdoor, the layer of the park was added and finally shaped to its final organic distribution to disperse the momentum of the wind. The elevated green carpet offered the opportunity of providing the users with diverse environmental options mainly diversified by the solar access. This option was provoked by the elevation of the residential buildings, strengthening the interaction that could happen between buildings and urban context.

The elevation of the residential buildings, driven by exploration of bioclimatic techniques made through passive solar design in London, exploited the bigger goal of the project: taking the distance from the previous conventional concept of providing the comfortable environment through the design of building services and to make the inhabitant appreciate the possibility of achieving comfort through sustainable means. In fact through the strategies adopted and the mutual interaction that the units and the garden generate, it was possible to reduce the hours below the comfort limit, set to 17°C, to a value within the acceptable range suggested by EN15251 without making use of building systems. In order both to achieve this result and to make the inhabitant active actor in controlling the natural elements in order to achieve his/her comfort, adaptive measures and diverse opportunities were studied. Within the residential building, these opportunities are not limited to the external adaptability of the openings and the internal spatial flexibility, but extended to the transitional space of the buffer-garden towards the north, implementing the environmental options offered to the user. The goal reached in the residential building is the greater benefit towards reducing dependance from non-renewable energy.

This term's project presented a vehicle through which the process of designing an architectural product was re-explored. It is fairly to say that defining this new way of approaching the architectural shape is a challenge by itself shedding the light on a different way of not only perceiving architecture but also life.

To improve the environmental qualities of the lives we lead today, it has to be acknowledged that a shift in the way we construct and perceive the role of our environments should change. Today's conventional buildings with their "ironed, static" environments has detached Man from his natural setting and weakened the role architecture plays in providing the ambient sheltered environment. Restoring the fundamental role that architecture has once played and the value of being in close contact with nature, a dynamic "dialogue" between architecture, nature and the inhabitant should be established, where both architecture and Man respond and adapt with the variations of the natural environment leading to a better quality of life and architecture.

This Term's project has helped me further understand and appreciate the benefits and potenials of this relationship that is at the core of an architecture that is environmentally sustainable.

Danah Dib

The task of designing an architectural object with the purpose of refurbishing the city, has consisted on a process from which I have gained significant knowledge. Not only specific learning about the site or the project themselves, but also about the methodological approach that makes sustainable environmental design, meaning a new scope from which to look at architecture.

In first place, I have been able to explore what sustainability involves, learning that it is a term that includes social, economic, urban, constructive and aesthetic features, among others. Therefore, it is an architectural characteristic that cannot be isolated, on the contrary, means a way of approaching design that needs of being aware of the consequences that the architecture object produces.

In second place, I had the chance to take advantage of learnings from previous work and other colleagues to make use of them for a better understanding of this project. This knowledge, together with the exploration of the chosen site and the local climate, has given me a better understanding of the city of London.

In third place, I have learned that comfort is a concept in which the occupants of a given building have a lot of responsibility with, and that having the possibilities to interact with the architectural object makes comfort something feasible to achieve in different environmental conditions. For this purpose, designing flexible and adaptable spaces can lead to effective habitable ways of living residential, commercial and outdoor spacings. Moreover, the fact of interacting with the buildings strengths the relation between occupants and environment, making inhabitants active and essential parts of the system 'environment-building-occupants'.

Finally, I have been able to test that buildings in a mild climate, as it is the London climate, can deliver comfort conditions to their occupants with independence from mechanical systems. This fact is only achieved by designing symbiotic relations between architecture and environment. And, for further investigations, it is my interest to test if this goal can be also achieved when designing with more extreme climatic conditions.

Ignacio Medina

As a continuation of the Refurbishing the City agenda, the Term 2 Project led the team into a thorough investigation into the *adaptive architecturing* of Sustainable Environmental Design.

As the project developed, the team faced a number of challenges, given the fact that the project was undertaken in London, a dense city in which solar availability is not only limited by latitude, but also by the urban context.

By selecting an area of great social deprivation with a plot in a very enclosed context, the group's strategies were able to seek innovative means of design. Complementing each other, the need for a varied and vibrant socio-economic environment met a diverse and complex design, intertwining the need for social interactions with the environmental richness sought by the group.

Focusing our efforts on the occupants, the program took shape as different inputs were considered. Layered, superposed or connected, the spaces generated from environmental inputs, merged into a complex succession of different opportunities for the users to interact, live and thrive from the starting point of 2015 and our envisioned evolution for 2050.

As the understanding of the Refurbishing the City's many facets were incorporated into the design, it was possible to realize the many levels in which the *architecturing* of Sustainable Environmental Design can impact from a single user's enhanced comfort to a city's role in the Climate Change scenario.

In the same way that environmental constraints were complemented by the area's socio-economic needs, the independence from non-renewable sources of energy was made possible –to a great extent– by providing a higher degree of interaction between the users and their immediate surroundings.

Sandra Morikawa

The definition of the architectural proposal, object of the term 2 team project, has been the occasion to explore the potential of the design approach that the Master in Sustainable Environmental Design propose. The most appreciated shift from the traditional architectural approach, that it propose, is the point of view from which an architectural proposal should be seen: from the user point of view. This shift opens infinitive way to be explored, since the satisfaction of a user is not limited to the thermal perception but it is defined through an interactive interchange of "information" whit the space. The architecture become the instument gave to user to allow his/her research of what is comfortable and not anymore a container of stable artificial environments as it is commun practice.

Since it has been shown that the energy consumption of building, that respond to the actual requirement of insulation, are extremely low, the challenge today is exploring strategies to eliminate systems in buildings and to make the inhabitant discovering again the lost values of being in contact with our original natural environment.

The term 2 project has been the mean to ponder on how the architecture of environmental sustainable design can be processed to define a diverse spatial definition that can accomplish the user's comfort. The project helped me understanding the potential of this approach, as said at the beginning, since it explores the limit of design defining the architecture as a mean and organism whith which the user can interact defining his/her comfort. On my point of view this fact rehestablish the real value of architecture as applied art.

Filippo Weber

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Appendix 2.2.1 Wind Analysis

As it is observed in the climatic analysis (Chapter 2.2), a series of CFD simulations were studied in order to have a deep understanding of the wind behaviour, since it is a highly unpredictable climatic agent. The predominat south, west and southwest directions of the wind were revealed by the weather data obtained from Meteonorm 6.0 (fig A2.2.1.1 and fig A2.2.1.2). The most significant effect caused by the morphology of the surroundings is a downdraught effect on the north side of the plot as the south wind collides the northern towers (fig A2.2.1.3 and fig A2.2.1.5). The west wind is pushed by the canyons shaped by the adjacent buildings (fig. A2.2.1.4), while the eastern wind enters the plot with no obstruction from the canal (fig. A.2.2.1.6).

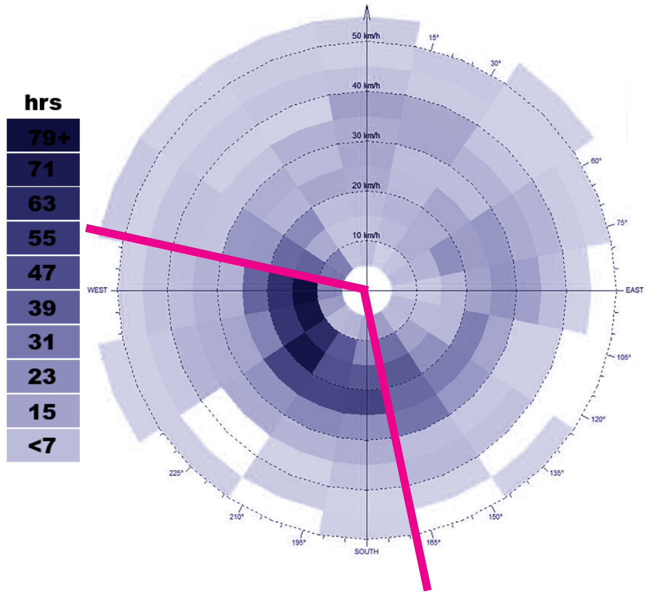


Figure A.2.2.1.1 Winter Prevailing Winds (Dec-Feb) - Wind Frequency [Weather Tool]
Source: after Tower Hamlets Weather File 1996-2005 [Meteonorm 6.1]

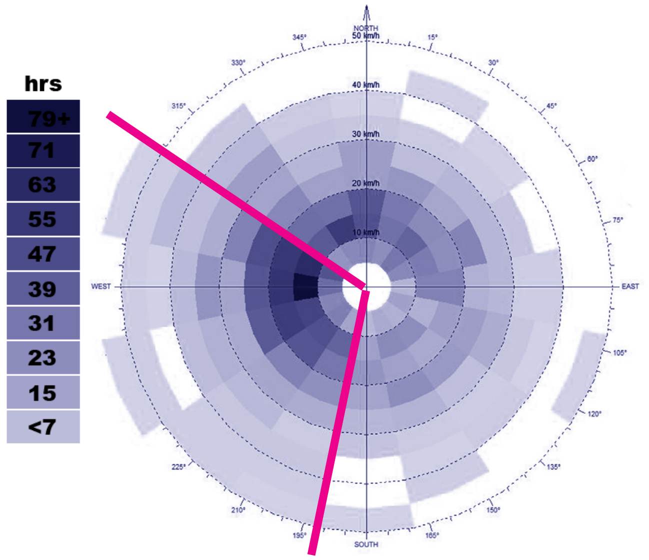


Figure A.2.2.1.2 Summer Prevailing Winds (Jun-Aug) - Wind Frequency [Weather Tool]
Source: after Tower Hamlets Weather File 1996-2005 [Meteonorm 6.1]

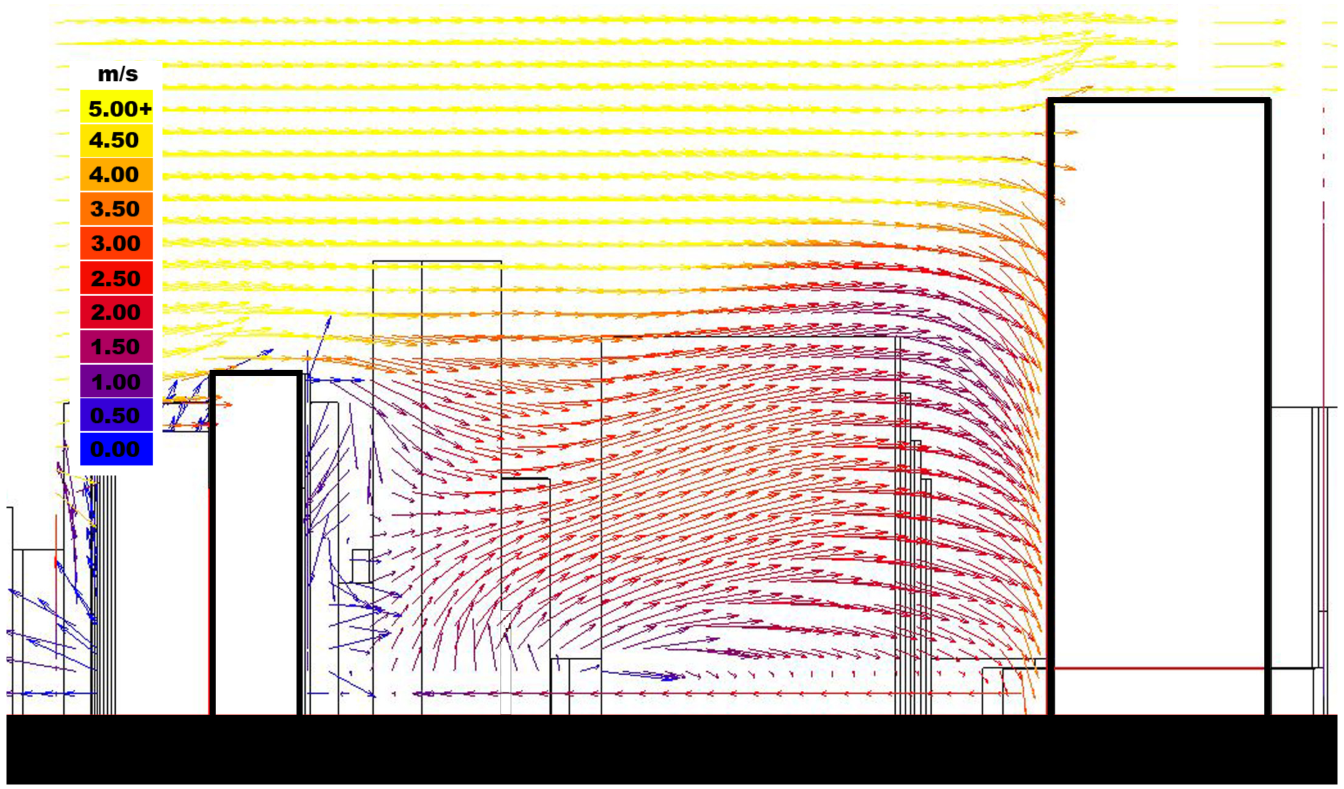


Figure A.2.2.1.3 Wind Flow Vector Southwest Section [Ecotect Winair] illustrating the downdrught caused by the tall building to the north when the wind is from the south
Source: after Tower Hamlets Weather File 1996-2005 [Meteonorm 6.1]

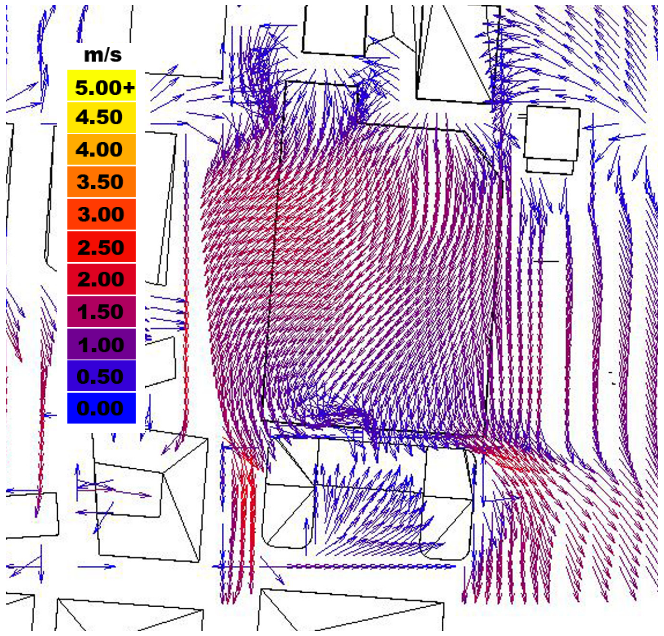


Figure A.2.2.1.4 Wind Flow Vector South [Ecotect Winair]
Source: after Tower Hamlets Weather File 1996-2005 [Meteonorm 6.1]

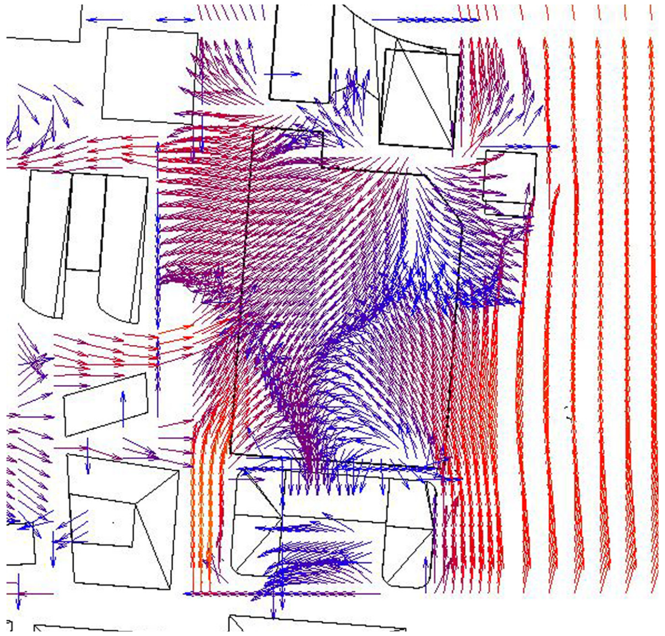


Figure A.2.2.1.5 Wind Flow Vector Southwest [Ecotect Winair]
Source: after Tower Hamlets Weather File 1996-2005 [Meteonorm 6.1]

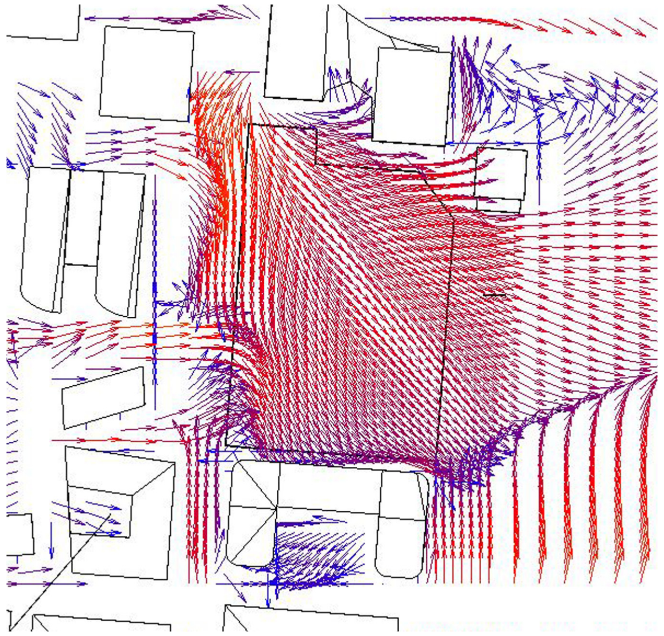


Figure A.2.2.1.6 Wind Flow Vector West [Ecotect Winair]
Source: after Tower Hamlets Weather File 1996-2005 [Meteonorm 6.1]

Appendix 2.3.1 Plot Solar Availability

Due to the enclosed context of the plot, a solar availability study was undertaken. Apart from the overshadowing studies show in Chapter 2.2, horizontal planes were analysed for different offsets from the ground level (see Figs. A.2.3.1.1 and A.2.3.1.2).

From Figures A.2.3.1.3 to A.2.3.1.6, it can be conluded that, for December, average daily values of Solar Radiation are maintained at approximately 300Wh or lower up until +30m, when the influence from the residential building on the South boundary starts to decrease.

This preliminary analysis was the first indicator that the contrast between these two levels (+00m to +30m and +30m upwards) should be incorporated as a key parameter to be exlored by the group (see Chapter 2.5 for the development of this criterion).

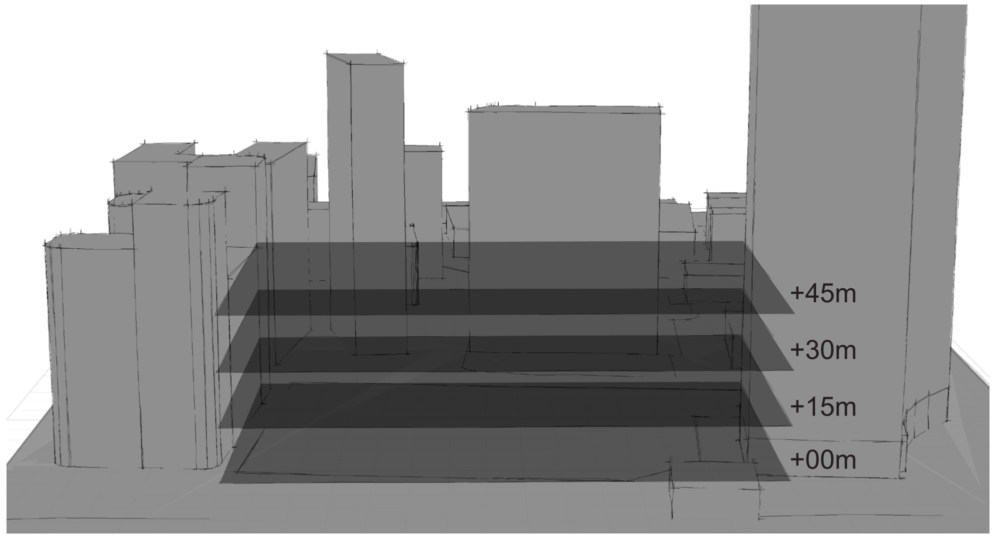


Figure A.2.3.1.1 Analysis Planes

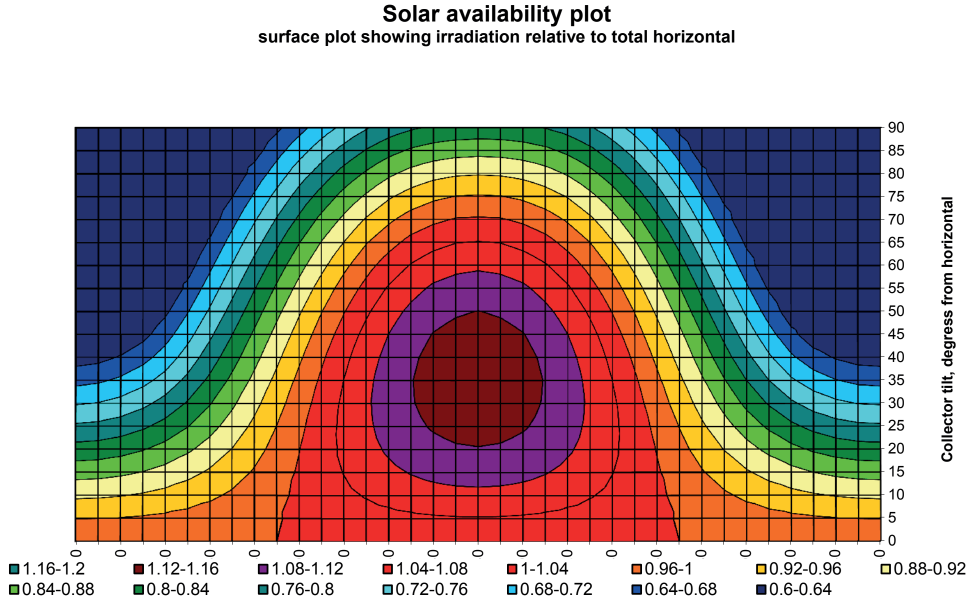


Figure A.2.3.1.2 Analysis Planes

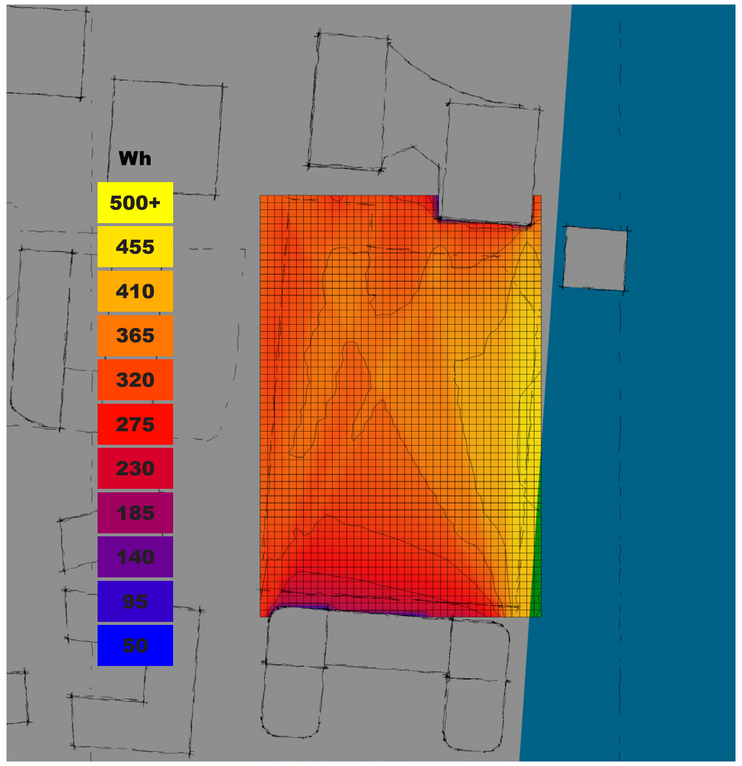


Figure A.2.3.1.3 Horizontal Daily Average Solar Radiation +00m

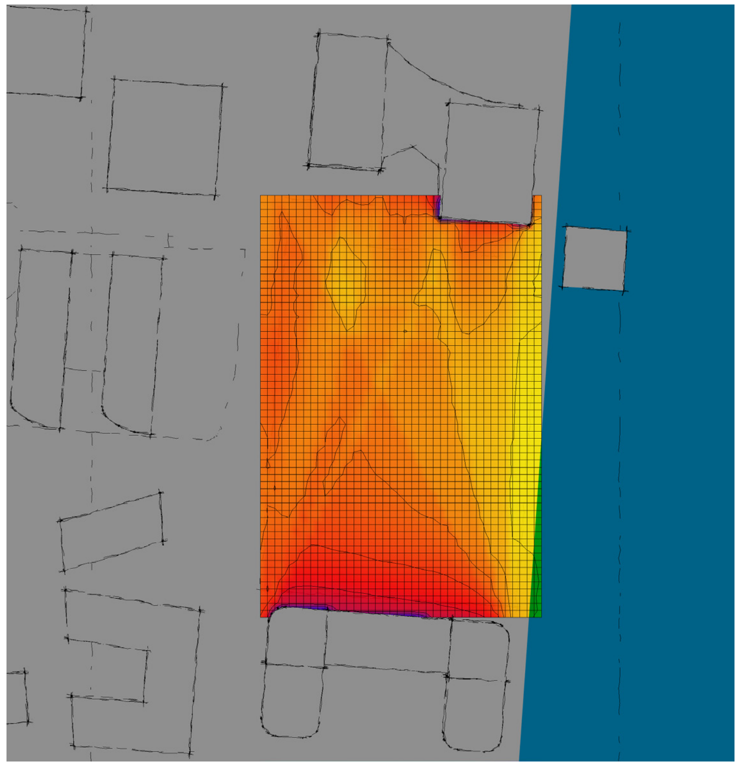


Figure A.2.3.1.4 Horizontal Daily Average Solar Radiation +15m

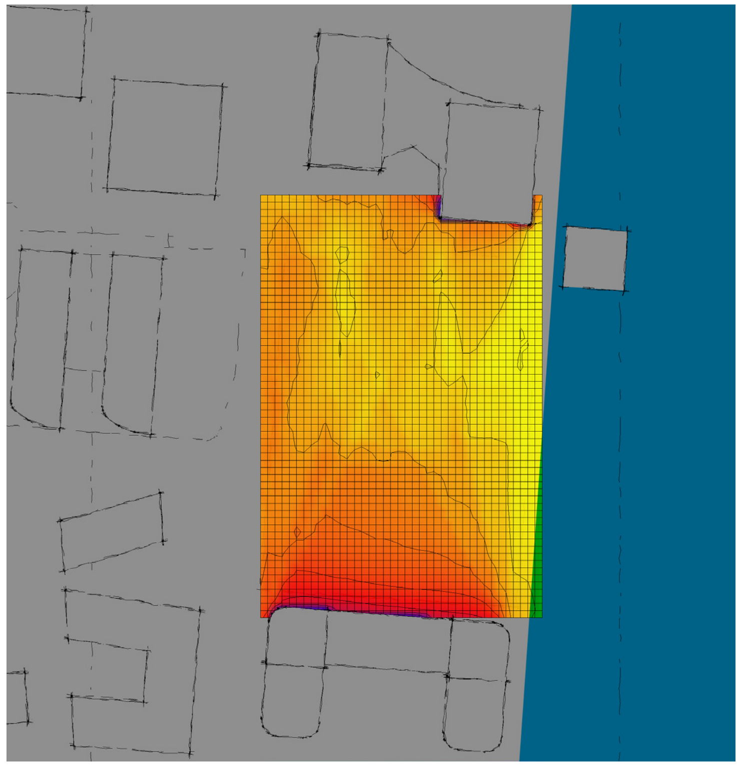


Figure A.2.3.1.5 Horizontal Daily Average Solar Radiation +30m

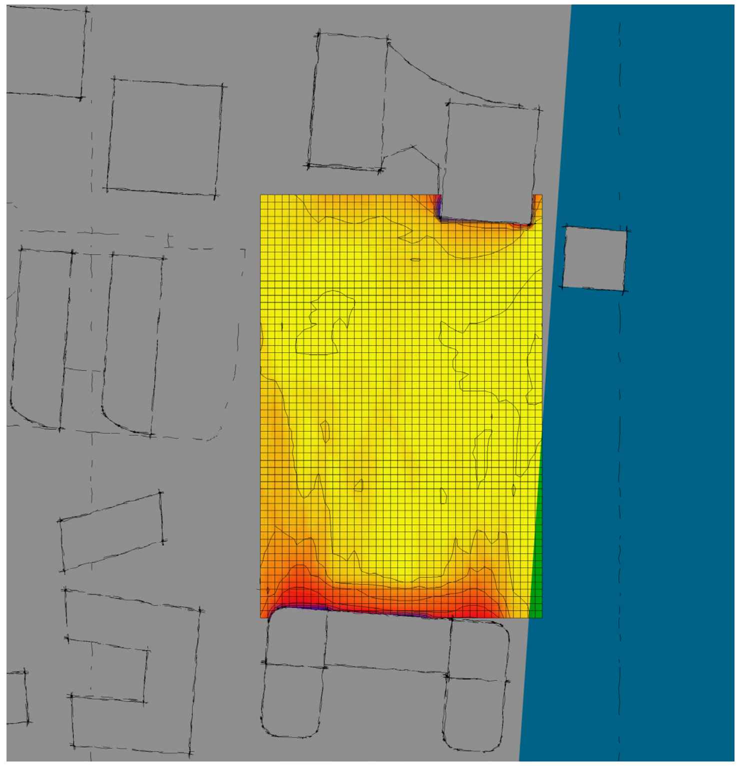


Figure A.2.3.1.6 Horizontal Daily Average Solar Radiation +45m

Appendix 2.3.2 Daylight Factor - gross calculations

Gross calculations for Daylight Factor were driven by the following formula:

$$\text{DFave} = [T.W.a.M] / [A.(1-R2)]\ \%$$

where:
T = diffuse transmittance of glazing (single = 0.85, double = 0.75)
W = net area of window (i.e. glass area)
a = angle (in degrees) in the vertical plane of visible sky from centre of window
A = total area of interior surfaces (incl. windows)
R = average reflectance of interior surfaces (~0.5)
M = maintenance factor to allow for dirt on glazing (~0.85)

Where fixed values taken by the group were:
T = 0.7
a = 67deg
R = 0.5
M = 0.85

Appendix 2.5.1 Solar Availability for Horizontal Buildings

From the process of elevating the residential horizontal buildings and tilting the facades, 3 buildings were proposed. Average Daily Radiation was calculated for December, the month of least global radiation in London, in order to confirm a range of 300Wh-400Wh of solar availability for the units. Sensitivity tests were later undertaken to confirm the positive influence of increased solar exposure (See Fig. 2.5.6 in Chapter 2.5).

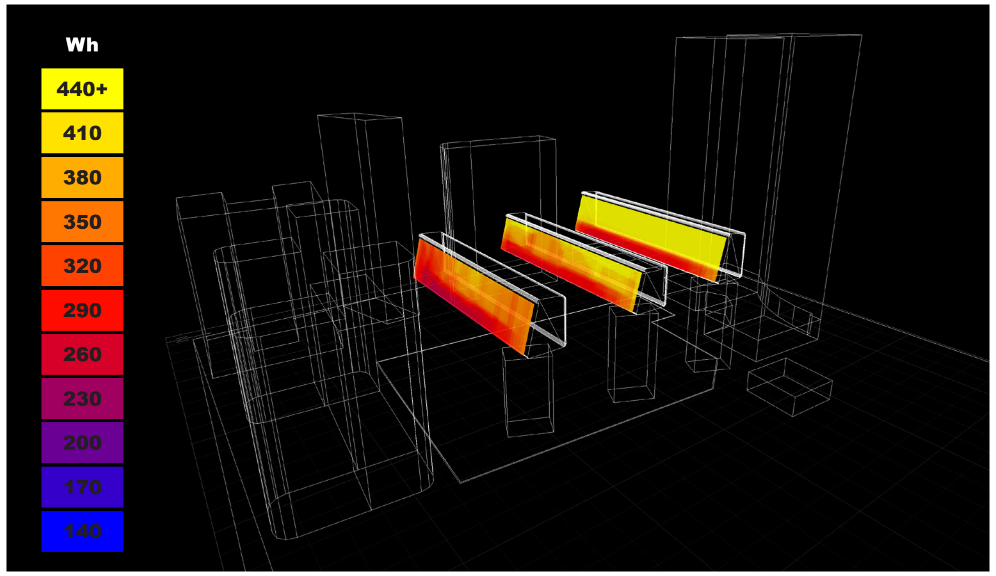


Figure A.2.5.1.1 Average Daily Radiation for December [Ecotect]

Appendix 2.5.2 Rotating Angle for Vertical Buildings

The rotating angle for the vertical buildings was taken from the sunpath diagram, allowing solar access during the first hours of Winter. This strategy granted not only increased solar access for the units (by making use of the unobstructed East bounday), but also provided the opportunity to increase views towards the canal.

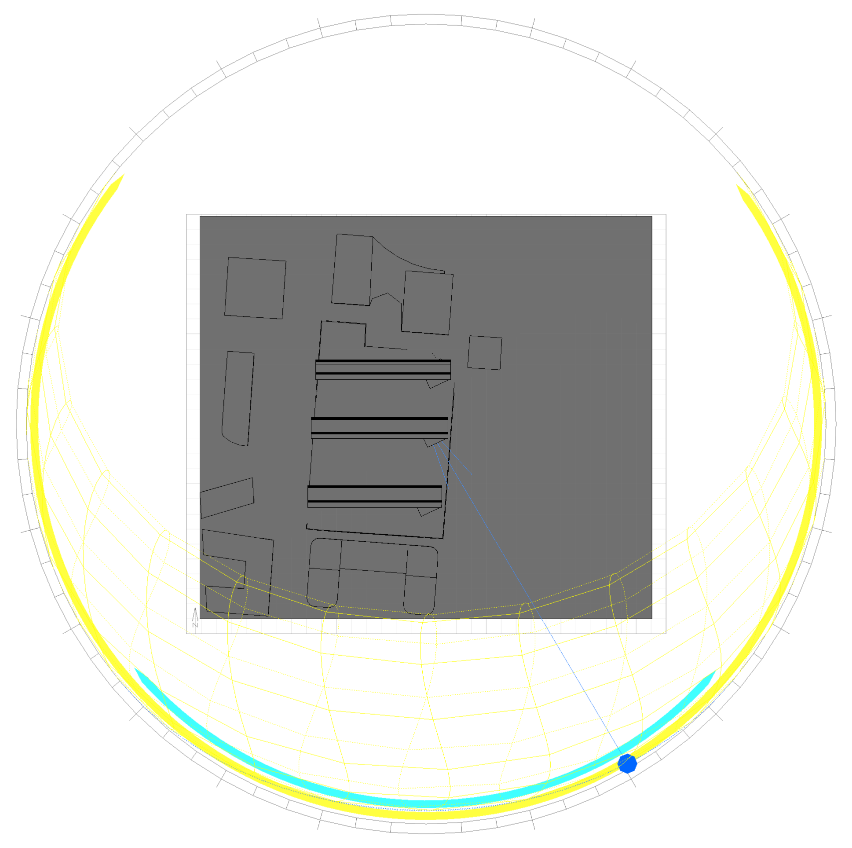


Figure 2.5.2.1 Annual Sunpath Diagram [Ecotec]

Appendix 3.2.1 Design Strategies for Wind

Figure A3.2.1.1 illustrates the initial studies exploring the idea of creating the canyons that would result in skimming flow regime (see Fig. A3.2.1.2) for the prevailing wind direction which is south and south-west. The skimming flow regime is created when a line of buildings are tightly spaced with height to width ratio that is greater than 0.65. Therefore, the canyons can be considered sheltered from the direct winds perpendicular to their axis which is south and south-west wind and the impact of the downdraught caused by the tall buildings to the north. The CFD simulations illustrate explorations in changing the height of the linear blocks therefore the width of the canyons.

Figures A3.2.1.3, A3.2.1.4 and A3.2.1.5, illustrate the design developments, while maintaining the idea of connection with the canal and the surrounding context. As it can be seen in Fig. A3.2.1.6, when the wind direction is from the west, the wind tunnel created by the surrounding context penetrates towards the proposed pedestrian canyons. The same pattern occurs when the wind direction is from the south-east (see Fig. A3.2.1.7), therefore, the proposed solution is to have adaptable elements that can close during winter to the west and can be opened in other seasons to allow wind movements through the canyons. In the case of the eastern part of the ground floor it is proposed to have a permeable sheltering, using trees and urban furniture.

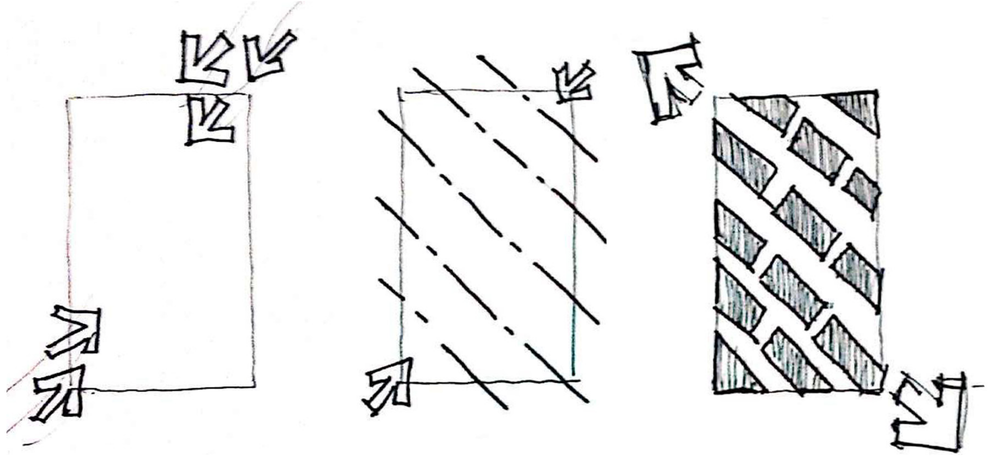


Figure A3.2.1.1 Prevailing winds ¦ sheltering strategy

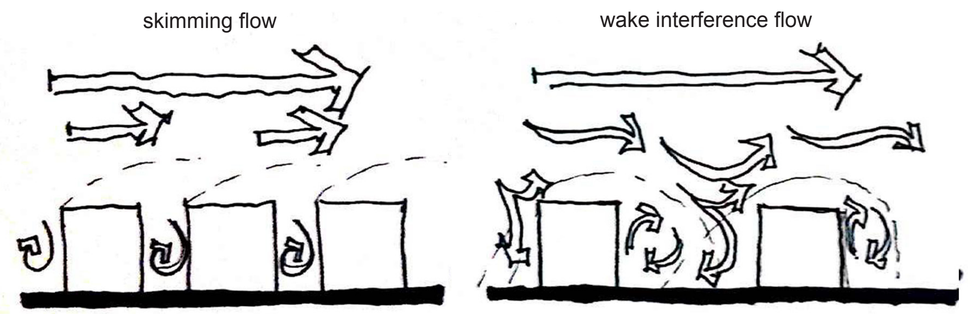


Figure A3.2.1.2 skimming flow ¦ wake interference flow

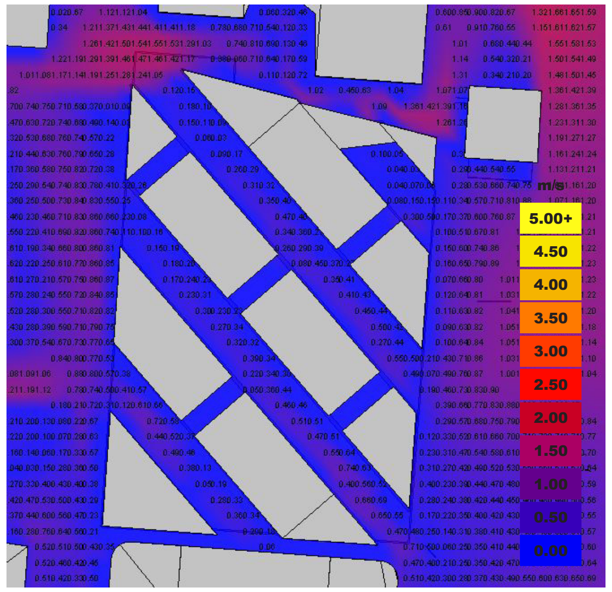


Figure A3.2.1.3 groundfloor - canyons
Initial massing studies CFD analysis prevailing wind from Southwest
grid at +2.00m (pedestrian level)

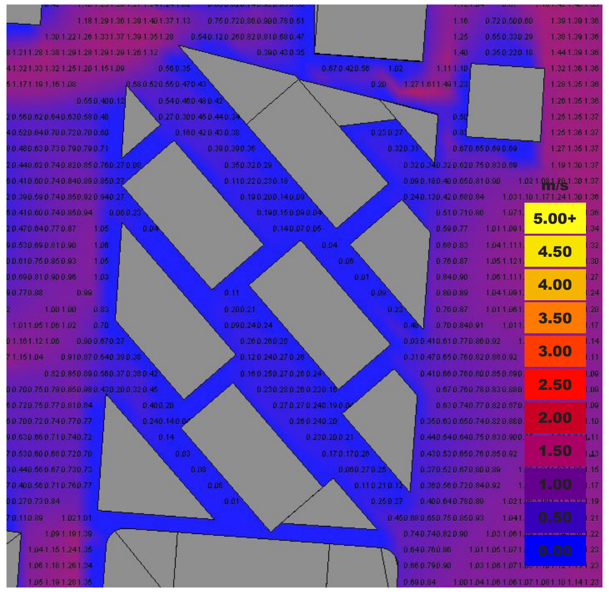


Figure A3.2.1.4 groundfloor - shifted canyons
Initial massing studies CFD analysis prevailing wind from Southwest
grid at +2.00m (pedestrian level)

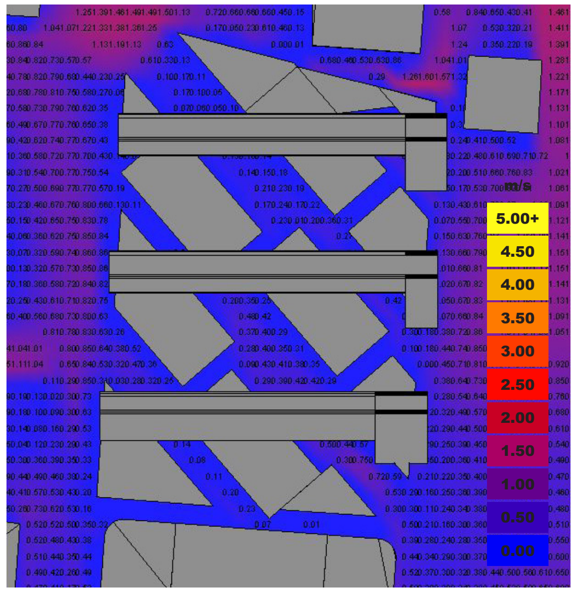


Figure A3.2.1.5 groundfloor - different heights
Initial massing studies CFD analysis prevailing wind from Southwest
grid at +2.00m (pedestrian level)

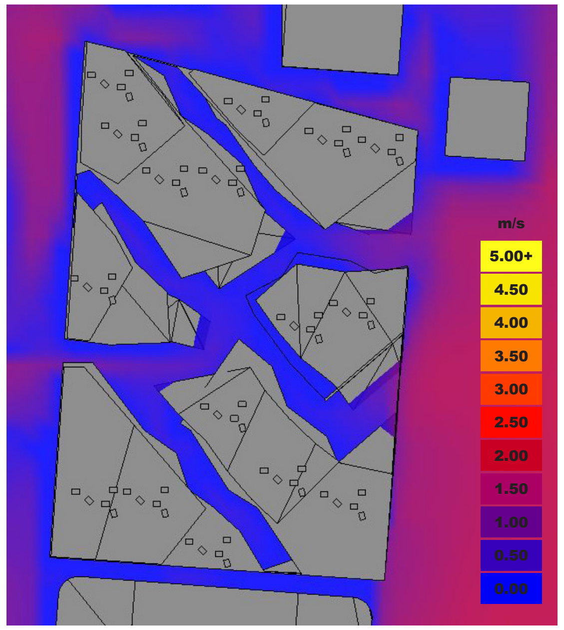


Figure A3.2.1.6 groundfloor
proposal CFD analysis prevailing wind from West
grid at +2.00m (pedestrian level)

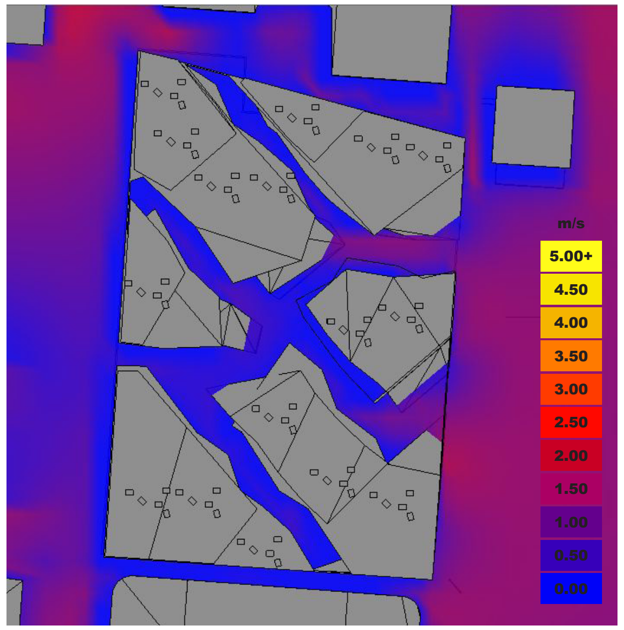


Figure A3.2.1.7 groundfloor
proposal CFD analysis prevailing wind from Southeast
grid at +2.00m (pedestrian level)

Appendix 3.2.2 Total Direct Solar Radiation

Figures A3.2.2.1 and A3.2.2.2 illustrate the total direct solar radiation in summer and spring, which creates environmental qualities that are different from the ones created by the 'green carpet', consequently providing the user with the opportunity of choice.

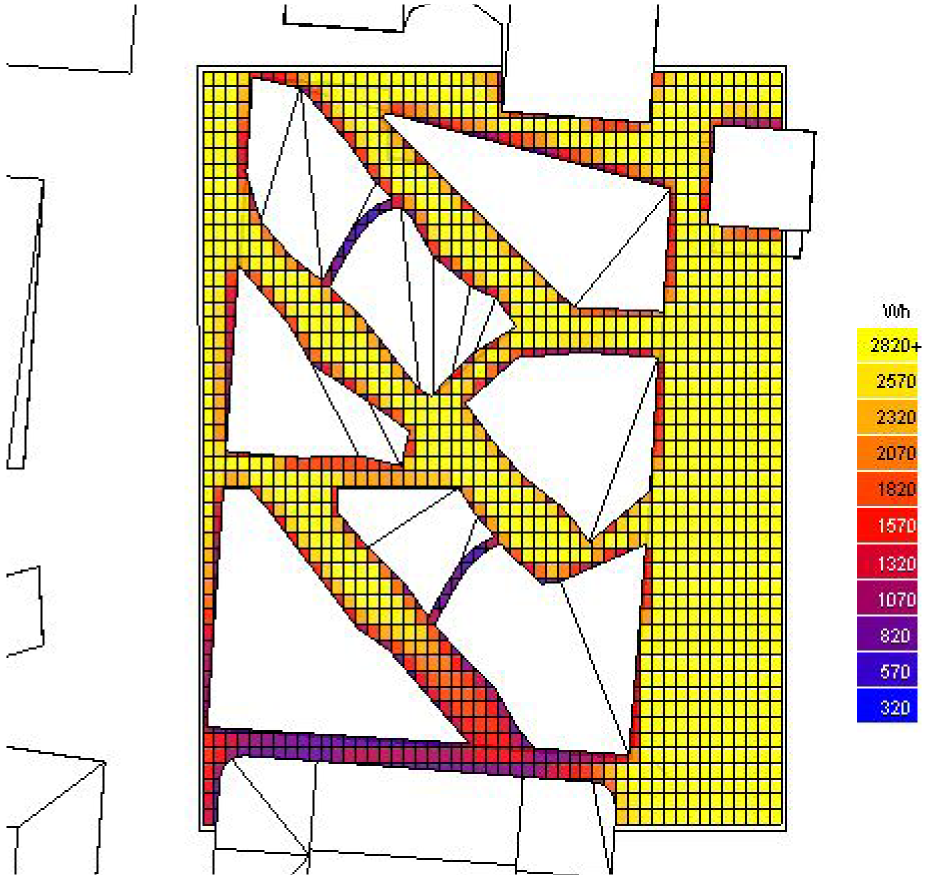


Figure A3.2.2.1 total direct solar radiation ¦ Summer [Ecotect]

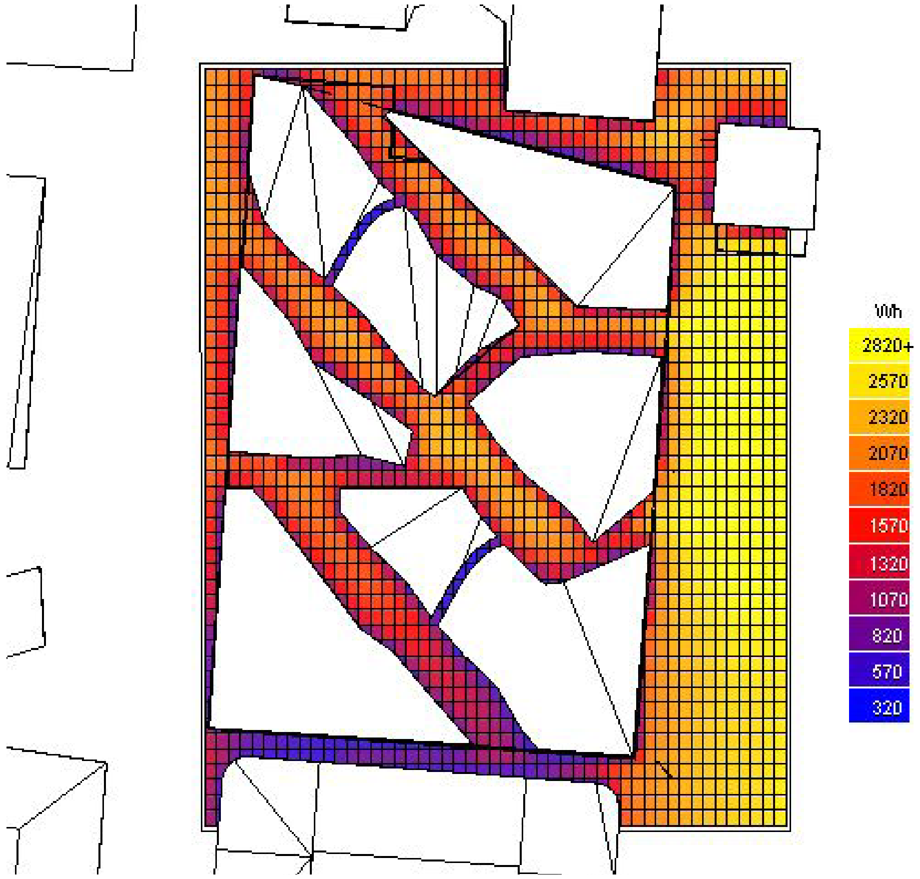


Figure A3.2.2.1 total direct solar radiation ¦ Spring [Ecotect]

Appendix 4.2.1 Daylight factor

In order to address the light quality in the residential units, studies were done using Radiance simulations. As it has been explained in the project brief (see Chapter 2.1) one of the main strategies followed was to have a high solar exposure. The result can be observed in Figure A4.2.1.1, where it shown high amount of natural light in the area adjacent to the south facade, whereas the result in the northern part of the units are considerably lower. The team took into consideration the potential of the units to be used as working spaces and, for that, back windows in the north facade were added, achieving the appropriate levels of daylight needed to develop working activities (see Fig. A4.2.1.2). In addition, it has also been described how the units incorporate a set of elements that give the inhabitants the opportunities to adapt the interior conditions to their needs.

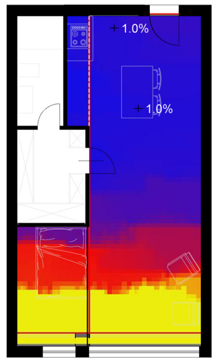


Figure A4.2.1.1 Daylight factor studies - 1 bedroom typology [without back window]

Figure A4.2.1.2 Daylight factor studies - 2 bedroom and 1 bedroom typologies [with back window]

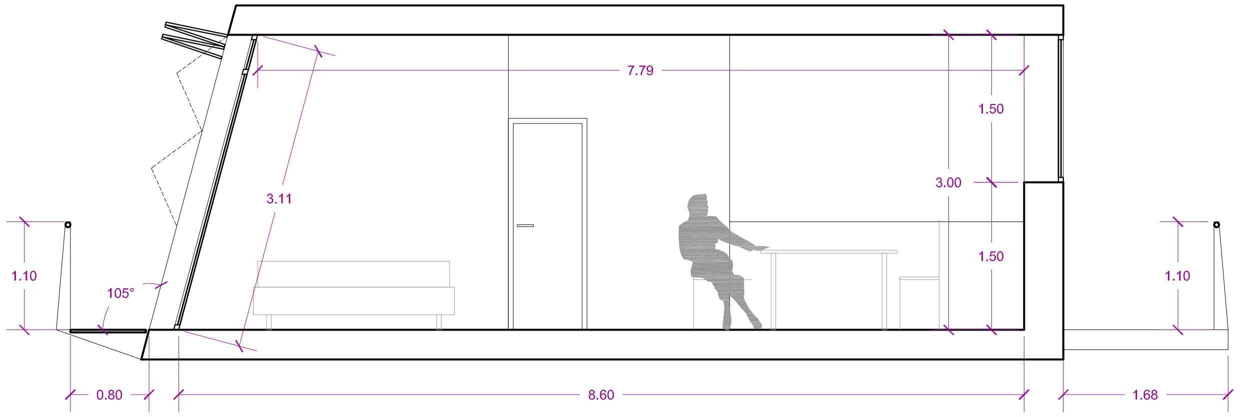


Figure A4.2.2.1 Studio typology - longitudinal section

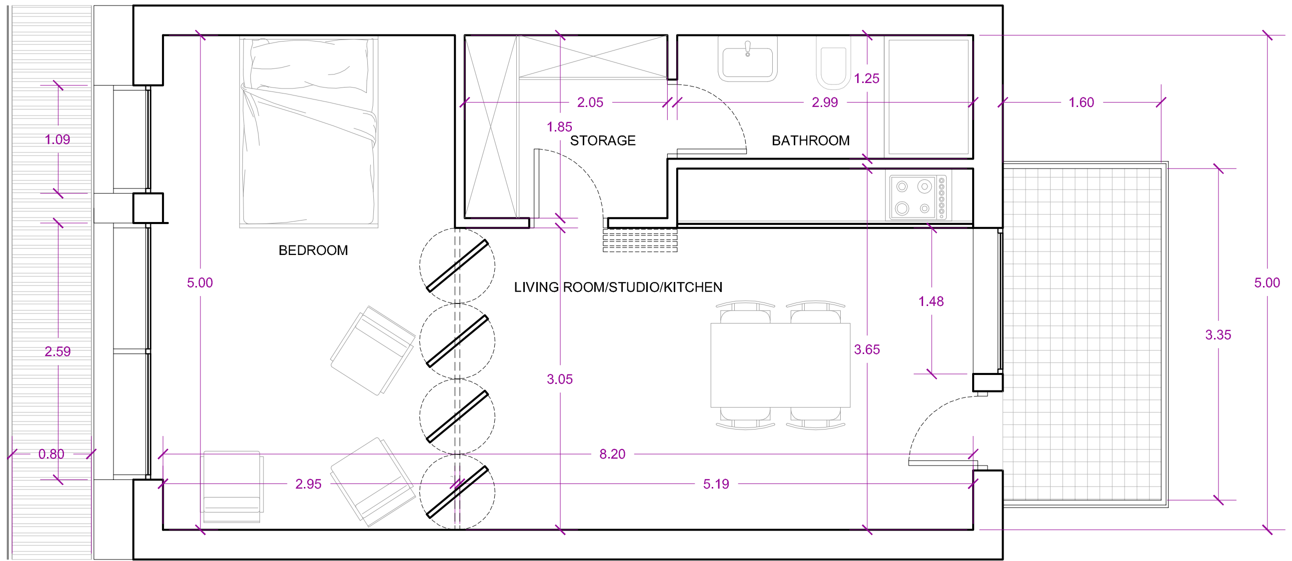


Figure A4.2.2.2 Studio typology - plan - Area: 30 m2

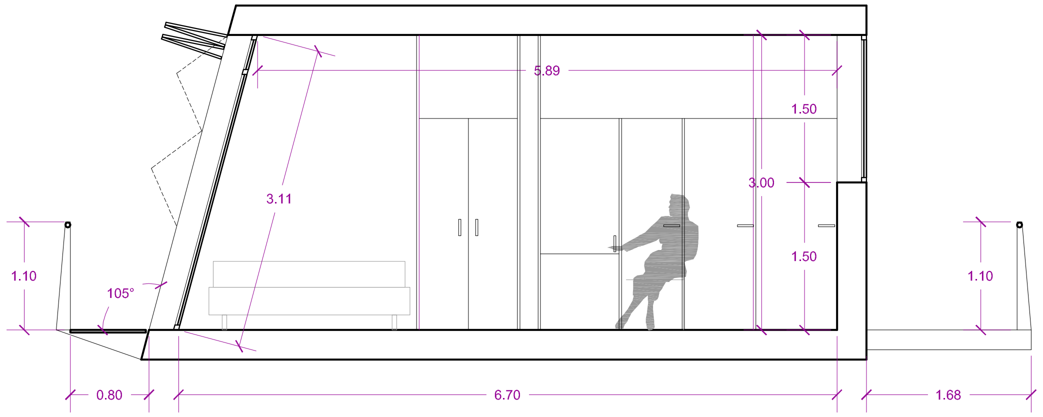


Figure A4.2.2.3 1 bedroom typology - longitudinal section

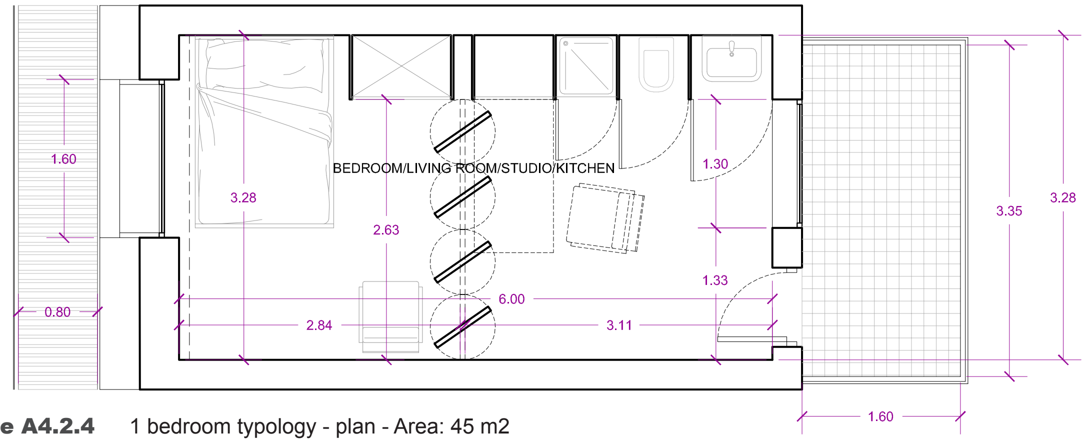


Figure A4.2.4 1 bedroom typology - plan - Area: 45 m2

Appendix 4.2.2 Unit Architectural Definition

The private space is defined by five different typologies that depend on their size in order to adapt to de potential occupants, and are: studio, 1 bedroom, 2 bedroom, 3 bedroom, and unit X, which is a transformation proposed to adapt to future changes in lifestyle and climate.

The goals and processes followed by the team are described in chapter 4, which lead to the definition of each typology, as figures A4.2.2.1, A4.2.2.2, A4.2.2.3, A4.2.2.4, A4.2.2.5, A4.2.2.6, A4.2.2.7, A4.2.2.8, A4.2.2.9 and A4.2.2.10 illustrate.

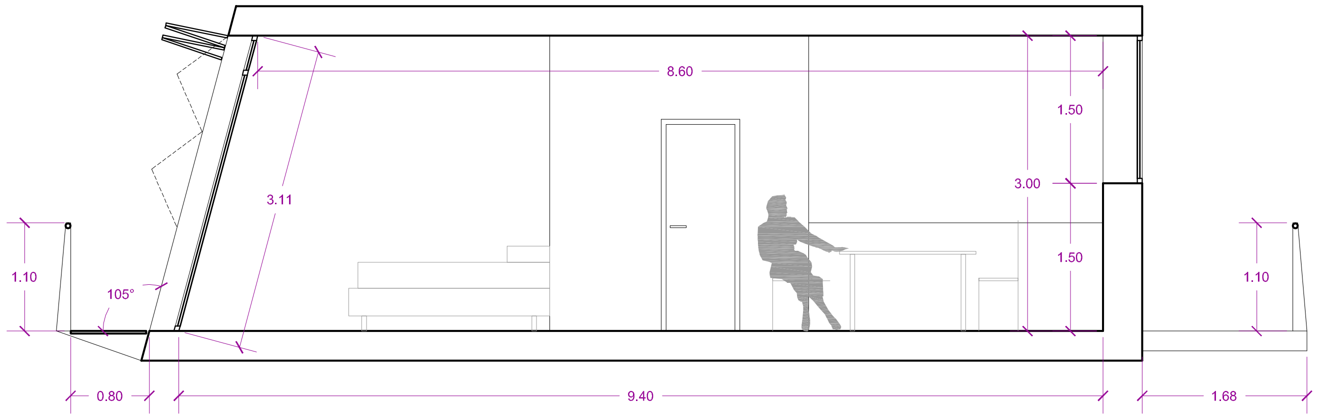


Figure A4.2.2.5 Unit X typology - longitudinal section

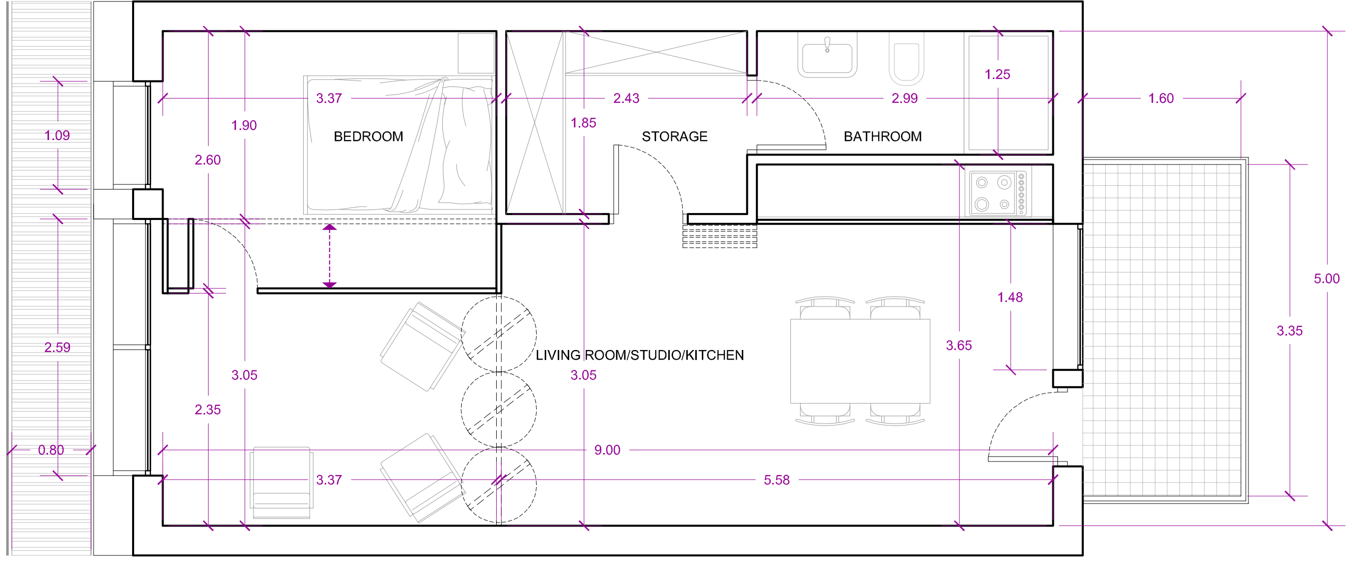


Figure A4.2.2.6 Unit X typology - plan - Area: 18.7 m2

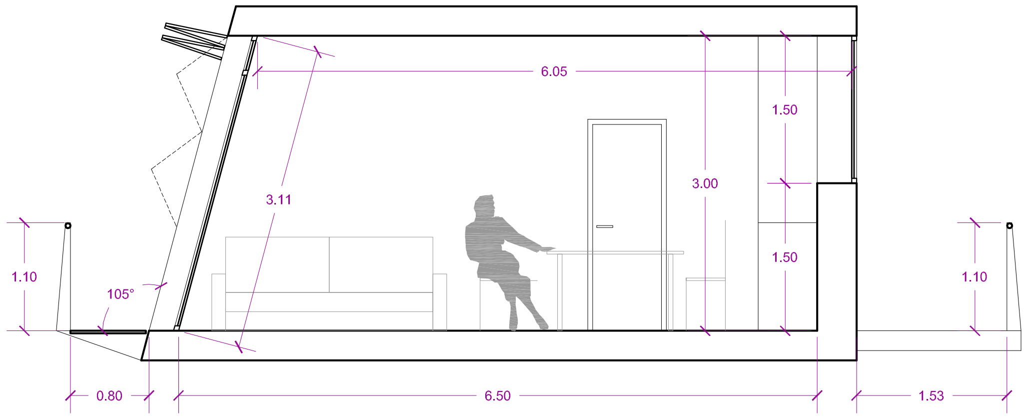


Figure A4.2.2.7 Unit X typology - longitudinal section

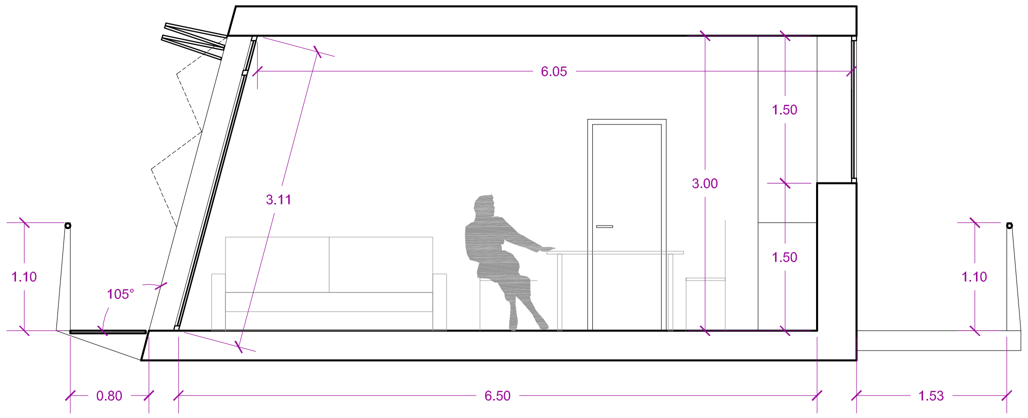


Figure A4.2.2.9 3 bedroom typology - longitudinal section

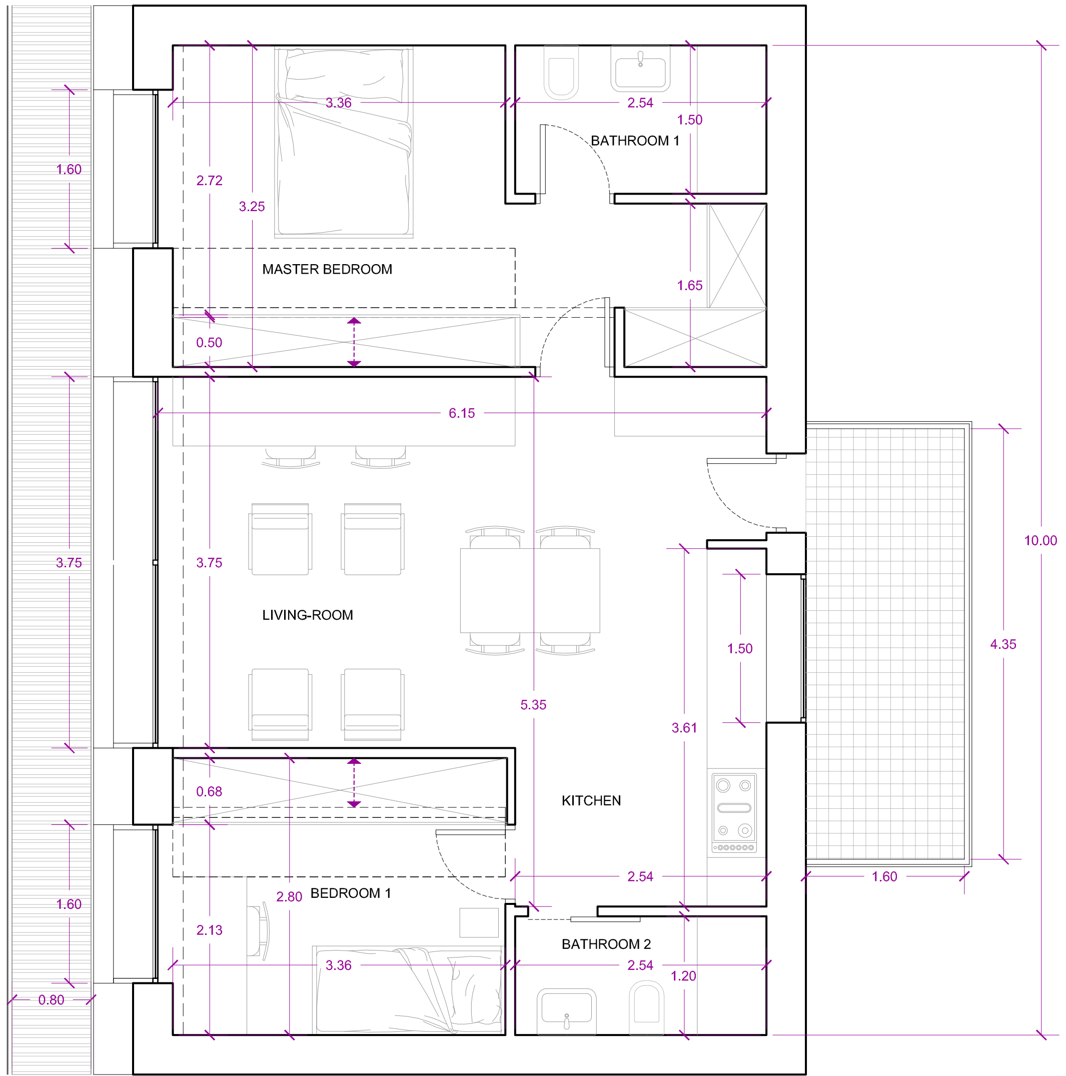


Figure A4.2.2.8 2 bedroom typology - plan
Area: 60 m2

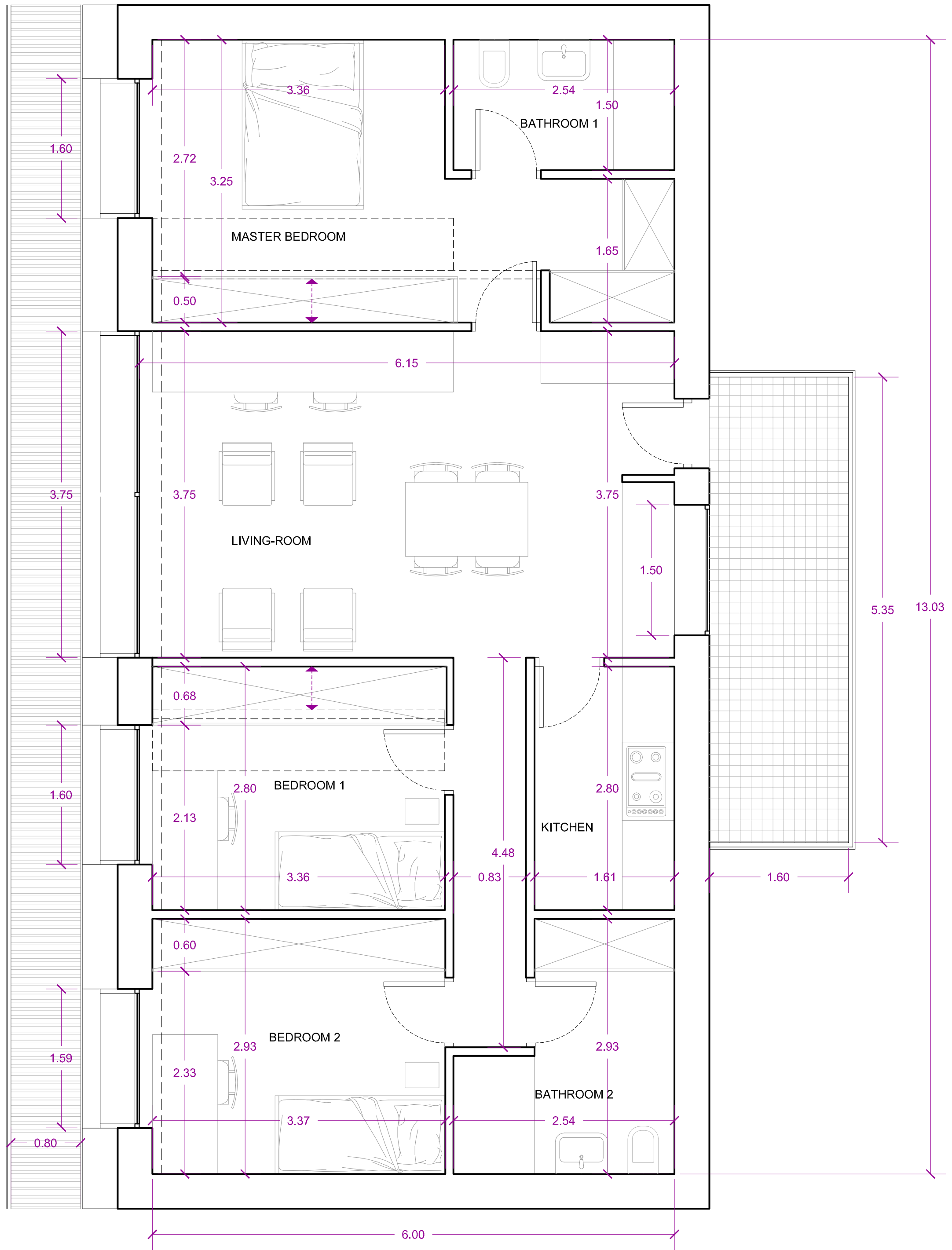
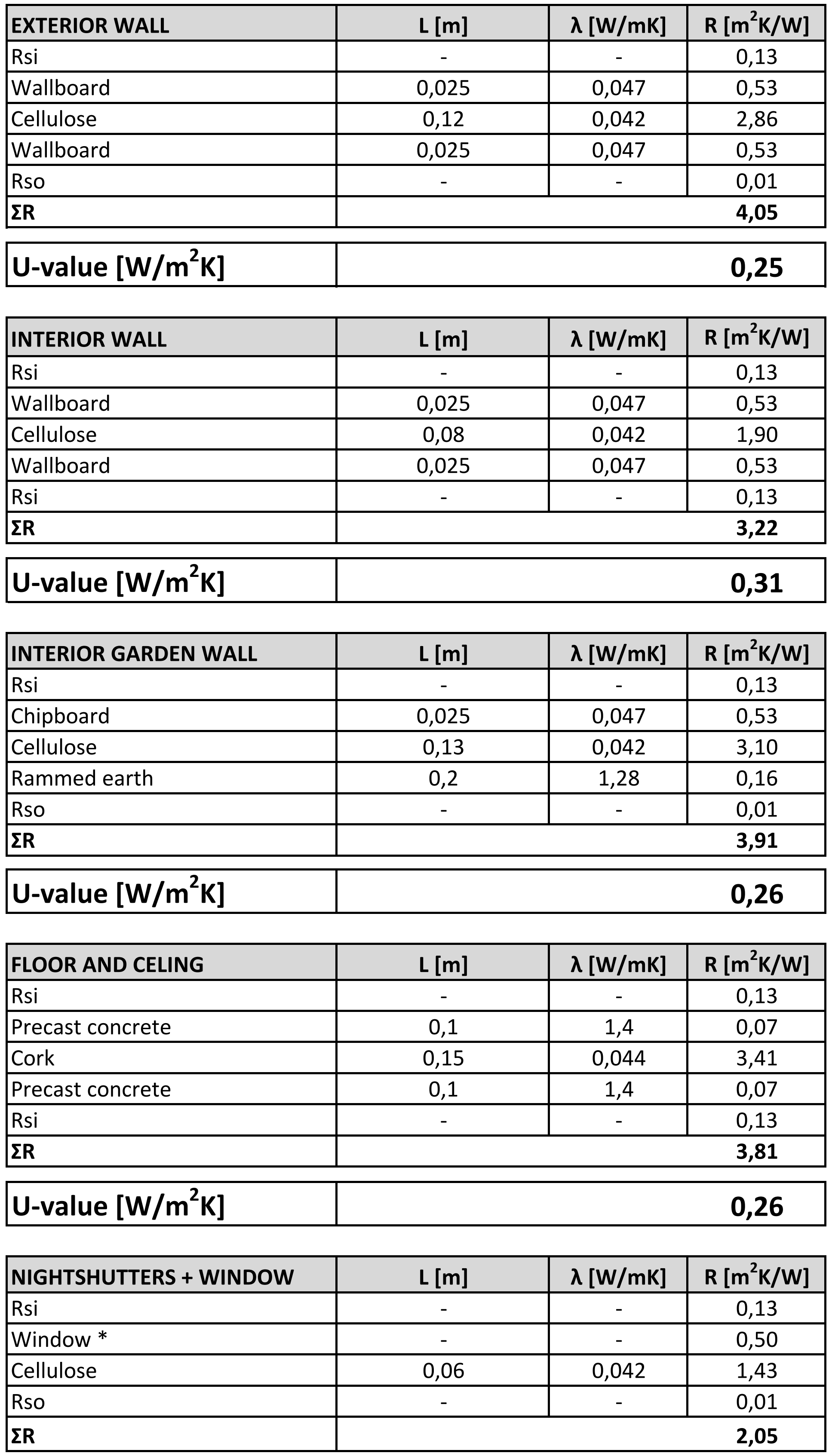


Figure A4.2.2.10 3 bedroom typology - plan
Area: 78 m2

Appendix 4.3.1 U-Values

The materiality is proposed based on different strategies previously described on chapter 4.3.1. The choice of materials also took into account the required thermal properties detailed on Term 2 Project Brief. In order to compose the different construction elements that present the required U values, different materials' properties were studied (CIBSE 2006), and the different sections were designed based on their thermal transmissivity. The composition and resultant U-value of different typical sections and construction elements are detailed in figure A4.3.2.1.1.



EXTERIOR WALL	L [m]	λ [W/mK]	R [m²K/W]
Rsi	-	-	0,13
Wallboard	0,025	0,047	0,53
Cellulose	0,12	0,042	2,86
Wallboard	0,025	0,047	0,53
Rso	-	-	0,01
ΣR			**4,05**

U-value [W/m²K]	**0,25**

INTERIOR WALL	L [m]	λ [W/mK]	R [m²K/W]
Rsi	-	-	0,13
Wallboard	0,025	0,047	0,53
Cellulose	0,08	0,042	1,90
Wallboard	0,025	0,047	0,53
Rsi	-	-	0,13
ΣR			**3,22**

U-value [W/m²K]	**0,31**

INTERIOR GARDEN WALL	L [m]	λ [W/mK]	R [m²K/W]
Rsi	-	-	0,13
Chipboard	0,025	0,047	0,53
Cellulose	0,13	0,042	3,10
Rammed earth	0,2	1,28	0,16
Rso	-	-	0,01
ΣR			**3,91**

U-value [W/m²K]	**0,26**

FLOOR AND CELING	L [m]	λ [W/mK]	R [m²K/W]
Rsi	-	-	0,13
Precast concrete	0,1	1,4	0,07
Cork	0,15	0,044	3,41
Precast concrete	0,1	1,4	0,07
Rsi	-	-	0,13
ΣR			**3,81**

U-value [W/m²K]	**0,26**

NIGHTSHUTTERS + WINDOW	L [m]	λ [W/mK]	R [m²K/W]
Rsi	-	-	0,13
Window *	-	-	0,50
Cellulose	0,06	0,042	1,43
Rso	-	-	0,01
ΣR			**2,05**

Figure A4.3.2.1.1 Hammond, G and C. Jones. 2006. "Inventory of Carbon and Energy." University of Bath, Department of Mechanical Engineering.
Calkins, M. "Materials for Sustainable Sites". New Jersey, 2009.
Fernandez, J. "Material Architecture". Oxford, 2006.

Appendix 4.3.2 Thermal comfort - Thermal mass studies

At first the analytic work was made to verify the performance with different materiality. Due to the team strategy of doing passive solar design, the fluctuation in temperature are extremely high if light weight materials are used - the red line show this fluctuations. So in order to store the heat produced by the solar gain a concrete layer of 10 cm in the floor and ceiling was tested. As it was expected, the thermal mass propriety of the concrete reduce the fluctuation, absorbing the heat during the day and realising it during the night. The benefit of this choice can be seen also during the summer week since it harmonise the internal temperature. The blue line shows the benefit of the heavy weight materials.

A test was made with wet clay as option to be explored. In this case the fluctuation are even lowered especially in winter. The test show the possibility of a deeper study, even if due to the urban context of the project the team decide not to explore further this option, expressed by the green line in figures A4.4.4.1.2 and A4.4.4.1.3.

Figure A4.3.2.1 Examples of different materials and finishes

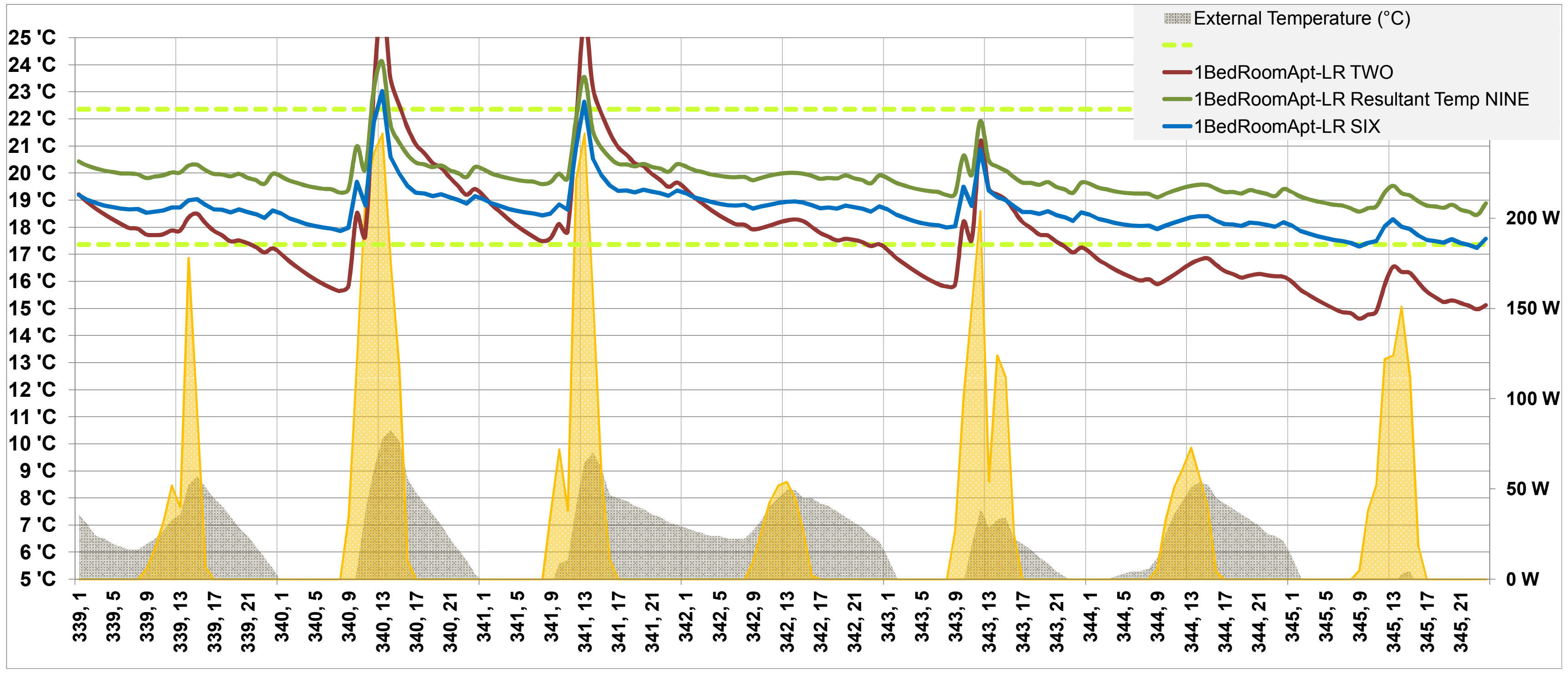


Figure A4.3.2.2 Predicted internal temperatures using thermal mass from concrete finishings in floor and ceiling- winter week

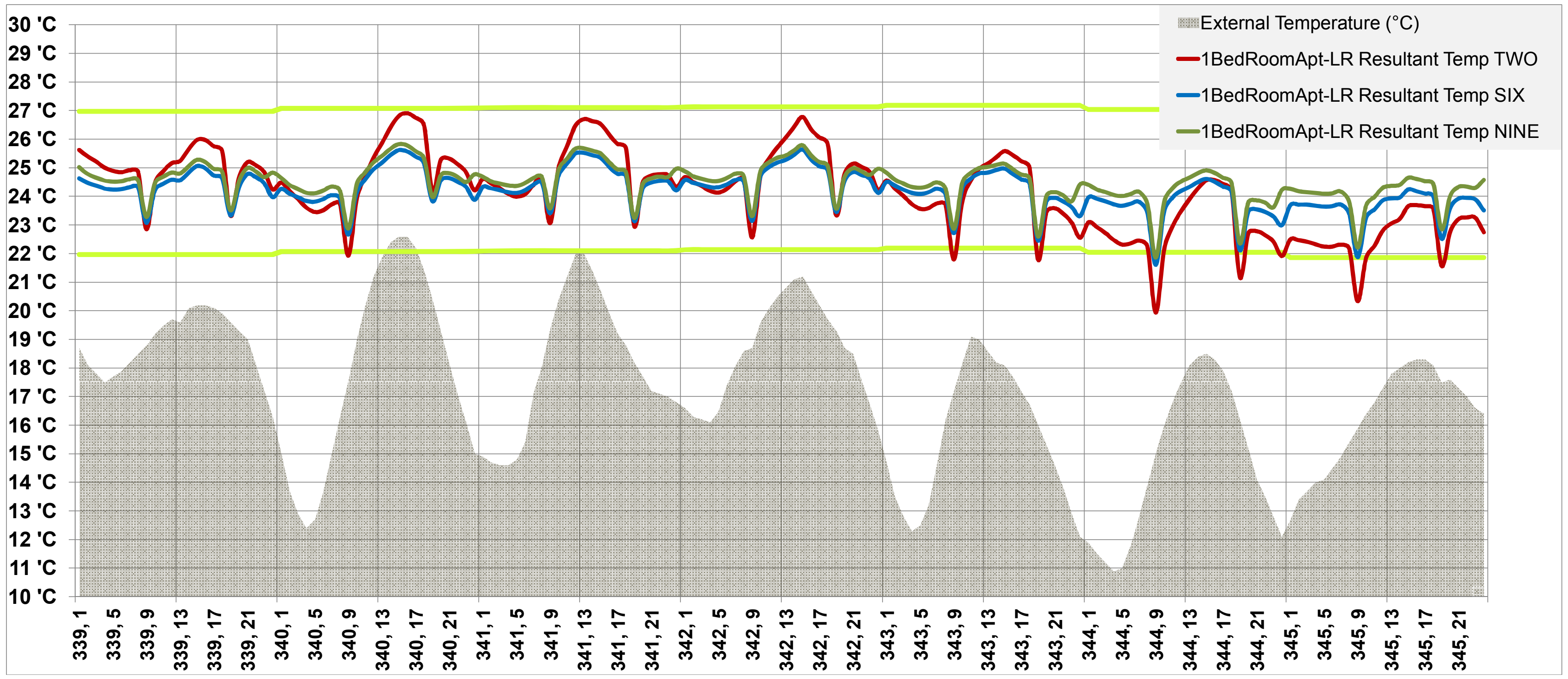
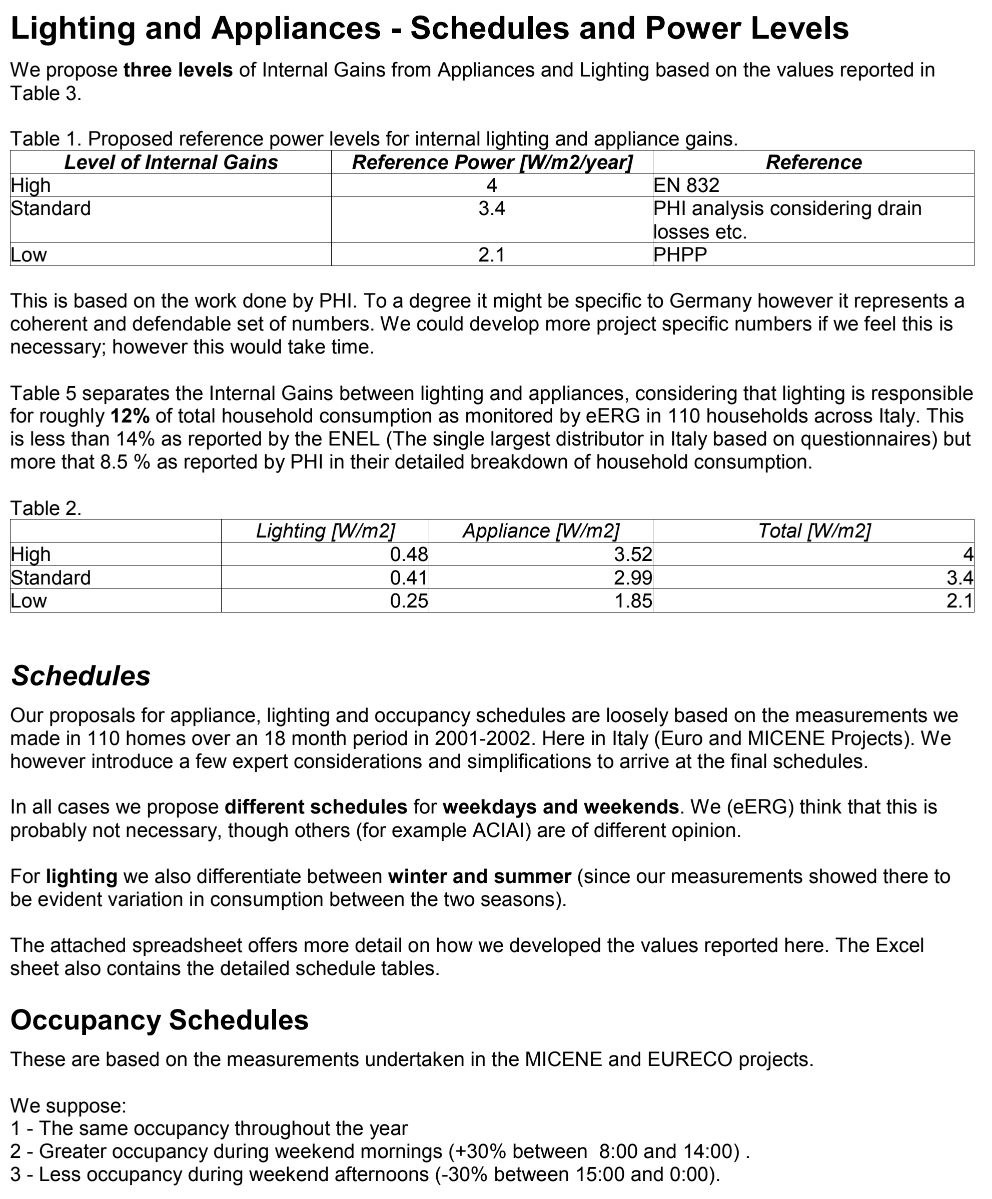


Figure A4.3.2.3 Predicted internal temperatures using thermal mass from concrete finishings in floor and ceiling- summer week

Appendix 4.4.1 Internal Heat Gains

As it was described in chapter 4.4.1, the analytic work developed in this project was based on the internal heat gains proposed in The Passive-on Project report on internal heat gains. Taking into consideration the possible changes in lifestyle and the increasing efficiency of technology in time, the team envisions a reduction of internal heat gains for the future. Consequently, the studies were based choosing a low pattern of internal heat gains, detailed in figure A4.4.1.1.



Lighting and Appliances - Schedules and Power Levels

We propose **three levels** of Internal Gains from Appliances and Lighting based on the values reported in Table 3.

Table 1. Proposed reference power levels for internal lighting and appliance gains.

Level of Internal Gains	*Reference Power [W/m2/year]*	*Reference*
High	4	EN 832
Standard	3.4	PHI analysis considering drain losses etc.
Low	2.1	PHPP

This is based on the work done by PHI. To a degree it might be specific to Germany however it represents a coherent and defendable set of numbers. We could develop more project specific numbers if we feel this is necessary; however this would take time.

Table 5 separates the Internal Gains between lighting and appliances, considering that lighting is responsible for roughly **12%** of total household consumption as monitored by eERG in 110 households across Italy. This is less than 14% as reported by the ENEL (The single largest distributor in Italy based on questionnaires) but more that 8.5 % as reported by PHI in their detailed breakdown of household consumption.

Table 2.

	Lighting [W/m2]	*Appliance [W/m2]*	*Total [W/m2]*
High	0.48	3.52	4
Standard	0.41	2.99	3.4
Low	0.25	1.85	2.1

Schedules

Our proposals for appliance, lighting and occupancy schedules are loosely based on the measurements we made in 110 homes over an 18 month period in 2001-2002. Here in Italy (Euro and MICENE Projects). We however introduce a few expert considerations and simplifications to arrive at the final schedules.

In all cases we propose **different schedules** for **weekdays and weekends**. We (eERG) think that this is probably not necessary, though others (for example ACIAI) are of different opinion.

For **lighting** we also differentiate between **winter and summer** (since our measurements showed there to be evident variation in consumption between the two seasons).

The attached spreadsheet offers more detail on how we developed the values reported here. The Excel sheet also contains the detailed schedule tables.

Occupancy Schedules

These are based on the measurements undertaken in the MICENE and EURECO projects.

We suppose:
1 - The same occupancy throughout the year
2 - Greater occupancy during weekend mornings (+30% between 8:00 and 14:00) .
3 - Less occupancy during weekend afternoons (-30% between 15:00 and 0:00).

Figure A4.4.1.1 Lighting and appliances heat gains study - page 1
Source: Andrew Pindar & Lorenzo Pagliano, eERG, Passive-on Project report. September 2005

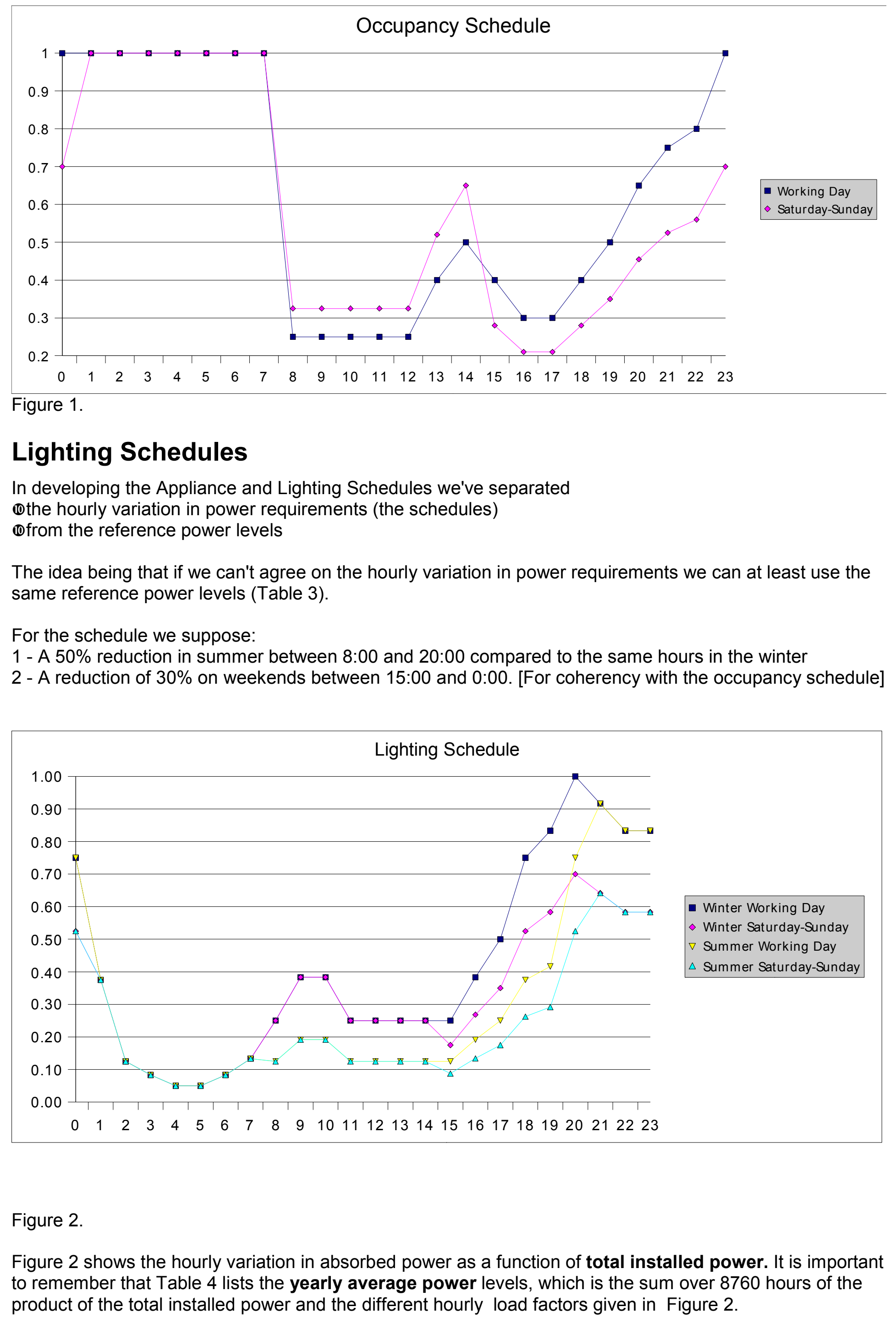


Figure 1.

Lighting Schedules

In developing the Appliance and Lighting Schedules we've separated
⑩the hourly variation in power requirements (the schedules)
⑩from the reference power levels

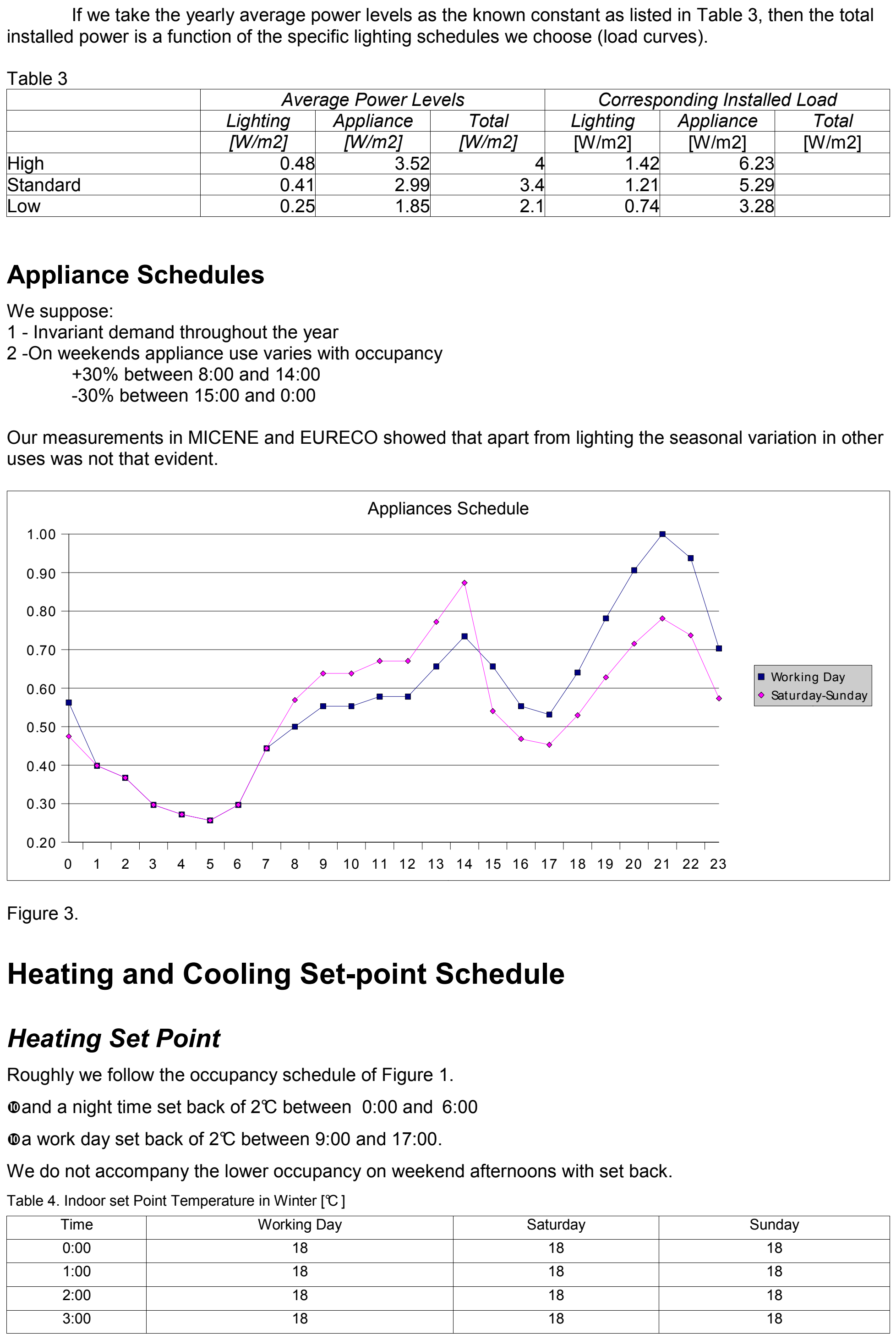
The idea being that if we can't agree on the hourly variation in power requirements we can at least use the same reference power levels (Table 3).

For the schedule we suppose:
1 - A 50% reduction in summer between 8:00 and 20:00 compared to the same hours in the winter
2 - A reduction of 30% on weekends between 15:00 and 0:00. [For coherency with the occupancy schedule]

Figure 2.

Figure 2 shows the hourly variation in absorbed power as a function of **total installed power.** It is important to remember that Table 4 lists the **yearly average power** levels, which is the sum over 8760 hours of the product of the total installed power and the different hourly load factors given in Figure 2.

Figure A4.4.1.2 Lighting and appliances heat gains study - page 2
Source: Andrew Pindar & Lorenzo Pagliano, eERG, Passive-on Project report. September 2005



If we take the yearly average power levels as the known constant as listed in Table 3, then the total installed power is a function of the specific lighting schedules we choose (load curves).

Table 3

	Average Power Levels			*Corresponding Installed Load*		
	Lighting [W/m2]	*Appliance [W/m2]*	*Total [W/m2]*	*Lighting* [W/m2]	*Appliance* [W/m2]	*Total* [W/m2]
High	0.48	3.52	4	1.42	6.23	
Standard	0.41	2.99	3.4	1.21	5.29	
Low	0.25	1.85	2.1	0.74	3.28	

Appliance Schedules

We suppose:

1 - Invariant demand throughout the year
2 -On weekends appliance use varies with occupancy
+30% between 8:00 and 14:00
-30% between 15:00 and 0:00

Our measurements in MICENE and EURECO showed that apart from lighting the seasonal variation in other uses was not that evident.

Figure 3.

Heating and Cooling Set-point Schedule

Heating Set Point

Roughly we follow the occupancy schedule of Figure 1.

➓and a night time set back of 2℃ between 0:00 and 6:00

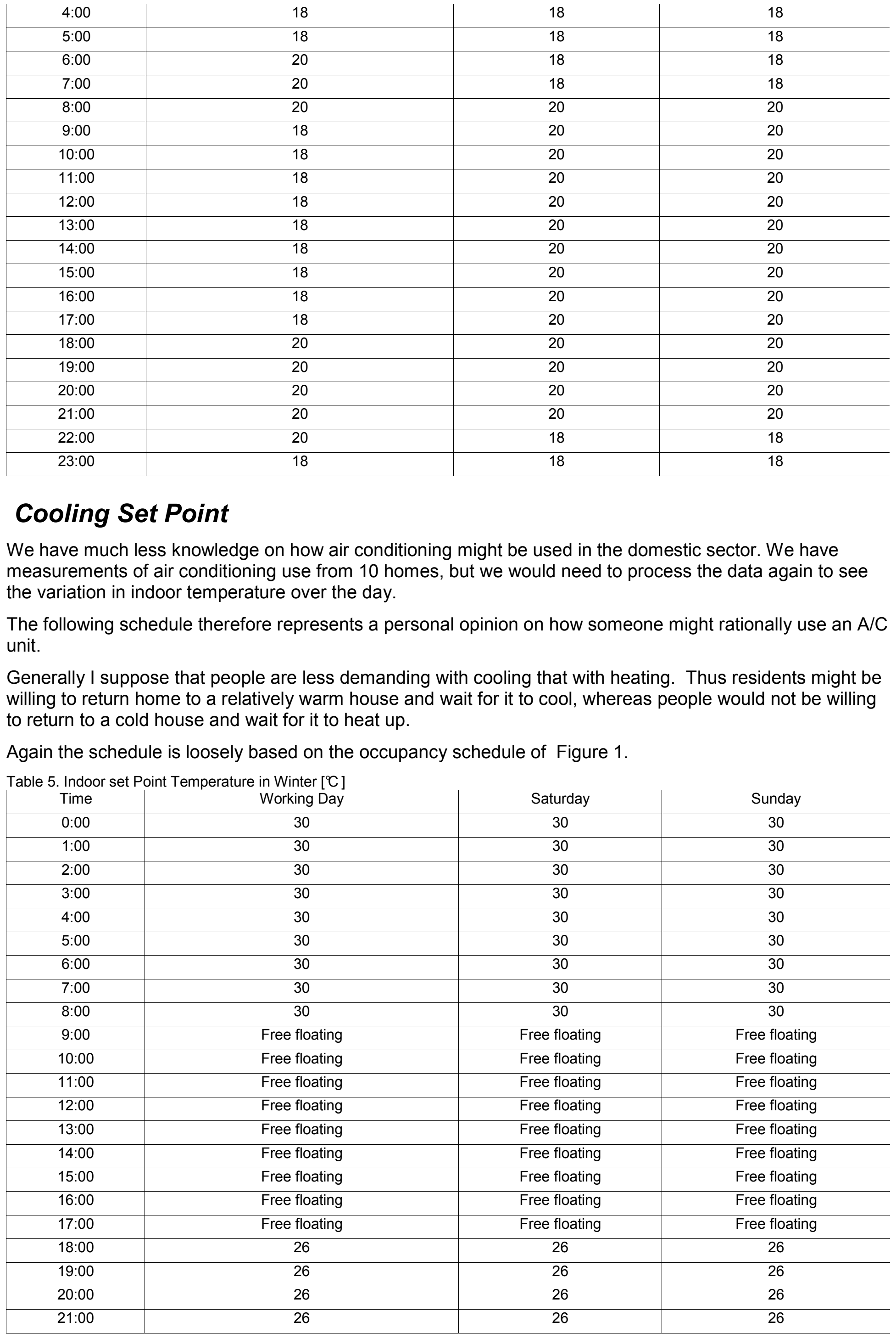
➓a work day set back of 2℃ between 9:00 and 17:00.

We do not accompany the lower occupancy on weekend afternoons with set back.

Table 4. Indoor set Point Temperature in Winter [℃]

Time	Working Day	Saturday	Sunday
0:00	18	18	18
1:00	18	18	18
2:00	18	18	18
3:00	18	18	18
4:00	18	18	18
5:00	18	18	18
6:00	20	18	18
7:00	20	18	18
8:00	20	20	20
9:00	18	20	20
10:00	18	20	20
11:00	18	20	20
12:00	18	20	20
13:00	18	20	20
14:00	18	20	20
15:00	18	20	20
16:00	18	20	20
17:00	18	20	20
18:00	20	20	20
19:00	20	20	20
20:00	20	20	20
21:00	20	20	20
22:00	20	18	18
23:00	18	18	18

Figure A4.4.1.3 Lighting and appliances heat gains study - page 3
Source: Andrew Pindar & Lorenzo Pagliano, eERG, Passive-on Project report. September 2005



Cooling Set Point

We have much less knowledge on how air conditioning might be used in the domestic sector. We have measurements of air conditioning use from 10 homes, but we would need to process the data again to see the variation in indoor temperature over the day.

The following schedule therefore represents a personal opinion on how someone might rationally use an A/C unit.

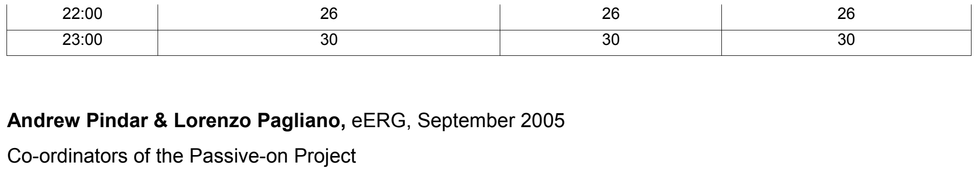
Generally I suppose that people are less demanding with cooling that with heating. Thus residents might be willing to return home to a relatively warm house and wait for it to cool, whereas people would not be willing to return to a cold house and wait for it to heat up.

Again the schedule is loosely based on the occupancy schedule of Figure 1.

Table 5. Indoor set Point Temperature in Winter [℃]

Time	Working Day	Saturday	Sunday
0:00	30	30	30
1:00	30	30	30
2:00	30	30	30
3:00	30	30	30
4:00	30	30	30
5:00	30	30	30
6:00	30	30	30
7:00	30	30	30
8:00	30	30	30
9:00	Free floating	Free floating	Free floating
10:00	Free floating	Free floating	Free floating
11:00	Free floating	Free floating	Free floating
12:00	Free floating	Free floating	Free floating
13:00	Free floating	Free floating	Free floating
14:00	Free floating	Free floating	Free floating
15:00	Free floating	Free floating	Free floating
16:00	Free floating	Free floating	Free floating
17:00	Free floating	Free floating	Free floating
18:00	26	26	26
19:00	26	26	26
20:00	26	26	26
21:00	26	26	26
22:00	26	26	26
23:00	30	30	30

Figure A4.4.1.4 Lighting and appliances heat gains study - page 4
Source: Andrew Pindar & Lorenzo Pagliano, eERG, Passive-on Project report. September 2005



Andrew Pindar & Lorenzo Pagliano, eERG, September 2005

Co-ordinators of the Passive-on Project

Figure A4.4.1.5 Lighting and appliances heat gains study - page 5
Source: Andrew Pindar & Lorenzo Pagliano, eERG, Passive-on Project report. September 2005

Appendix 4.4.4.1 Thermal comfort - Internal Garden

Figures A4.4.4.2.2 and A4.4.4.2.1 shows the strategy and the benefit of the garden-buffer in the apartment environment through the analysis of the one bedroom resultant temperature. The blue line on figure A4.4.4.2.3 shows the predicted temperature during the coldest week of the winter if fresh air required by the inhabitant, and is taken from outside. The red line in the same figure (fig A4.4.4.2.3)shows the shift if that air is taken form the garden buffer, that during this week has a temperature higher than outside, as shown by the brown line. To approach the comfort band, further adaptive measures must be used. The green line (fig A4.4.4.2.3)shows the benefit of keeping the insulated shutter closed, for the purpose of reducing heat losses from the windows during the cloudy days and when the outdoor temperature drop to daily average of 1-2 °C.
Finally a test was made (fig A4.4.4.2.4) preheating the fresh air required. The orange line show its benefits. Nonetheless, the team decided to avoid mechanical systems in the building to follow the strategies of total passive solar design, and relying on the idea that a link with the outdoor weather is part of the benefit that this kind of design can offer, especially when applied to residential buildings the occupants behaviour can be highly adaptive.
The graph below (fig A4.4.4.2.4) shows the results of the predicted indoor temperature during the warmest day of the summer. The little drops are created by the user when opening the windows to “change the air” during the day. In addition, the tilting windows are kept minimum open to allow some cross ventilation. And the thermal mass of the concrete and ceiling are enough to keep the indoor temperature within the comfort zone.

The figures in the next page (fig A4.4.4.2.5, fig A4.4.4.2.6, fig A4.4.4.2.7 and fig A4.4.4.2.8) show the results for the extreme weeks during winter and summer for the other rooms in the one bedroom apartment and the two bedroom apartment.

Note: the extreme weeks were taken from the weather file of Meteonorm 6.1 for tower of hamlet. the file provides a typical average year on the base of analysis made during the year from 1996 and 2005

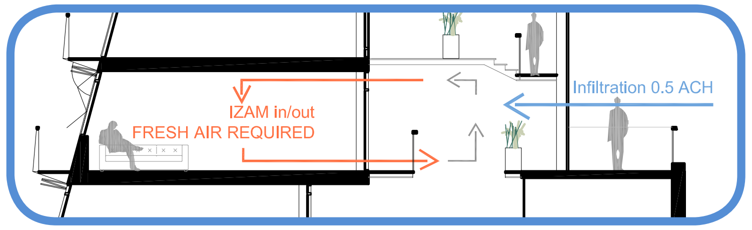


Figure A4.4.4.2.1 Schemes of air movement between units and buffer garden summer

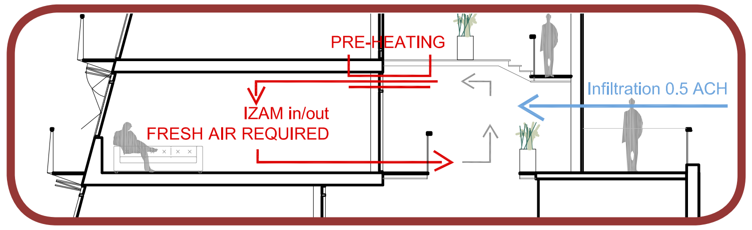


Figure A4.4.4.2.2 Schemes of air movement between units and buffer garden winter

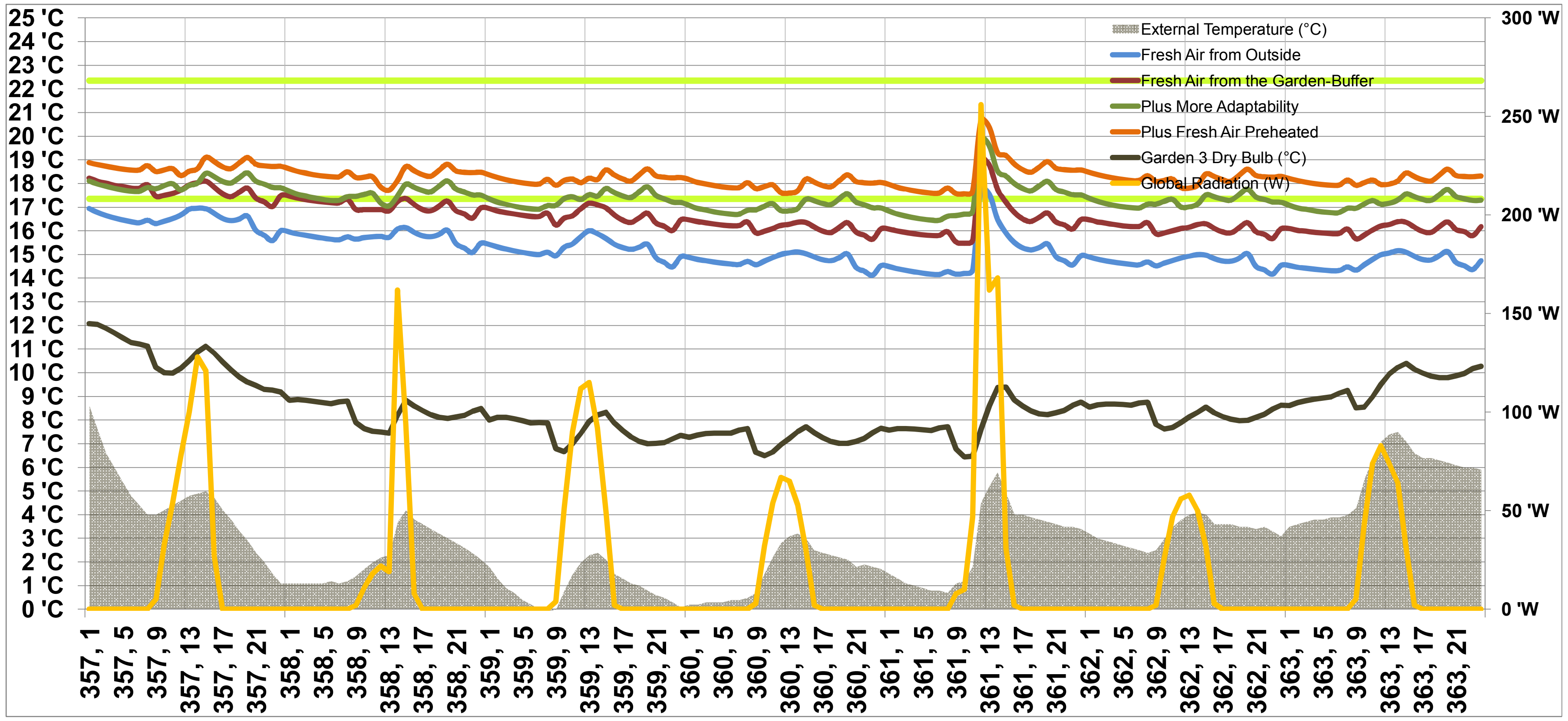


Figure A4.4.4.2.3 Resultant temperature for one bedroom typology and dry bulb temperature for buffer garden during an extreme winter week

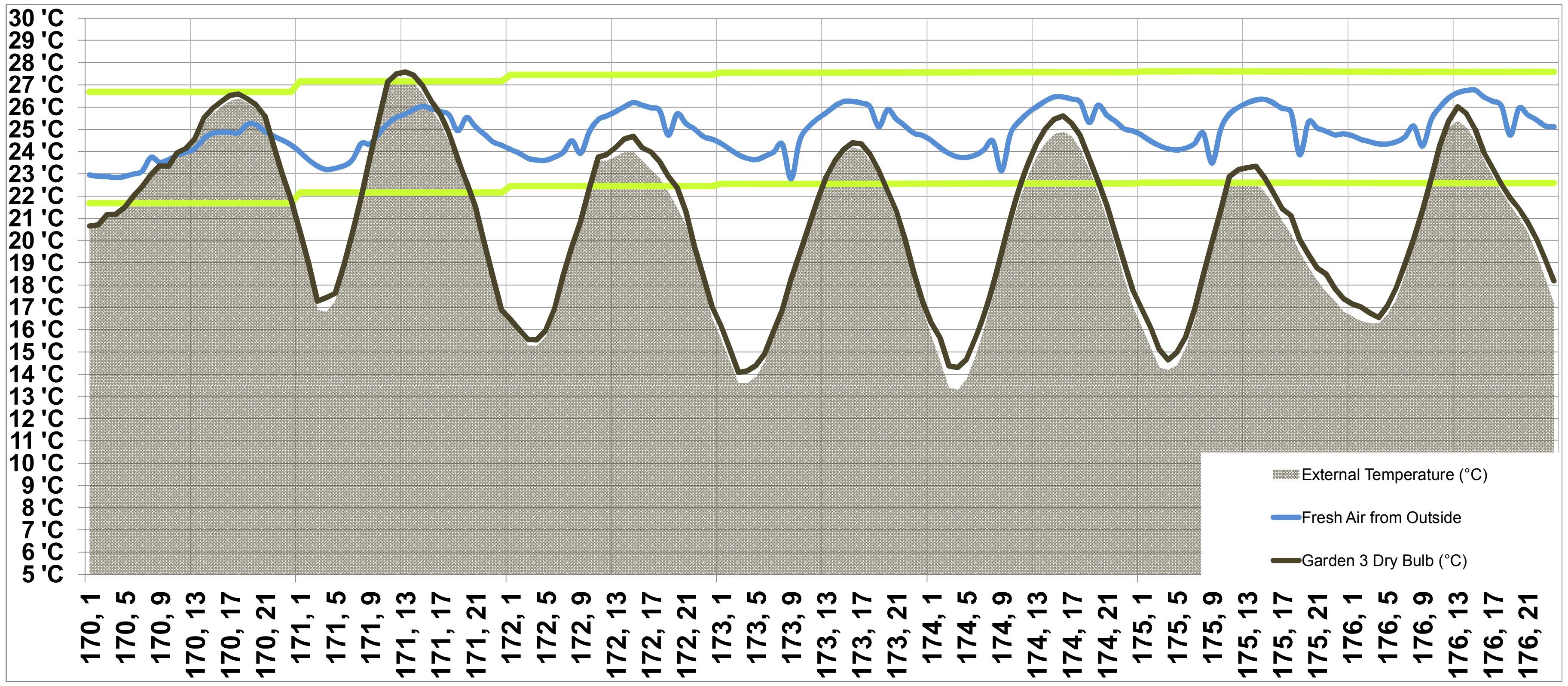


Figure A4.4.4.2.4 Resultant temperature for one bedroom typology and dry bulb temperature for buffer garden during an extreme summer week

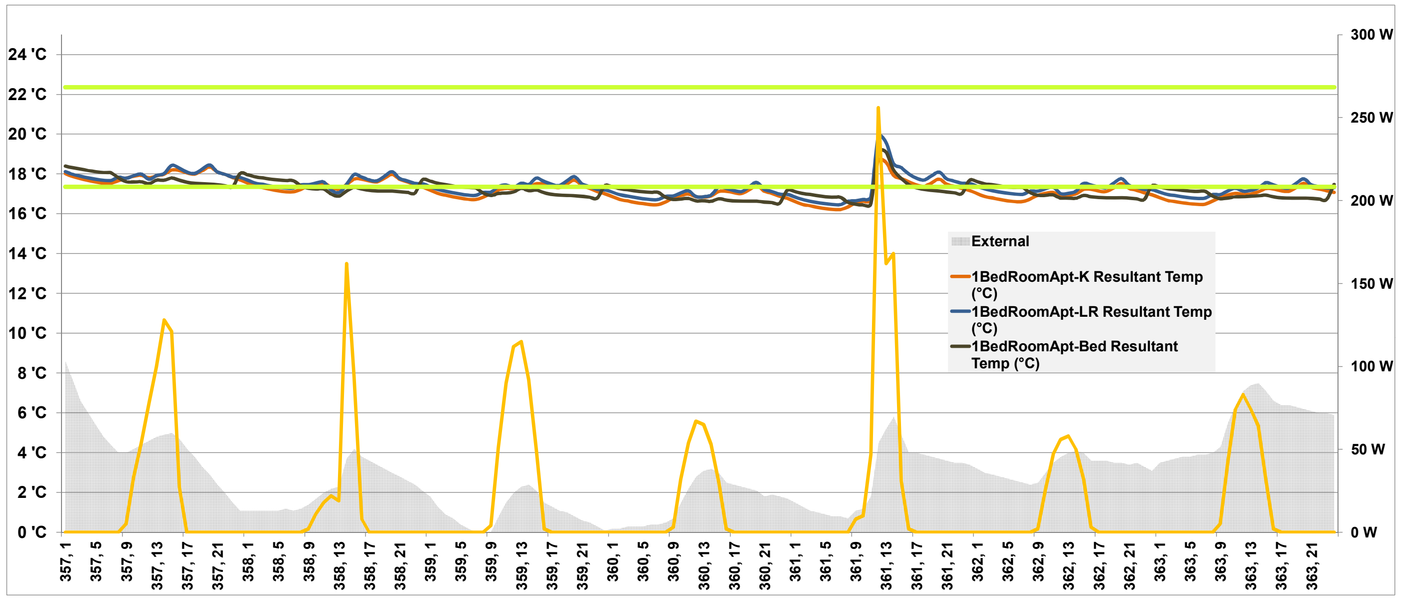


Figure A4.4.4.2.5 Resultant temperatures for the different spaces of the 1 bedroom typology during an extreme winter week

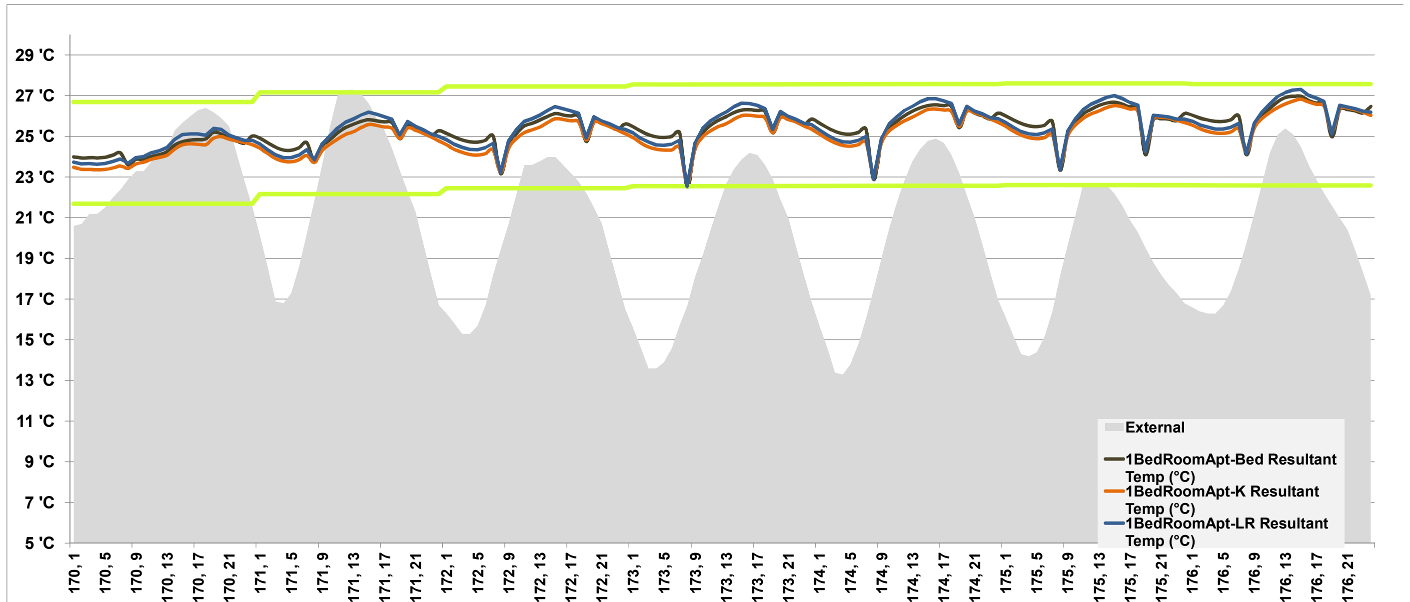


Figure A4.4.4.2.7 Resultant temperatures for the different spaces of the 1 bedroom typology during an extreme summer week

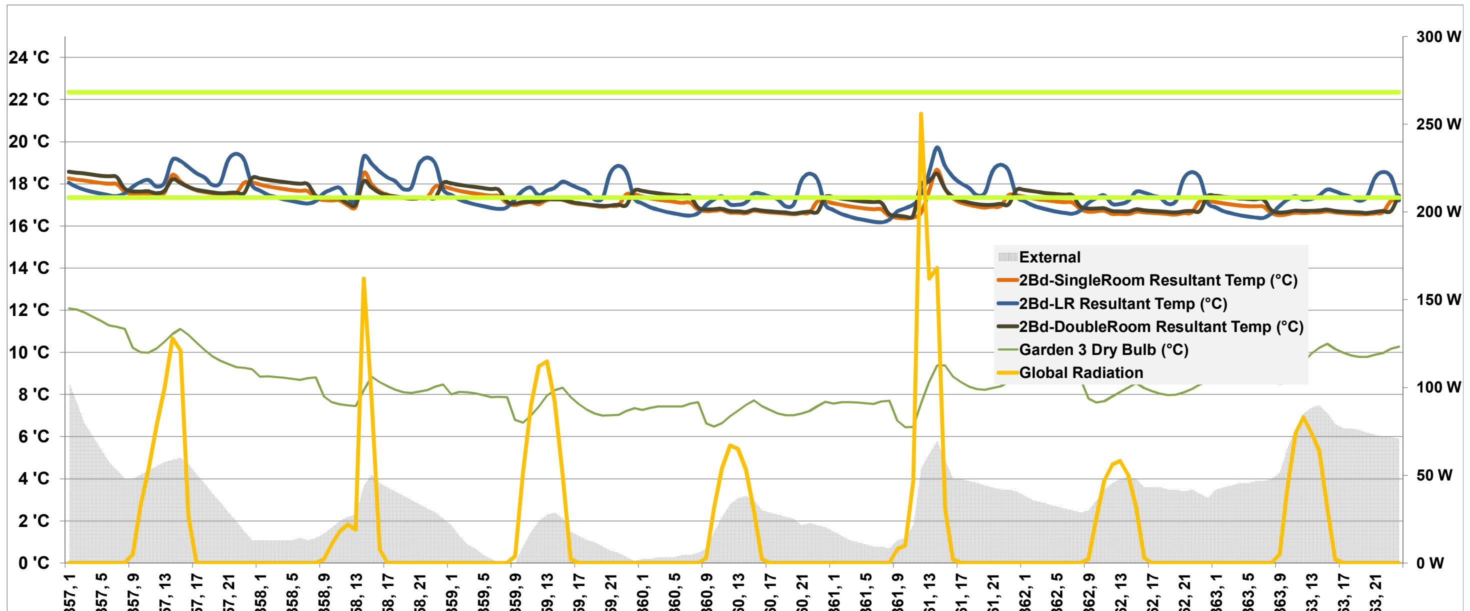


Figure A4.4.4.2.6 Resultant temperatures for the different spaces of the 2 bedroom typology during an extreme winter week

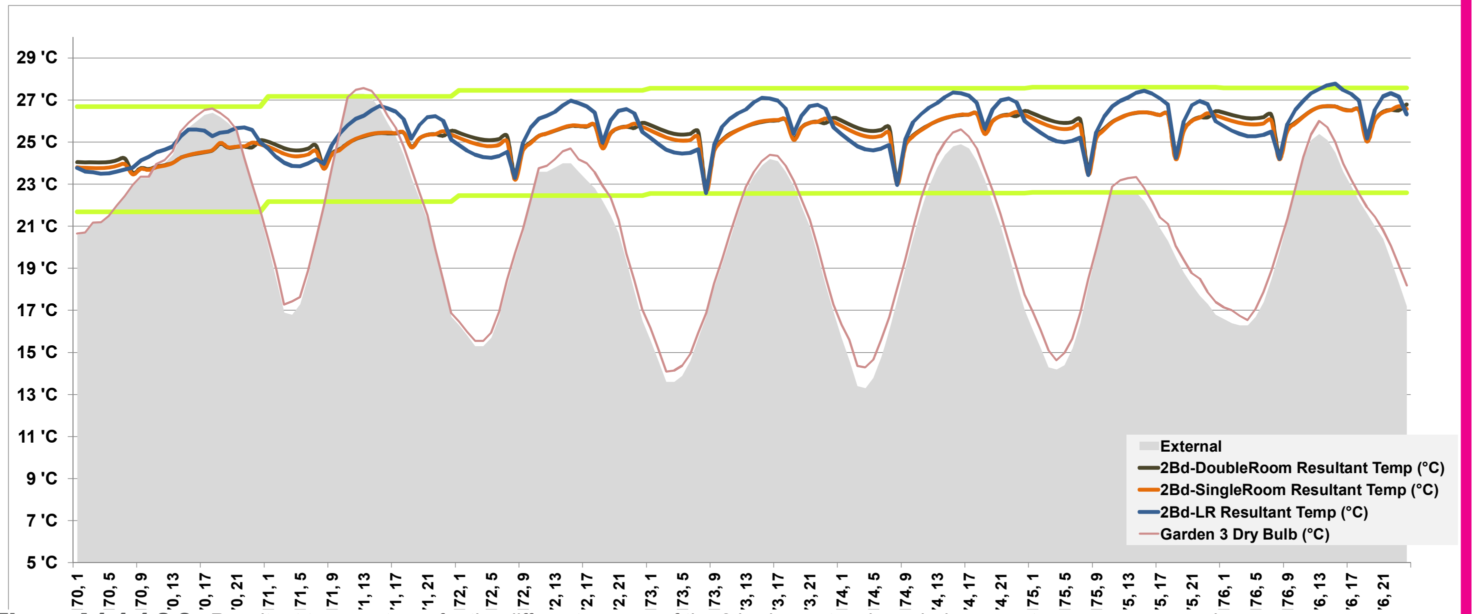


Figure A4.4.4.2.8 Resultant temperatures for the different spaces of the 2 bedroom typology during an extreme summer week

An analysis was made to compare the results of the strategy adopted on a typical winter week.

on the left the figure A4.4.4.2.7 shows the comparison between our case and if the window are was reduced by 50% (blue line). As it can be seen, the fluctuation is reduced due to the lower solar gain, and the final temperature is 1K lower. Therefore, the team's strategy does not show any disadvantage during summer due to its adaptability to external conditions. Moreover, it has been thought that the proposed window to floor ratio is adequate for the purpose of the concept design.

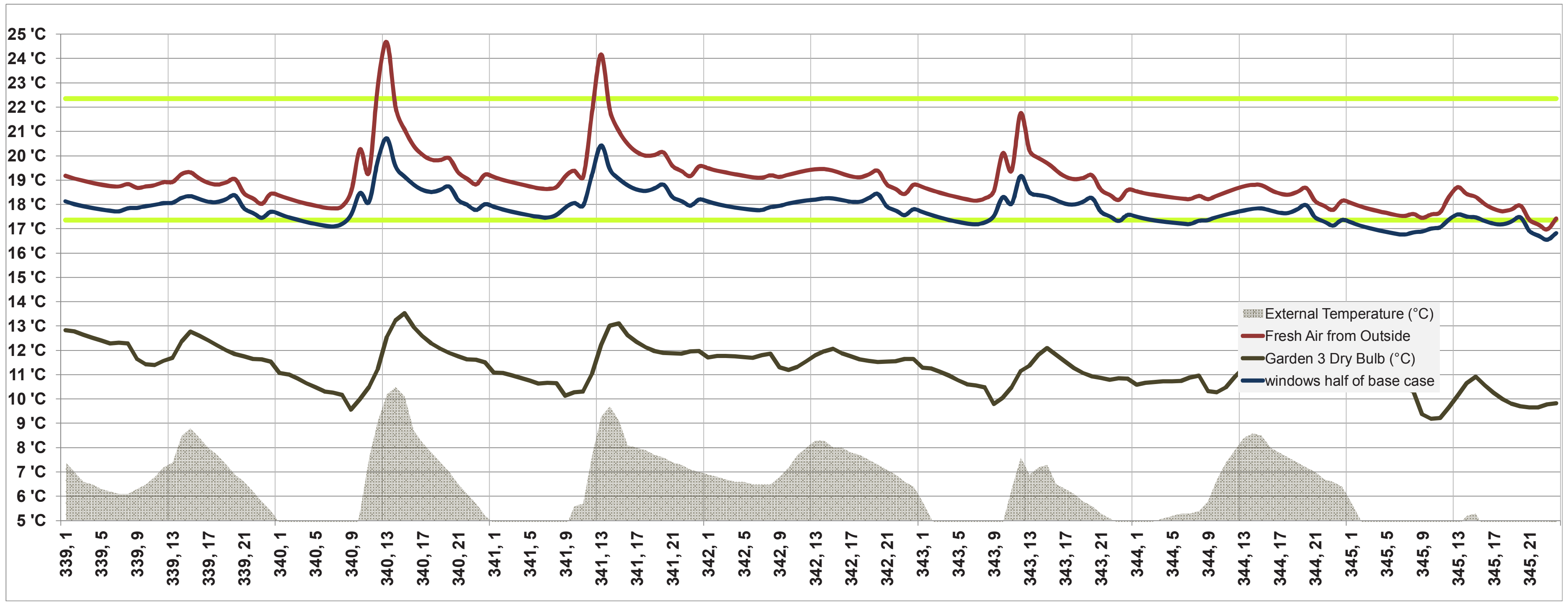


Figure A4.4.4.2.9 Comparison between resultant temperatures of different window areas in the studied unit during a typical winter week

Appendix 4.6.1 UK residential energy consumption

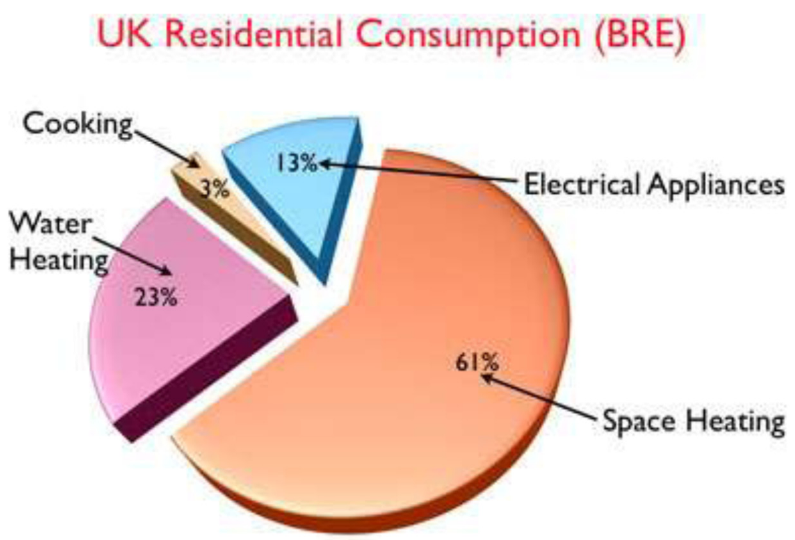


Figure A4.6.1.1 UK Residential Consumption
Source: BRE in Alan Harries, Renewable Energy Technologies

Appendix 4.6.2 Solar availability for urban farming

In order to ensure that urban farming can take place in the plot, lux levels were analysed for the mid-season period. Considering that the average required lux levels by plants to ensure that photosynthesis can take place is of 500- 1000 lux over a 8-hour period per day, it is possible to say that the plot, at a 6 m elevation from the ground floor, is suitable for agriculture.

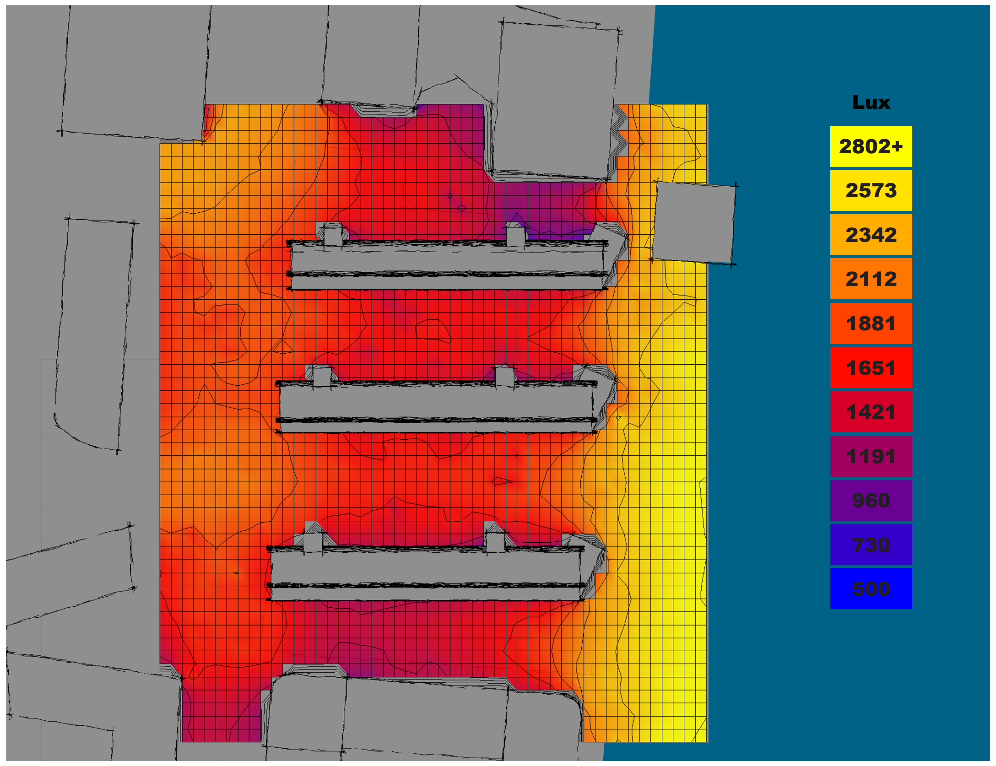


Figure A4.6.2.1 Cummulative daily illuminance levels for mid-season

Appendix 4.6.3 Plot's approximate residential energy consumption and production

After calculating the approximate Residential energy consumption for the Plot (see Table A.4.6.3.1), values for annual global radiation on a 30^{o} from horizontal tilted plan were calculated after data from Satel-Light (see Table A.6.3.2) and input in the formulas for approximate energy production from the Max Fordham & Partners report (see Table A.4.6.3.4). The available area for PV application was also calculated (see Table A.6.3.3) and inputed in the formula. This formula takes into consideration the efficiency of the panel, as well as the losses from the panel and distribution system, being reliable for rough calculations.

Table A4.6.3.1 Approximate Residential Energy Consumption for the Plot

Domestic Energy Consumption				
Afloor	no floors	Atotal	consumption	
[m2]	[no]	[m2]	[Wh/m2]	[kWh/a]
602.22	17	10237.74	2.1	188,333
48.93	12	587.16	2.1	10,801
102.82	13	1336.66	2.1	24,589
88.41	13	1149.33	2.1	21,143
			total	244,867

Table A4.6.3.2 Global Radiation for Tilted Plane (30deg from horizontal)
Source: After Satel-Light data [www.satel-light.com]

Global Tilted Radiation average daily [Wh/m2]	days in the year	Global Tilted Radiation annual [kWh/m2/a]
3153	365	1150.845

Table A4.6.3.3 Calculations for PV available area

no of arrays	height	lengh	area
[no]	[m]	[m]	[m2]
3	2.8	90	756
4	2.6	5.3	55.12
1	2.6	90	234
total area for solar electrical			1045.12

Table A4.6.3.4 Approximate Annual Energy Production by Photovoltaics
Source: After Max Fordham & Partners In Association (1999)

S = 1045.12 x 1150.845 x 0.18 x 0.95 = 205.674 kWh/a

E = 205.674 x 0.8 x 0.9 = 148.085 kWh/a

Area [m2]	yearly global radiation [kWh/m2/y]	panel efficiency [%]	total annual output over maximum [%]	correction factor [%]	loss factor [%]
1045.12	1150.845	0.18	0.95	0.8	0.9

[S] uncorrected annual output	205,674	kWh/a
[E] approximate annual energy production	148,085	kWh/a

Appendix 4.6.4 BPVs bio-photovoltaics

Still in research phase, biophotovoltaics are expected to be available, with competitive market prices to PVs, by 2016, 2021.

Although energy production could not be calculated, BPV application was considered due to the Plot's potential of offering different solar radiation levels for continued research with Cambridge University.

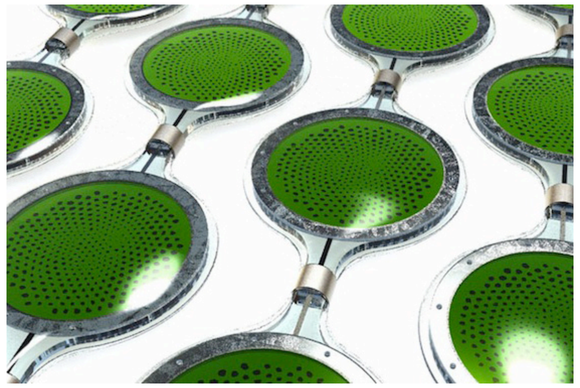


Figure A4.6.4.1 BPV application illustration 1
Source: Driver, A and Bombelli, P. (2011). Cambridge University.

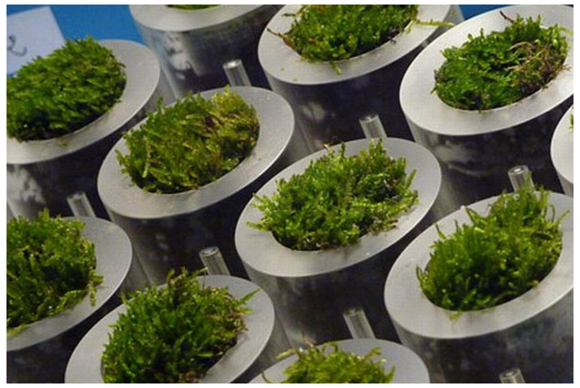


Figure A4.6.4.2 BPV application illustration 2
Source: Driver, A and Bombelli, P. (2011). Cambridge University.

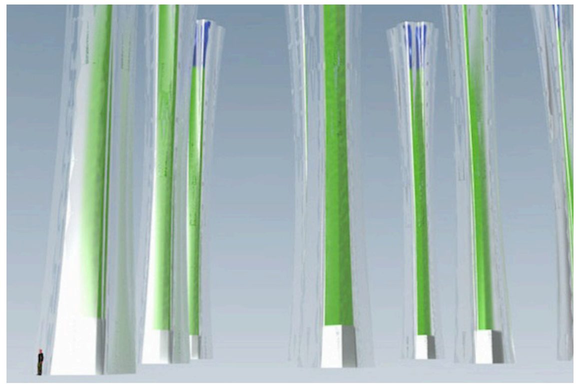


Figure A4.6.4.3 BPV application illustration 3
Source: Driver, A and Bombelli, P. (2011). Cambridge University.