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Term 2 Project - Refurbishing the City
Barbican Estate

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DECLARATION:

"I certify that this piece of work is entirely my/our own and that any quotation or paraphrase from the published or unpublished work of others is duly acknowledged."

Signature of Student(s):

Date: **29th March 2012**

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Abstract

This Term's design project was a continuation of our Refurbishing the City research agenda. Our case study was to analyze the Barbican Estate as a refurbished project. Its purpose was to build on the findings of last years Term 1 case study, providing a vehicle for design explorations that makes use of the principles and tools introduced by the taught programme. The design proposal led us to explore future visions of the city, following from the London 2050 Design Charette. This design project addressed issues on urban morphology, transportation, and environmental design focusing on housing and home-work environments with refurbished schemes. Our Project team drew upon the results of last year's first term project on the Barbican Estates fieldwork and simulation studies and helped us set design priorities and establish formal, typological, functional, programmatic and environmental design criteria's. The design proposal contributed to environmental sustainability and the quality of life in the estate which in turn will help the cityscape. Our project focused on showing occupant thermal and visual comfort based on the application of passive techniques and adaptive architecture. Our project also stated the remaining energy end-uses in buildings, both thermal (domestic hot water, cooking) and non-thermal (artificial lighting and domestic appliances). Lifestyle trends and developments in the technology of domestic appliances was reviewed in terms of the changes in year 2050 to establish the likely energy demand for these end-uses and how these demands can be met from photovoltaic panels and photovoltaic thermal panels.Finally, the energy demand was taken into account keeping in mind the existing structure and construction type as it is a listed building regulations (Grade II).

As stated above, the Barbican is a listed building, however, the listing regulations is reviewed every 5 years meaning that there is potential for the building to be revamped accordingly as the year's go by. It is a mixed-used, mainly residential complex, with three distinct housing typologies; the tower, terraced and mews style apartments (a three storey house). Commercial buildings include the Barbican Centre which includes an amphitheatre, galleries, a conservatory, a food court, and recreational open spaces. Institutional centres include two schools; a Girl's school and the Guildhall Music School, the Museum of London and the St.Giles church. It is strategically located in the financial district of the City of London and is within reach of three tube stations; Barbican, Moorgate and St Paul's station. The Barbican which was designed post war is relatively open to the public along its peripherals, due to the commercial facilities;however the estate itself catered to a more private residential complex.

The first design objective was to improve the environmental conditions and quality of life in the city. This was done throughimproving the connections physically as well as visually in the barbican estate and the cityscape. This was mainly done by allowing vehicular access within the estate but on a different level keeping in mind the privacy of the residents. In addition, the proposal allowed visual comfort by increasing the amount of daylight within the existing open spaces as well as the lower ground levels of the estate The environmental conditions were improved within the internal layout of the apartment blocks with minimalistic interventions to achieve quality of space and thermal comfort. the use of the existing district heating system by making changes only within the apartments from electric underfloor heating to hot water pipes.
The third was to develop architecture of sustainable environmental design. By keeping in mind that it was a retrofit building, very limited amount of changes could be made to achieve good architectural quality and environmental performance.One of the changes made within the design proposal was too improve the usage of the balcony which was redundant in the existing scenario. There were changes made in the internal layout in order to achieve minimal energy loads by keeping in mind the occupancy patterns within the apartment. Another architectural intervention looked at was to improve the privacy within the blocks as well as understanding the relationship between the residential block and its surrounding buildings. All of these changes was made with respect to the existing character of the existing facade. The main sustainable architectural strategy was to improve the daylight quality within each apartment block which was achieved by incorporating a light well within the structural system of the existing block.

In order to obtain the above mentioned objectives we went through a number of steps which involved fieldwork, questionnaires and interviews with the residents, usage of instruments to measure air temperature, the amount of daylight, illuminance, etc. Analytical work was carried out to understand energy loads within the existing apartments and various strategies were carried out to improve these loads. For our initial study, we went through literature to understand retrofitting buildings, improving energy loads, architectural strategies for sustainable design as well as the importance of connections between the private residential spaces and the private peripheries. All of the evidence achieved from these various steps helped or contributed to our design proposal as well as the final outcome of the design. Case studiesfrom previous years and precedence of existing buildings also helped us to formulate our design proposal.

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Section 1.1 Introduction

Context and Landuse

The barbican is centrally located close to the financial district of the City of London and it lies to the north of the St. Paul's Cathedral and it can be accessed by two major streets, the Aldersgate Street on the west and Beech Street on the north. Designed initially as a residential estate, it is surrounded by large office blocks and a few residential blocks. Vehicular access is restricted within the estate and elevated walkways act as pedestrian access routes throughout. Within the estate, apart from the residential units, there exist various commercial buildings such as the barbican arts centre on the north which comprises of exhibition halls, food courts, art galleries, restaurants, and library and office spaces. Towards the south lies the Museum of London. Interspersed within the courtyards are additional educational facilities such as the Guildhall School of Music and Drama and the City of London School for girls as well as the St. Giles Church. The estate consists 3 of different typologies of residential blocks such as terraced apartments, 3 tower blocks and the one-storey Mews Style which are arranged around various semi-private courtyards. One of the apartment blocks is on a pilotis , an influence of Corbusian architecture, which is above the water body. The Barbican has two large green open spaces on the east and west sides, which is for private use within the barbican estate. Reminiscence of the roman wall is also seen within the entire complex and the construction of the complex has kept this heritage wall intact figure 1.2.

Occupancy

As stated previously, the Barbican was designed to house the professional class – young singles and young couples. As shown in Fig 80% of the apartments are dedicated to this class hence having more one and two bedroom apartments in the complex. The reason as to why we chose to study the terracing blocks is due to this very reason since the flat typologies in the terracing is the most common within the complex. This in turn will allow us to provide principles and strategies that can be applied throughout the Barbican – both the east and west sides figure 1.3.

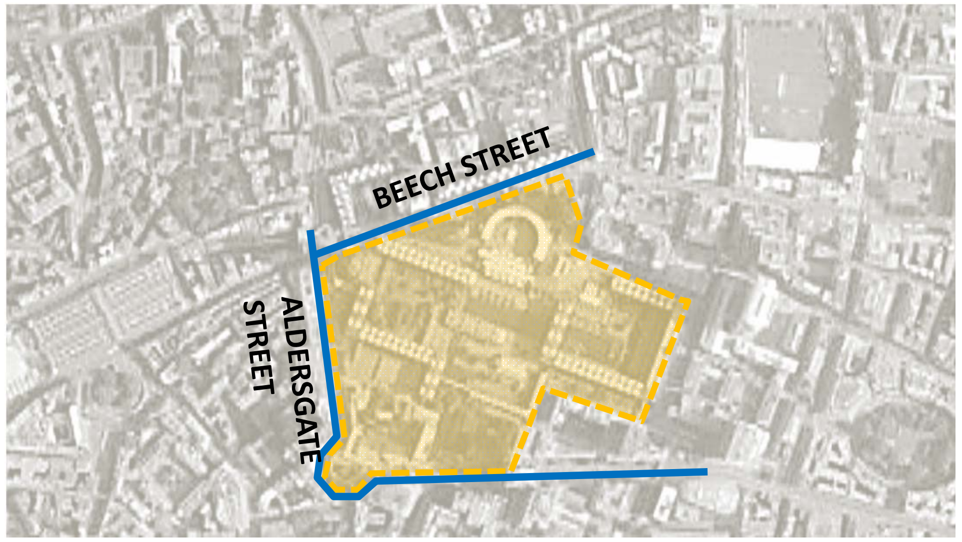


Figure 1.1: Barbican Location

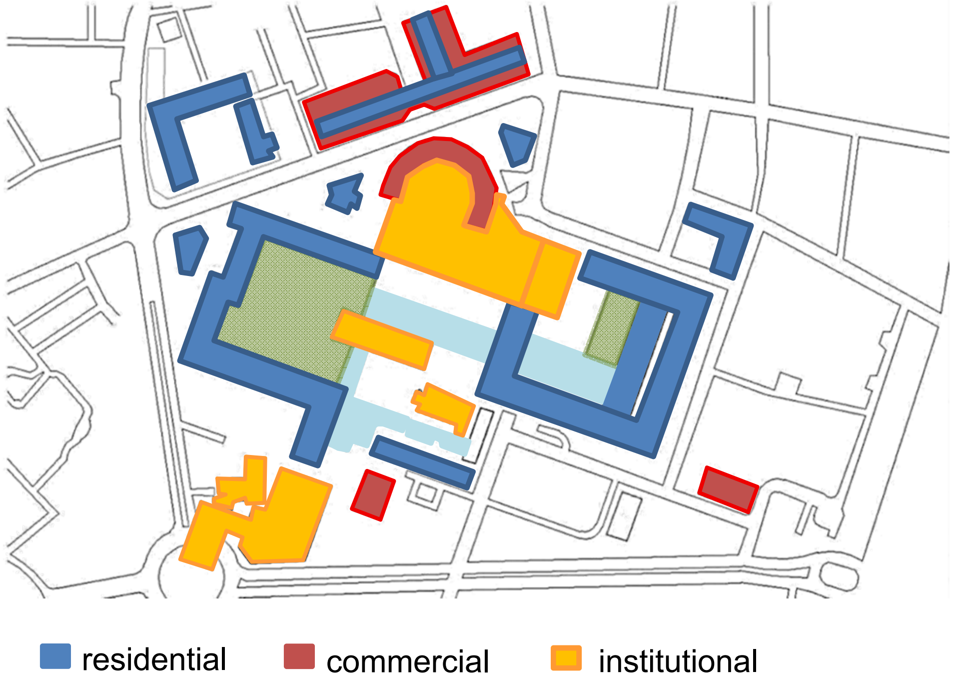


Figure 1.2: Site Plan

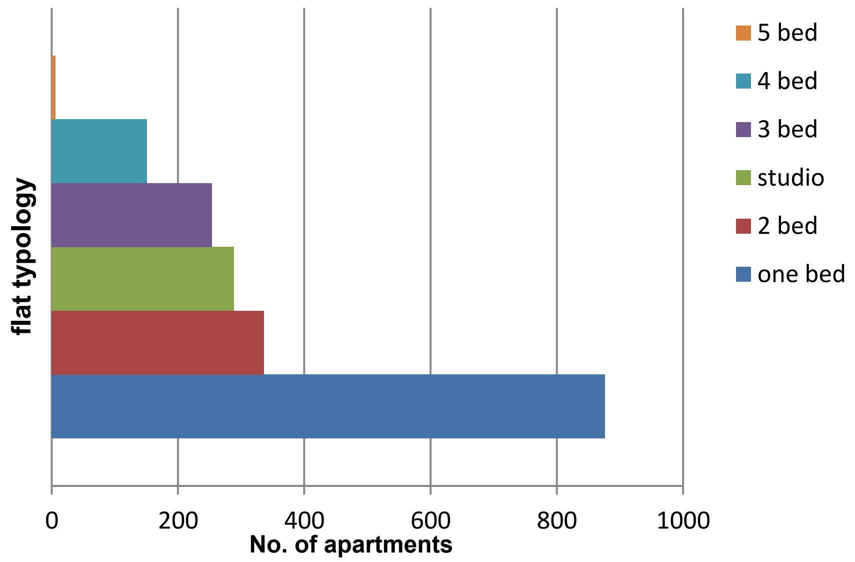


Figure 1.3: Apartment Types


Figure 1.4


Figure 1.5


Figure 1.6


Figure 1.7


Figure 1.8


Figure 1.9

Fig 1.4 shows speed house and Willoughby House overlookinhg the Speed Garden

Fig 1.6 shows the Frobisher Crescent building with wooden louvers as shading device.

Fig 1.8 shows the remnants of the Roman Wall within the Barbican Estate.

Fig 1.5 shows the Gilbert block on pilotis.

Fig 1.7 shows the Barbican Arts Center with public outdoor spaces

Fig 1.9 shows the St. Giles Church, a religious building centrally located within the estate.

Section 1.2 Introduction

History

The Barbican was built from 1952 - 1982 on a 45 acres bomb - damaged site. It was a competition design won by Geoffrey Powell, Peter Chamberlin and Christof Bon. It was one of the largest building schemes of the post war period, located in the Cripple gate area, now known as the financial district in the City of London. It was named after the word “Barbecana” which means fortified gateway. The architects vision for the Barbican was to create a high density, communal environment providing the residents with the opportunity to enjoy the advantages of having lawns, terraces and a lake whilst living in a small walled town which protected the residents within the complex (1).With this vision Barbican rose from the ashes as a development with 2018 number of flats, on a podium above levels of at least 2000 car parking spaces with gardens above underground lines, hence providing a total pedestrian area within the complex being up to double the actual size of the site.(12)

From the beginning, in 1945, the architect’s visualization of London and the Barbican was to be adaptable for future scenarios(2).They also envisioned that by 1953, the city would become a residential district and would be of a professional class hence the need for the Barbican residential complex to cater to this demand. During that time, there was also a dire need for safety for the pedestrians on the streets due to the increasing congestion within the streets. This led to the initial designs of having the Barbican as a walled residential community, separating itself on various levels from the city. Vehicular accesses were to be on ground levels whilst pedestrian accesses were integrated on higher levels acting as ‘streets in the sky’. Due to the separation and inaccessibility of the streets from ground level, an uneasy relationship was seen between the public and private spaces and resulted in residential deprivation and hidden isolation of the Barbican Arts Centre (2).The barbican took its precedence from the Dolphin Square of Victoria built in the 1930’s a residential estate and Albany in Piccadilly both of which had reminiscence of class and glamour.

1945 - The design of the Barbican revolved around having open flats linked by picturesque windows facing generous balconies overlooking the gardens. Within the internal spaces of the apartments, the single rooms were replaced by multi functional spaces to cater for future scenarios. The terracing was also built in respect to St Paul’s height limitations hence it only comprised of 8 - 10 storeys. The terracing were also raised on pilotis connecting themselves to higher levelled pedestrian streets. The apartments had double height ceiling with open planned spaces. The verticality and horizontality which is seen in the current Barbican was also adapted. All these characteristics are an influence from Corbusian architecture.

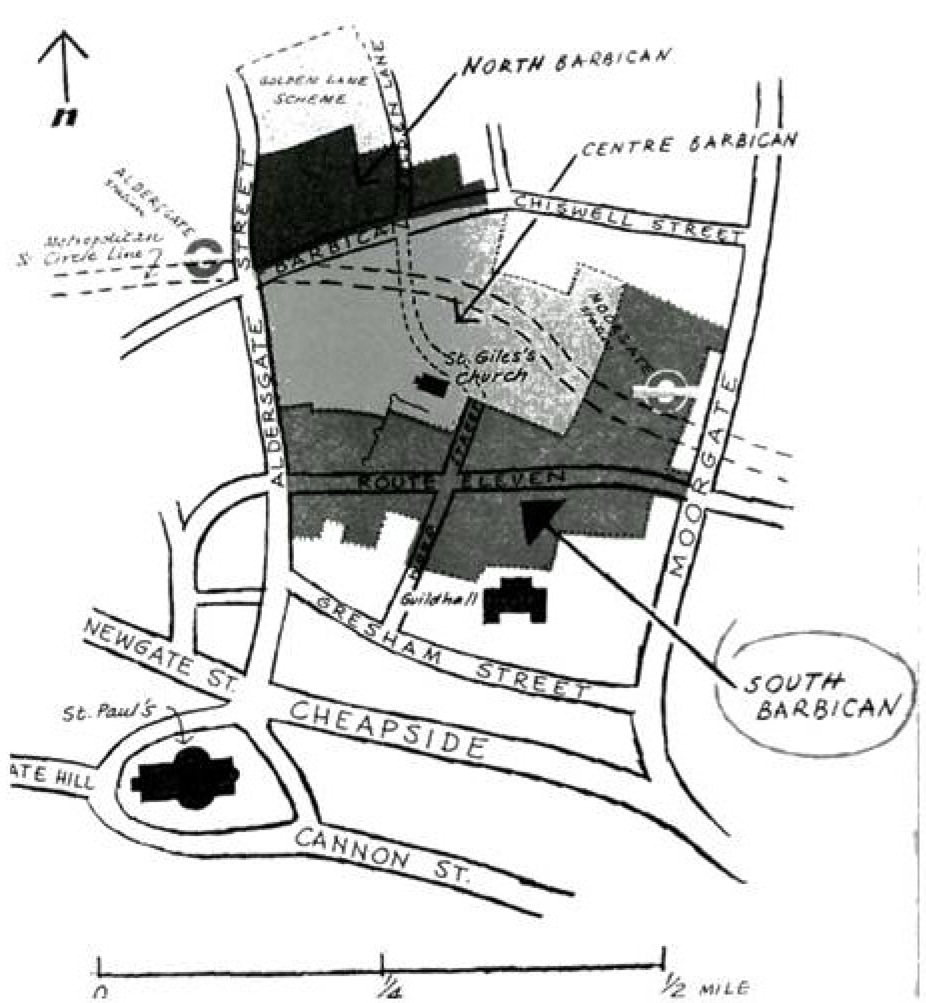


Figure 1.10: initial site zoning

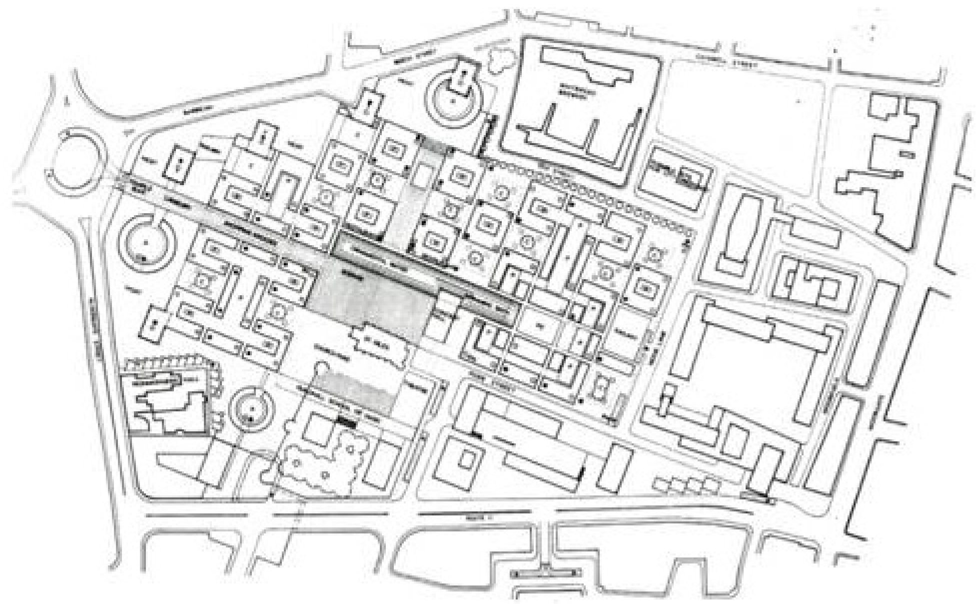


Figure 1.11: master plan 1945

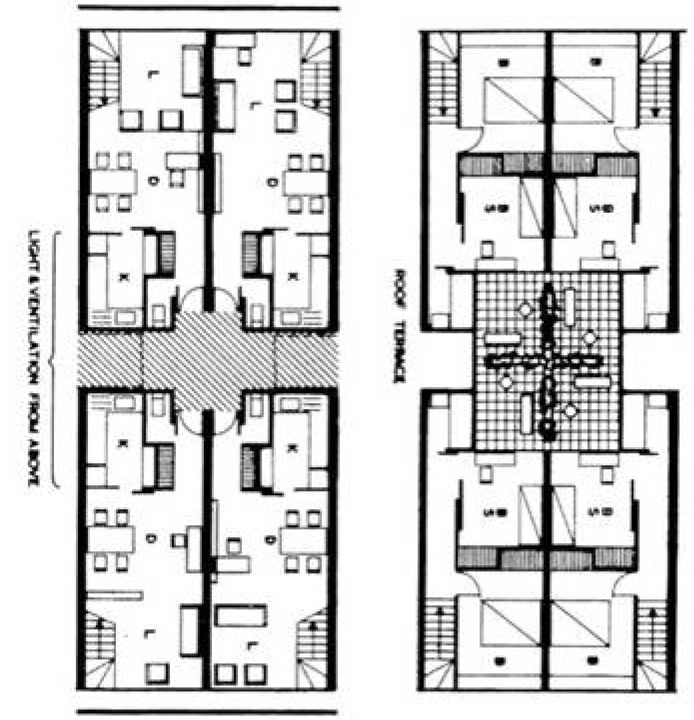


Figure 1.12: Apartment Types 1945

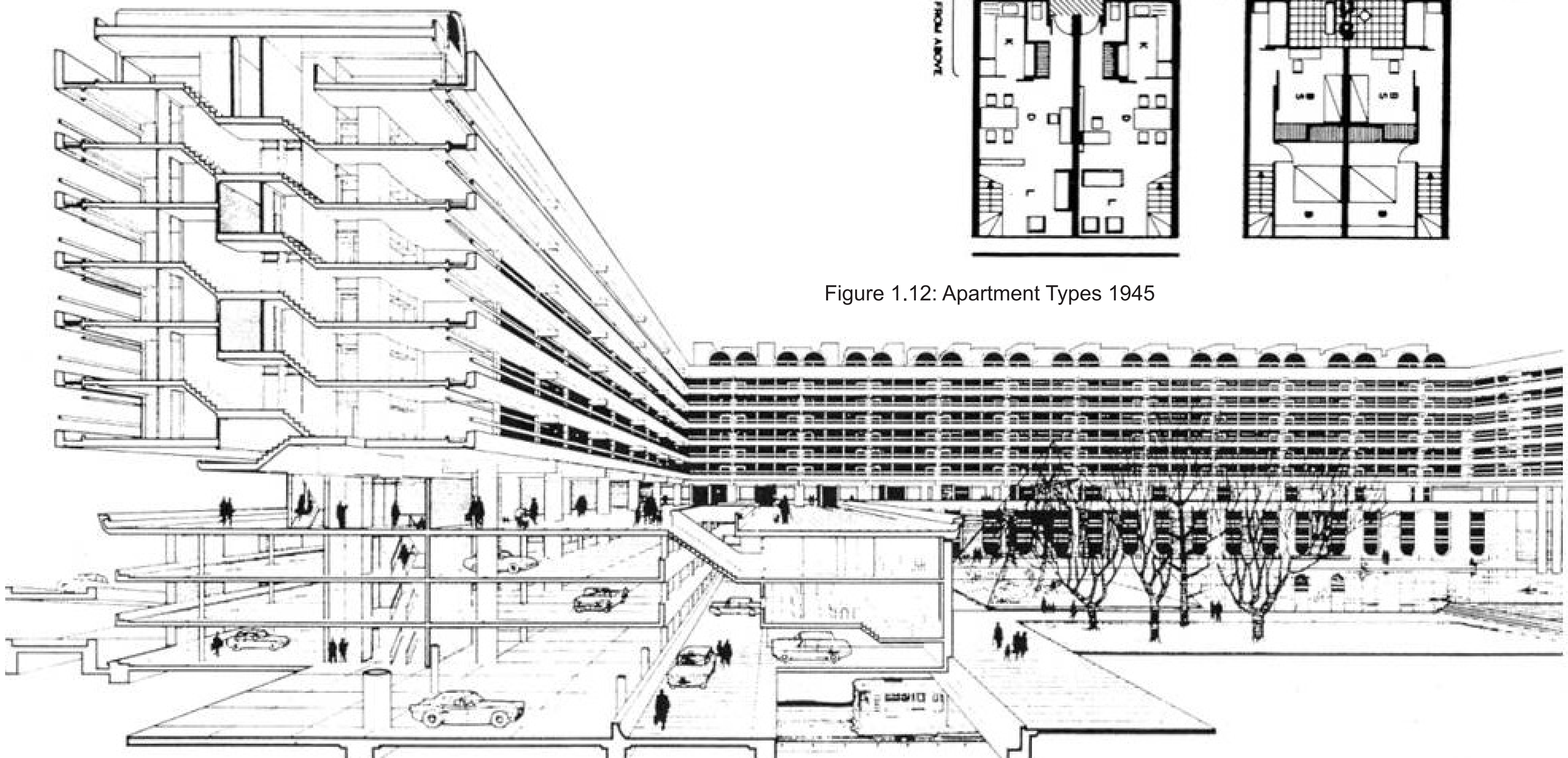


Figure 1.13: sectional perspec

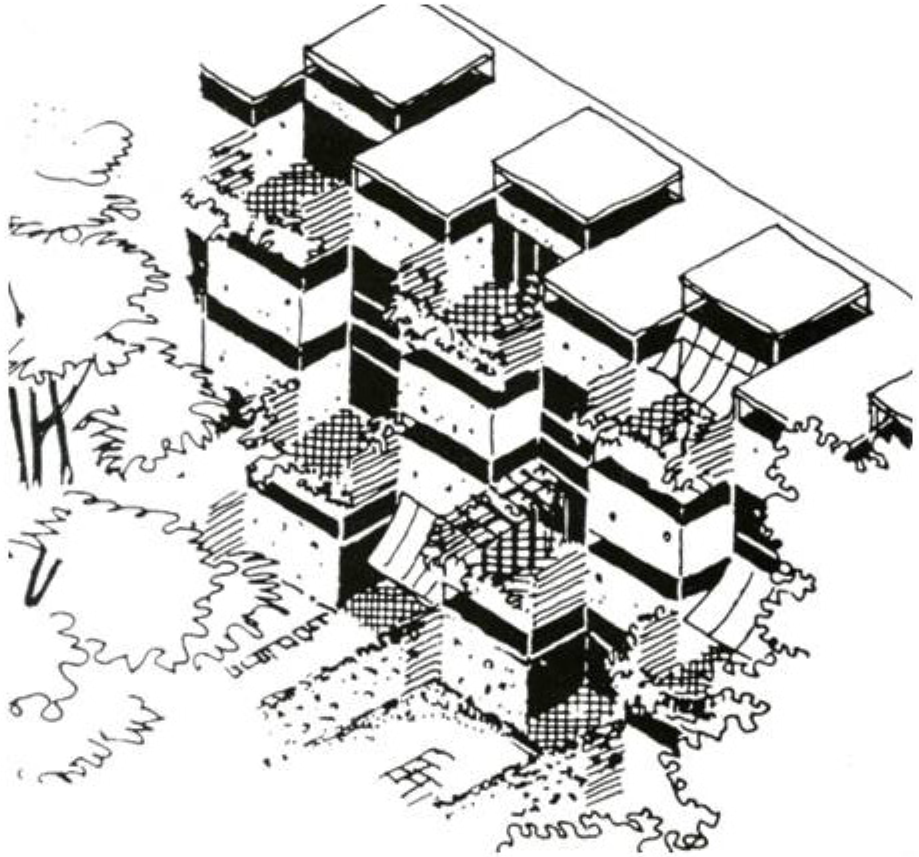


Figure 1.14: Apartment Types

Figure 1.15: Apartment Types

Figure 1.16: Apartment Types

Figure 1.17: Apartment Types

1953 to 1956 - The towers were designed to reduce ground density. Terracing was added to create private internal spaces for the residents whilst the rooftops had communal gardens accessible to the penthouse residents. At first, the density was 300 people per acre, however this was reduced down to 80 people per acre as the school's and larger open spaces were needed to be integrated in this point of time.

After the 1956 plans, the Barbican was supposed to be cladded with marble - bright white marble. Due to relatively high construction costs at that time, the materiality was changed to rough, hammered concrete, which then led to the Barbicans current image of honest expression in materiality. It was then decided instead of using pre stressed concrete sections made off-site; the entire complex was then made of poured concrete in-situ.

The last plans from 1956 - 1975, accommodated to another 6500 people and integrating a commercial promenade within the Barbican Art's Centre which faced the lake. A reduction of balcony sizes were also made due to the construction system involved, as the balconies were a continuation of the floor slabs, posing a limitation as to how wide it could go to, without increasing the need for extra supporting structure. The vistas and sunken courtyards were then removed and replaced by two large squares as open spaces, within the complex, to cater to the residents.(1)

Description

Planning	:	1945 - 1965
Construction	:	1974 - 1982
Area	:	45 acres
Sector	:	Residential Complex
Funding	:	Corporation of London
Address	:	The Barbican, Silk Street, EC2Y 8DS, London
Architect	:	Peter Chamberlin, Geoffrey Powell, ChristofBon
Client	:	Greater London Council
Engineer	:	Arup
Construction	:	Poured concrete in-situ
Materials	:	Hammered Concrete, Clay tiles and Brick
Flat Typologies:		140 types
No of Flats	:	2014

Section 1.3 Introduction

<u>Discription</u>

<u>Shadow Analysis</u>

As seen from the sun path diagram, during the summer months there is very little amount of overshadowing on the open spaces as well as the apartment blocks, but during the winter there is a great deal of overshadowing from the surrounding buildings throughout the entire site. For our design proposal,we have focused on one part of the barbican estate marked by the red dotted box. It consists of four apartment blocks with the large courtyard.

<u>Past, Present, Future</u>

Previously, the Barbican had the first towers built within the area, as there were height limitations with respect St Paul's; hence the terracing's accessibility to daylight internally. In addition, due to the large, open courtyards, the terracing was hardly ever overshadowed. Currently, the immediate context of the Barbican area is changing in its skyline; Buildings are being redeveloped as towers especially in the north-east, east and south-eastern orientations. Thus, the terraced housing, facing these orientations are being overshadowed. In addition, external views within these terraced blocks will then be restricted due to the rising of these buildings. Since the balconies are already not being used, the limitation in views will then impose a further disregard for the need and use of these balconies. We predict that in the coming future, more buildings surrounding the Barbican would only grow higher, engulfing the Barbican.
(figure 1.21, figure 1.22, figure 1.23)

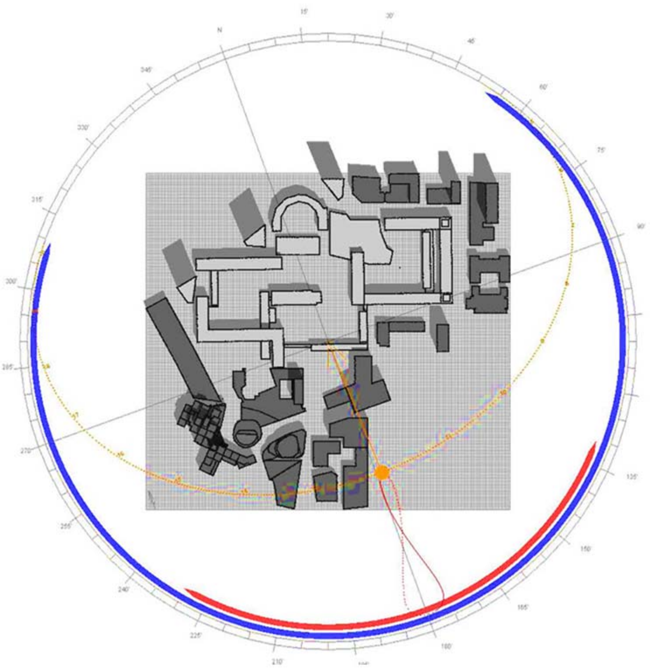


Figure 1.18: Sun Path - Summer

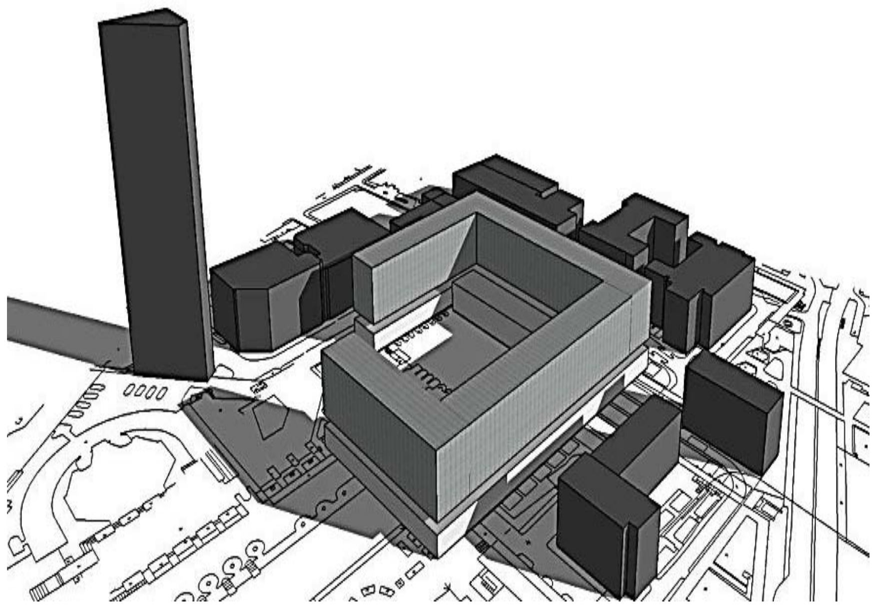


Figure 1.21: Past

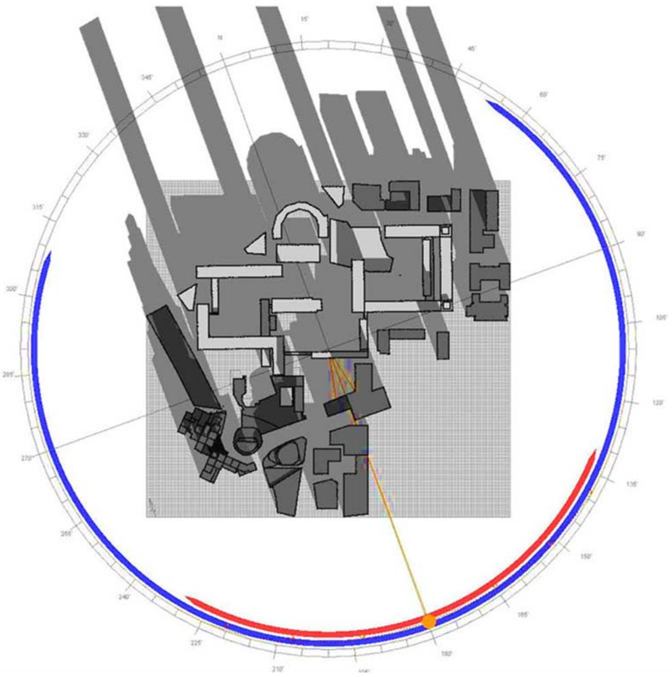


Figure 1.19: Sun Path - Winter

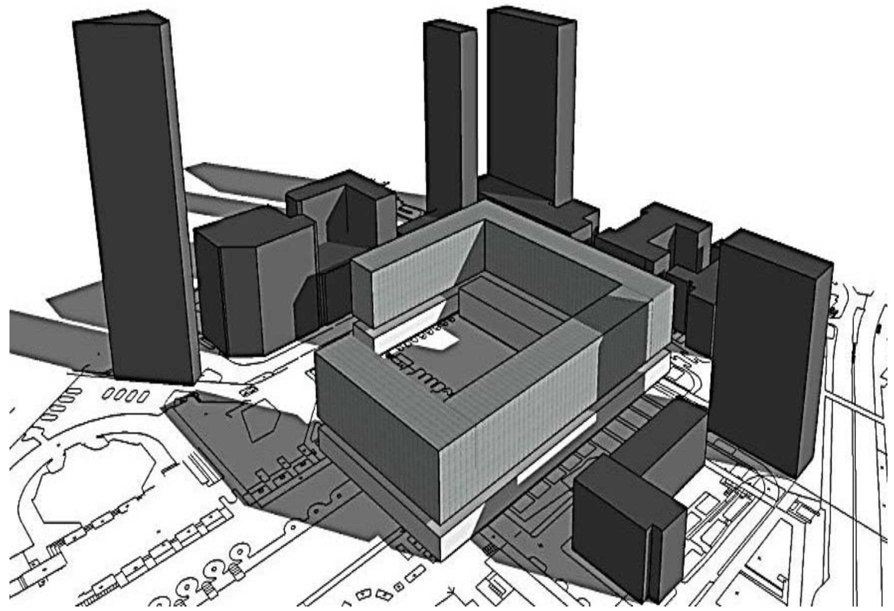


Figure 1.22: Present

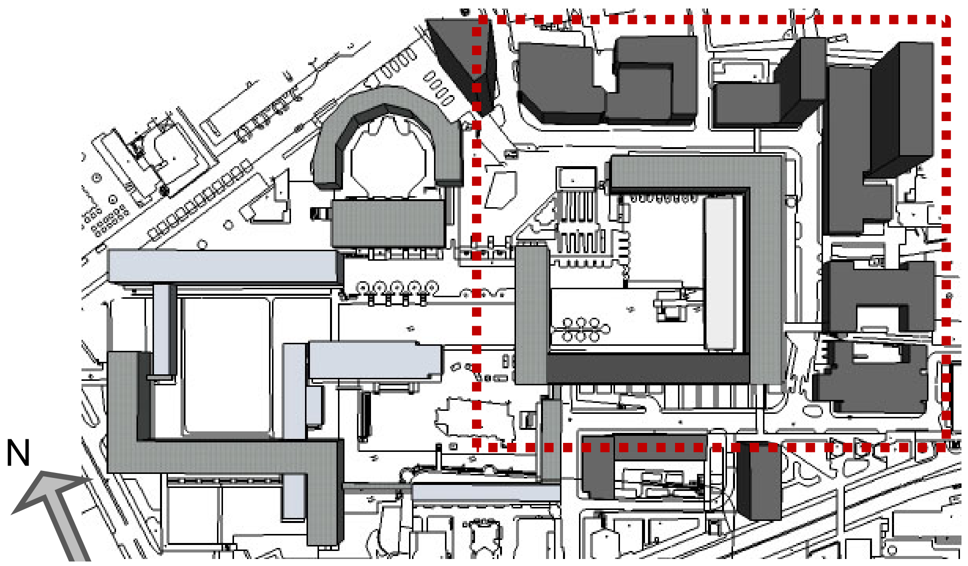


Figure 1.20: Area of study - Terraced blocks

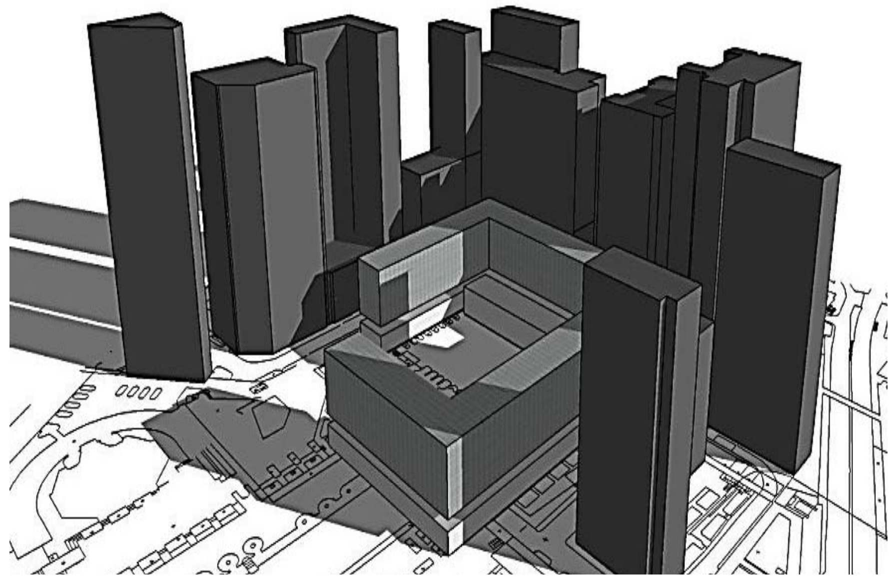


Figure 1.23: Future

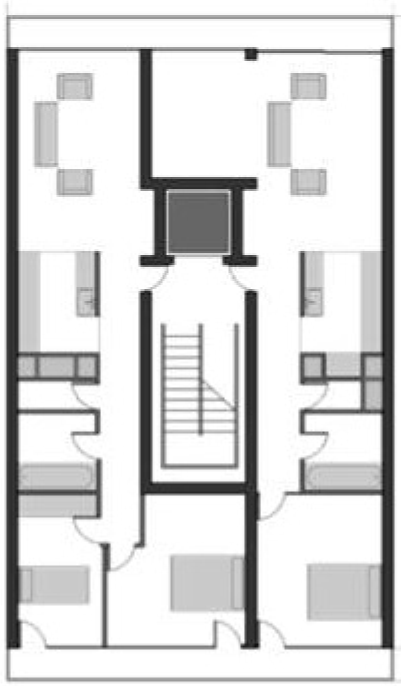


Figure 1.24: Typical Plan - Southern Block

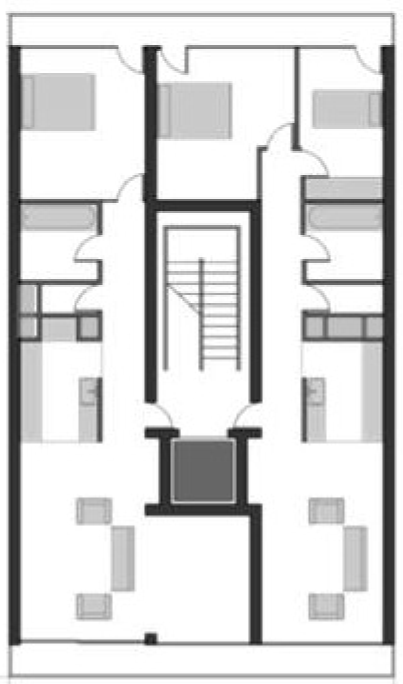


Figure 1.25: Typical Plan northern Block

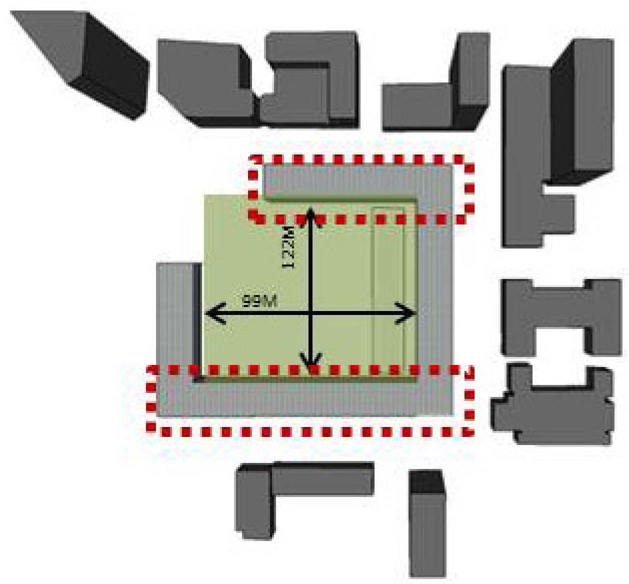


Figure 1.28: southern and northern blocks

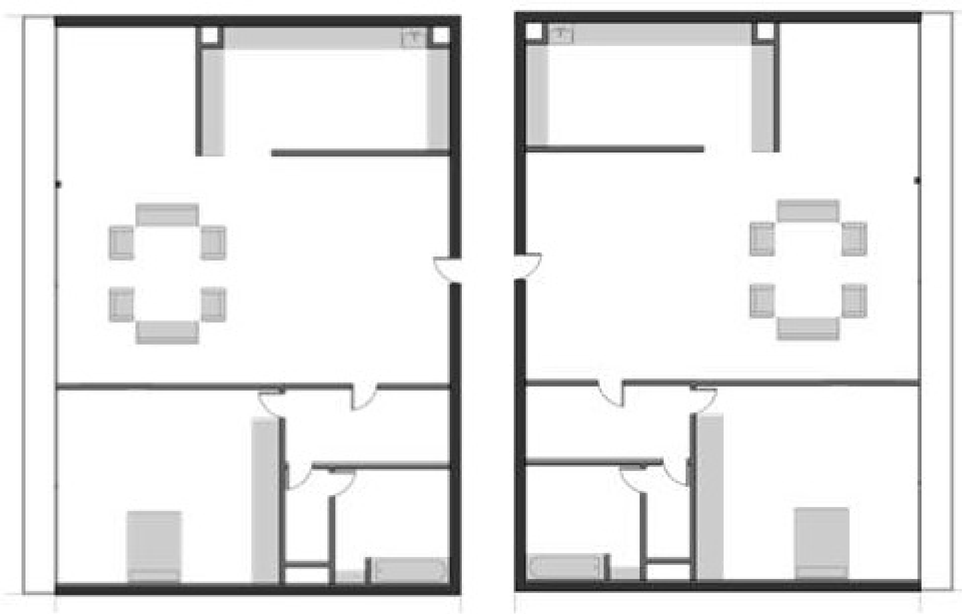


Figure 1.26: Typical plan - Western block

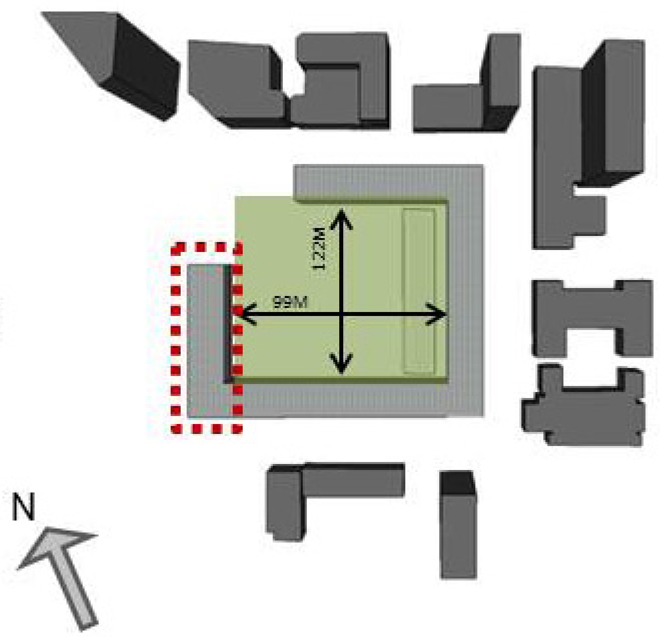


Figure 1.29: western block

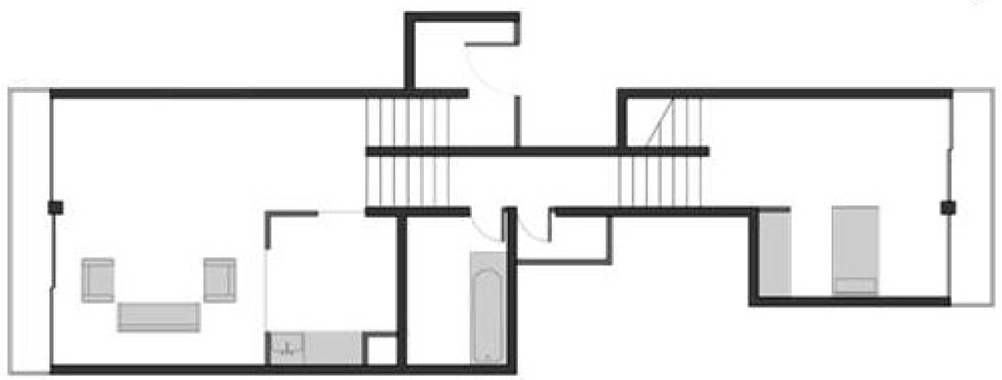


Figure 1.27: Typical plan - Eastern Block

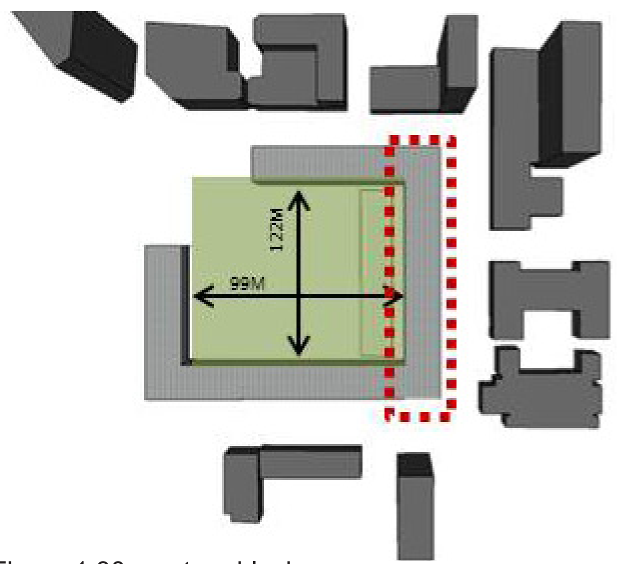


Figure 1.30: eastern block

<u>The Four Terraced Blocks</u>

This study focused on a set of residential blocks comprising terraced apartment typology that surrounds the courtyard on the east of the barbican estate. The size of the courtyard is 99m x 122m.

The Andrewes House is towards the south and is orientated in the north-south direction.Within the southern block (Andrewes), all the living rooms are located in the south facing the external streets of the site, whilst the bedrooms, in the north, face the internal courtyards. Currently, the balconies which are incorporated on both of these facades, and due to the width of the balconies – 1 meter, it proves to be unusable.They are used as fire escapes and in most cases, acts as storage compartments. These unusable balconies are common to all four blocks figure 1.24 and figure 1.28

The Northern block, Speed House, also faces the north-south direction. The living room spaces in the whole block faces south, thus in this case, it faces the internal courtyard instead of the street, with the bedrooms on the north, facing the street. With both the north – south orientated blocks, two apartments share a service core on all 7 levels. figure 1.28

The Willoughby House is located on the east and is oriented in the east-west direction. The bedrooms in this block are located in the east, facing the external streets, whilst the living room faces the internal courtyards. In this case, the service cores are located at the edges of the building hence; a central spine is located in the middle of the floor plan allowing access into the apartments. figure 1.27 and figure 1.30

The Western block, Gilbert House is similar in orientation to the Eastern (Willoughby) block. However, Gilbert, unlike the eastern block, has single facing facades whereby the apartments are located on either the west or east side of the block. This block located centrally on the site, allows both the single facing apartments to gain the internal courtyard views. The apartments are accessible through a central spine similar to the eastern block (Willoughby) as the cores are located at the edges.
figure 1.28 and figure 1.29

Section 1.4 Introduction

Barbican Case Study 2010 - Mews Block

Term 1 SED 2010 case study focused on the mews housing located on the eastern side of the site. It has the same construction type as all the four blocks of the barbican estate. It is similar to the east and west blocks – ie. Willoughby house and Gilbert house. The analytical and fieldwork done in the case study of the previous year helped us identify the existing energy loads of the apartment and the various concerns and issues that affect the barbican estate. Due to the mews being 3 storey's high, overshadowed by the eastern block and the way the spaces are configured internally, daylight does not penetrate through much even though there is a high ceiling to floor height with 30 - 40% window to floor ratio. The internal walls and spaces then become an obstruction for good daylight distribution.
The fieldwork for this project which involved occupant interviews done during this case study helped us to understand the kind of people who live in the barbican , occupancy patterns and the overall day to day activities within the internal space of the apartment as well as the outdoor spaces of the estate.

In terms of materiality, due to similar construction and material type, we took the U Values and material type for our simulations.(9)

Materials

Internal Walls	:	Exposed Concrete with white rendered finish
Roof	:	Steel + Glazing (Barrel Vault)
Glazing	:	Single Glazed

U values

Internal Walls	:	1.7
Roof	:	1.4
Glazing	:	5.6

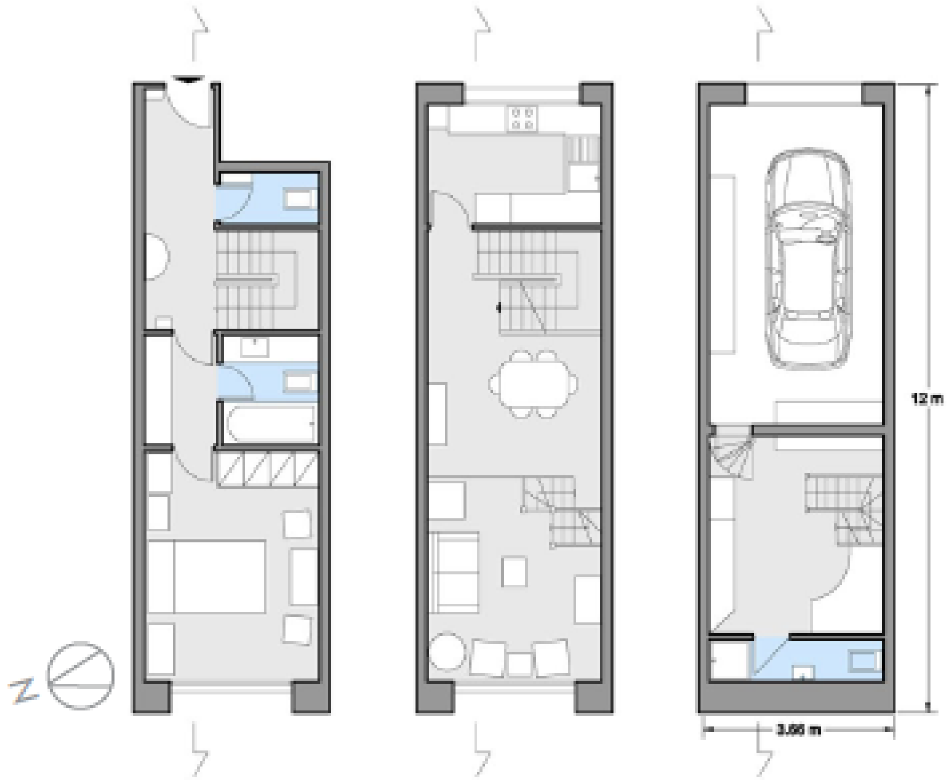


Figure 1.31: Typical plan - Mews block

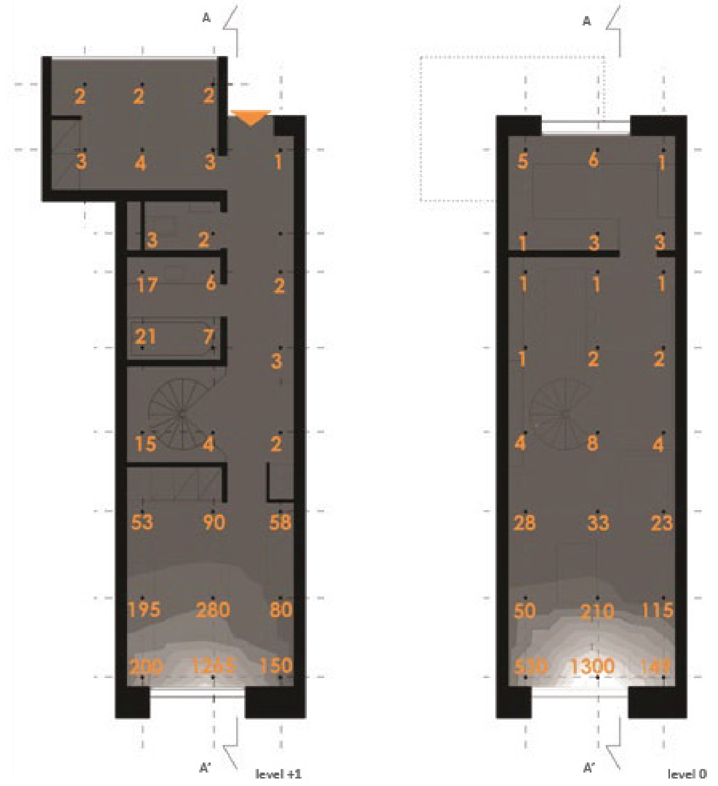


Figure 1.33: Plan showing illuminance in flat

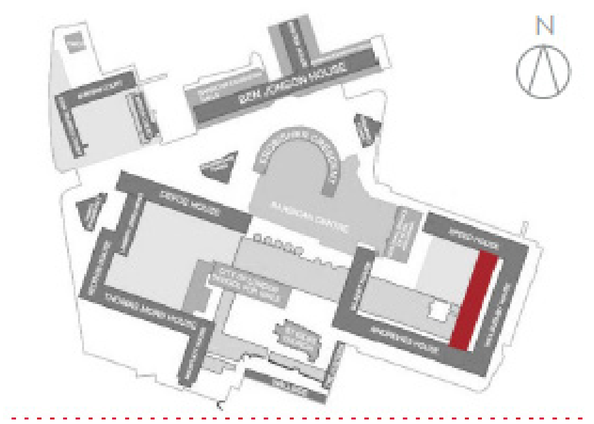


Figure 1.32: Location on mews block

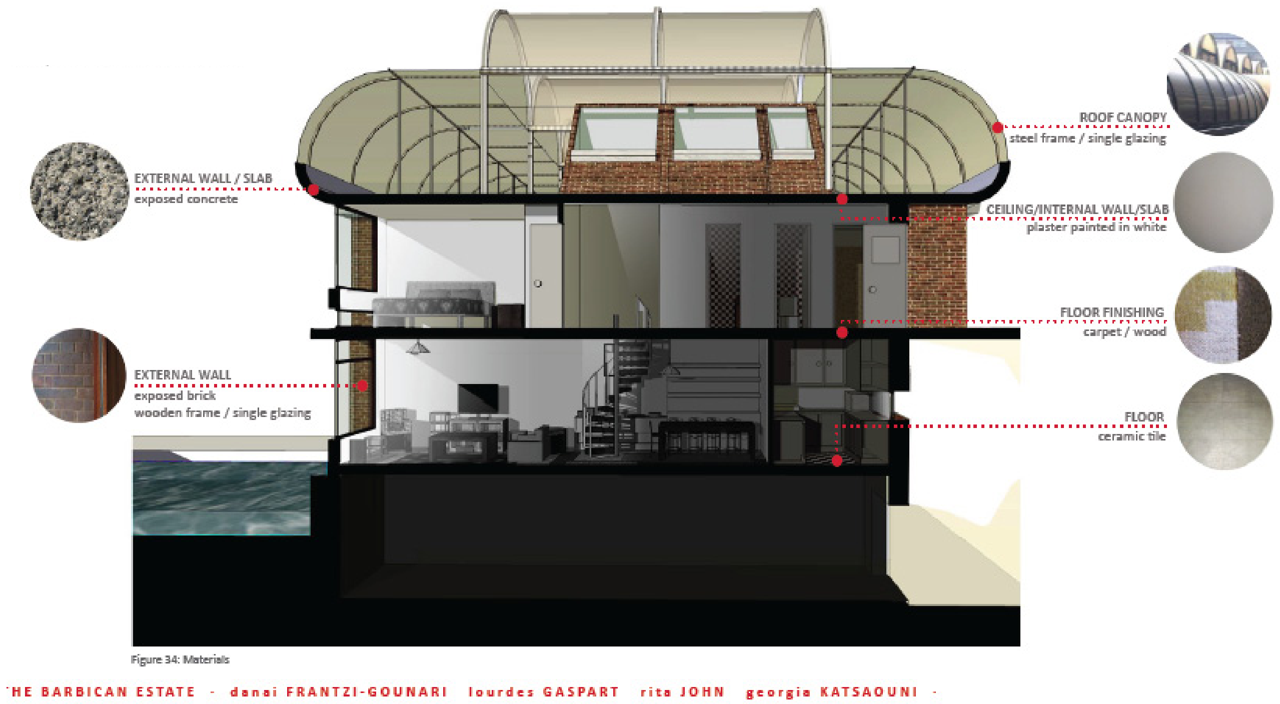


Figure 1.34: Section showing materials

Figure 1.35: Ground Floor Plan

Figure 1.36 - 1st Floor Plan

Figure 1.37: Ground Floor Plan

SECTION 1.5 Introduction

Park Hill Estate

Park Hill is a residential complex located in Sheffield, Central of England. The reason as to why this residential complex was taken as a precedent is because it is another listed building which has similar limitations as to how much can be changed within the building. It is a Grade II listed residential building and was constructed within the same era with similar construction type. In addition, this complex was also built around the idea of pedestrian connections being elevated above ground level – as streets in the sky. These elevated walkways are about 1 meter in width, similar to the terraced balconies in the Barbican. It is currently used for circulation around the Park Hill. The blocks are 9 storeys in height and similar to the eastern block of the Barbican, the service cores are at the edges of the blocks. The first intervention that we learnt and also used similarly within our scheme was the removal of their existing lift cores which was then used only as fire escapes. The external envelope of the lift cores were stripped out to increase visual connections between the ground levels and the blocks. In our scheme, in the southern and northern block, in which two apartments share a core, we removed the internal staircase whilst still keeping the lift for vertical circulation, and created a light well to allow more light to penetrate lower into the floor levels.

The second intervention from Park Hill taken into account is the change in window frames and the standardization of these windows with a +/- tolerance of 40mm.

The final intervention was the change to new screed and the addition of insulation on the elevated streets. In our scheme we have added insulation internally on the balconies.

The subtle design interventions along with the drastic moves made during the refurbishing of the Park Hill helped improve the strategies used for this Barbican design proposal. The biggest importance of studying the Park Hill as a precedent was to understand the possible design interventions with respect to the desirable ones keeping in mind the external aesthetics and the main concept of the project as it is a refurbished building.(11)

Section 1.5 Introduction

ISSUES IN BARBICAN

All of the mentioned issues are improved by the design strategies proposed for the Barbican.

Deep Plan
As shown in the section all the residential blocks in the complex was designed as a deep floor plan. In the Southern and Northern block (Andrewes and Speed) the distribution of the functions within the layout is actually the main reason for the uneven distribution of light within the given space. The main core of the apartment the kitchen, toilet and bathroom is placed alongside one another creates a dark corridor as both the edges are opaque and obstructs the entry of light. Even with the clear 3.2m height span, the corridors are relatively dark within the spaces. In the Eastern block the plan is on split levels and similar to the spatial configuration of the plan of the Southern block (Andrewes), hence the light distribution is reduced with the integration of the corridor.

Obstructions
As the surrounding context is rising in its density and height, the east, north east and south eastern parts of the Barbican will be affected in terms of how much daylight it would receive. This would also decrease solar radiation that would inevitably increase the heating demands required for the residential blocks. The main blocks affected would be the a southern (Andrewes) Eastern (Willoughby) and the Northern (Speed) block, which will be blocks addressed mainly in this design proposal.

Self shadowing at Corners
Due to the block layout on the site and the orientation, the blocks face self-shadowing of itself from each other. The southern block (Andrewes) is self-shadowed on the eastern facade from the eastern block (Willoughby), this eastern block gets overshadowed from the Southern block (Andrewes) on the south, and the Northern block (Speed) is self- shadowed by the Eastern block.

Privacy
Due to the proximity of the blocks to each other, the residents face an issue with privacy whereby due to the glazed facade, the residents could see into each other's apartments. More specifically for the corners.

Heat Loss Through Glazing
Due to the glazed facade, floor to ceiling, of single glazing in certain flat typologies, there is a significant amount of heat loss from the apartment. Hence increasing heat demands internally.

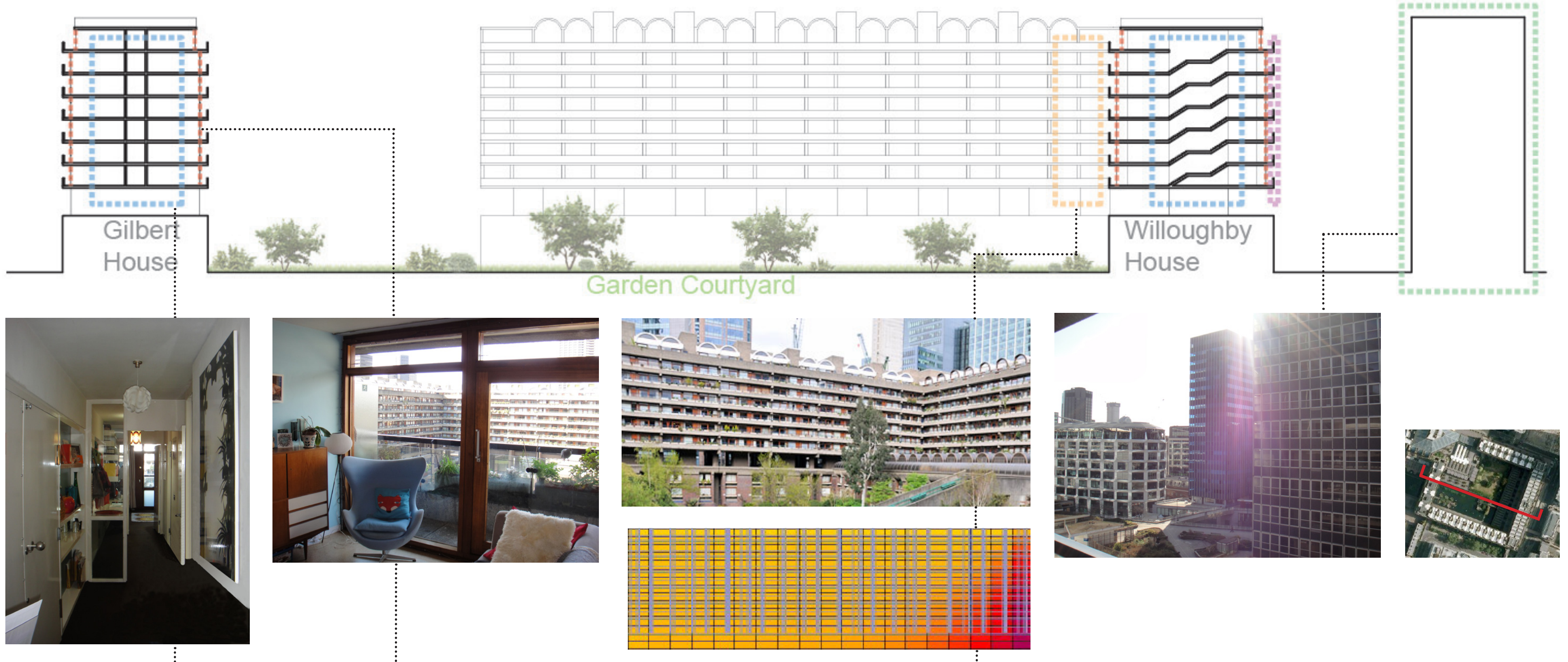


Figure 1.38: Section through east/ west blocks

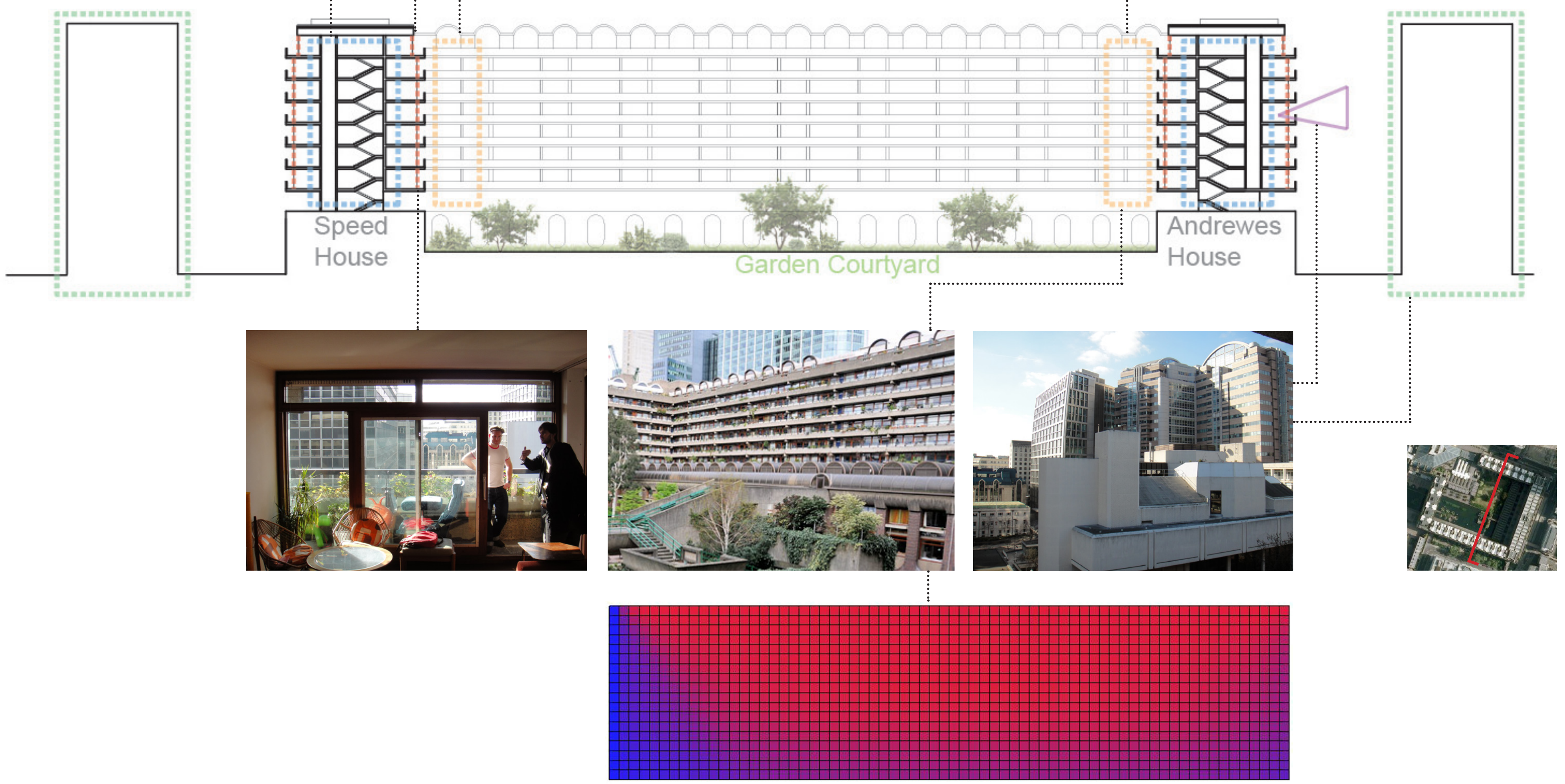
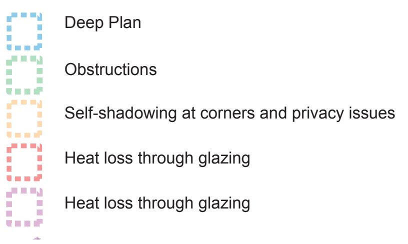


Figure 1.39: Section through north/ south blocks



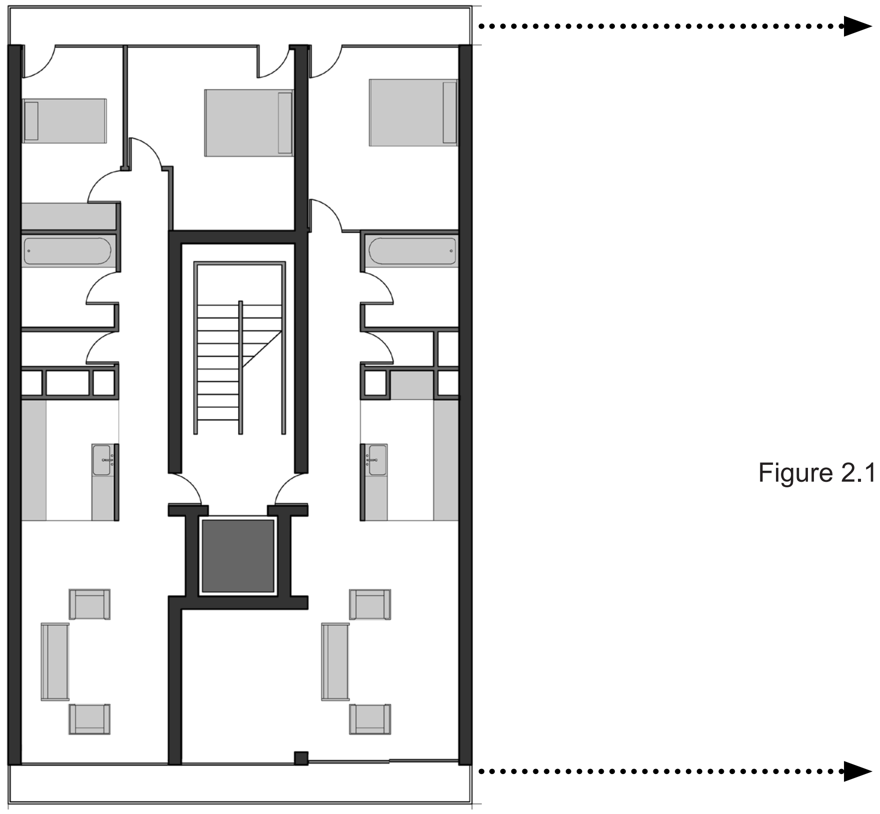
Design Proposal

Section 2.1 Andrewes House - South

INTRODUCTION OF TYPICAL FLAT

The Andrewes house is on the Southern part of the block. The block contains he penthouse level, garden flats located below the podium level, and six floors of flats in between. The block contains 192 flats of 13 different types ranging from 2 to 4 rooms. The maximum no of flats are type 20/21, which has been used for this design intervention proposal for the Barbican Estate.

The Sky View factor shown in figure 2.1 and 2.2 respectivly show the obstructions seen from the surrounding buildings. The northern facade (figure 2.1) receives more obstruction due to self shading as compared to the obstructions seen in the southern facade (figure 2.2) from the surrounding buildings.



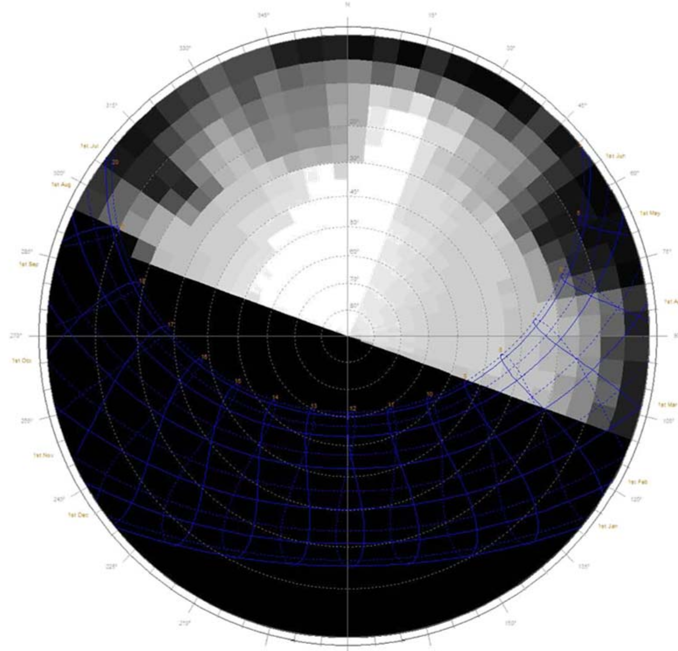


Figure 2.1: Sky factor - Northern facade

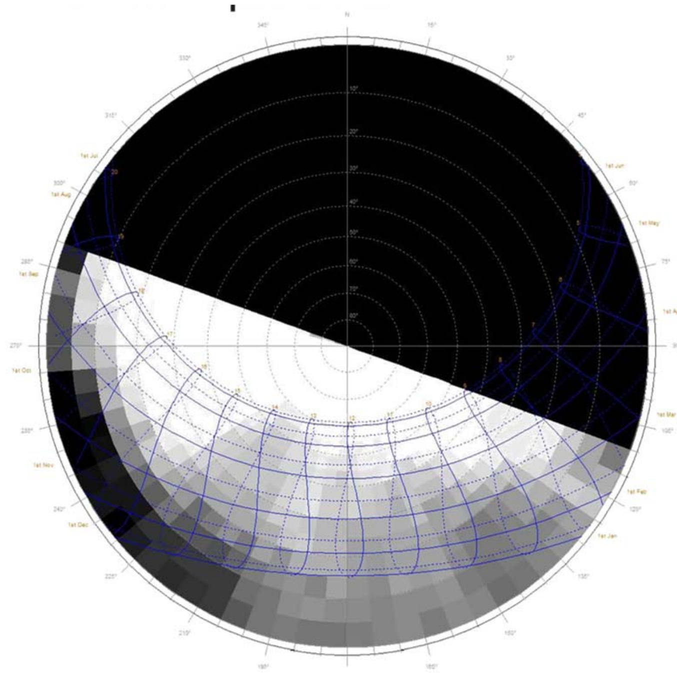
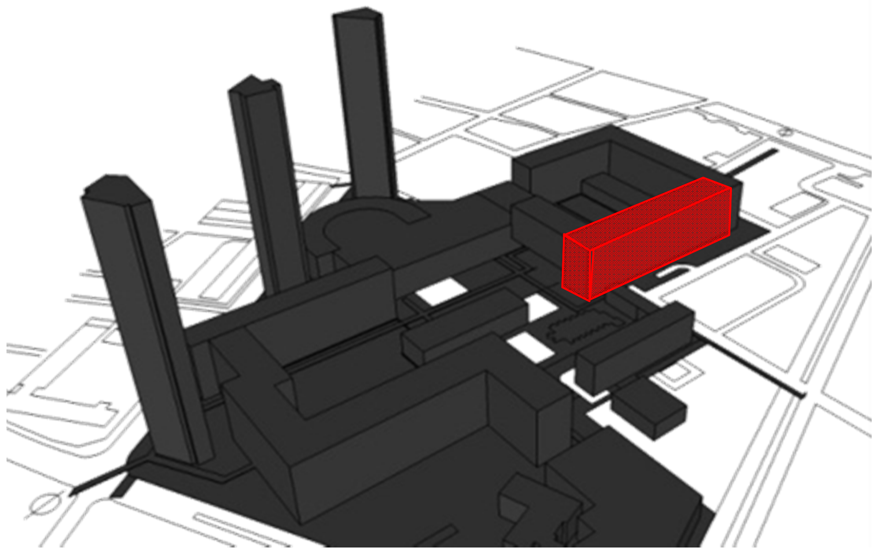


Figure 2.2: Sky Factor - Southern Facade



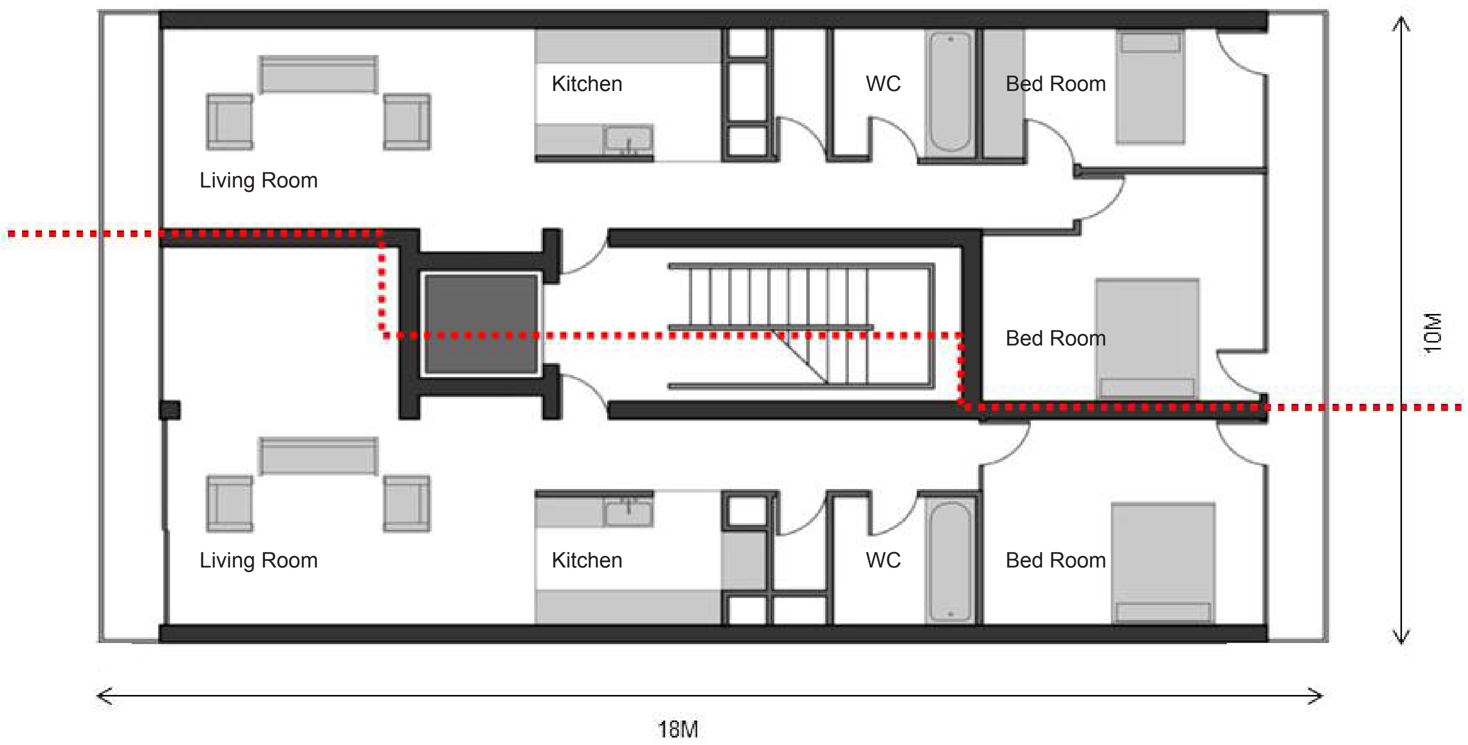


Figure 2.3: Plan of flat type 20 and 21

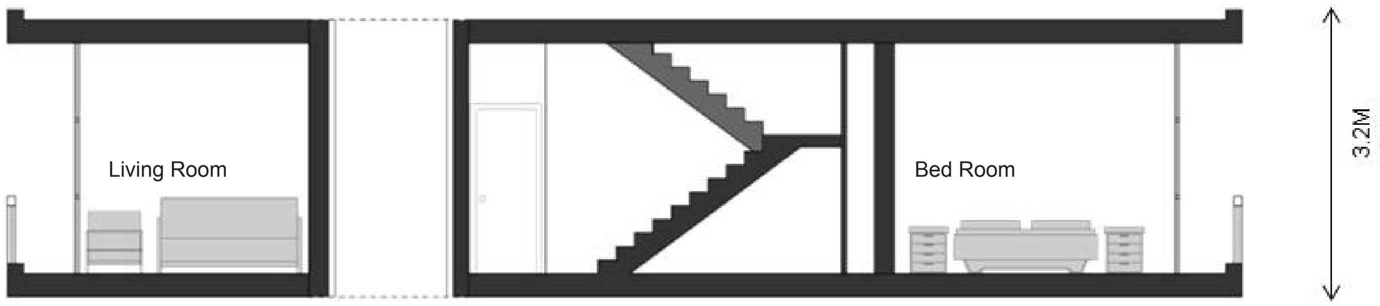
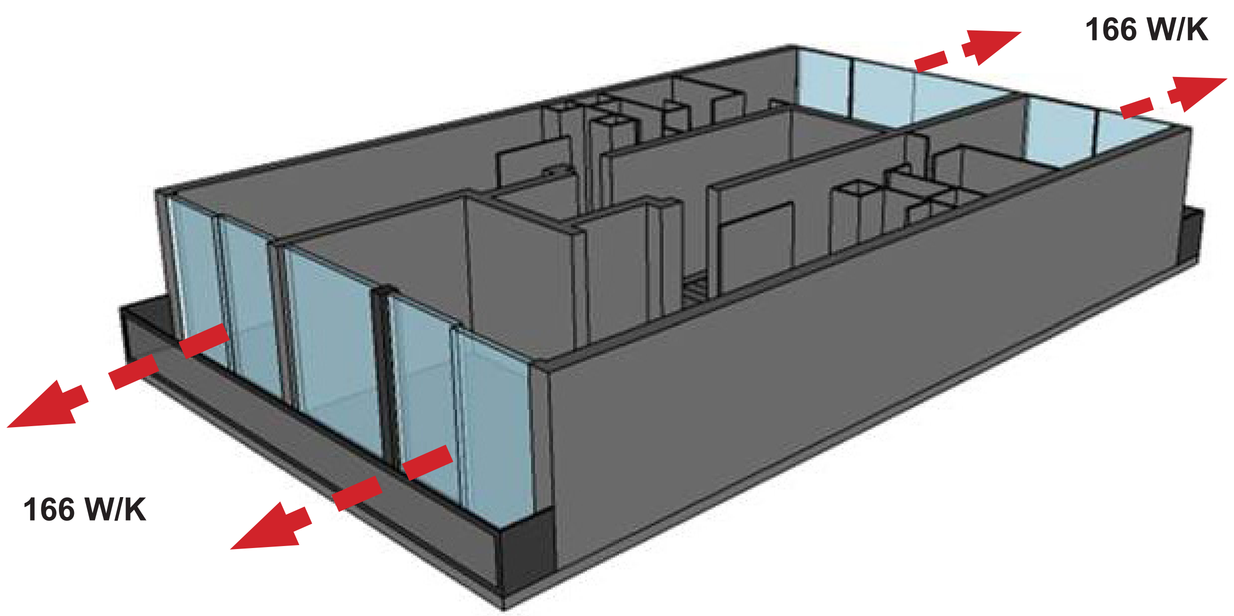


Figure 2.4: Section



U Values:

Glazing: 5.6 W/(m²K)

Walls: 1.6 W/(m²K)

Heat loss coefficient for flat type=2.07W/m²
Infiltration=1.4ac/h

Figure 2.5: Heat loss through glazing

The lift core and the staircase are catered to two flats on either side. The entrances to these blocks are at regular intervals and do not have a double loaded corridor running in between them. Each flat has their living room facing Fore Street and the bedroom facing the courtyard. The flat chosen is the most common in the block type within the block, and the only differentiation factor is the subtle changes in the area located for the living spaces for the bedrooms. The Andrewes is a single storey flat with 3.2 m clear height. As the building was built during post World War 2. The construction materials had very high U Values for windows as well as walls which was 5.6w/m²k and 1.6 w/m²k respectively with an infiltration rate of 1.4 ac/h. The total heat loss due to the high glazing ratio (43%) for the apartment is 166w/k. The heat loss co-efficient for the flat type 20/21 is 2.07w/m²k.

Section 2.2 Andrewes House

FIELD WORK

The fieldwork was based upon a unit in the Southern block (Andrewes), 6th floor located at the edge of the block which connects to the Eastern Block (Willoughby).

It is a type 20/21, regular flat.

The family that resided in this flat is a professional couple with two young children.

Some of the major findings were the materials of the internal layout of the apartment, untouched exposed concrete, cork floor with tiles as cladding and some of the walls were re painted.

As seen from the images, the two balconies on both the ends which were 1m in width were used as storage and not for any recreational activities.

The corridor connecting the bedroom and the living in the case of this resident was converted as a work space which was artificially lit even through the day.

The study area adjacent to the living area, was converted into the children's bedroom, thus increasing visually increasing the area of the space due to the use of the sliding doors.

The kitchen which was a partially closed plan, has one opening facing the living area.

As seen from the image the view outside from the living room was that of very high commercial buildings causing excessive amount of glare within the apartment.

One of the significant information obtained was the that there was under floor heating system with no control of the thermostat. Even with high U values of the windows and walls, due to the inability to control the heating system caused overheating during the winter months, resulting in the windows being opened by the residents during winter.

The bedroom balcony facing the courtyard allows a better quality of light, with no excessive glare and has a higher visual appeal than the southern balcony.

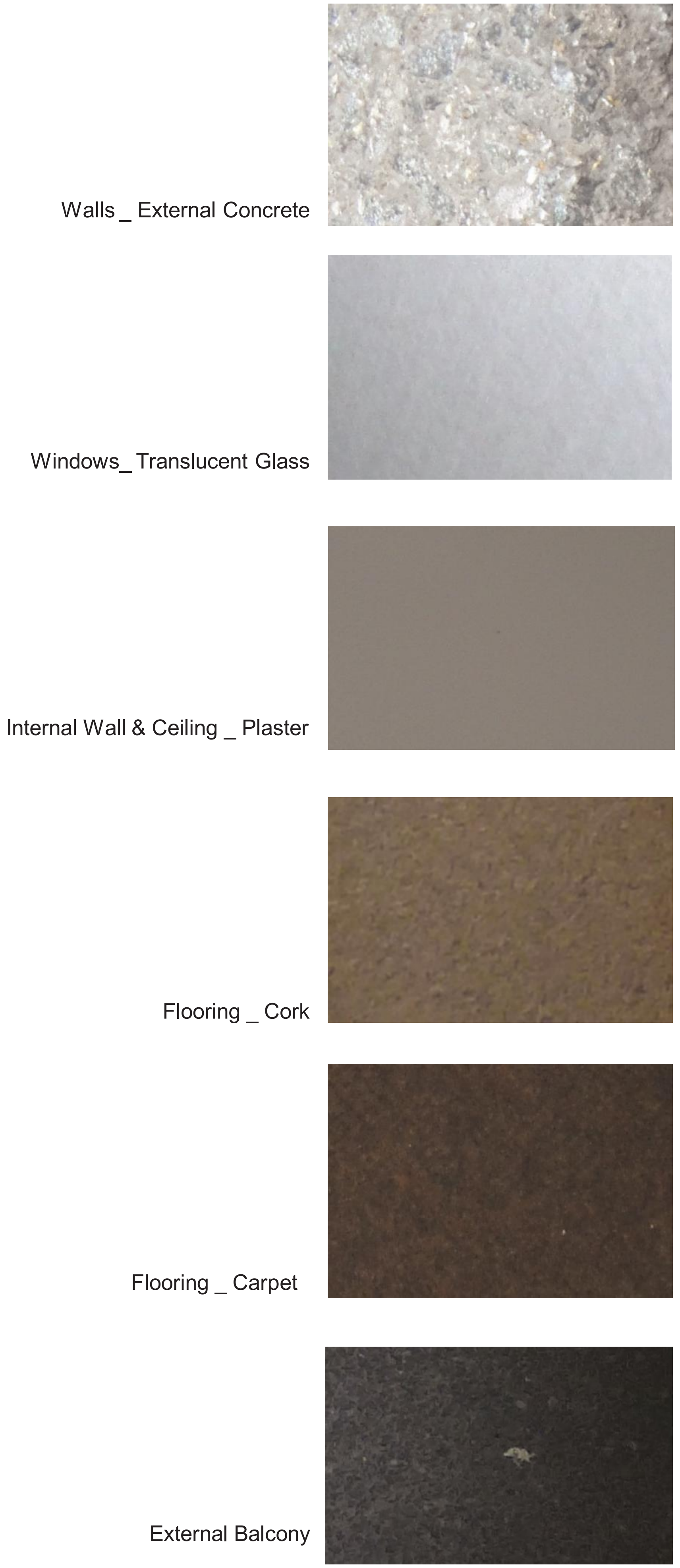
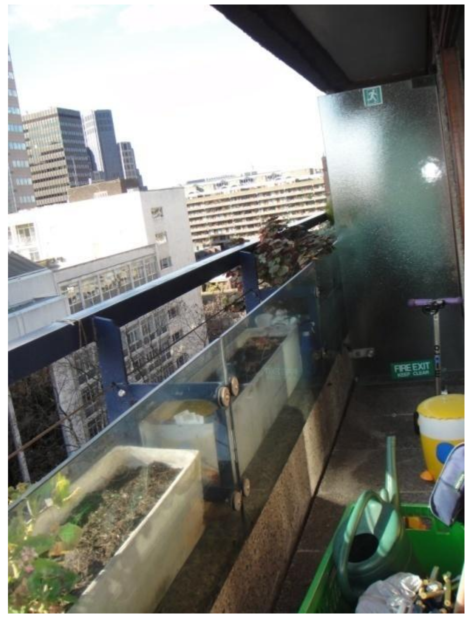
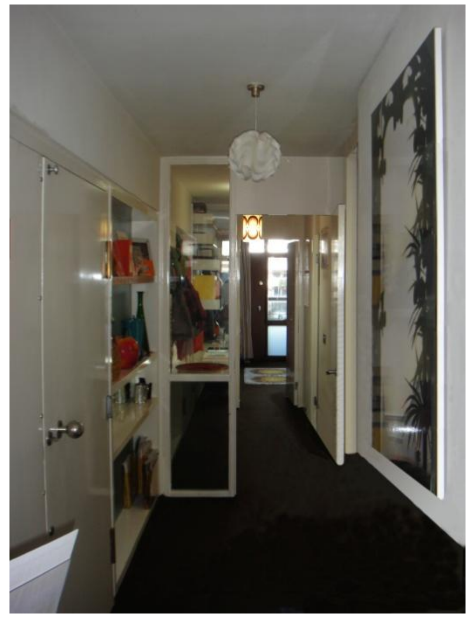


Figure 2.1: Material





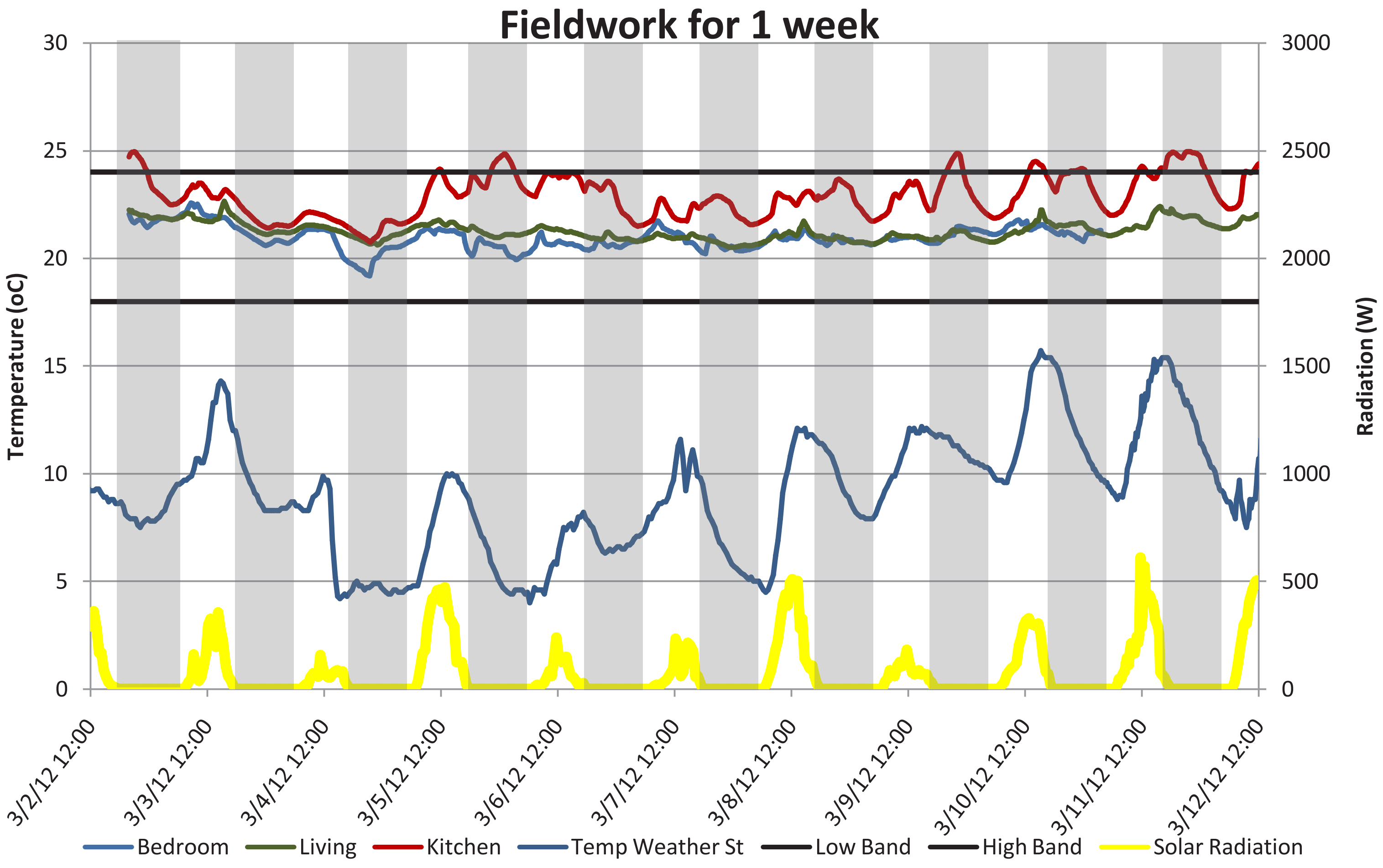


Figure 2.2: Graph showing internal temperature of flat

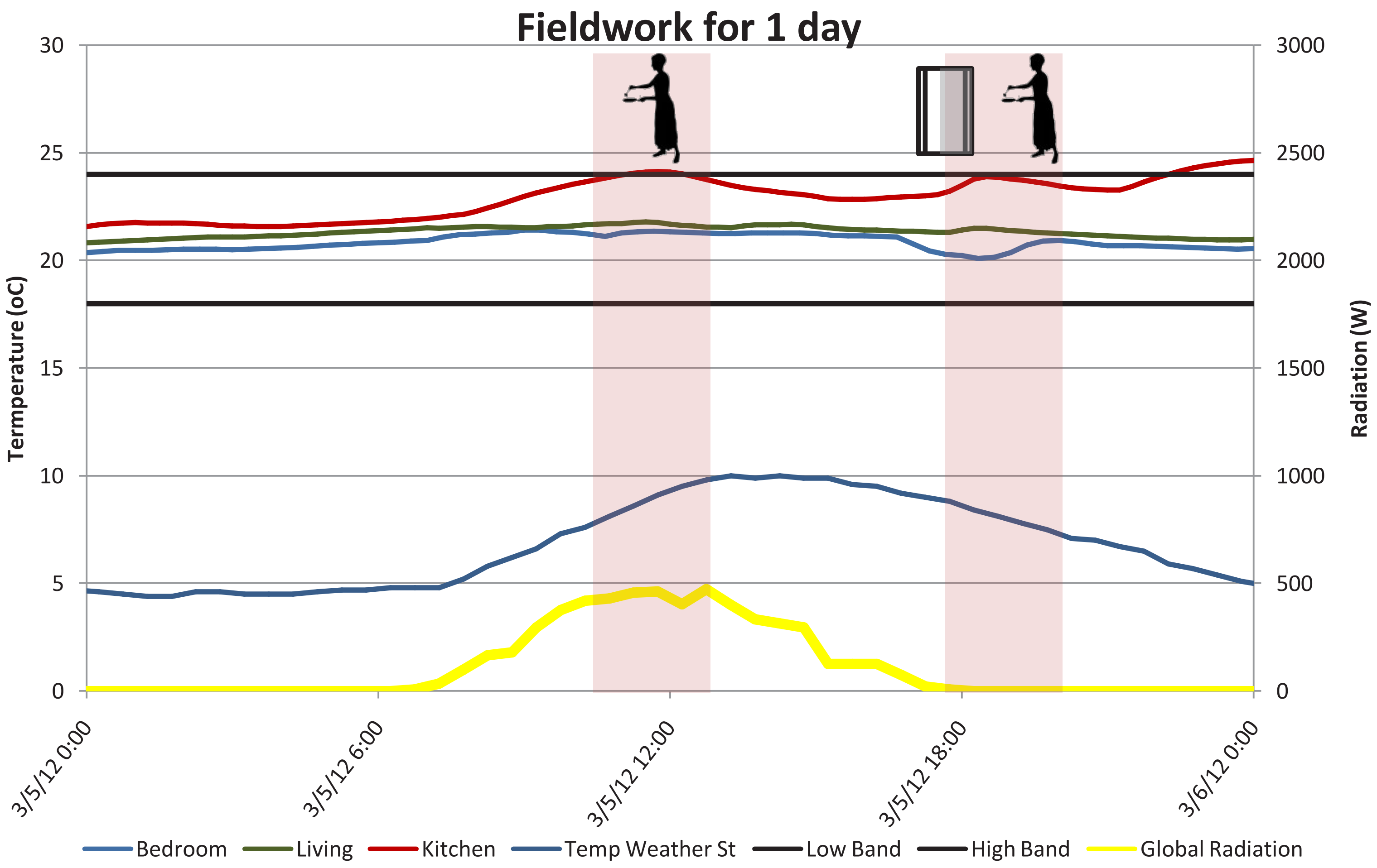


Figure 2.3: Graph showing internal temperature of flat

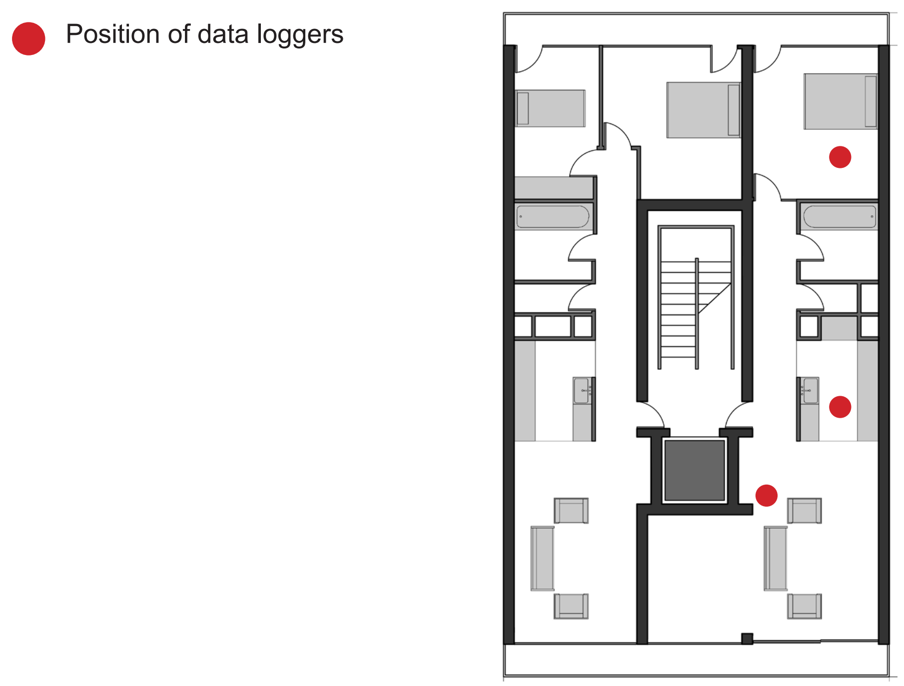
Data loggers were placed in three strategic points of the flat, over a period of one week.

The graphs seen show a constant temperature throughout the day in the living and the bedroom as the heating system was on continuously.

The peaks observed are seen only in the kitchen when they were cooking. The second graph emphasizes on one particular day of that week to understand the relationship between the overheating in the kitchen and the temperature of the bedroom. The first peak seen marked in pink represents rise in temperature when they cook in the kitchen, keeping the living and bedroom constant.

Another major observation made on analyzing the results of the data loggers was that the external temperature was considerably lower than the internal temperatures within the apartment. These temperatures were well within the comfort band but it was closer to the upper limit of the band.

The second peak in the day sees the rise in temperature again but also indicates the opening of windows, thus lowering the temperatures in the bedroom. this results prove that the continuous heating system within the flat is more of a disadvantage in generating excessive energy loads than actually providing comfort to the residents. As a design proposal from the following observations made, the most important aspect catered to was to provide comfort levels with the help of passive strategies and to limit the use of the heating currently.



Section 2.3 Andrewes House - South

HEATING LOADS

The flat types 20 and 21 were chosen for the case study. This choice was based on the number of flats that are equal or similar, representing the majority type of this block.

As the Barbican estate is a listed building, the limitations for refurbishments are revised every 5 years. Hence, two scenarios were explored. The first one with the possible changes as per the listed building rules on the present day or precedent within the existing building typologies. The second scenario was the desirable situation, designed considering changes made in the regulations thus creating the possibility to modify the internal layout of the building as well as subtle changes to the exterior façade.
In order to evaluate the energy efficiency of the block a series of simulations using EDSL TAS software were done. The main variable analysed was the building envelop, so the model used has some simplifications. The surrounding buildings weren't modelled as well as the block itself, so overshadowing effects were taken out of the equation. Also the apartments were modelled as one unit of space, this means any particular gain or loss of heat would be distributed equally throughout the area. This kind of model has some limitations as it doesn't take into consideration the possibility of occupant adaptation, migrating for a hotter or cooler spot in the apartment. It was thought that, since the Barbican estate has a district heating system with no occupant control, this was a good simplification for analysing the energy spent on heating. The thermostats of the flats were set at a minimum of 18 °C. Internal heat gains were considered as the heat produced by appliances, lighting for illumination by the occupants. For the simulation people were modelled emitting 100W, and for appliances and lighting 3.4W/m² was used [5].

Each flat has an area of 80 m². The glazing ratio of both flats are 43%, however the flat with two bedroom have the major part of its glazing area facing north while the one with one bedroom has its major part of its glazing area facing south. The thermal properties of the materials and infiltration rates of the flat were set based on previous studies of the Barbican estate (Term 1 SED Project, 2010) and it is listed below:

U-values
Walls 1.6W/m²K
Single Glazing 5.6W/m²K

Infiltration 1.4 Ach

It can be seen in the figure 2.4 that the possible scenario contains the largest drop on heating energy consumptions. The considered saving was achieved by changing the U-value of the windows. The infiltration rate was reduced to 0.25 Ach (air changes per hour) while the glazing was changed to low-e double glazing (U-values 2.0W/m²K). These measures made reduced the heating energy by a third achieving the yearly amount of 40kWh/m². Further the application of insulated night shutters (mean U-value with double glazing 0.9W/m²K) resulted in a decrease of around 5kWh/m² y. The desirable scenario considered the possibility to change the façade as well as others architectural attributes. A sensitive analysis among the modification of the glazing ratio was made. The reduction of the glazing area was made from 30% to 10%. It started with the reduction of the glazing areas facing north until it resulted in a loss of architectural quality, only then

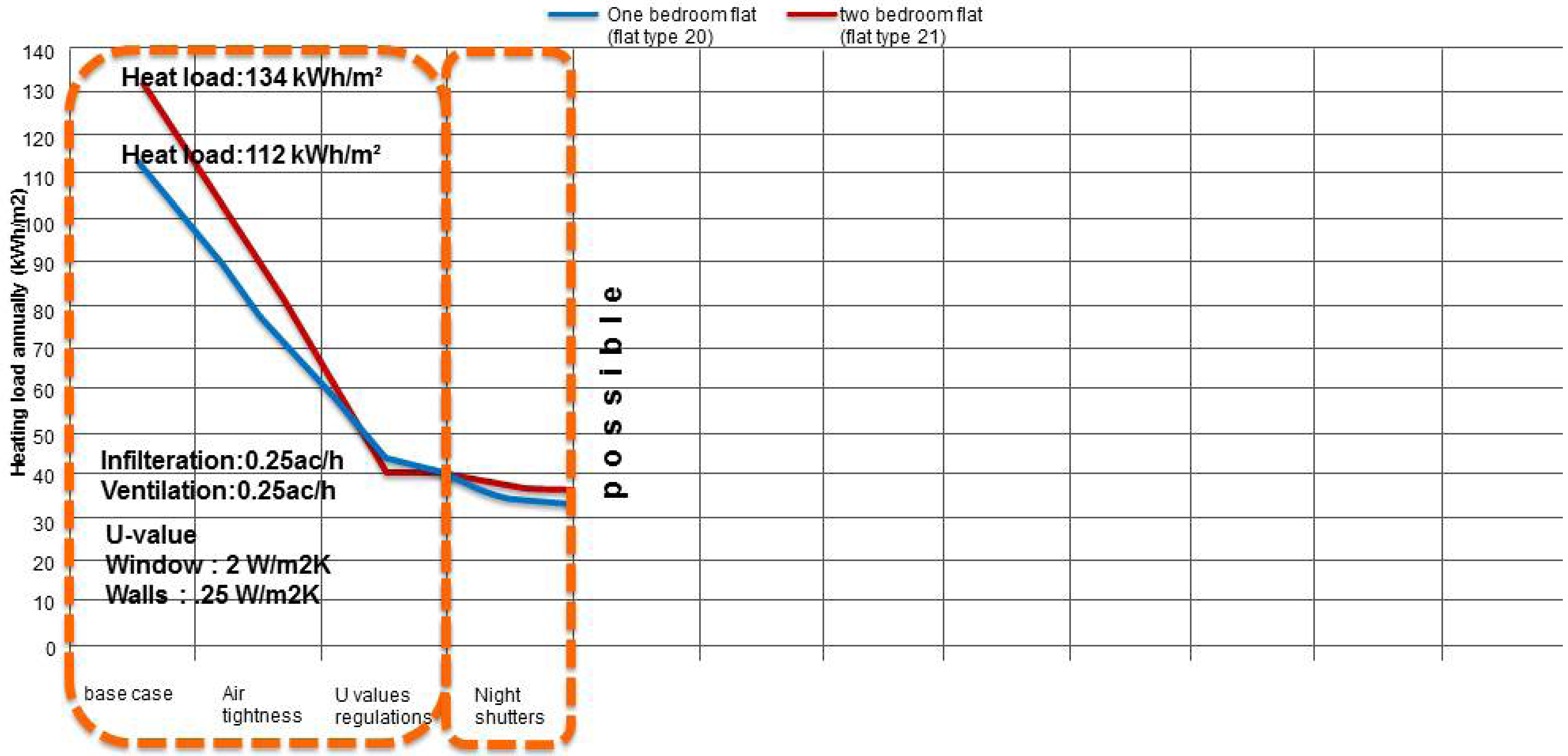


Figure 2.4: Thermal analysis

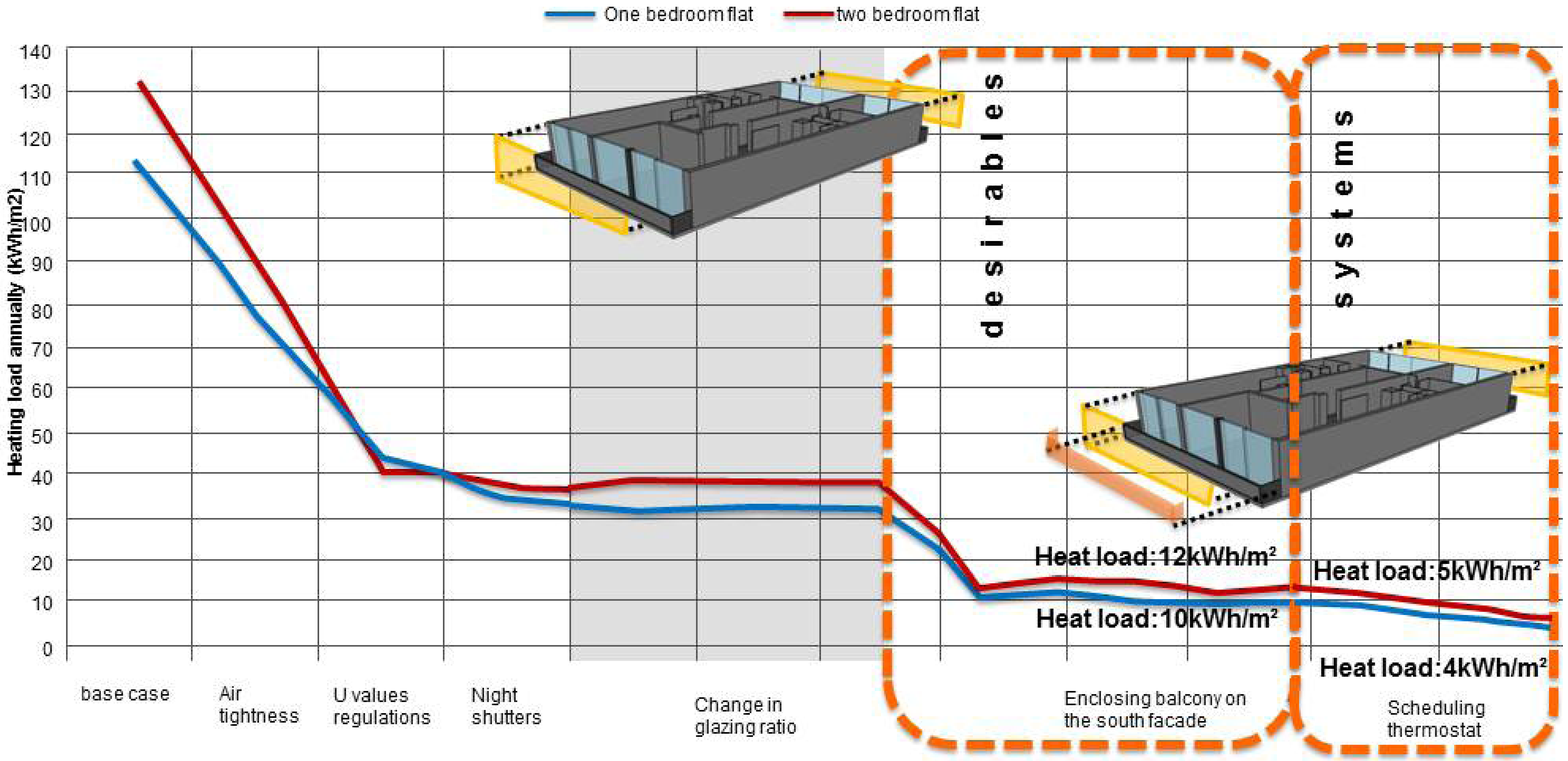


Figure 2.5: Thermal analysis

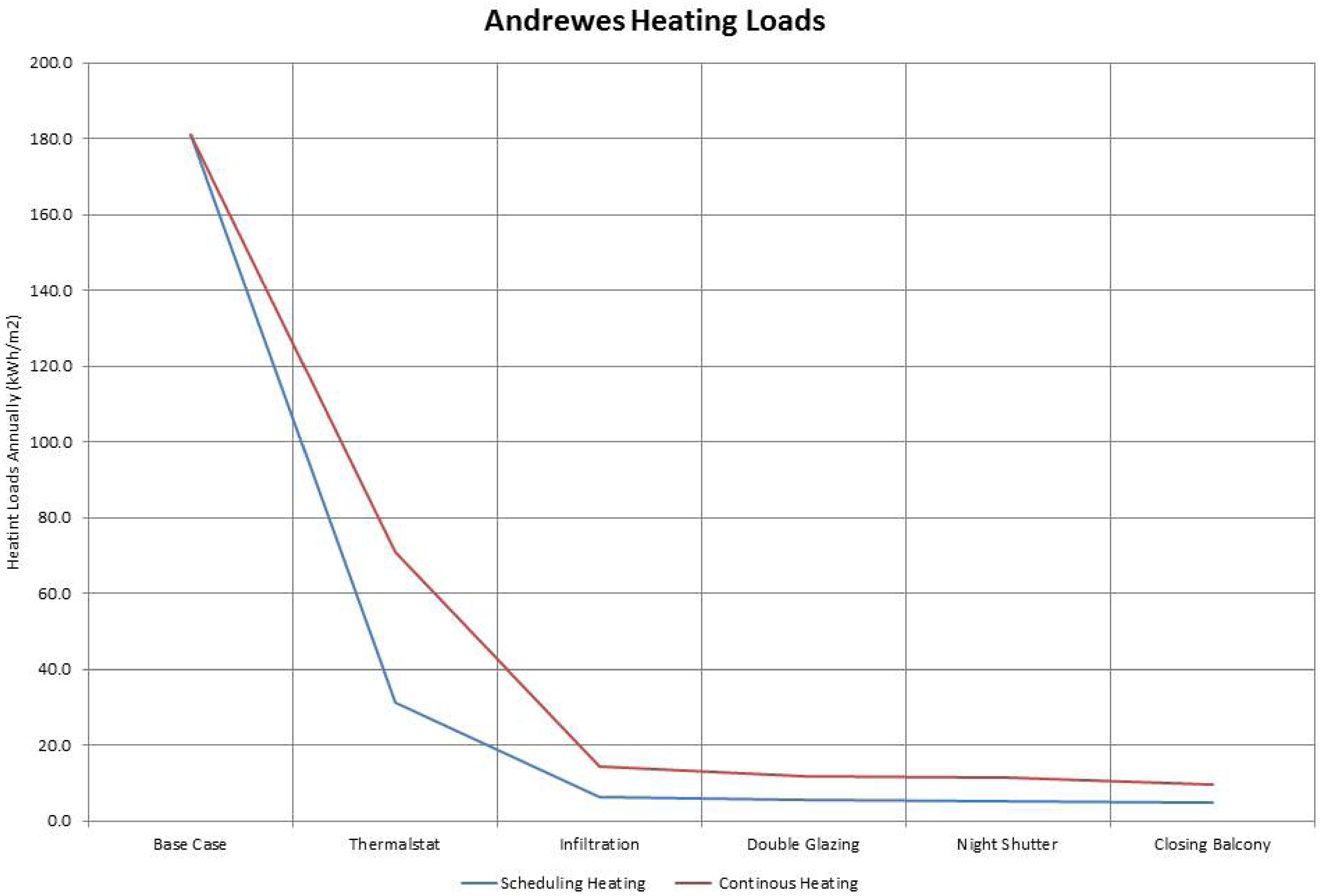


Figure 2.6: Heating Loads

Figure 2.7: Thermostat - Scheduling pattern

the south were subjected to a change. There was no evidence of improvement of energy savings. These results could be due to various numbers of reasons. One of the main reasons was that the glazing modifications were only considered after the improvements on materials and the use of shutters. Another reason was that the high thermal inertia of the building tends to stabilise the heat balance affecting the sensibility of the heat loss from the windows. One design strategy considered was to enclose the balcony in order to create a buffer area. The area of the balcony heats up because of the direct solar radiation during the day and releases this heat at night. The changes in the building systems were looked at only after all other possible as well as desirable changes. There are two major reasons for this; firstly, the main aim was to reduce the demand with passive strategies as far as possible before applying any kind of new system. Secondly, the heating system which already exists in the Barbican would need to be completely replaced. This is due to the fact that the electrical under floor heating system is part of a district system for the whole Barbican State. None of the apartments have control on their temperature and the change in the system will require a complete refurbishment of the floor system.. Since it has the greatest impact on the flat in terms of replacing materials and more costly, it was considered as the last resource. Therefore, new hot water pipe based under floor heating system is proposed and with it the possibility of differentiating the temperatures between rooms as per its functions. In this case, two different limits of temperature were set in the bedroom and in the living room.

To explore a different strategy of refurbishment, a second study was made contemplating the systems as the first modification (Figure 2.6). In this case each room of the flat was modelled as a different unit. The base case, as per fieldwork, all the rooms were set at 22 °C. Two situations were studied, one with a constant heating at 18 °C and the other with the thermostat following the occupant behaviour of a professional couple. In the situation of the professional couple, the living room was simulated to have a lower limit of 18 °C during occupied hours and to be free running during unoccupied hours. The bedroom lower limit was 15°C due to the fact that during sleeping hours the occupants would use blankets and other layers. However, the bedroom would be heated at 17 °C while the occupants are awake in the bedroom. In the simulation the thermostat were set at 17 °C during two hours of the day, just before the occupants wake up and one hour before they go to sleep.

It can be seen that the major drop happened with the set of a new thermostat temperature and with the control of infiltration. But, it will only be possible to reduce infiltration if the windows were refurbished. And it would be desirable to change to double glazing to improve the quality of the space. Finally, the design intent involved the changes in the internal layout of the flat which was also regarded in the two sets of simulations. The change of orientation, placing the bedrooms on the south and the living on the north, made no change on the heating energy balance it was purely done for aesthetic and visual value. This was due to the fact that, although the functions had changed in orientation, the global radiation or orientation of the whole block didn't change. So, it remains with the same solar characteristics as well as the same envelop.

Section 2.4 Andrewes House - South

WINTER CLOUDY - LIVING ROOM

The living room was simulated with the changes in the internal layout, which is it was facing north. This situation implicates this room doesn't receives direct solar radiation. Therefore the only way to elevate its temperature is through internal gains or with extra energy from the heating system which is regulated.
The figure 2.8 shows the living room temperature in a period of three consecutive days of a typical winter cloudy week. The temperature of the living remains between 10K to 12K above the outside temperature. It can be seen that with the reduction of infiltration and the improvements on the glazing the temperature is constant at 16-17 °C, although it never reaches 18 °C, which required additional heating too do so.

SUMMER SUNNY - LIVING ROOM

A period of three consecutive days of a typical summer sunny week was taken under consideration. For a worst case scenario, these three days demonstrate how the building responds to a hot period in relation to overheating. The temperatures found through simulations never crossed over 28 °C even on the hottest day of the year, as it can be seen on figure 2.9. The temperature remains constant and it doesn't fluctuate along with the variation of the outside temperature. This was expected since the room is not affected by solar radiation.

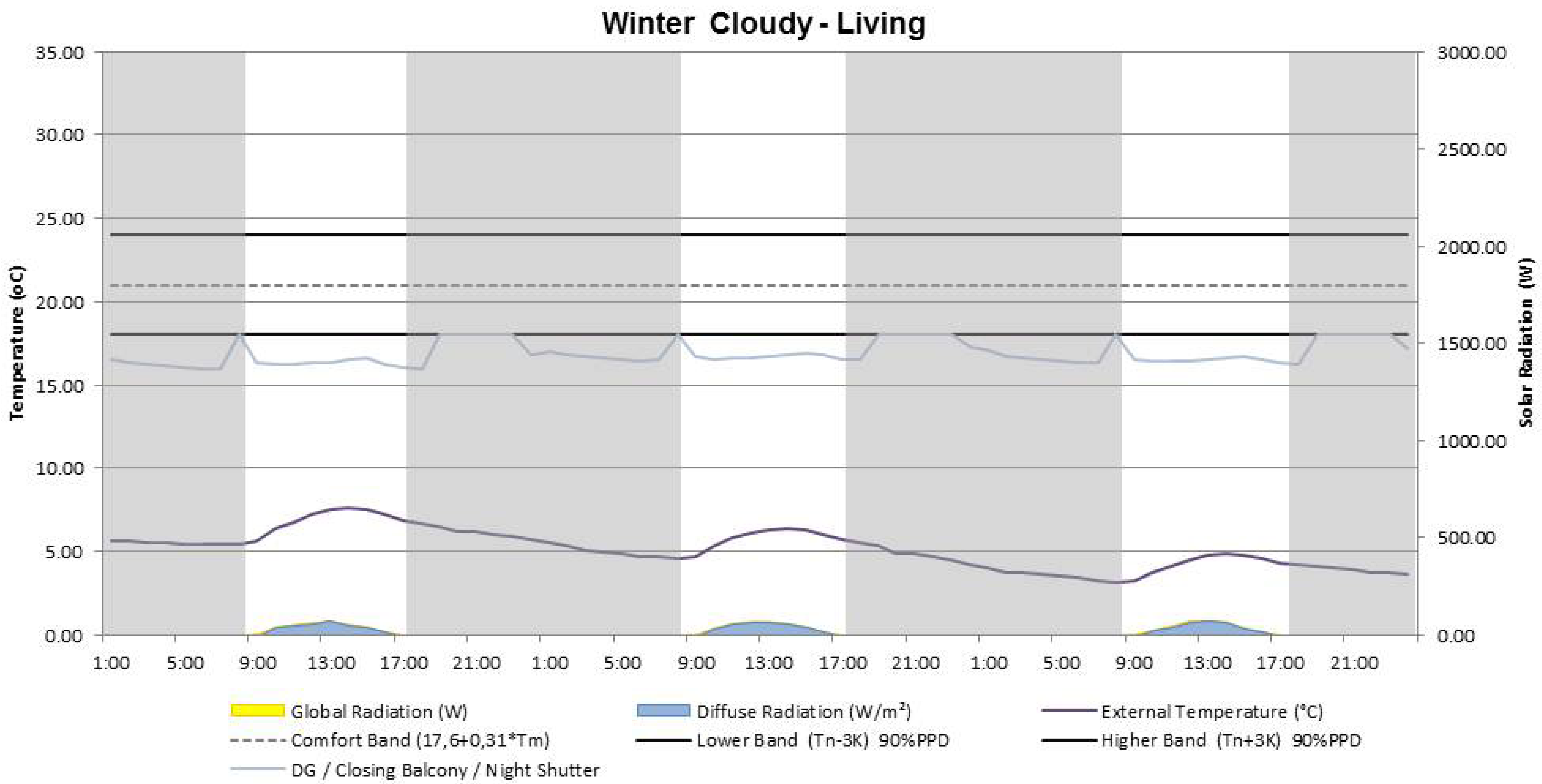


Figure 2.8: Simulation of living room temperature

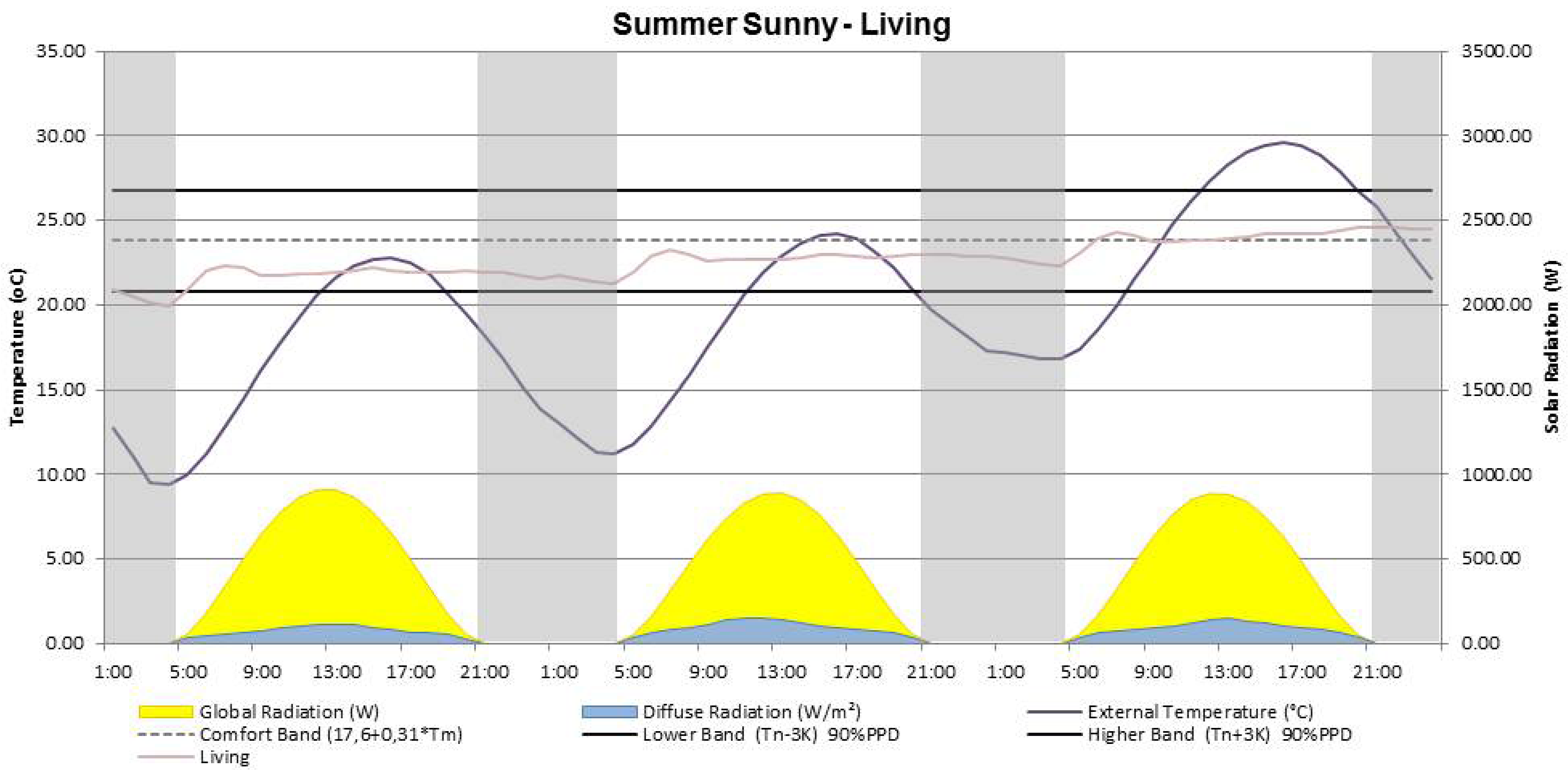


Figure 2.9: Simulation of living room temperature

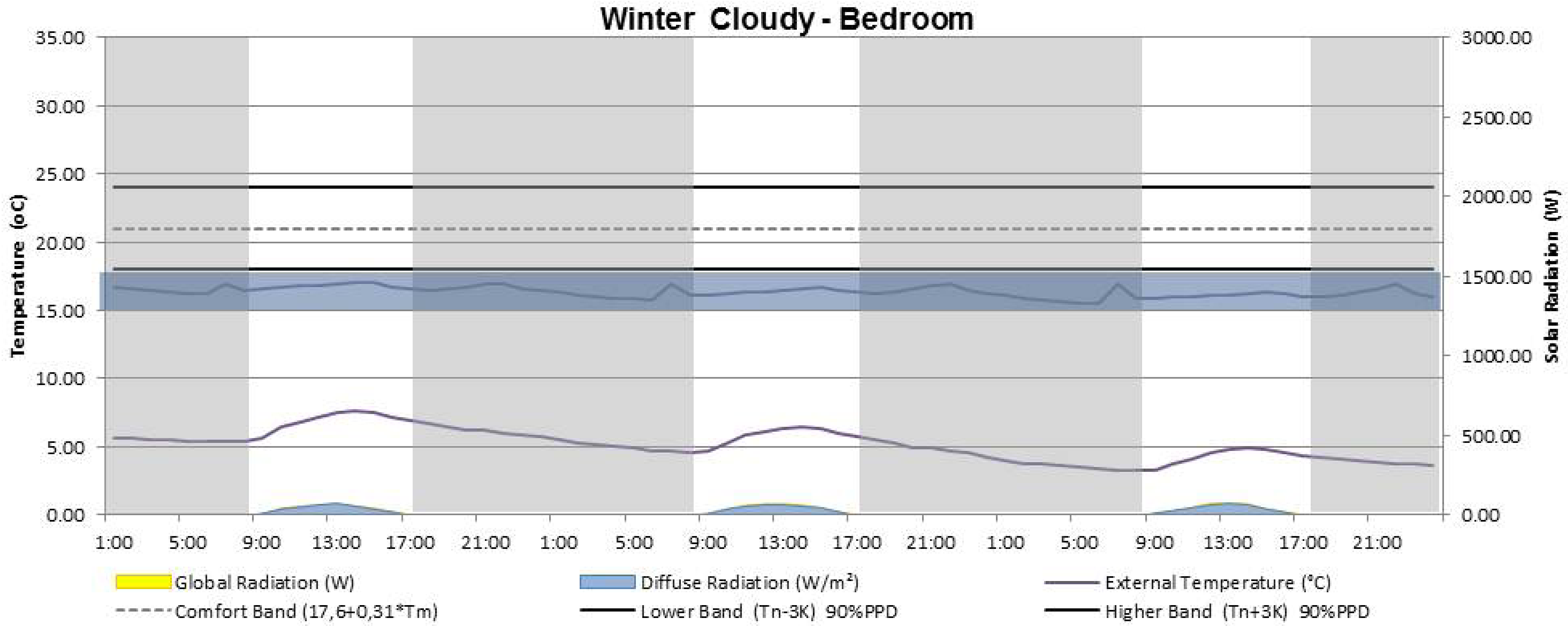


Figure 2.10: Simulation of living room temperature

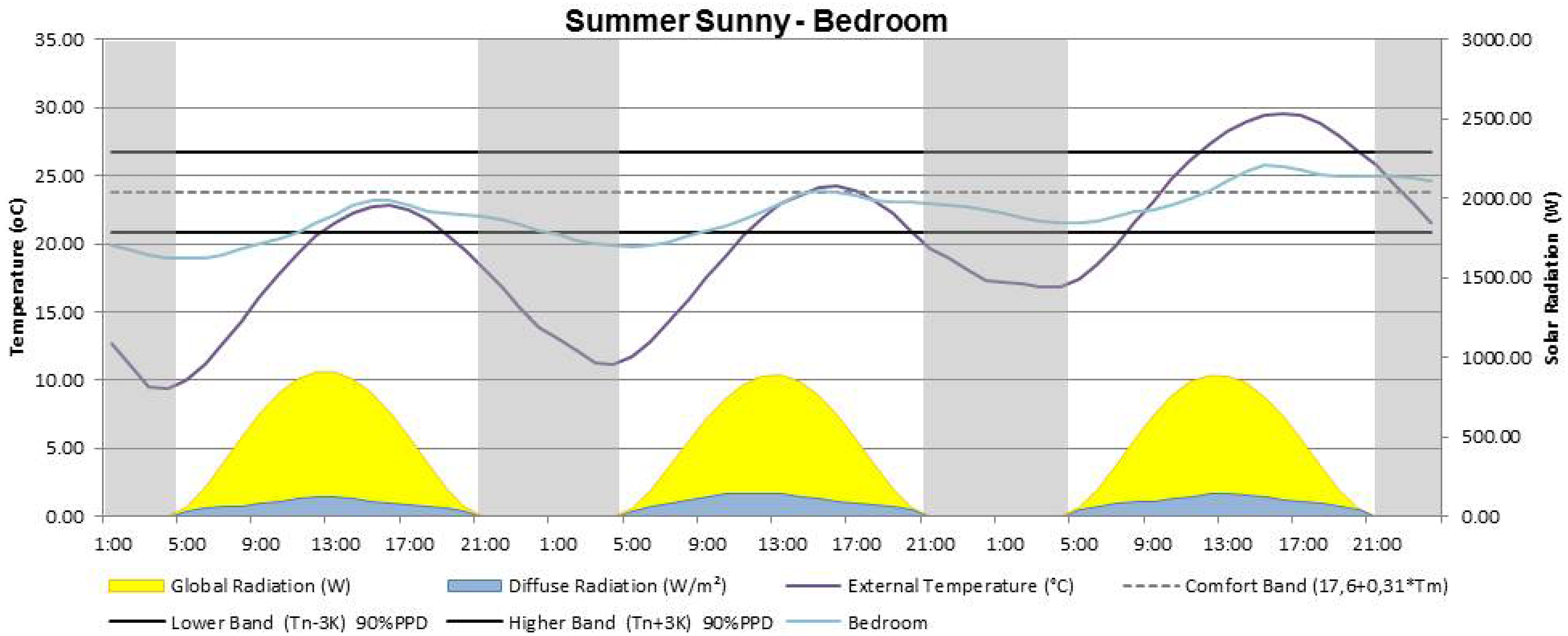


Figure 2.11: Simulation of living room temperature

Figure 2.12: Thermostat - Scheduling pattern

WINTER CLOUDY BEDROOM

The bedroom was simulated facing south considering also the change of internal layout of the flat. The figure 2.10 shows the temperatures of the bedroom in a typical winter cloudy week. It can be seen that between the periods which the heater is turned on (7:00 and 22:00) the temperature of the room never fell below 15 °C, which is a comfortable temperature for sleeping. This proves it is possible to have the heaters on only for certain periods when the occupants are awake in the room. A significant amount of energy is be saved, however it depends on the occupant behaviour. Regulating thermostat is completely dependent on occupant behaviour and usage of the space which can be heightened by providing them with a possible comfortable environment for living.

SUMMER SUNNY BEDROOM

During the summer period the figure 2.11 shows that the room responds well to hot days. The thermal mass of the building helps stabilizing the temperature throughout the day. Also the balcony works as a shading device during the summer period when the sun has a higher angle. It is important to make sure that the balcony remains open throughout the summer months, in order to increase ventilation and not act as a buffer space like during the winter periods. The temperature doesn't cross the limit set of 28 °C even with the outside temperature is at 30 °C.

Section 2.5 Andrewes House - South

Internal Layout

In the southern block, Andrewes, in the existing scenario, the living rooms faces the street externally. According to the sky view factor, the southern facade is obstructed by the surrounding buildings hence limiting daylight internally. In addition, due to the rising buildings within the context , the views externally from this space will be restricted, hence limiting the use and need for the balcony on this side of the block. Since there is a limitation in the amount of solar radiation received internally, the strategy was to integrate a conservatory when in winter could be used as thermal buffer zone (elaborated in the next section) and in summer could be opened. However, this would then disrupt the views for a living room as this thermal buffer is also used for circulation. As an architectural feature, a flip in the function of this space was considered, by flipping the living to the northern side, which was the bedroom, and moved the bedroom to the southern side. With the flip of the functions, this would allow the living room to appreciate the advantage of having a view, since now it would face the internal courtyards. figure 2.17

Figure 2.13: no privacy facing the courtyard

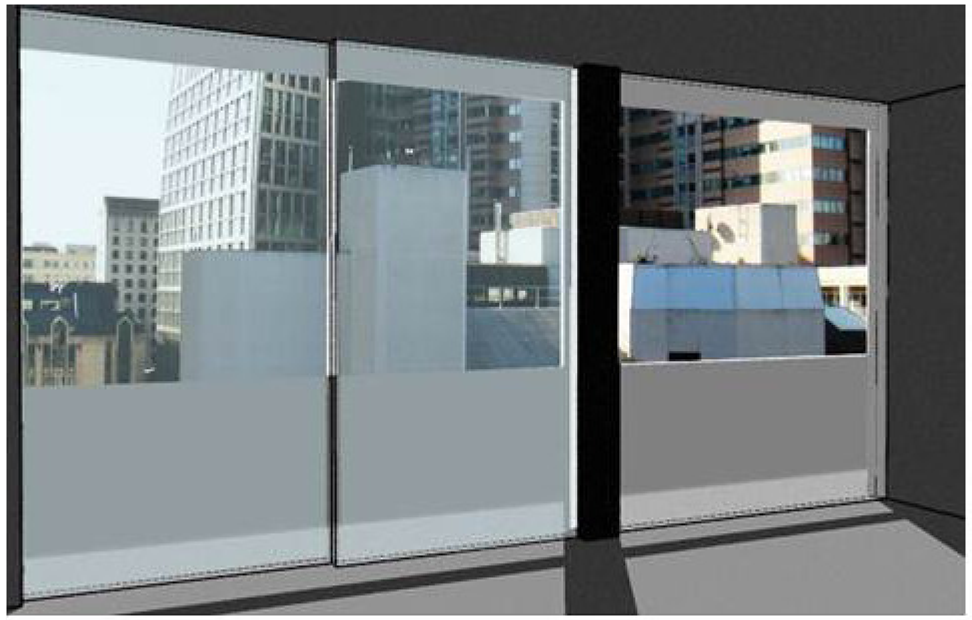


Figure 2.14: existing view from the south facade,living room

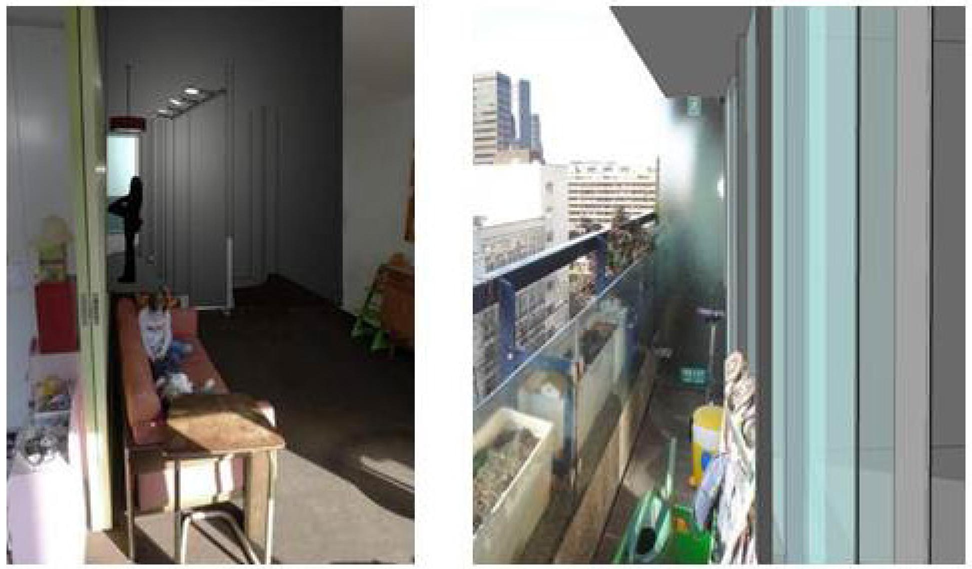


Figure 2.15: insufficient daylight and unused balcony space

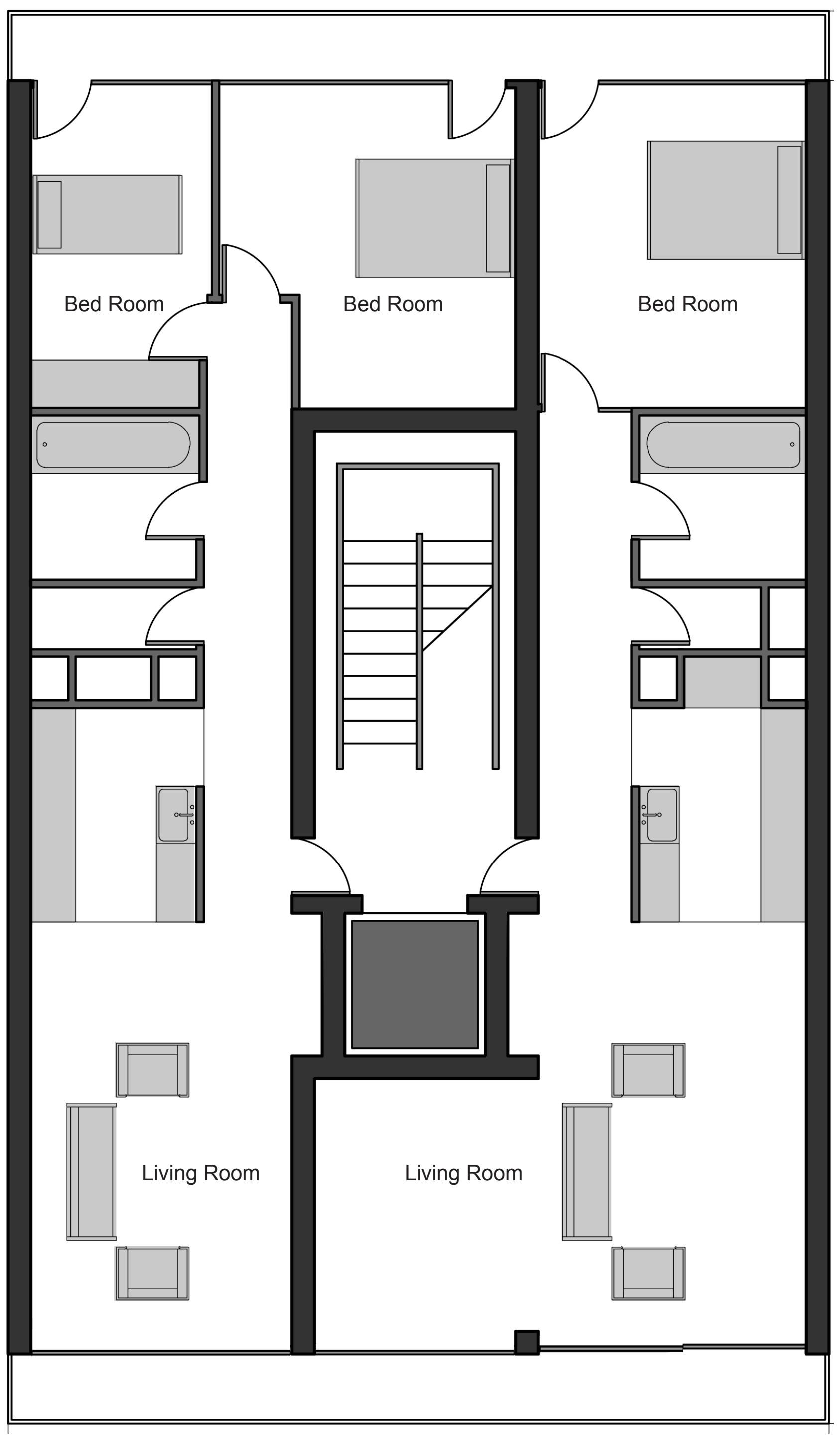


Figure 2.16: Plan Base case

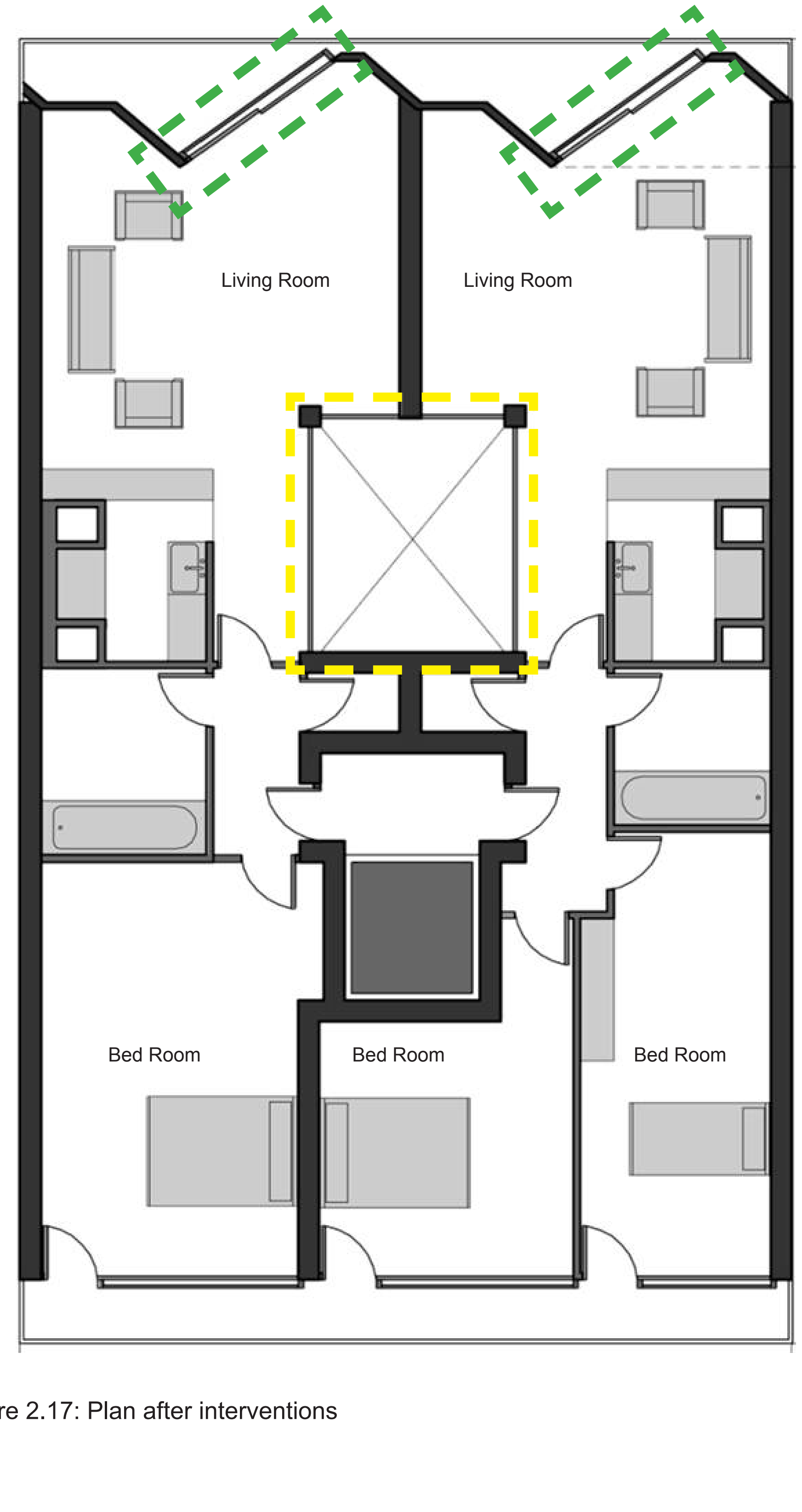


Figure 2.17: Plan after interventions

On the northern side, due to the close proximity of the blocks to each other in the corners of the blocks, privacy becomes an issue . With the glazed facades, the residents are able to look into each other's living rooms. As an intervention, to address this issue of privacy, in the corner blocks, the northern glazed facade is tilted to face away from the adjacent block.(figure 2.13). This also increases the ability for the internal space to gain more daylight due to the 20 degree tilt facing south, whilst still maintaining the views into the courtyard. This also results in the increase of balcony width from 1m to 1.8 m allowing for more occupancy use of the balconies. Since the southern side (bedroom) balconies are being used for circulation, this northern balcony will then cater for a more private use of the balcony space. (figure 2.15)

In the internal layout, the staircase cores catering to both the apartment types, since it runs the entire height of the Andrewes block as a design intervention it was changed it to a light well. As the lift core is the main vertical circulation spine for the south block, the landing area on each floor is increased in size thus reducing the area of the light well between the two apartments. However, still suffices to increase the daylight to an adequate quantity in the two apartments as required by guidelines.

Section 2.6 Andrewes House - South

Night Shutters and Buffer Zone

Being a listed building and having limited design strategies to improve architectural and daylight quality within the apartments, occupant based adaptive strategies are taken into consideration. As a proposal, occupant's usability for each function within the apartment was considered. Shutters on the internal façade for the bedroom along with a thermal buffer zone were additional elements that were added.

The night shutters being a possible design intervention helped reduce the energy loads of the apartment. This strategy is acceptable as these shutters exist within the barbican estate on the façade of Frobisher Crescent building (figure 2.18).The night shutters used are insulated wooden panels which are movable in nature. The adaptive quality of the shutters allows the occupants to decide the amount of light received within that particular room which eventually also improves the comfort level (temperature) considering that particular resident's needs.

As seen from the figures, variations in the usage of the night shutters for different conditions of the day confirm the adaptive quality of these shutters (figure 2.19-figure 2.21).

The buffer zone on the south façade is a desirable quality that has been added to further reduce the heat loads of the apartment. As the corridor is now the main circulation spine for the Andrewes house, it makes the space more communal and usable. As this is one of the adaptive strategies, the buffer zone can be opened up during summer and closed to heat up the space during winter. As the existing balcony is 1m in width and was a redundant space in the current scenario, the application of the thermal buffer has increased its usability (figure 2.22).

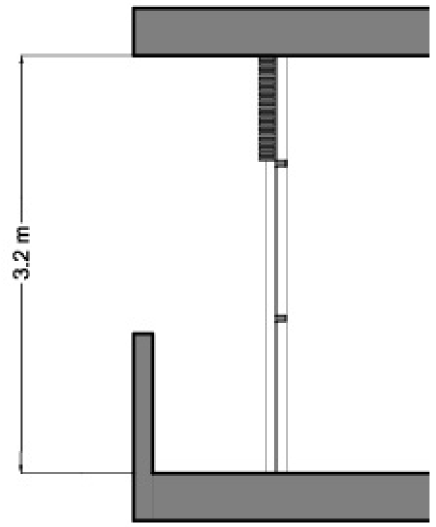


Figure 2.19: Section - Shutters up

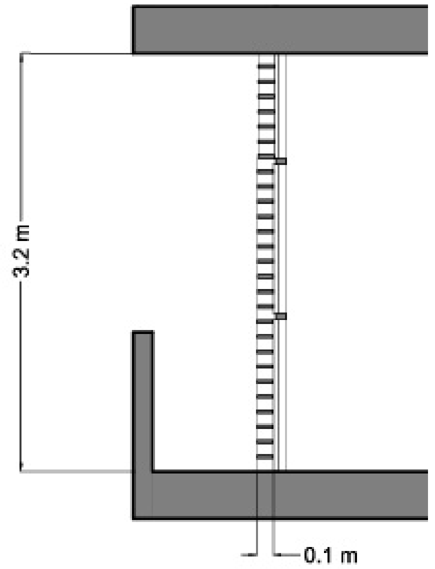


Figure 2.20: Section - Shutters down

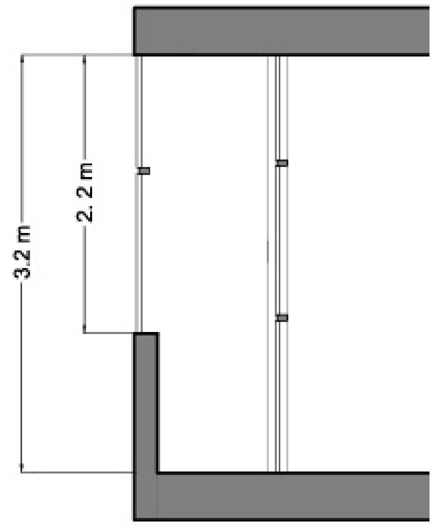


Figure 2.21: Section - Thermal buffer

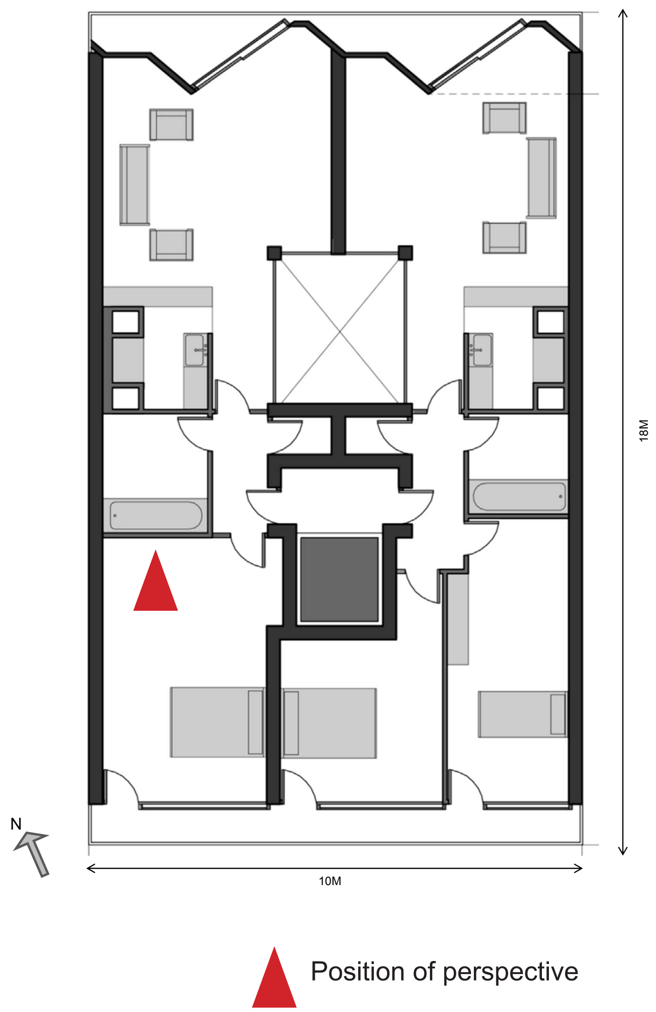


Figure 2.18: Section - Shutters used in other builings in the Barbican

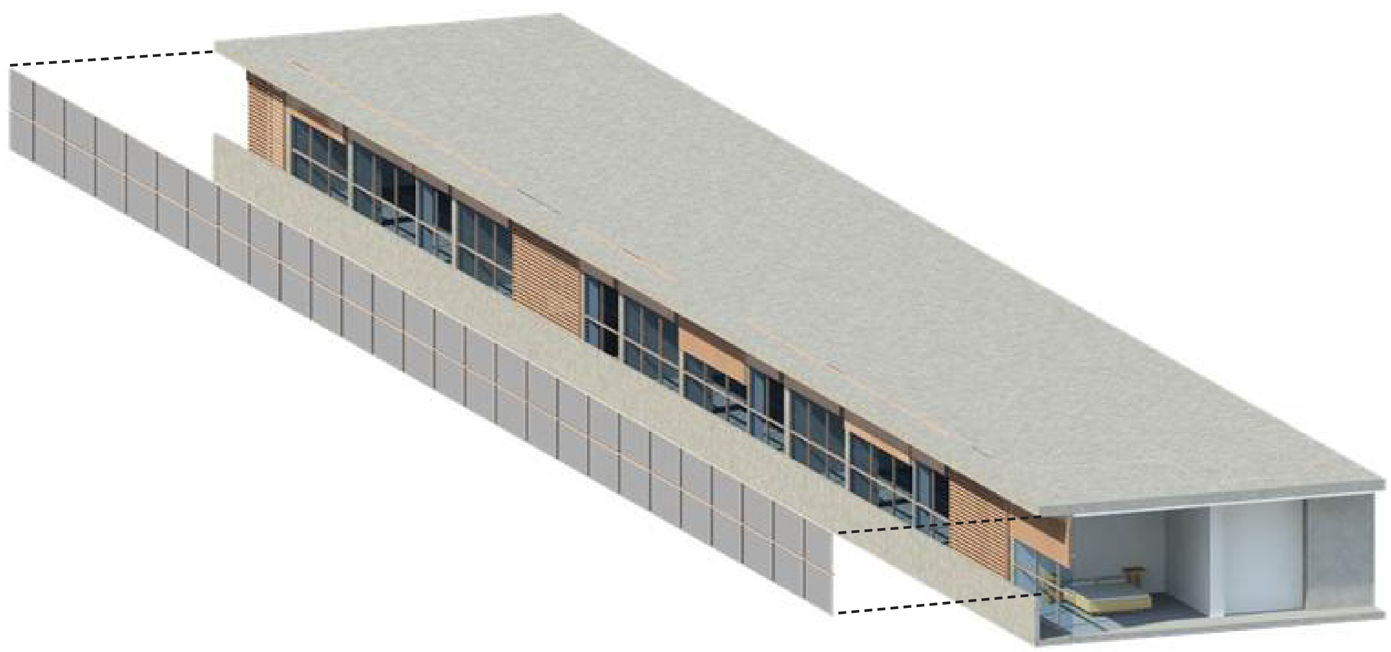


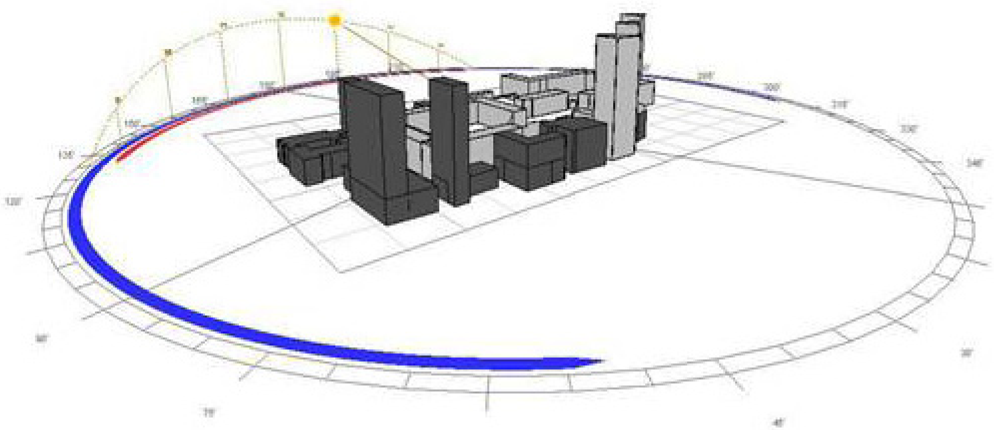
Figure 2.22: Axonometric view - Shutter and buffer

Figure 2.23: Winter Sunny- Shutters Up

Figure 2.24: Winter Sunny - Shutters Down

Figure 2.25: Winter Night - Shutters Closed

Figure 2.26: Winter Cloudy - Shutters Up



Sunpath Diagram - Winter

<u>Figure 2.23: Winter Sunny - Shutters up</u>
External Temperature: 13 °C
Internal Temperature: 22.3 °C

<u>Figure 2.24: Winter Sunny - Shutters down</u>
External Temperature: 13 °C
Internal Temperature: 21.4 °C

<u>Figure 2.25: Winter Night - Shutters Closed</u>
External Temperature: 4.6 °C
Internal Temperature: 16.2 °C

<u>Figure 2.26: Winter Cloudy - Shutters up</u>
External Temperature: 6.4 °C
Internal Temperature: 16.4 °C

Section 2.7 Andrewes House - South

Living Room

Similar strategies have been adapted in the living room which faces the north façade of the Andrewes block as that of the south façade. As the living area balcony which faces the courtyard is a more usable space due to the changes made in the internal layout made as mentioned earlier. The tilted facades cater to the increase in area of the balcony as well as increase the privacy of the adjacent apartments. The night shutters on the tilted façade work in the same adaptive manner as seen in figure whatever.

As mentioned earlier, the balcony facing the south is more communal and used for circulation whereas the balcony on the north adjoining the living room with the tilted facades caters to the privacy of the residents. As an entire apartment layout, the residents benefit from both the semi-private as well as the private semi outdoor spaces.

As a design proposal, it was important to understand the occupants visual comfort from inside the apartment block to the balconies and then to the open green spaces in the courtyard. The change in the tilted facades in the corner of the Andrewes block as seen from the figures does not change the external façade drastically and makes the balcony more usable (figure 2.27).


Figure 2.27: View from balcony to courtyard


Figure 2.28: External view of facade


Figure 2.29: External view form courtyard

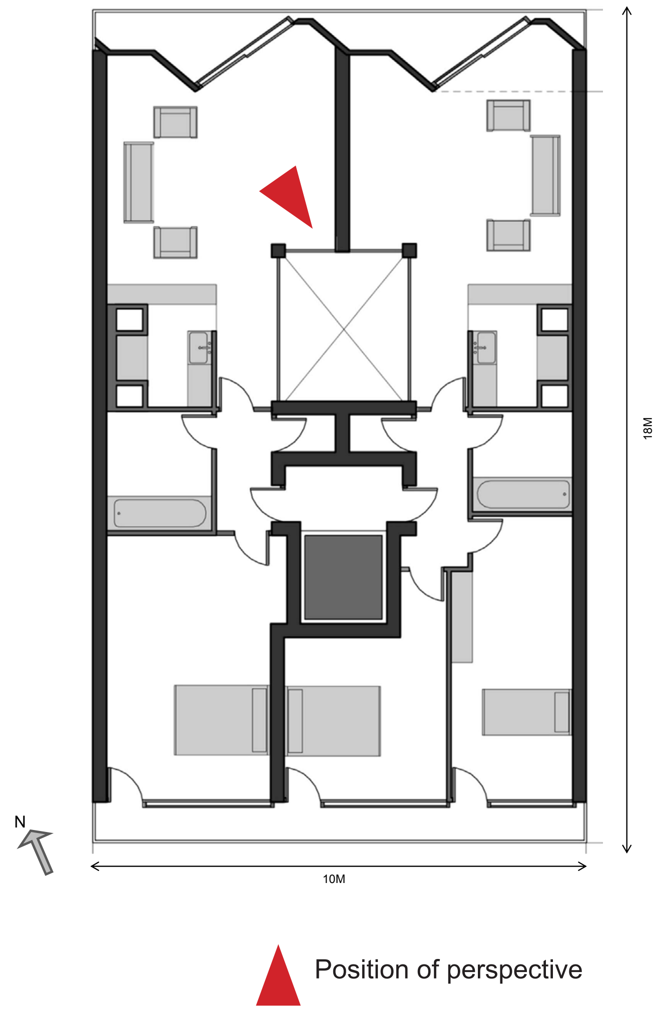
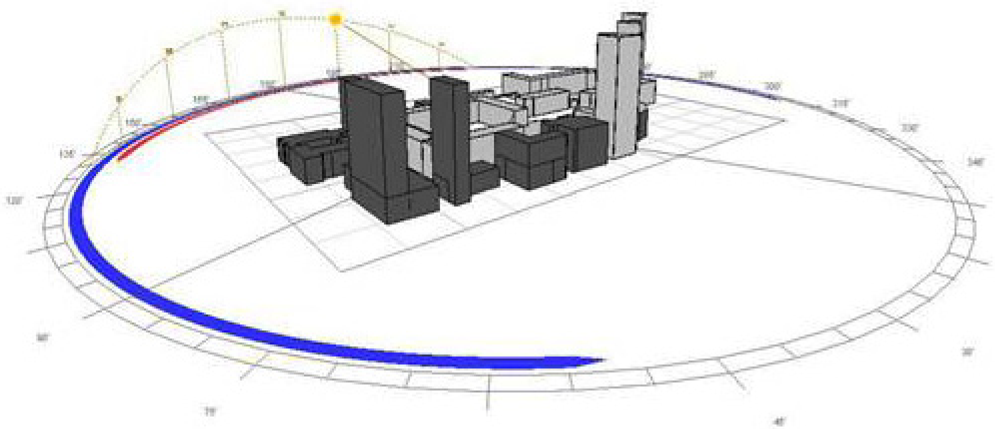


Figure 2.30: Winter Cloudy - Shutters up

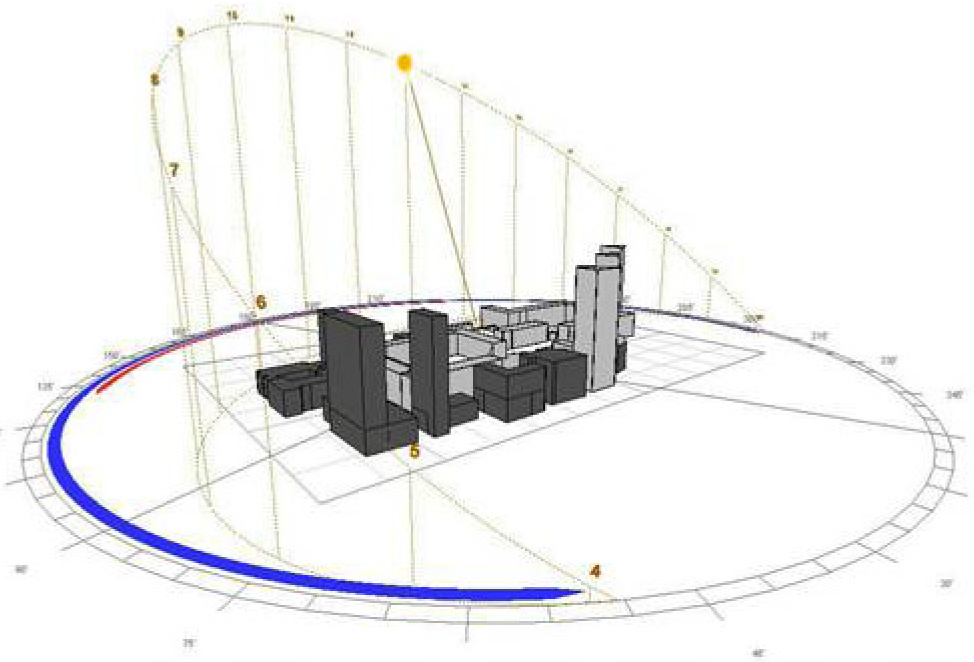
Figure 2.31: Summer Sunny - Shutter up

Figure 2.32: Winter Sunny - Shutters up

Figure 2.33: Winter Sunny - Shutters down



Sunpath Diagram - Winter



Sunpath Diagram - Summer

<u>Figure 2.30: Winter Cloudy - Shutters up</u>
External Temperature: 6.7 °C
Internal Temperature: 16.7 °C

<u>Figure 2.31: Summer Sunny - Shutters up</u>
External Temperature: 23.9 °C
Internal Temperature: 28.3 °C

<u>Figure 2.32: Winter Sunny - Shutters up</u>
External Temperature: 13.0 °C
Internal Temperature: 17.2 °C

<u>Figure 2.33: Winter Cloudy - Shutters up</u>
External Temperature: 13.0 °C
Internal Temperature: 17.2 °C

Section 2.8 Andrewes House - South

Daylight Studies

The apartment layout of the Andrewes block is a deep plan which is 10 m by 18m length with a height of 3.2 m. Even though the plan layout is that of a deep plan, the available height of 3.2 m caters to most of the daylight requirement within the apartment block. The distribution of the functions within the layout is actually the main reason for the uneven distribution of light within the given space. The main core of the apartment the kitchen, toilet and bathroom is placed alongside one another creates a dark corridor as both the edges are opaque and obstructs the entry of light. As seen from the simulations done through Ecotect, the daylight factor received from the two windows at the opposite end s of the apartment provides visual comfort only till the edge of the corridor. The orientation as mentioned before, of the Andrewes block is north and south. The amount of daylight which can be received should be able to illuminate the entire area which is not seen in the current scenario (figure 2.34)

The design strategy used for the apartment within the Andrewes block was to design a light well within the existing structure of the block. The staircase core which is converted in the proposal, into a light well is removed allowing a complete void through the seven floors of the block. The layout of the plan is maintained as per the existing function. Additional simulations are done to analyze the changes and the increase in daylight factor. Simulations done in Ecotect with the addition of the light well , it is observed that the apartment layout receives an even distribution of light. The daylight factor now is between 4.5% to 5.5% which suffices within the requirements (figure 2.35 and figure 2.37).

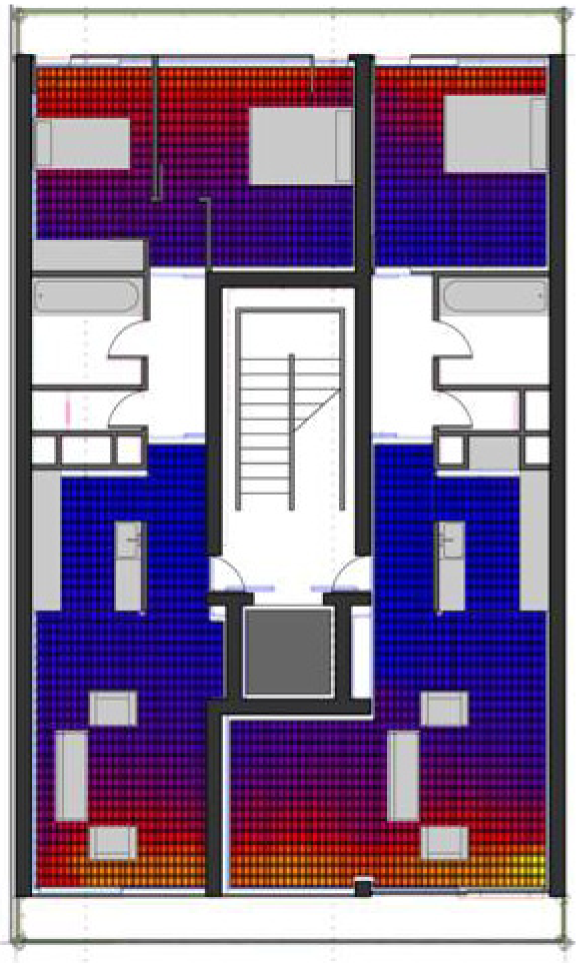


Figure 2.34: Daylight factor - Base case

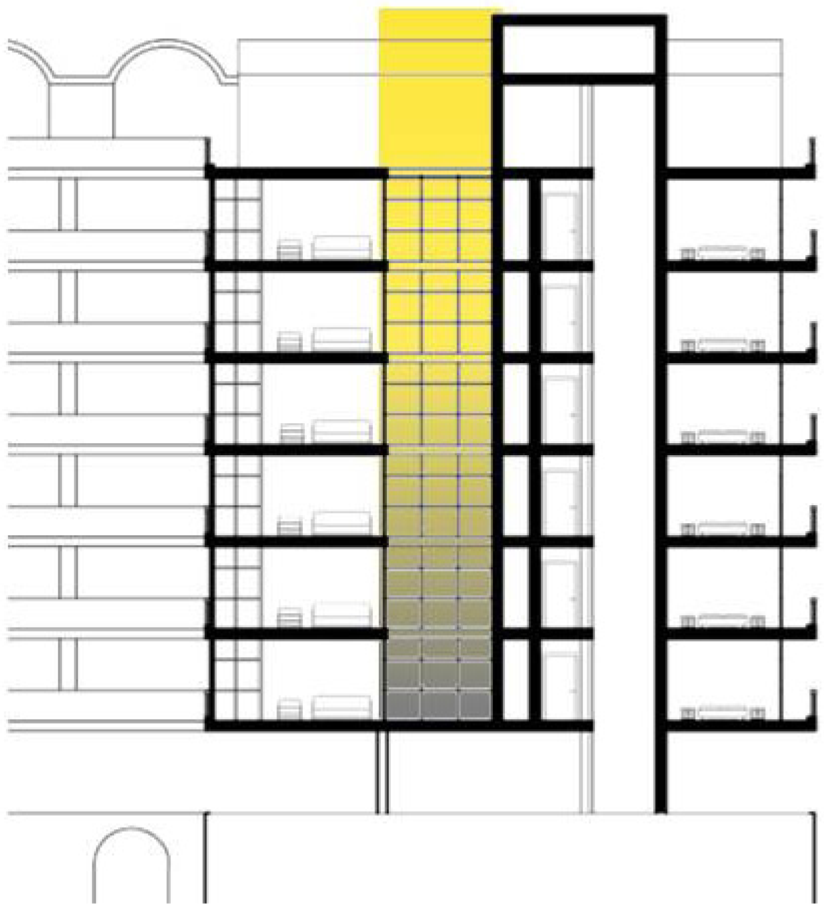


Figure 2.36: Section - Lightwell

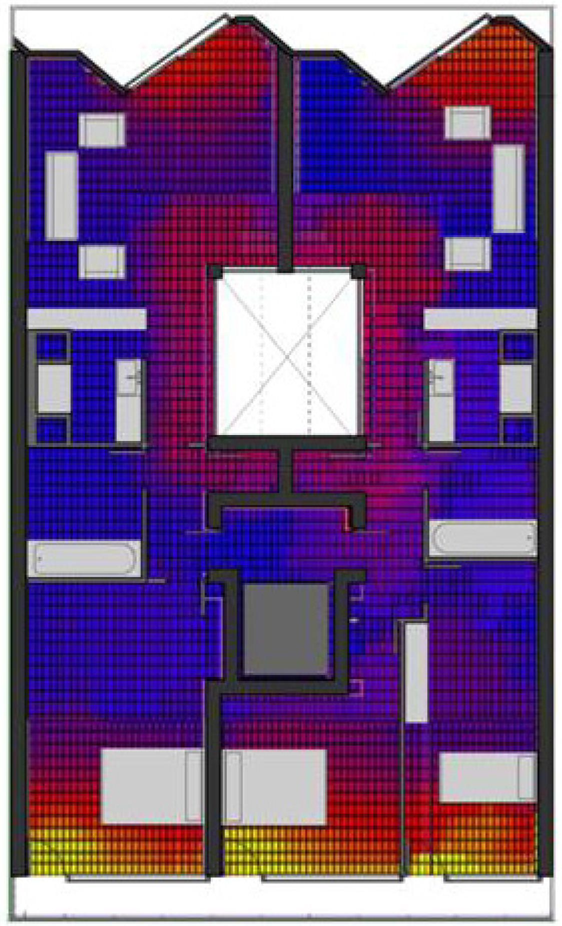
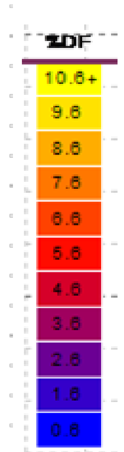


Figure 2.35: Daylight factor - Interventions



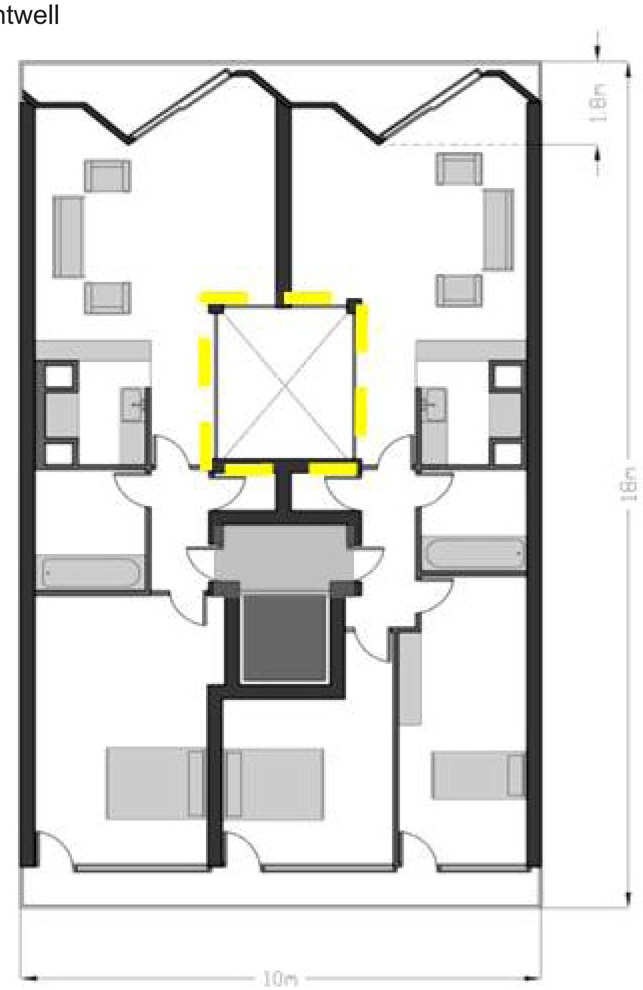


Figure 2.37: Plan - Lightwell

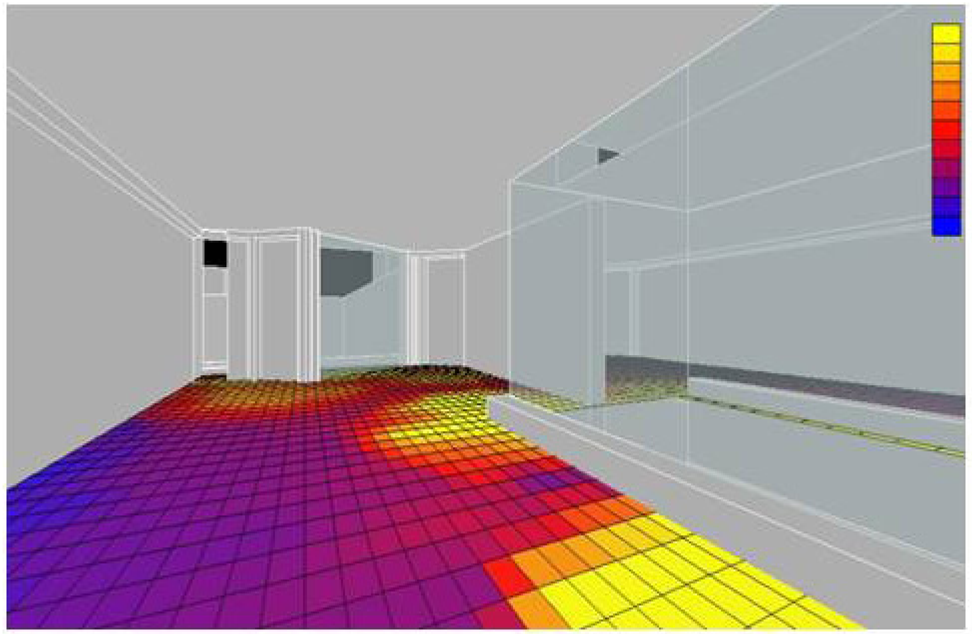


Figure 2.38: Daylight factor

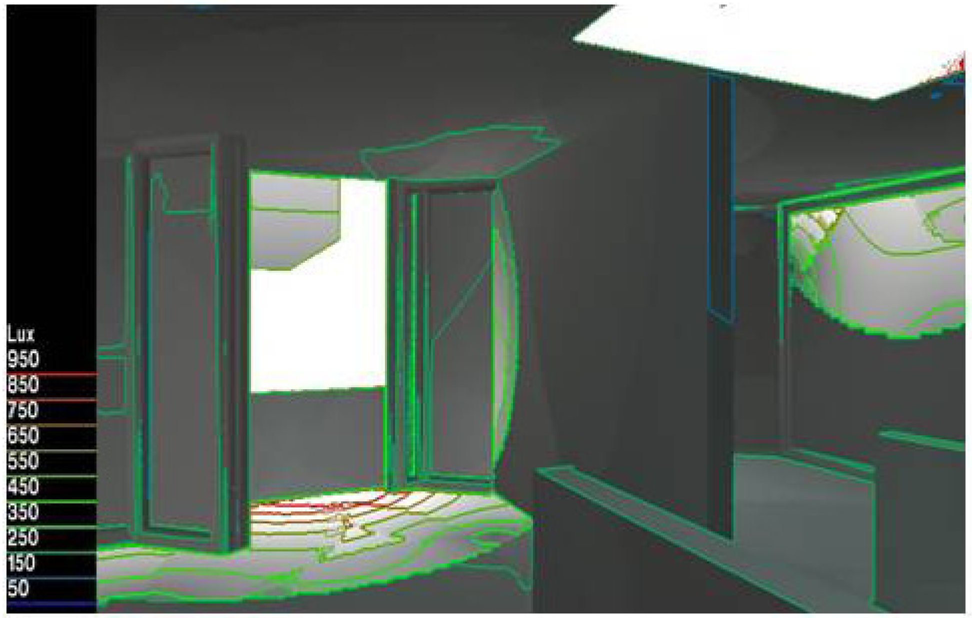


Figure 2.39: Illuminance

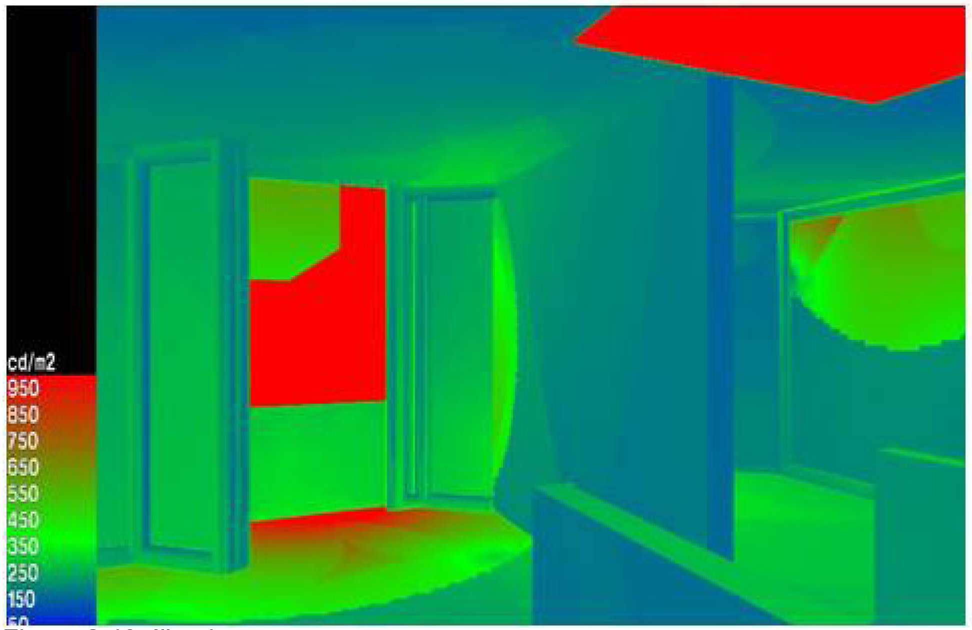


Figure 2.40: Illuminance

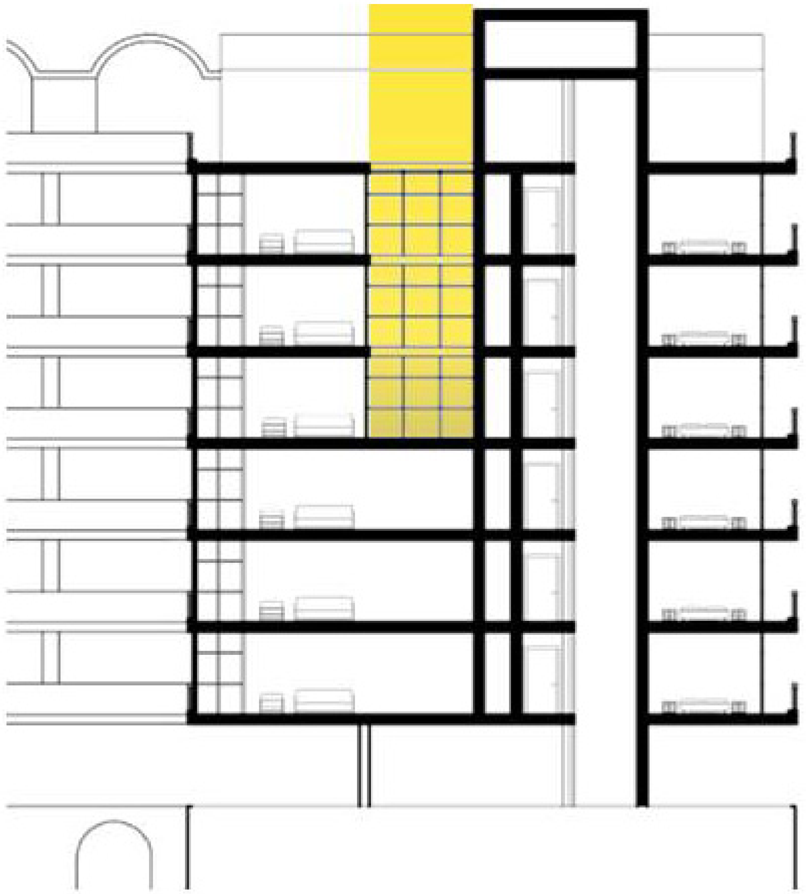


Figure 2.41: Section - Adjusted Lightwell

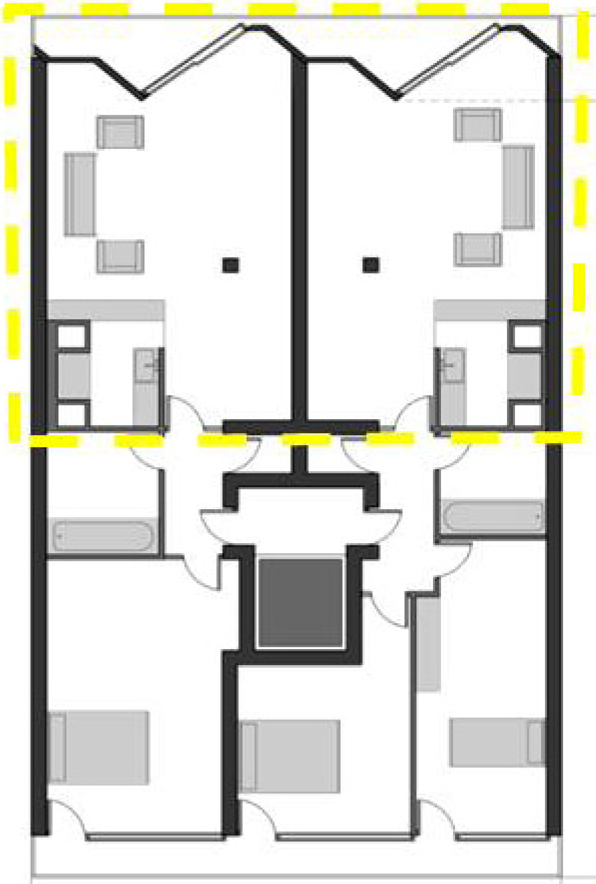
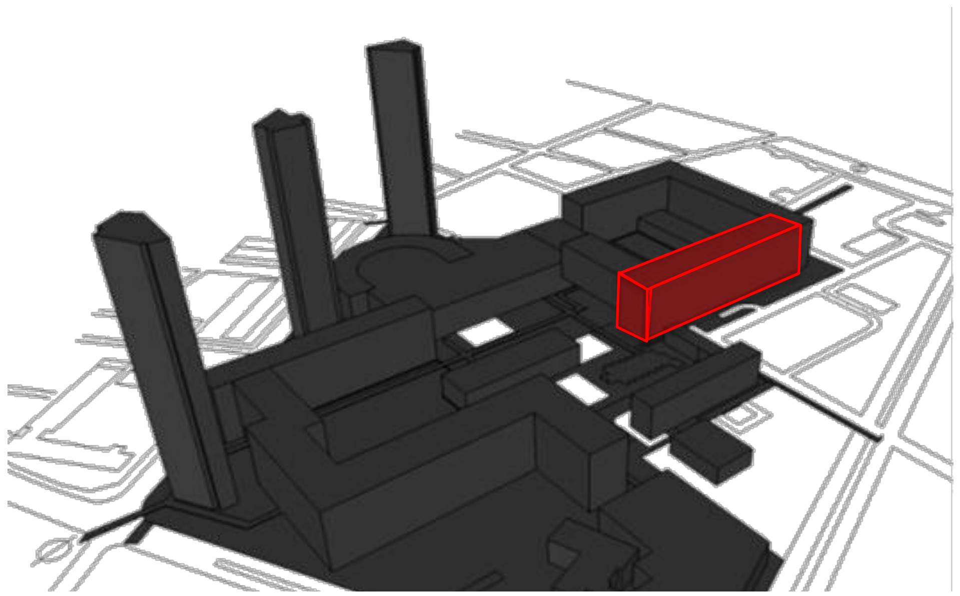


Figure 2.42: Plan - Bottom floors

Further analyzing the introduction of the light well, one of the observations that were made was that the light does not penetrate to the bottom three floors of the block thus not catering to improving the daylight quality within the apartments. As seen in Fig. the bottom three floors are given additional space within the living areas and the light well is eliminated thus improving the quality of space architecturally and if not, improving visual comfort (figure 2.41 and figure 2.42).



Section 2.9 Andrewes House - South

Thermal Mass Analysis

Sensitive analysis was done in TAS trying to understand the influence of the mass in the apartment.

In terms of fieldwork and the occupant interviewed , the concrete walls were taken into account without any additional materials like furniture, internal finishes and wall furnishings. Since the occupant is of a professional class with young children, the amount of personal belongings is less. In the future, with the increase of number, in a family, as well as change in occupant behaviour, personal belongings would tentatively increase resulting in the need of a larger floor area. Hence simulation was done based on this scenario. This showed, that the temperatures did not change drastically hence proving that the mass effect could be off use in the future with the change in number of occupancy and living trends.

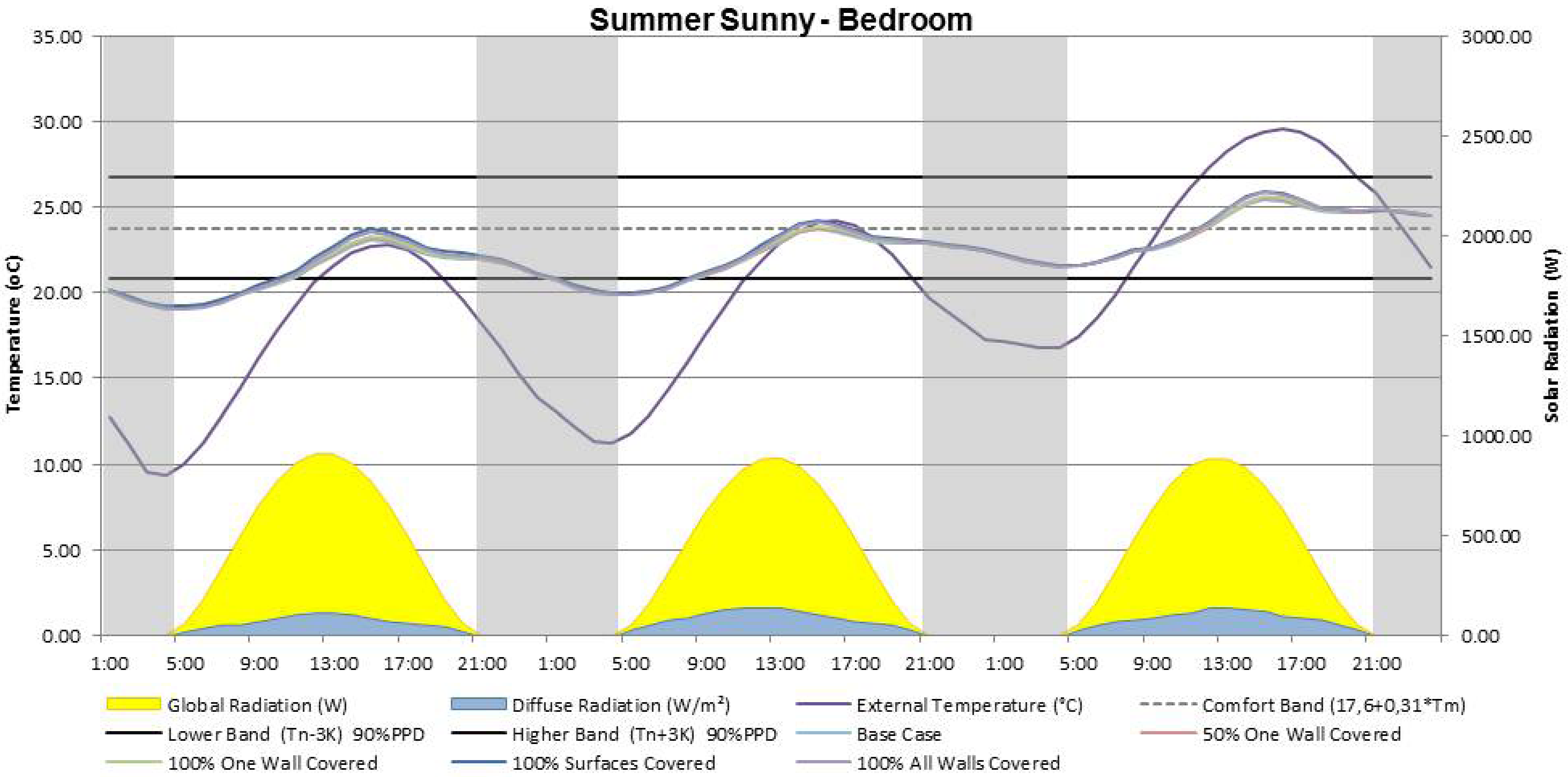


Figure 2.41: Ground Floor - Base Case

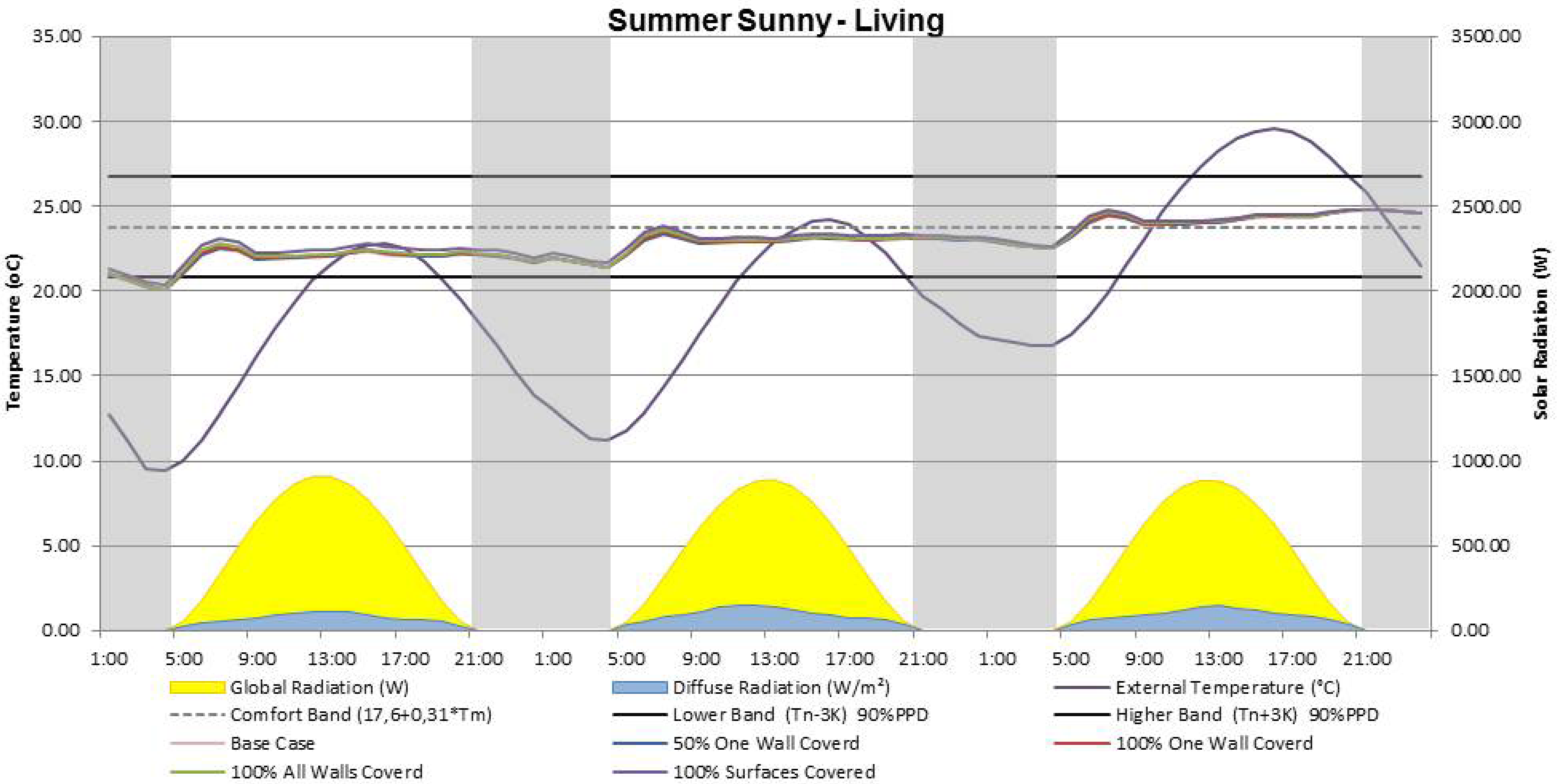


Figure 2.19: Ground Floor - Base Case


Figure 2.42: Base Case for thermal mass simulations


Figure 2.43:Additional furniture and finishes thermal mass simulation


Figure 2.44: Maximum addition of finishes and people thermal mass simulations

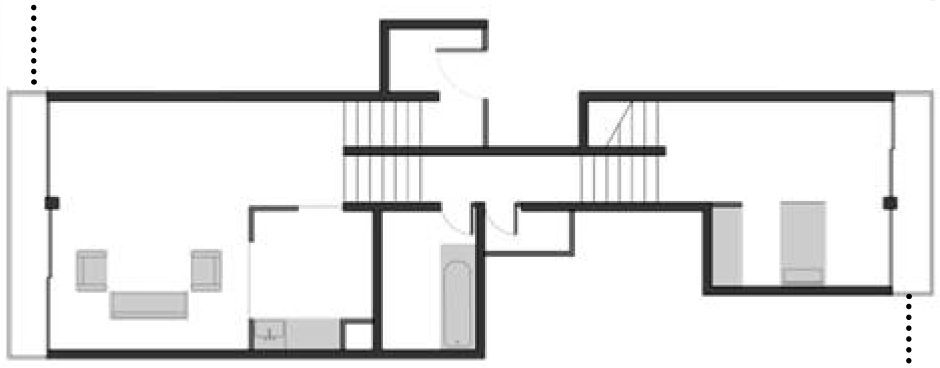
Section 3.1 Willoughby House - East

INTRODUCTION OF TYPICAL FLAT

The Willoughby House is a terrace block which lies along the Eastern edge of the estate. The sky view factor shows that there is significant obstruction occurring on the east façade due to the surrounding tall buildings. The west façade on the other hand has self shading that occurs due to the Andrewes House and Speed House that lie adjacent to it. The Willoughby house overlooks the Brandon Mews which faces the Speed Garden (figure 3.1 and figure 3.2).

This block contains 148 flats of 25 types ranging from 2-4 rooms and consisting of various typologies such as regular flats, maisonettes and penthouses. The maximum no. of flats are the maisonettes type, which has been used for this design intervention proposal for the Barbican Estate.

Central corridors run from one end of the block to the other with lift and stair cores at either end and one at the centre. The flats are typically arranged in a 'Scissors pattern' .The flats are arranged along a single-loaded corridor. In the chosen flat, all the living rooms face the garden and all the bedrooms face Moor Lane (figure 3.3 and figure 3.4).



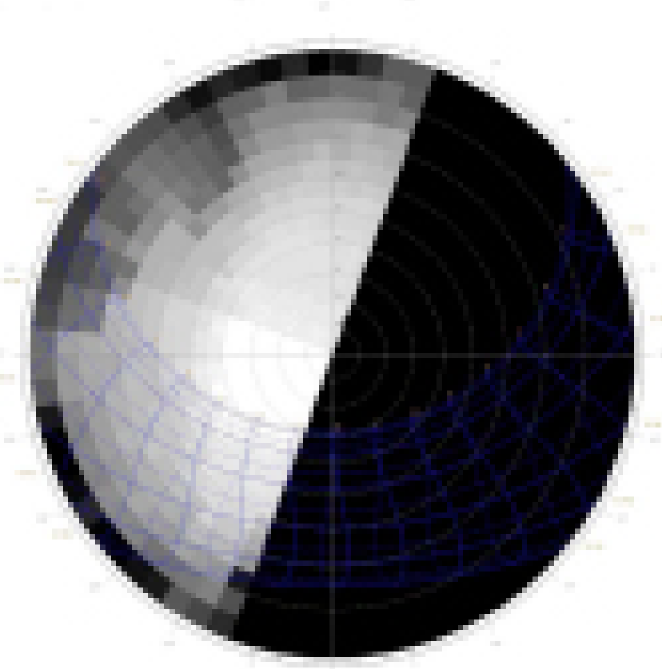


Figure 3.1: Sky factor - East facade

Fi

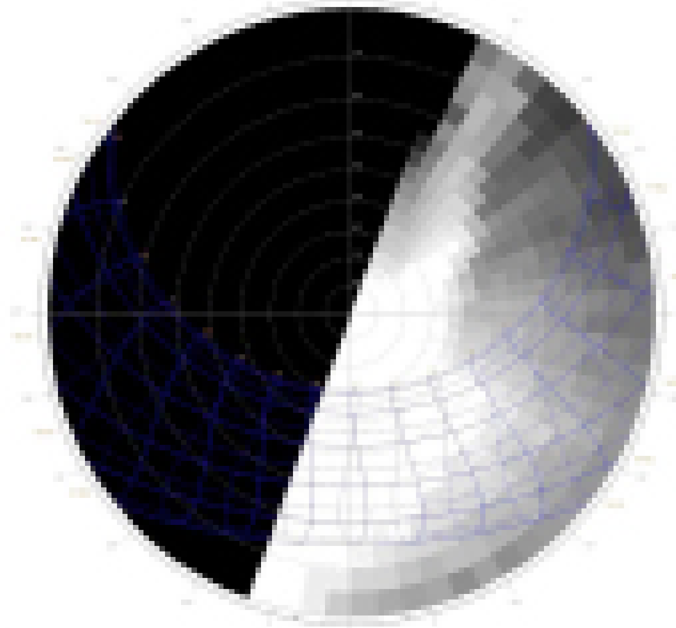
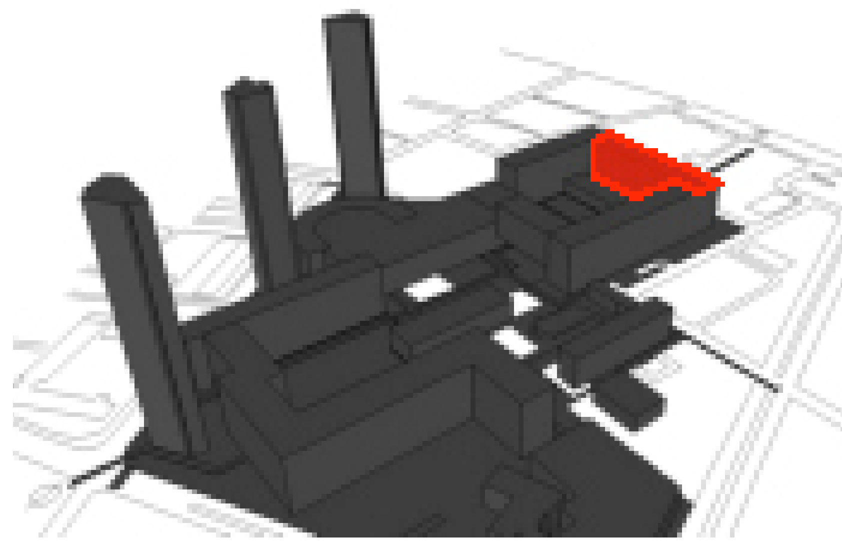


Figure 3.2: Sky factor - West facade



The construction materials had high U values for windows and walls which were 5.6 w/m²K and 1.6 w/m²K respectively with an infiltration rate of 1.4 ac/h which is the same as that of Andrewes. The total heat loss due to high glazing ratio (43% on the west and 35%on the east) for the apartment is 157.8w/k on the east and 122.4w/K on the west .The heat loss coefficient for the maisonette is 1.45w/m²K (figure 3.5).

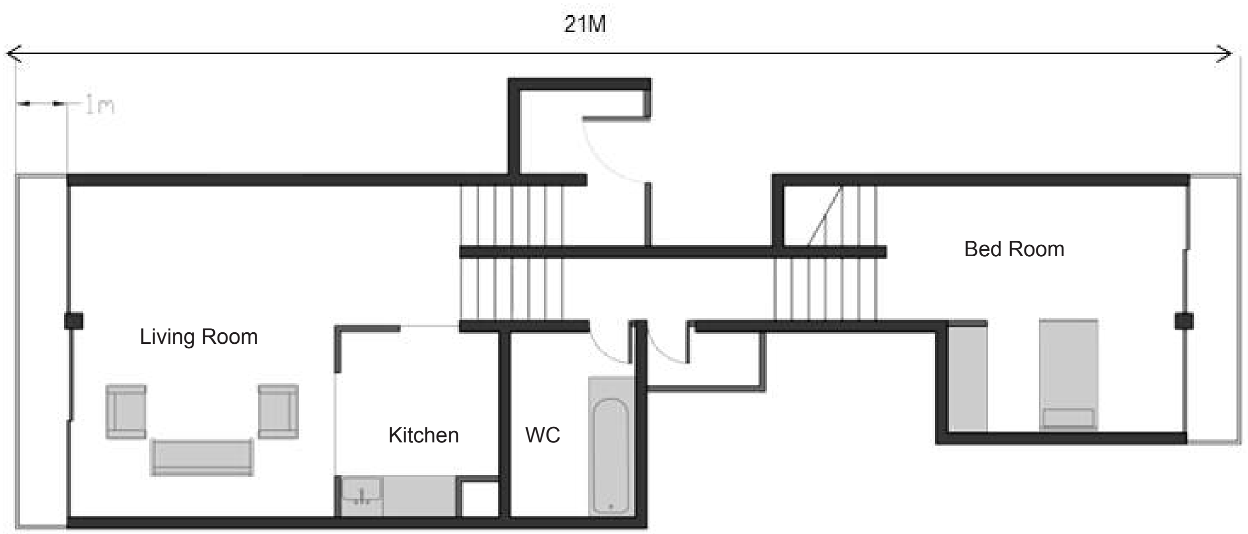


Figure 3.3: Plan - Typical flat

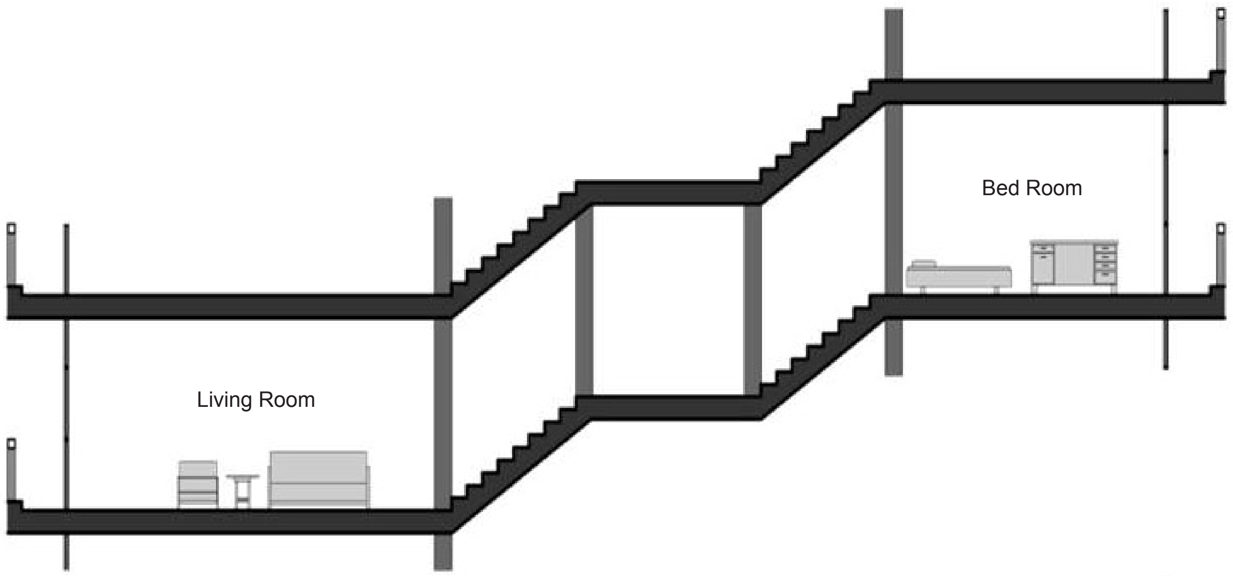


Figure 3.4: Section

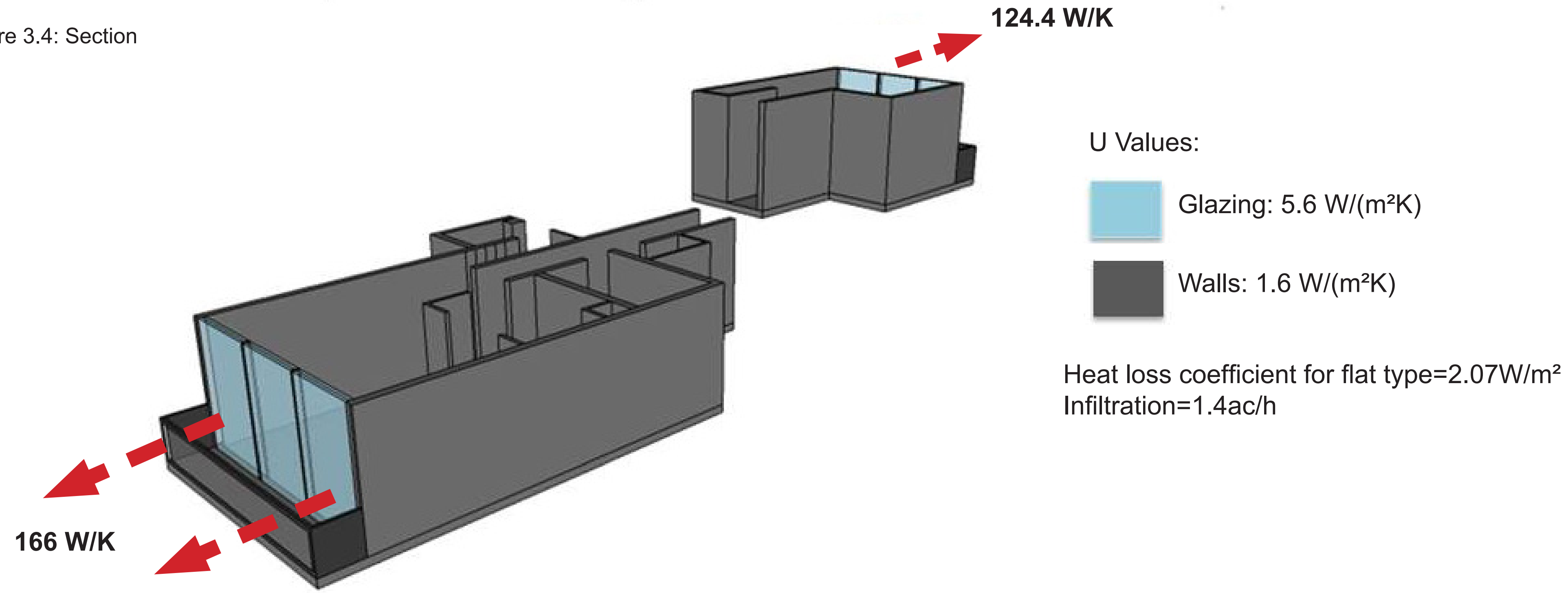


Figure 3.5: Heat loss through glazing

Section 3.2 Willoughby House - East

Heating Loads

The second apartment typology studied was in the eastern block (Willoughby). It has an east to west orientation. As a focus, the most common flat, in terms of its spatial configuration, was studied. The living is located on the western side of the block, facing the internal court yards and the bedrooms on the east facing the street. The total area of the flat is 92m². A similar process was undertaken for Willoughby as per done with Andrewes - South Block, in terms of the possible interventions. The only major desirable intervention taken was to incorporate the existing balcony into the internal layout of the plan. Thus increasing the floor area of the bedroom to around 100m².

The first set of simulations (using EDSL TAS software) also showed that the changing of the existing single glazed windows to double glazing would in turn reduce the heating loads drastically (figure 3.6). The reduction of infiltration from 1.4ac/h to 0.25 /ach, and the addition of isulative materials to standard regulations (U Values) had an enormous impact on energy savings. Even though there were significant drops in heating load demand, a few more strategies were employed to see how much it would reduce further without diminishing the flat's qualitative aspect in the Barbican. Similar to the a South Block - Andrewes, a study the reduction of the glazing ratio did not significantly affect the heating loads as expected. However, by incorporating the balcony into the internal floor area and having to push out the existing glazing onto the balcony parapet, this resulted in a reduction of the window ratio to 20% from 43% (figure 3.7). This is so that the concrete balcony parapet is still kept in respect to the existing building. In the existing scenario, the eastern balcony of which is incorporated into the plan as an intervention, could be done so, as this balcony is not used for circulation or any recreational purpose, making it redundant to the residents. Thus by incorporating it into the plan proved to be beneficial in terms of reducing heating loads and also by gaining extra internal floor space for the bedrooms. This intervention of incorporating the balcony into the internal plan, the facade was on the external periphery of the block hence increasing the amount of solar radiation that it receives, thus reducing the heating loads needed during winter. The use of night shutters as louvers in summer would reduce the amount of solar radiation decreasing the need for cooling loads. As per the simulations, currently there is no overheating hence no cooling loads with the night shutters/ louvers.

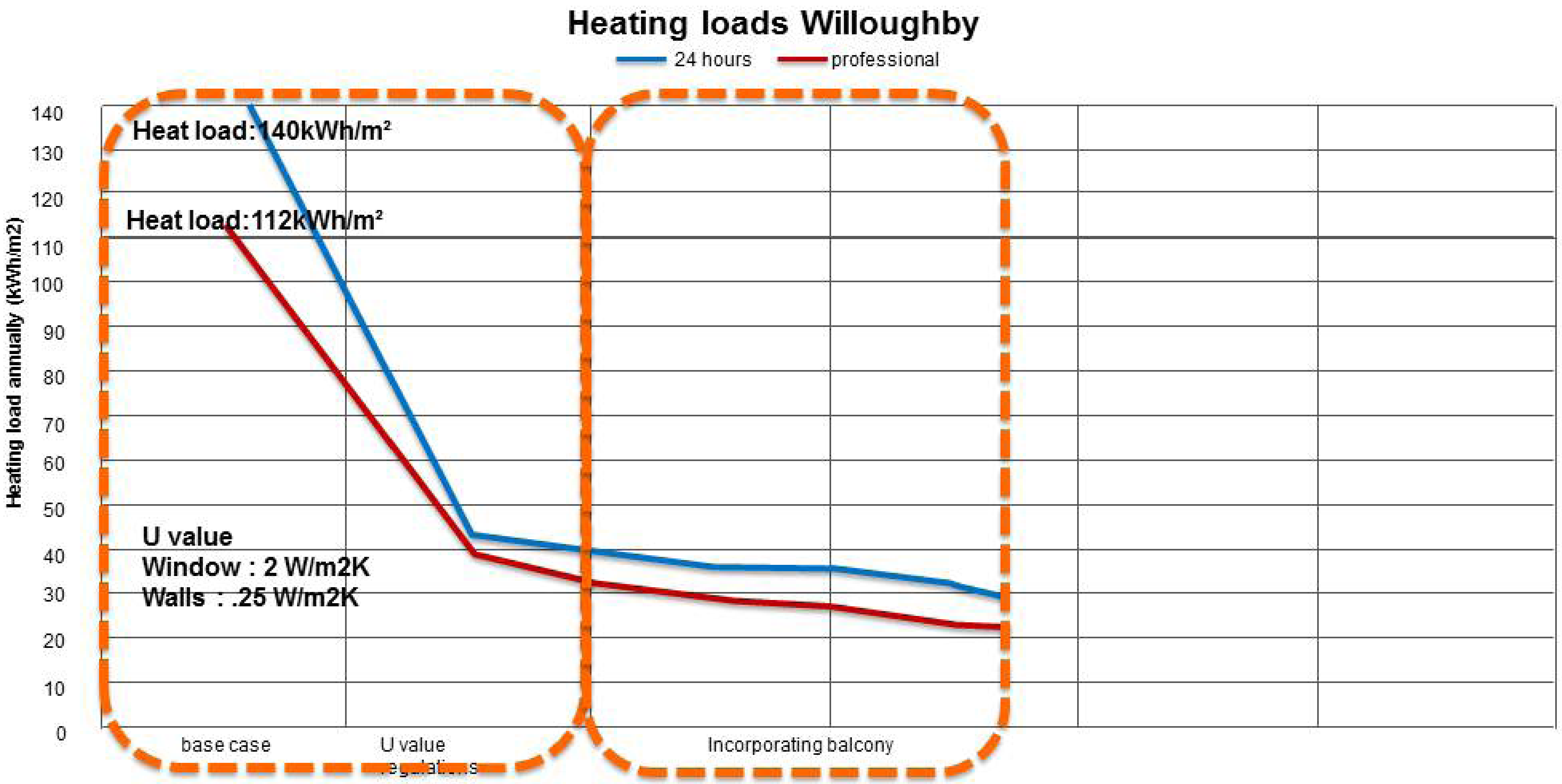


Figure 3.6: Thermal analysis

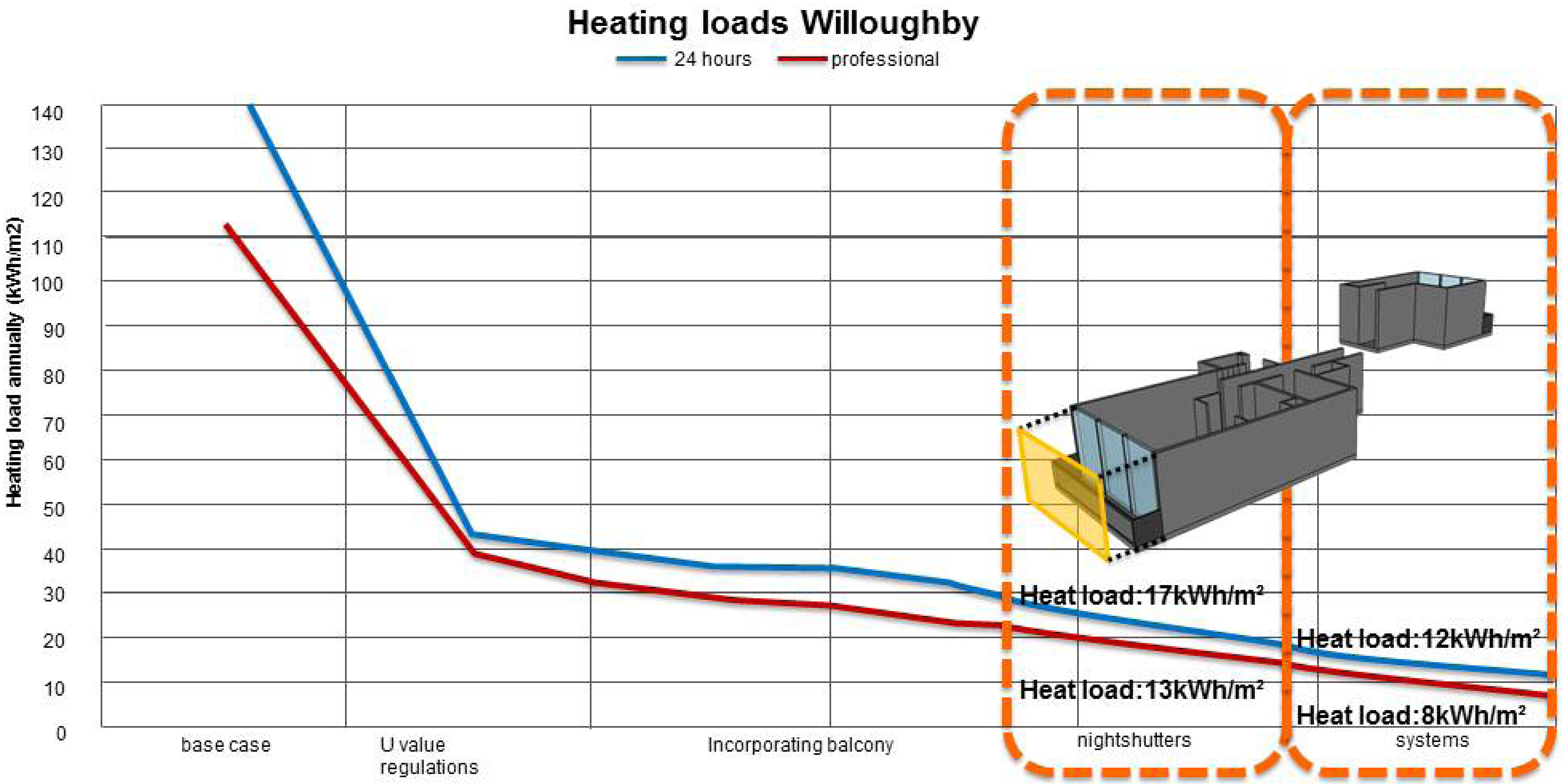


Figure 3.7: Thermal analysis

On the second set of the simulations, each room was zoned separately. The thermostat was adjusted separately to cater for different occupational needs, timings and comfort requirements of the bedroom and living space. These simulations were done exactly as per Andrewes, in terms of its scheduling in timing and comfort temperatures. With the ability to change the heating system, the energy spent on heating also dropped below 10 kWh/m² yearly, reaching 8 kWh/m² (figure 3.8).

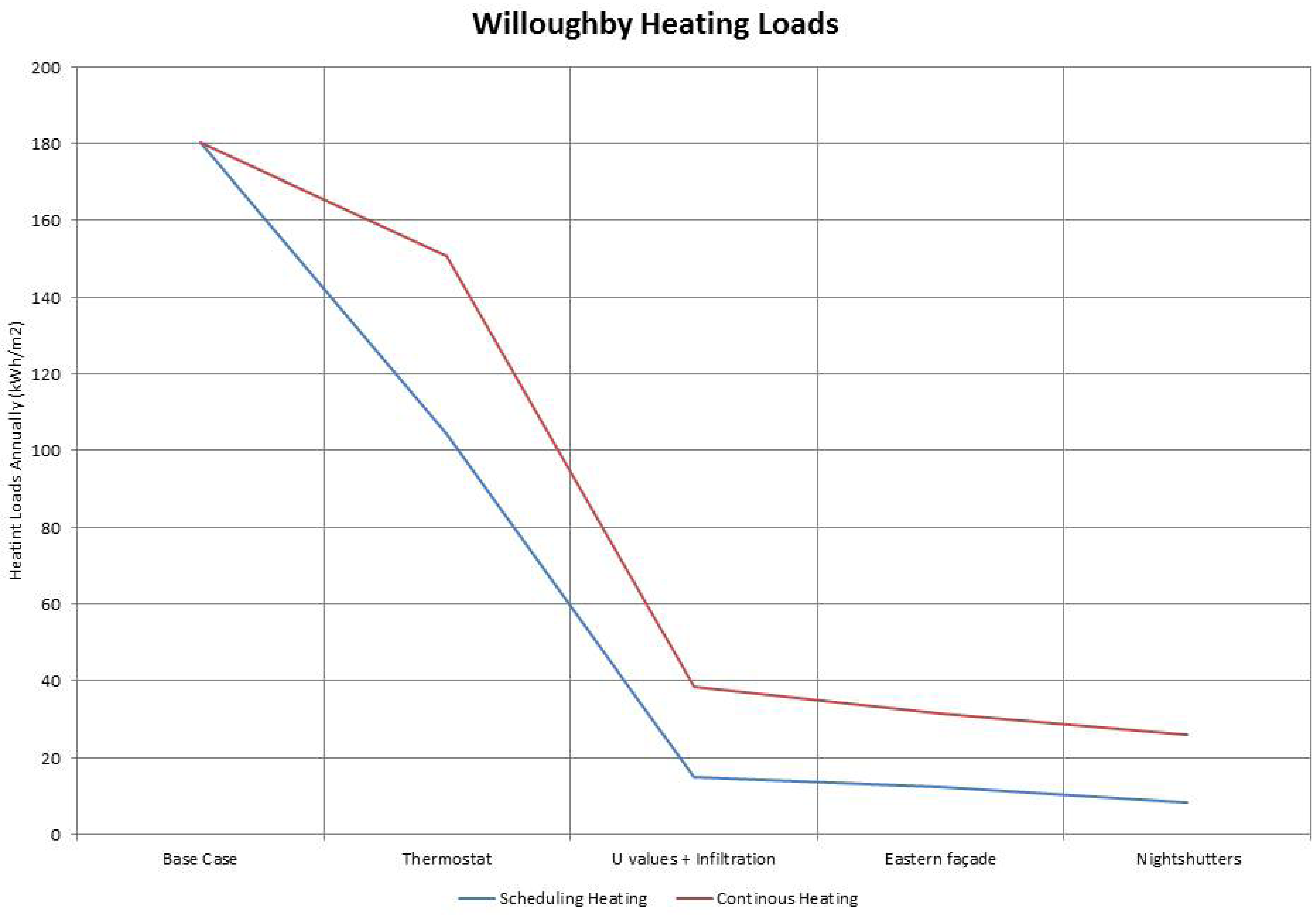


Figure 3.8: Heat Load

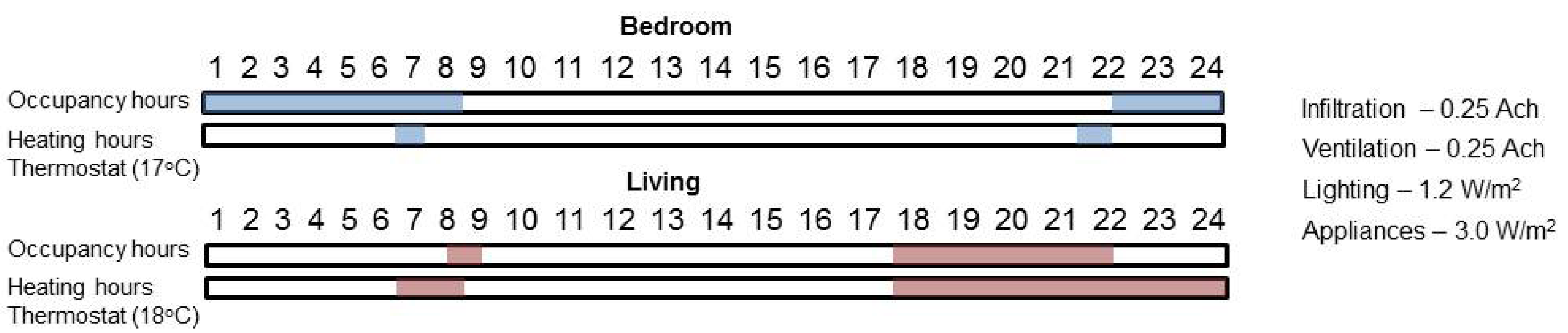


Figure 3.9: Thermostat scheduling pattern

Section 3.3 Willoughby House - East

WINTER CLOUDY - LIVING AND BEDROOM

Since the temperatures are lower in winter and there is no heat gain from direct solar radiation in a cloudy situation additional heat from systems will be required to achieve comfort levels.

SUMMER SUNNY - LIVING

The figure 3.11 shows the temperatures for the living room. Contradictory to the pattern of the bedroom, the living room's temperature after midday. The sun inclination in the afternoon is not blocked by the balcony. hence similar strategies of using the night shutters as louvers in the summer is used for living as well.. After using the night shutter as louvers, the temperature decreases below 28 °C .As mentioned previously, the louvers would act to decrease overheating in the living room on a summer day.

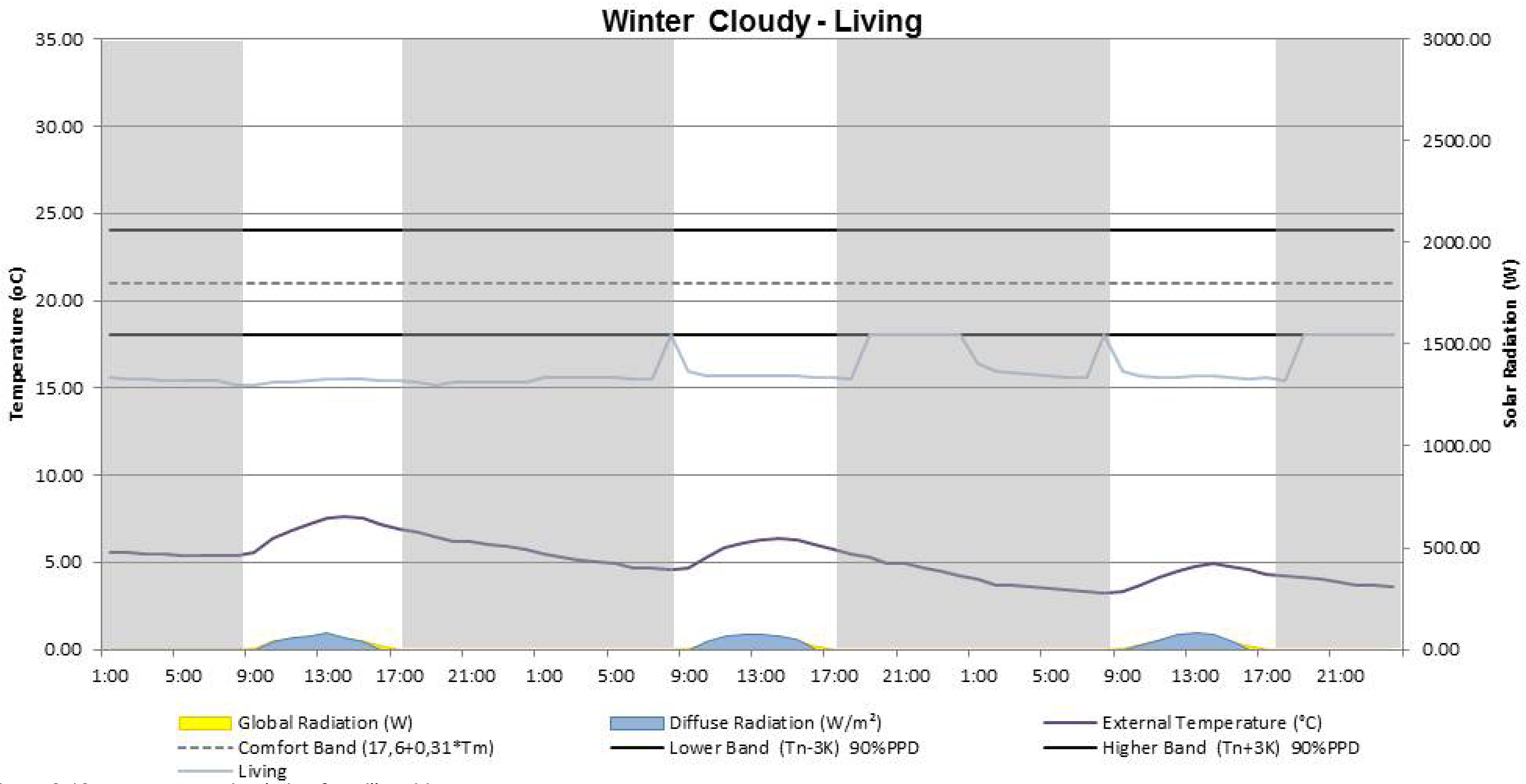


Figure 3.10: temperature simulation for willoughby

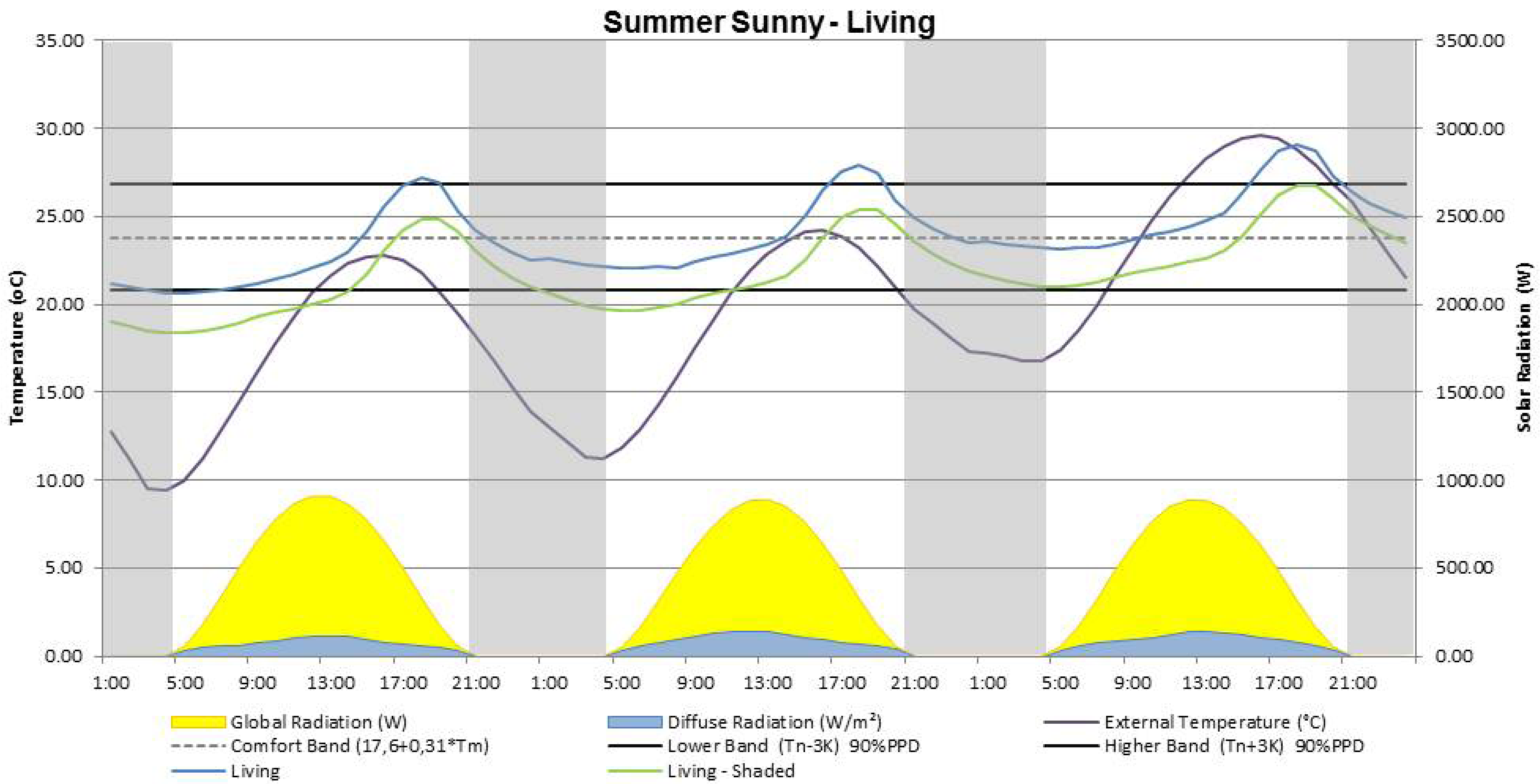


Figure 3.11: temperature simulation for willoughby

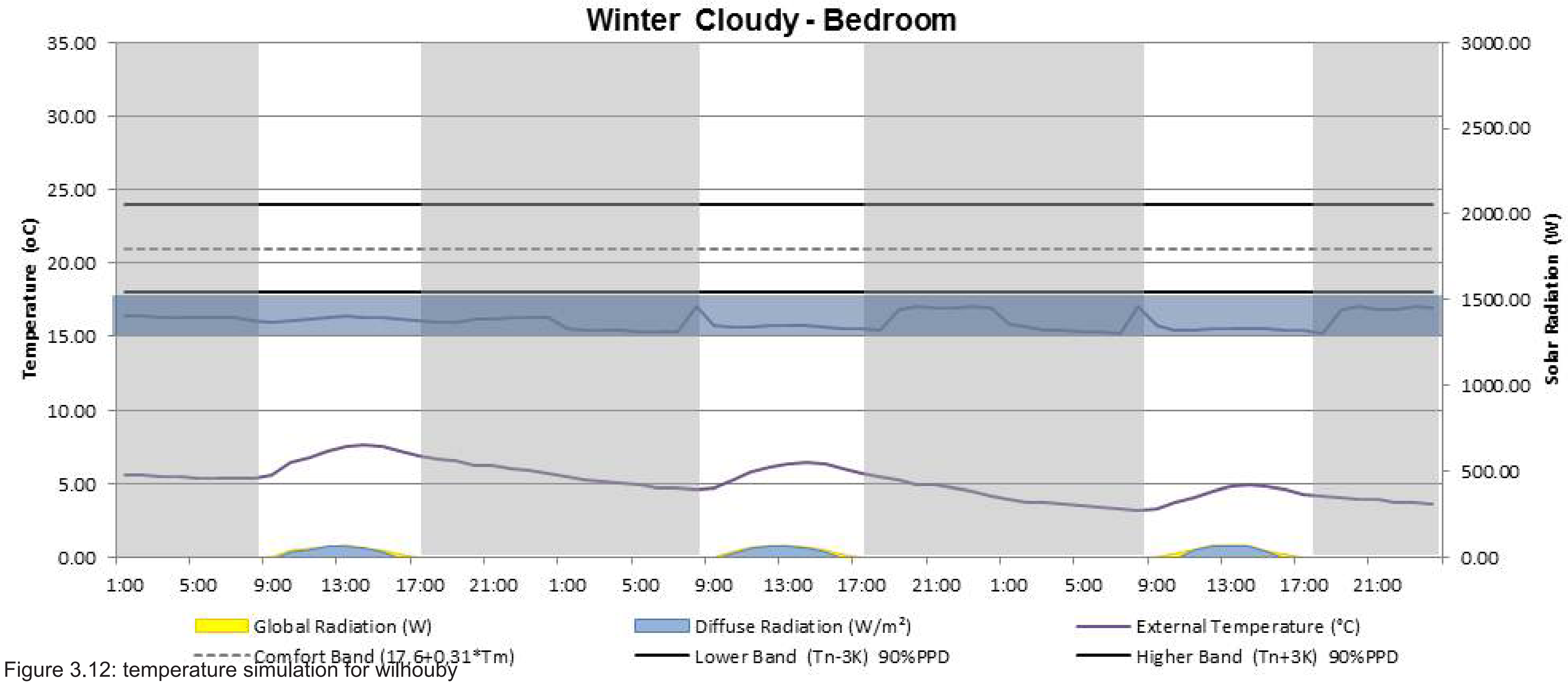


Figure 3.12: temperature simulation for wilhouby

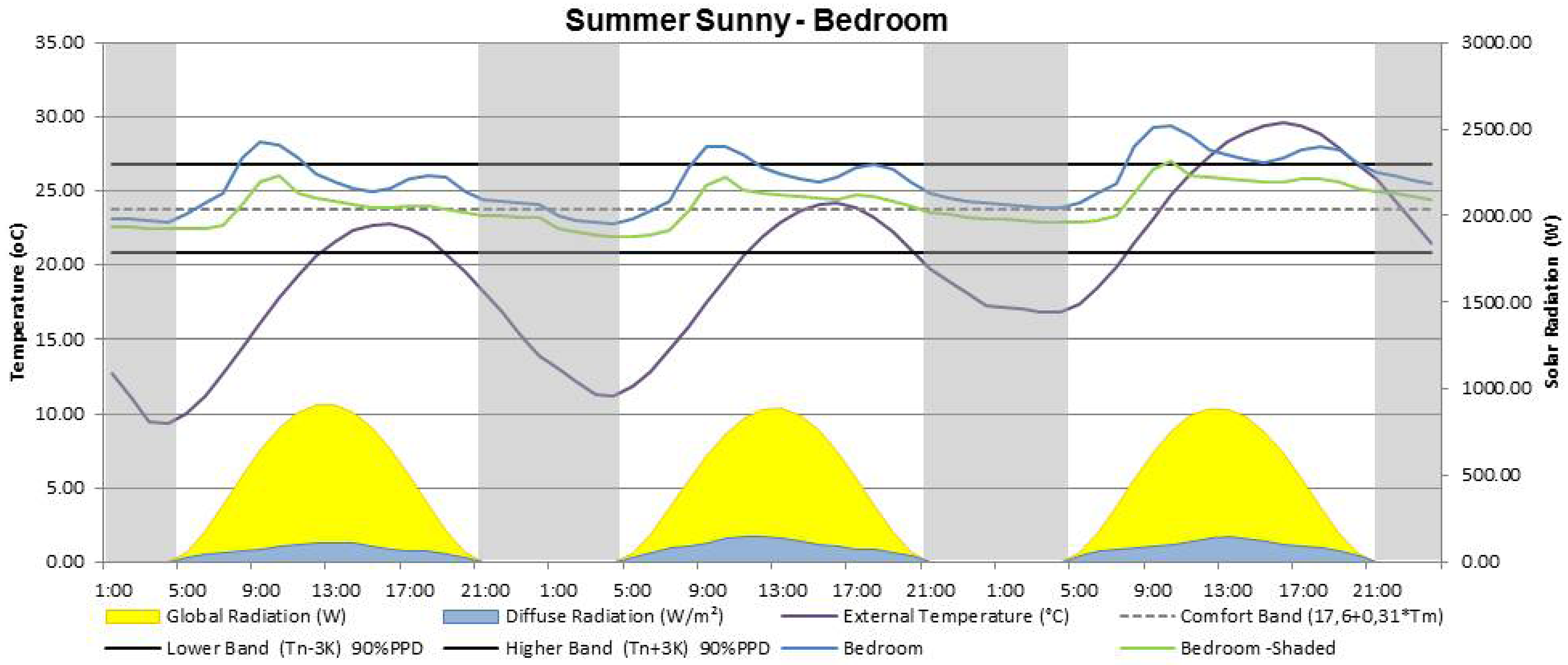


Figure 3.13: temperature simulation for willoughby

Figure 3.14: thermostat scheduling

SUMMER SUNNY- BEDROOM

the figure 3.13 shows the temperature pattern for a particular day in summer. The period of the highest temperature of the room does not coincide with the increase of external temperature. This is because it is an eastern facing room. The space receives solar radiation through the morning increasing its temperature. The sun has inclined angles during the first hours of the day and as the balcony was incorporated into the plan, it does not act as a shade from direct solar radiation and thus allows the room to overheat during summer. The temperature reached 30 °C before midday while the external temperature was still 22 °C. The night shutters were integrated in the summer design thus acting as louvers ,it was possible to decrease the temperature during the whole day to comfort levels.

Section 3.4 Willoughby House - East

Night shutters and incorporating the balcony

Strategies similar to that of the Andrews block were adapted in both the living and bedroom of the Willoughby flats that is facing the west and east respectively. The night shutters as seen in the figures work in an adaptive manner based on occupancy control.

In the bedroom of the flat which faces the east the balcony has been incorporated within the internal space of the room. This hence increases the amount of solar radiation on the eastern façade. The night shutters in this case help control the amount of heat penetration internally. As seen in the figures during summer the shutters can be pushed down to reduce the excessive radiation within the flats whereas in winter the shutters are up in order to allow more radiation so as to achieve comfort levels.
The two figures for summer months with open as well as closed shutters indicate occupant control to achieve comfortable temperatures within the flats.

As the surrounding buildings facing the eastern façade of the Willoughby block are increasing in height and density the views from the bedroom become limited due to which the night shutters can be used continuously by the occupant's through the summer months.

Figure 3.15: Willoughby existing eastern facade

Figure 3.16: Willoughby after interventions eastern facade

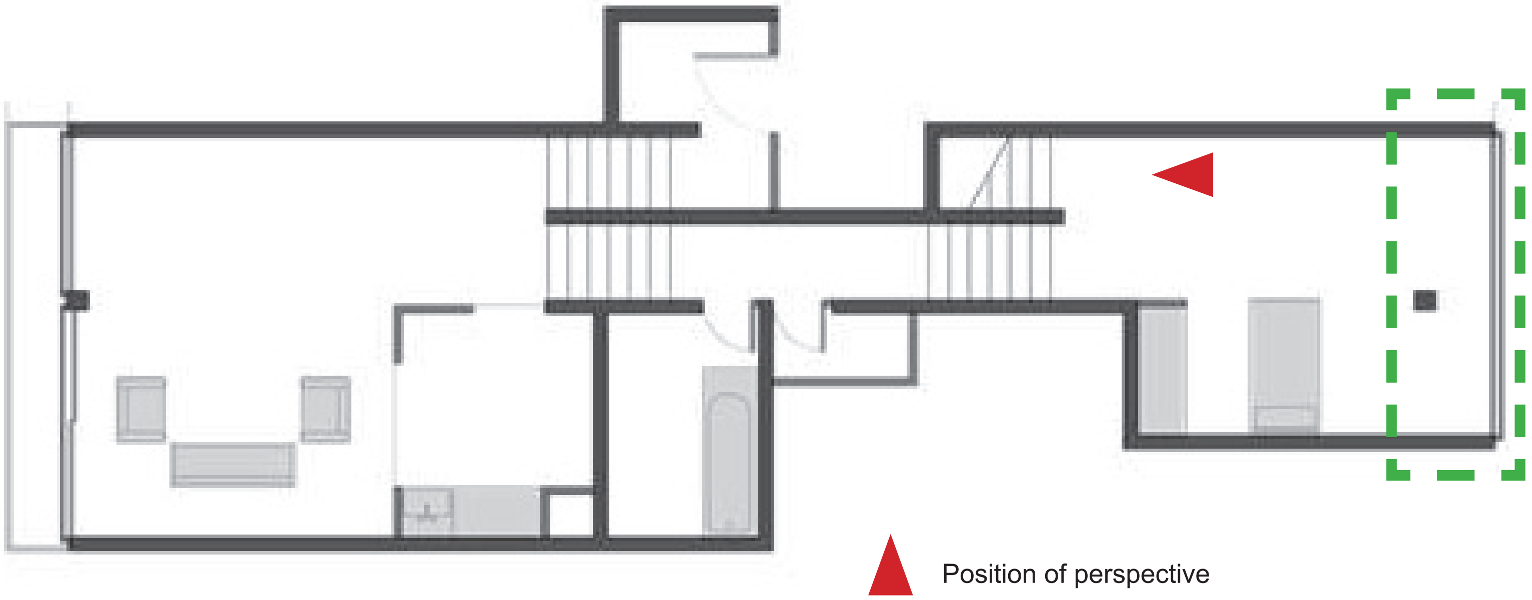


Figure 3.17: Winter cloudy shutters up

Figure 3.18: Winter nite shutters closed

<u>Figure 3.17: Winter Cloudy - Shutters up</u>
External Temperature: 6.4 °C
Internal Temperature: 15.7 °C

<u>Figure 3.18: Winter Night - Shutters Closed</u>
External Temperature: 4.7 °C
Internal Temperature: 15.3 °C

<u>Figure 3.19: Winter Sunny - Shutters up</u>
External Temperature: 13.0 °C
Internal Temperature: 18.0 °C

<u>Figure 3.20: Winter Cloudy - Shutters down</u>
External Temperature: 13.0 °C
Internal Temperature: 17.0 °C

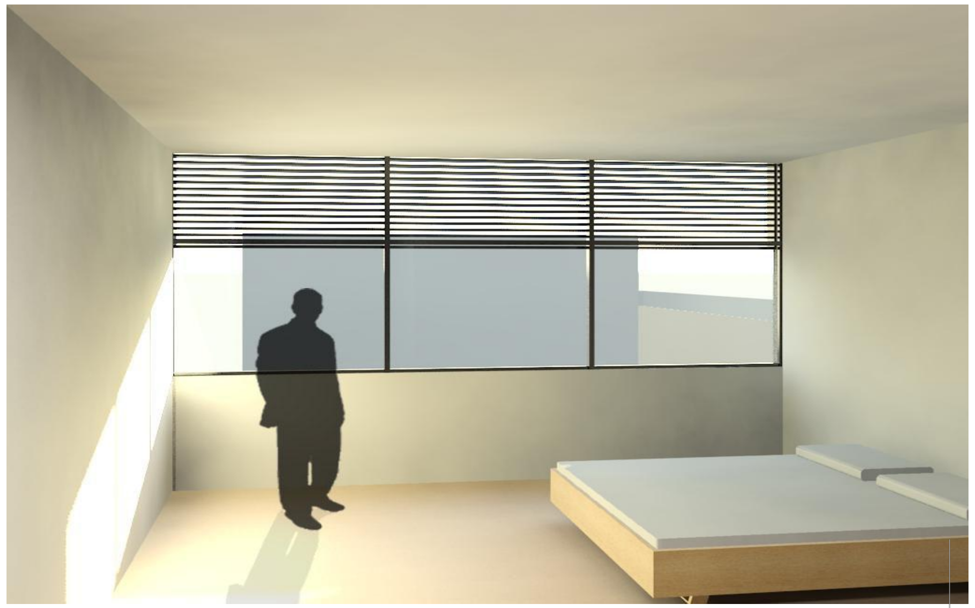
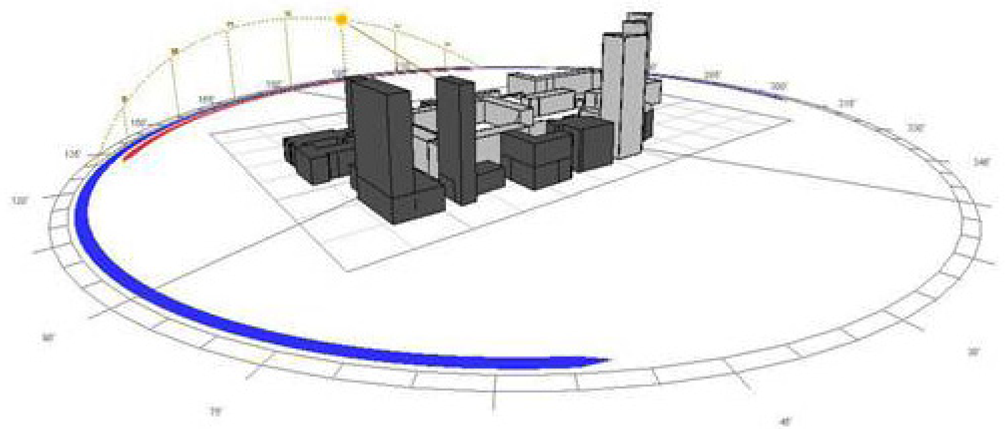


Figure 3.19: Winter sunny shutters up

Figure3.20: Winter sunny shutters down



Section 4.1 Renewable energy

PV Panels

After looking all the passive strategies, within the blocks of the Barbican estate, systems such as photovoltaic panels and district heating system was used as renewable energy to further reduce energy loads. The design proposal wanted to achieve minimum energy loads only through passive strategies). By adding the renewable energy systems. these heating loads was brought down (Andrewes was 12 wh/m^2) and (Willoughby was 8 wh/ m^2).

Fig 4.1 is the solar radiation runs from Ecotect was done to determine the amount of solar radiation received on the roofs of the blocks. The calculations show the amount of energy that is produced from these allocated spaces. In addition to this energy supply for future scenarios, where the surrounding buildings are growing in density and height, Fig. 4.2 shows the highlighted area so the roof of the blocks where we can put the PV panels. The Barbican Center which is the commercial building of the complex can house the PV panels on the roof, as it would be one of the few structures that would not receive overshadowing from the surrounding buildings as it is located within the centre of the site.

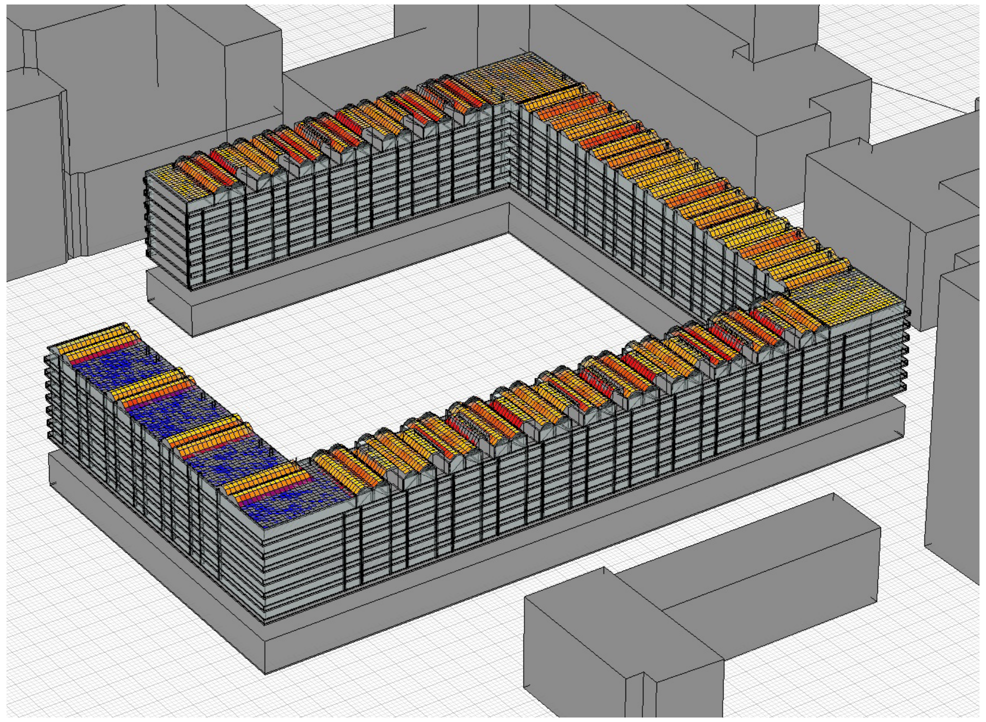
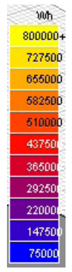


Figure 4.1: solar radiation for the roof



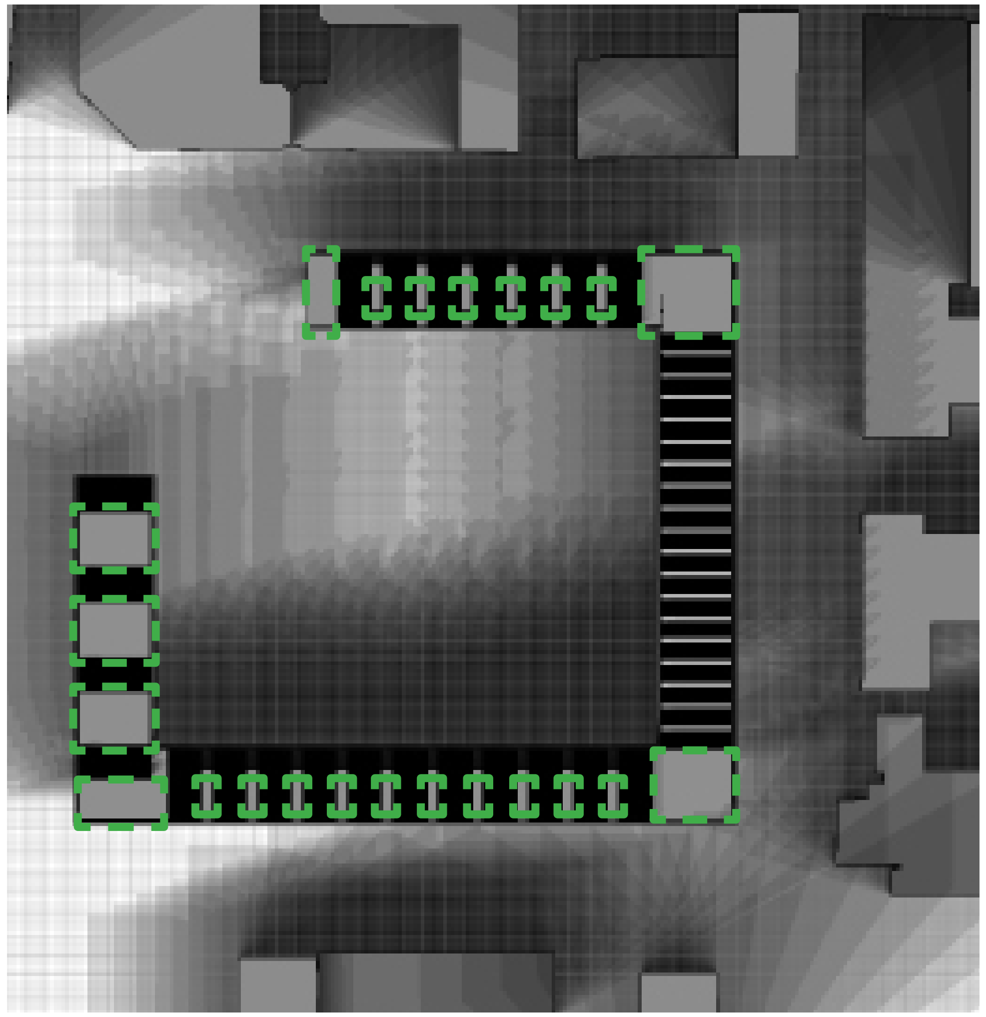


Figure 4.2: shadow analysis for the barbican site

Total Block Area - 41440 m2
Heating 5.0kWh/m2 - 207000 kWh/y
Appliances + Lighting 3.4kWh/m2 - 140000 kWh/y
Total Demand – 8.4kWh/m2 - 347000 kWh/y

- ESTIMATED AREA OF PV PANELS-1200m^2
- ASSUMING 6kW, 30 PANELS COULD BE FIT 46m^2
- EVERY 30 PANELS GENERATES 5500kWh OF ENERGY
- TOTAL NUMBER OF PANELS REQUIRED 780

HENCE
143000kWh/A ENERGY CAN BE GENERATED FROM THE BARBICAN 4 RESIDENTIAL BLOCKS

- ESTIMATED AREA OF PV PANELS OF BARBICAN CENTRE-8200m^2
- ASSUMING 6kW, 30 PANELS COULD BE FIT 46m^2
- EVERY 30 PANELS GENERATES 5500kWh OF ENERGY
- TOTAL NUMBER OF PANELS 5340

HENCE
979000kWh/A EMERGY CAN BE GENERATED FROM THE BARBICAN CENTRE

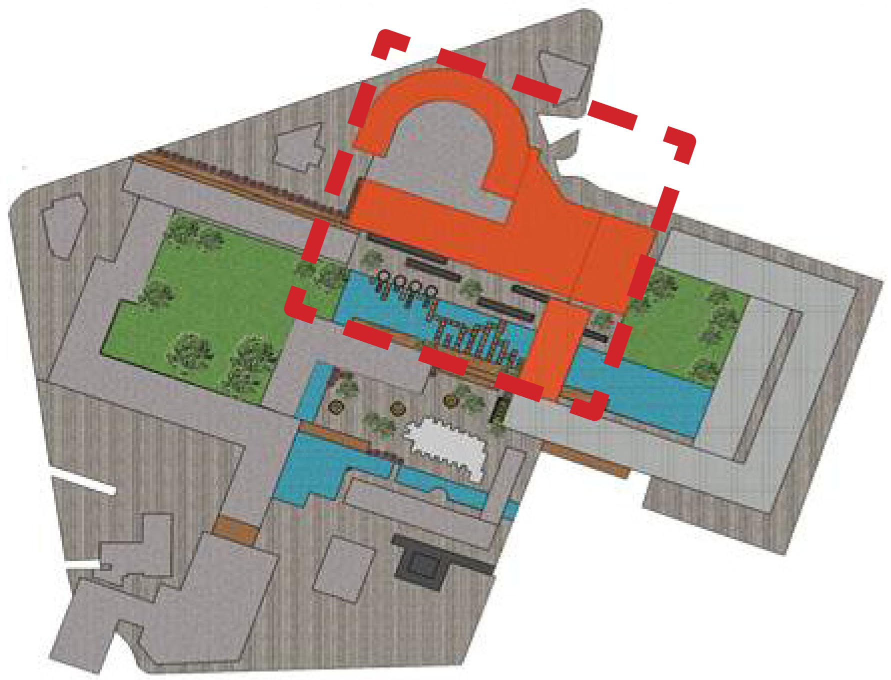


Figure 4.3: additional area available for future scenario

Section 4.2 District Heating System

District Heating System

The Barbican estate has a district heating system connected to an electrical under floor heating system. This system does not allow occupancy control of the thermostat. As this design proposal caters to occupant sensitivity, scheduling of the thermostat was important so as to control the temperatures within the flats as well as reduce heating demands. In order to achieve this, the current system was replaced by a hot water under floor heating system. As seen from the Fig.4.4 the system is placed on top of the concrete slab with a thickness of 50cm overplayed with a circuit of hot water pipes.

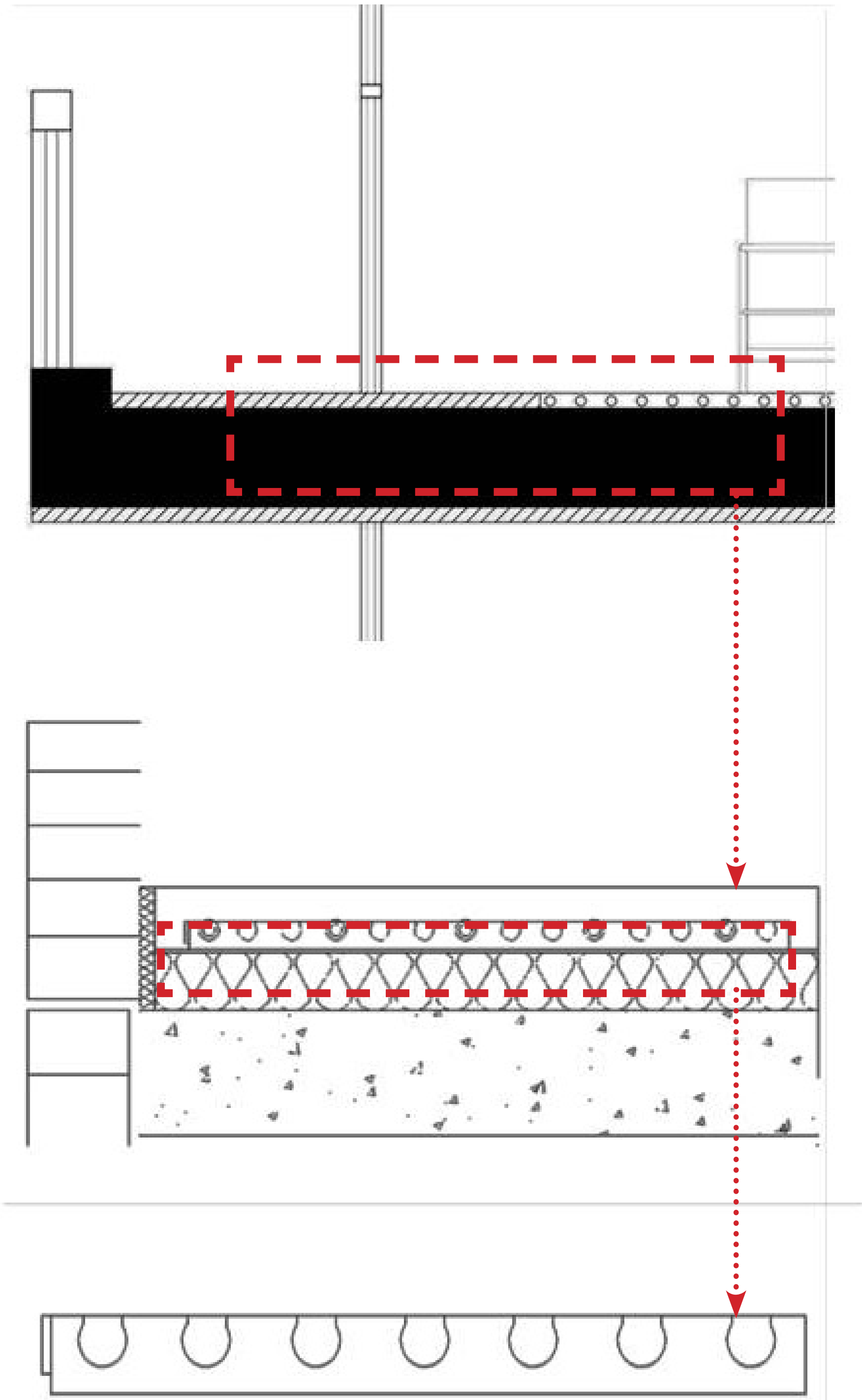


Figure 4.4: hot water heating system layout

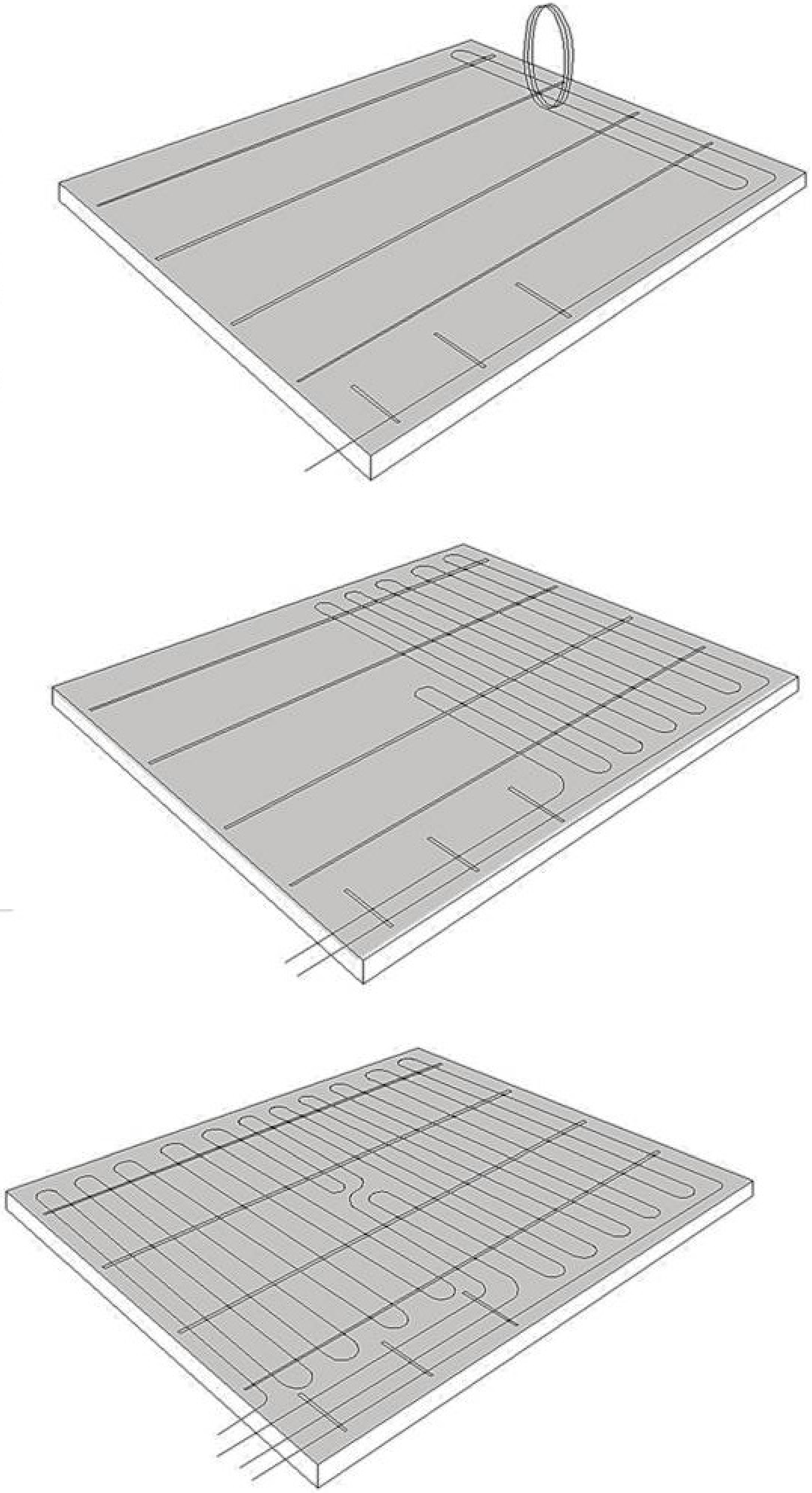


Figure 4.5: hot water heating system circuit diagram

Section 5.1 Future Scenarios

As per the fieldwork, which is shown in Fig 5.4 and after the interviews with the residents, one of the first conclusions that was drawn was that the Barbican estate was designed to cater to professionals. Considering the next 20 to 50 years, as per statistics shown in Fig.5.3 the families grow larger and area required for these families will increase. Thus, a certain number of the apartments per block would need to cater to a scenario of the increase in family number. Considering the Barbican is supposed to work as a gated community, catering to this increase would avoid them from moving out of the Barbican.

To justify such a scenario is possible, analytical work was done, which involved simulations for the same apartment size with increased number of people (2 to 4) figure 5.4, and also increasing the floor area (by joining two apartments together) with the increase of the people per apartment, Conclusion drawn was that the heat loads don't change with respect to the increase of the number of people as the thermal mass for the building type as mentioned in the previous section suffices to maintain the comfort levels.

The existing thermal mass would also cater to the climate change in 2050 keeping in mind the increase in temperature for both in winter and summer, as the thermal mass in the building type will be beneficial to both the heating loads in the winter and the cooling loads in summer (figure 5.6 and figure 5.7).

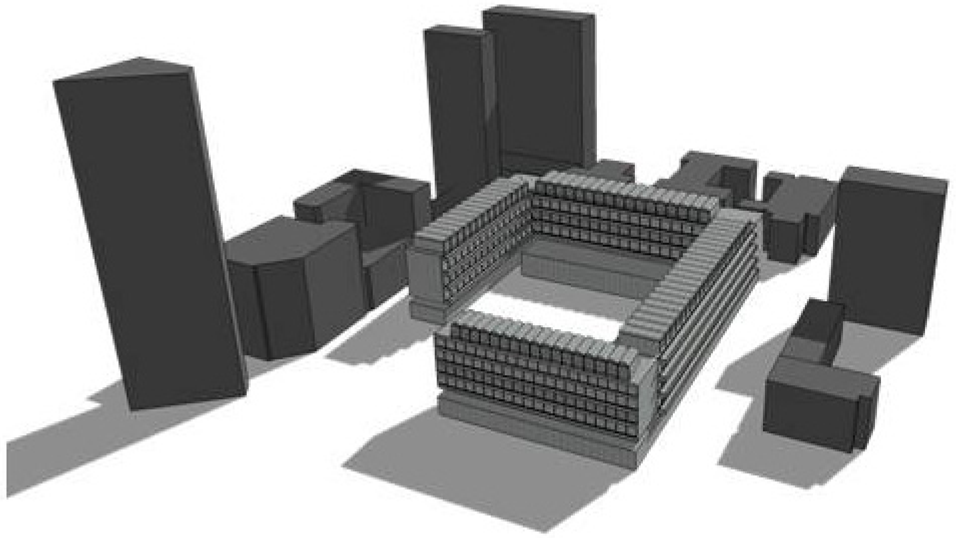


Figure 5.1: First Floor - Base Case

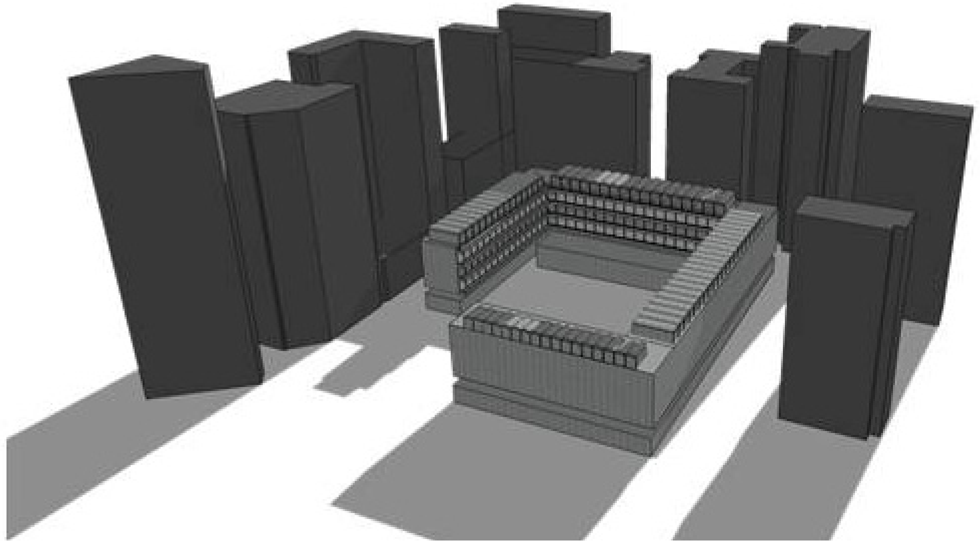


Figure 5.2: First Floor - Base Case

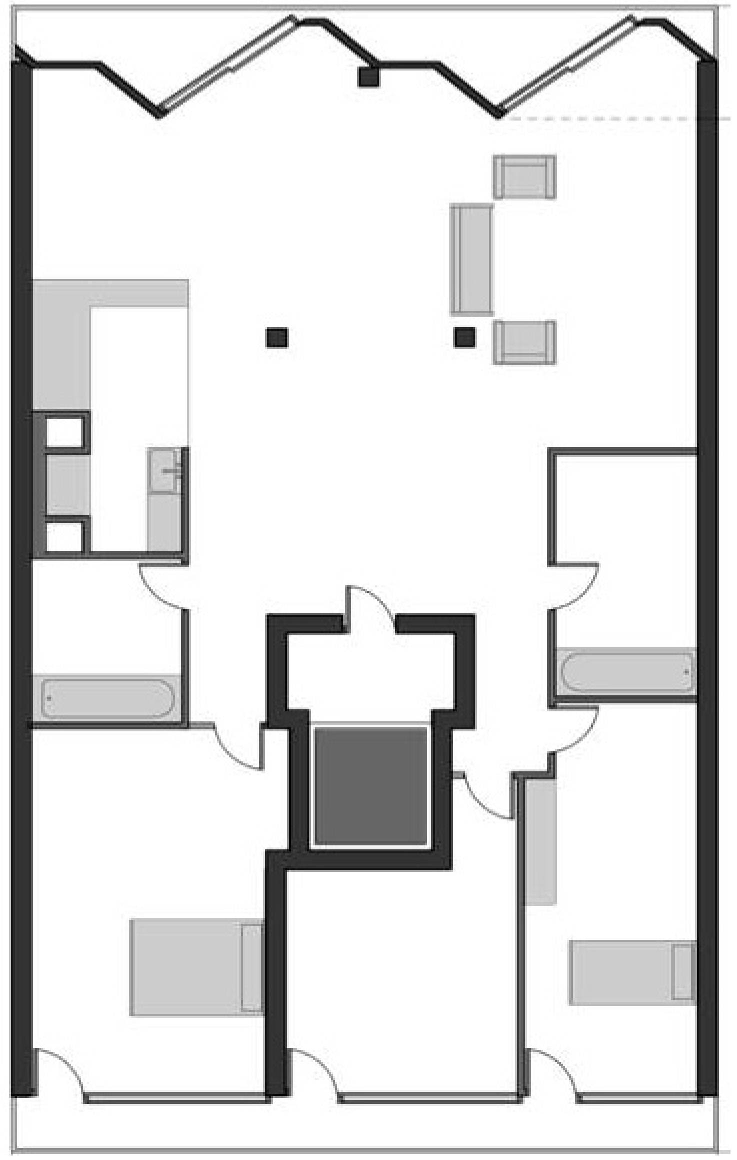
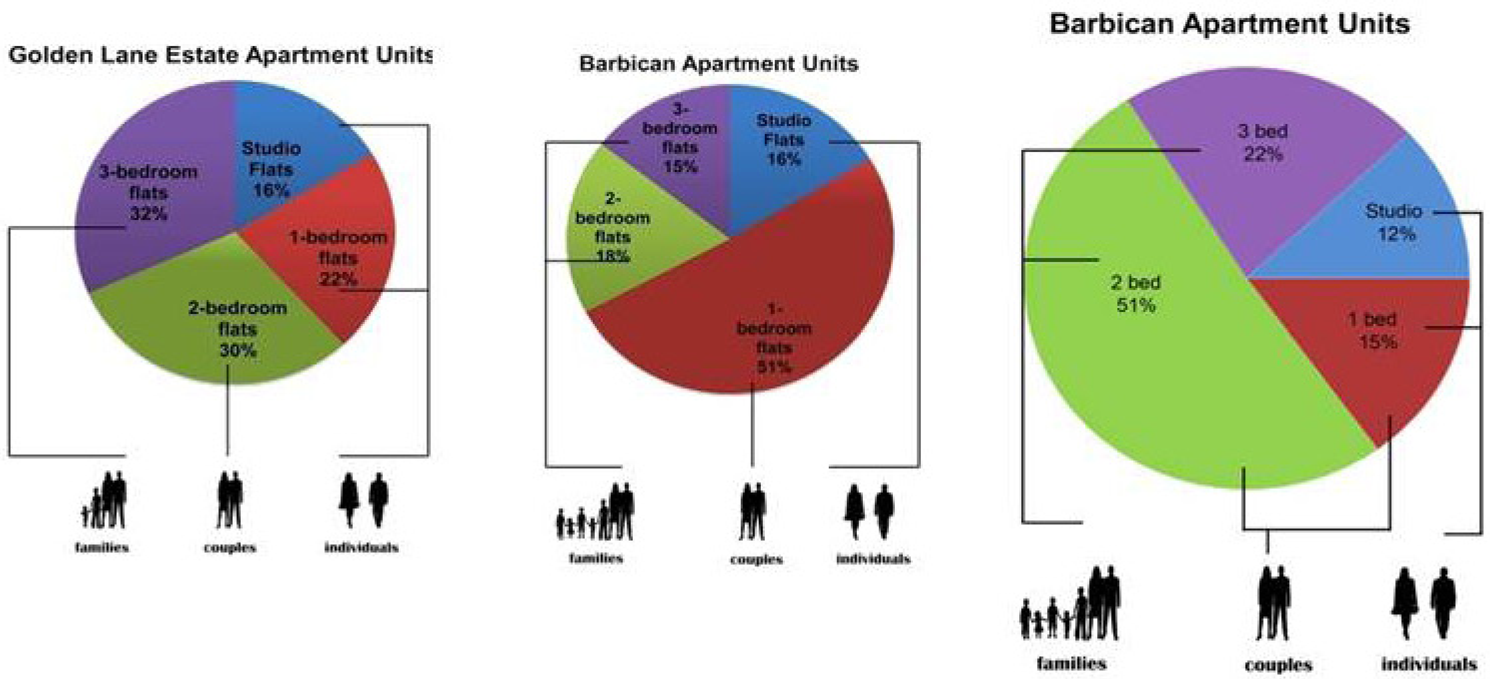


Figure 5.4: First Floor - Base Case



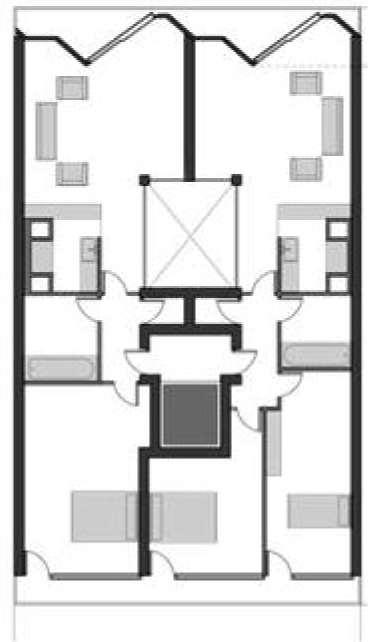


Figure 5.3: First Floor - Base Case

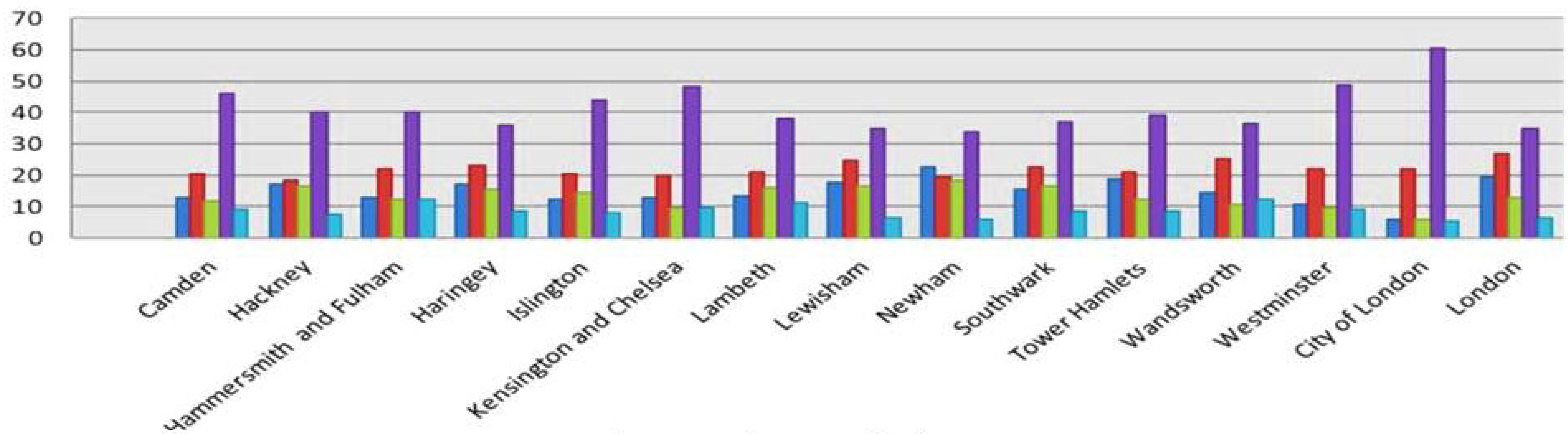


Figure 5.5: First Floor - Base Case

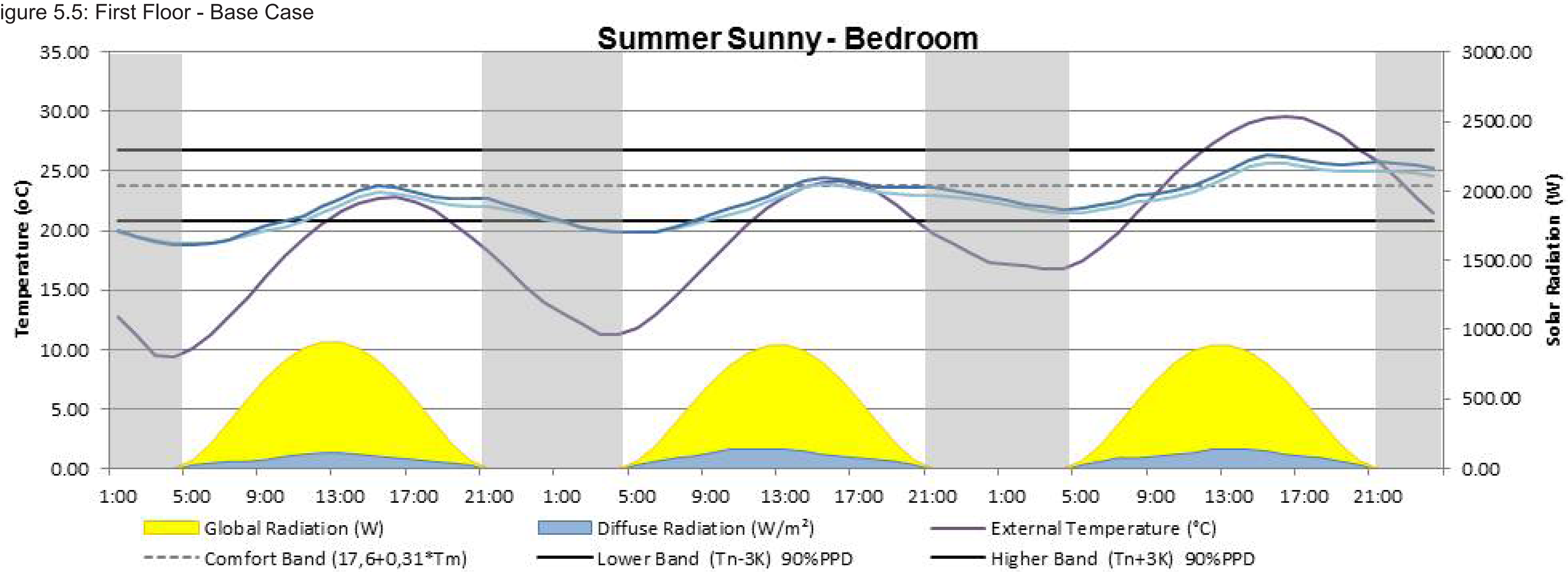


Figure 5.6: First Floor - Base Case

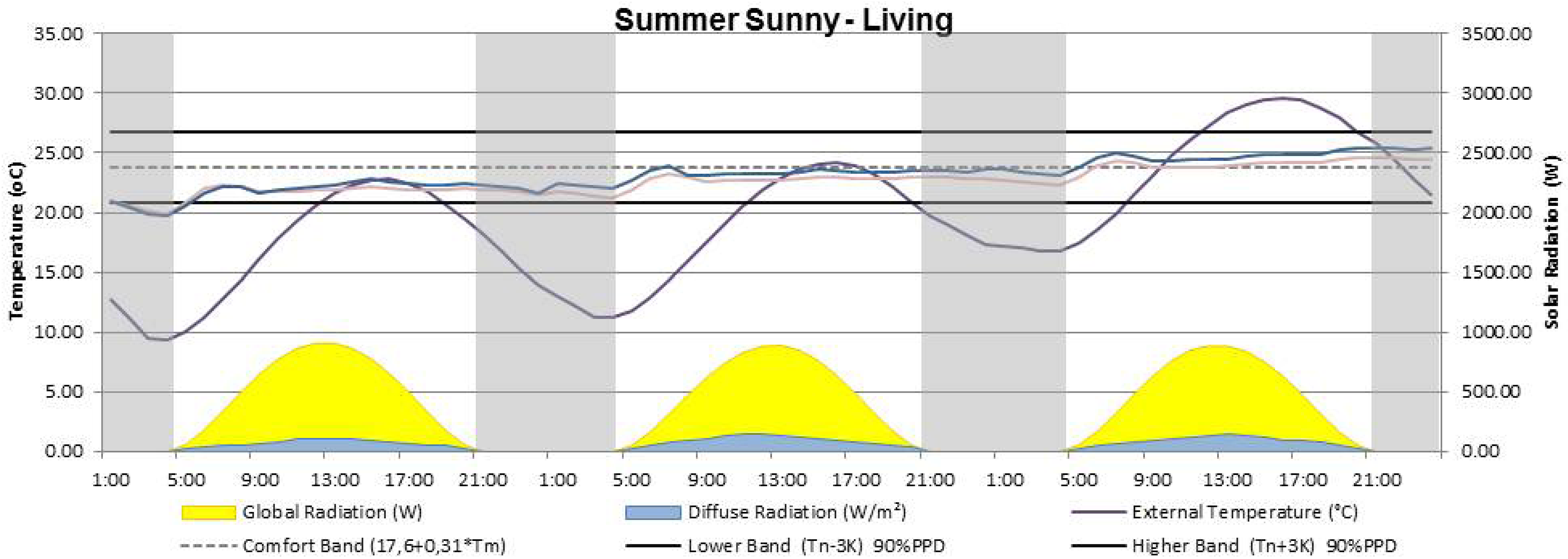


Figure 5.7: First Floor - Base Case

Section 6.1 Master Plan

The main design intent of the master plan was to increase the physical connections between the public peripheries around the estate and the commercial functions within the complex like the Barbican Centre, the amphitheatre and the concert halls. This disconnection which is present in the current scenario of the master plan is due to the financial feasibility, that if they were to create a walkway from the north to the south, during that time, would have been more expensive more than the buildings itself .

Barbican has three pedestrian and vehicular entries into the site. The first is the Southern entrance from the Museum of London which physically connects to St Paul's tube station. The second being the northern entrance from Silk Street, which physically connects to Moorgate station and the third is the North West entrance from Alders gate Street connecting to the Barbican Station. Currently the elevated walkways act as both public and private connections for circulating through the site. However, this circulation runs through the residential parts of the Barbican (figure 6.1).There is no evident public and private separation of circulation and the inability for the public to pass through the site on a north to south axis poses as an issue of inaccessibility. In terms of the vehicle accesses, the strategy used within the design proposal was to have an underground vehicular access connecting these existing zones without actually interfering with the private pedestrian walkways on the upper levels. There is abundance of open green spaces within the entire Barbican Estate. There is two main public areas which is the Barbican promenade and the space around the St. Giles church. These two areas were to cater to public access as well which is one of our main strategies within our design intervention for the master plan. Car parking spaces are allocated on the peripheries of the site, which are connected to the podium levels through stairs and lifts. Thus to be able to walk to the Barbican Arts Centre, located on the north, from the Southern entrance one would need to walk through the terracing blocks.

In our scheme, for external connections, we have added another entry on the Southwest of the site, From Fore Lane for extra public entry and dispersal points. This allows a connection straight to Moorgate station. Internally, we have created connections, through the use of ramps, first from the Museum of London to the St Giles Church. The exit/ entrance from Fore Lane also allows one access to the St Giles Church directly from the street (figure 6.2). The surrounding space of the St Giles church has been dedicated to the public, hence by increasing the accessibility of this space, more public activities which could include the church programmes, can be held in this space. Seating pods are created in this space to provide for public amenities, as currently there are no spaces to sit. In the summer, the trees would provide for shade and in the Winter as this space being open to the highest amount of daylight with the new additions of the seating places could cater for a more comfortable public space.

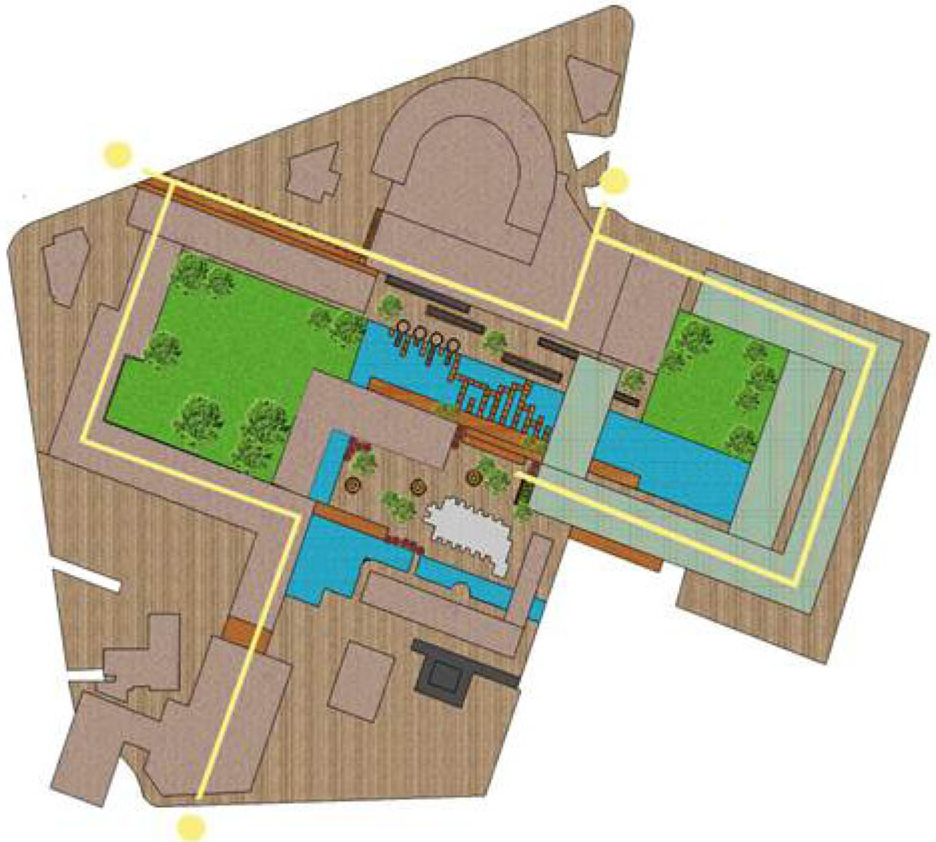


Figure 6.1: existing vehicular connections

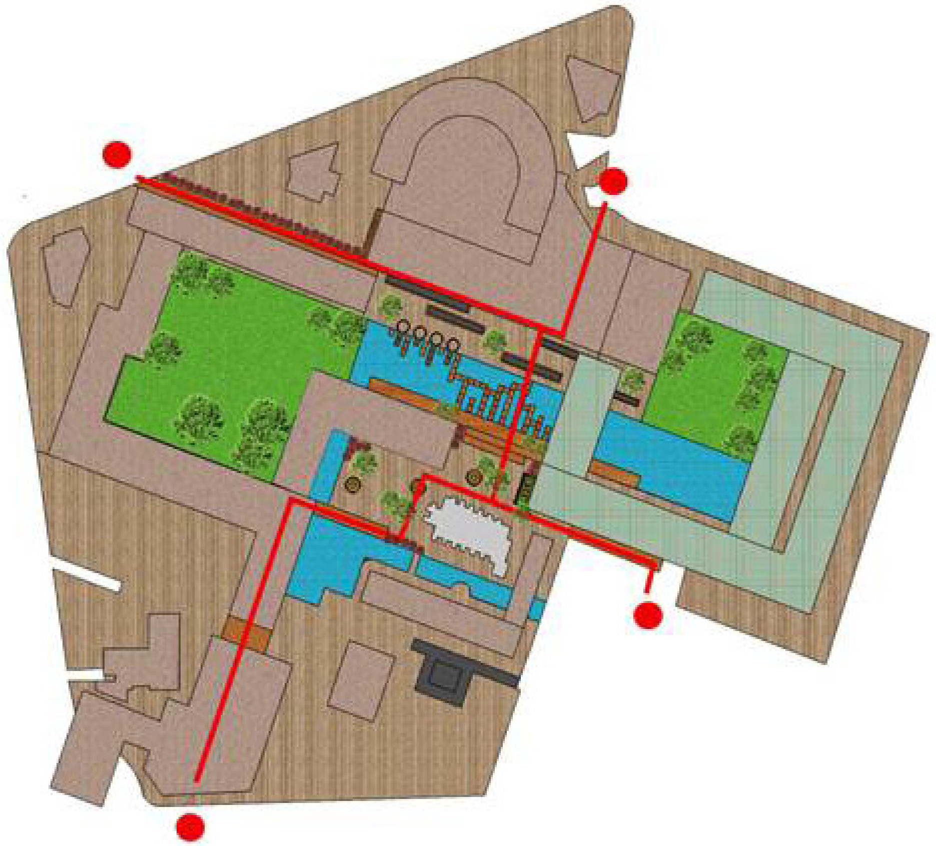


Figure 6.2: proposed circulation pattern

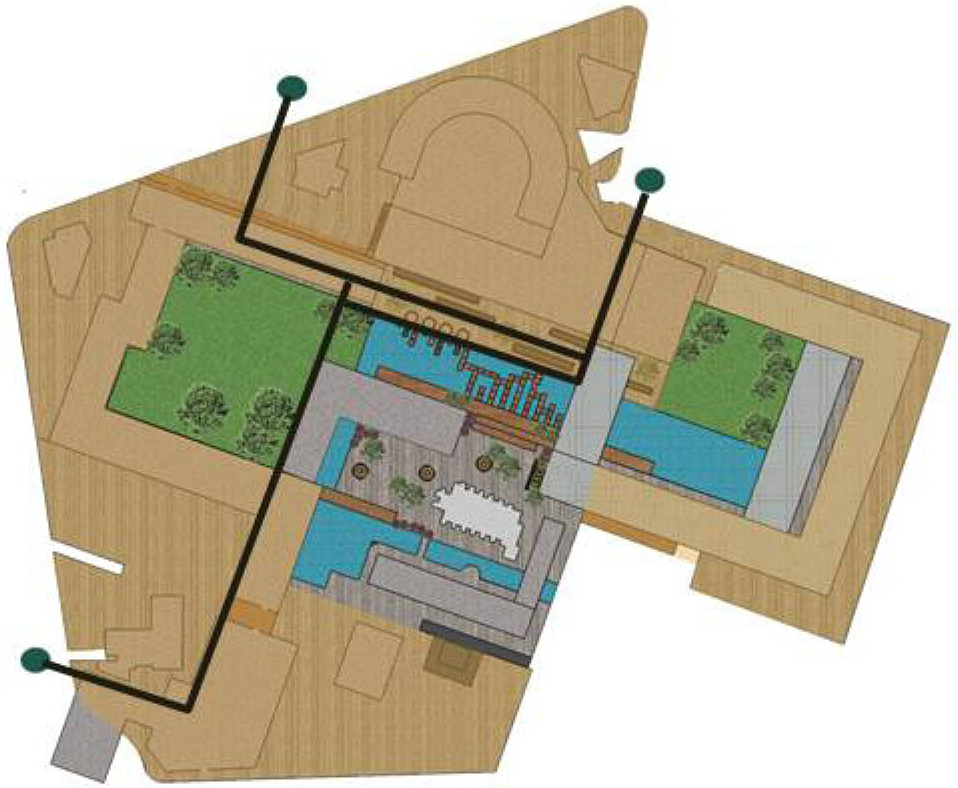


Figure 6.3: proposed vehicular pattern

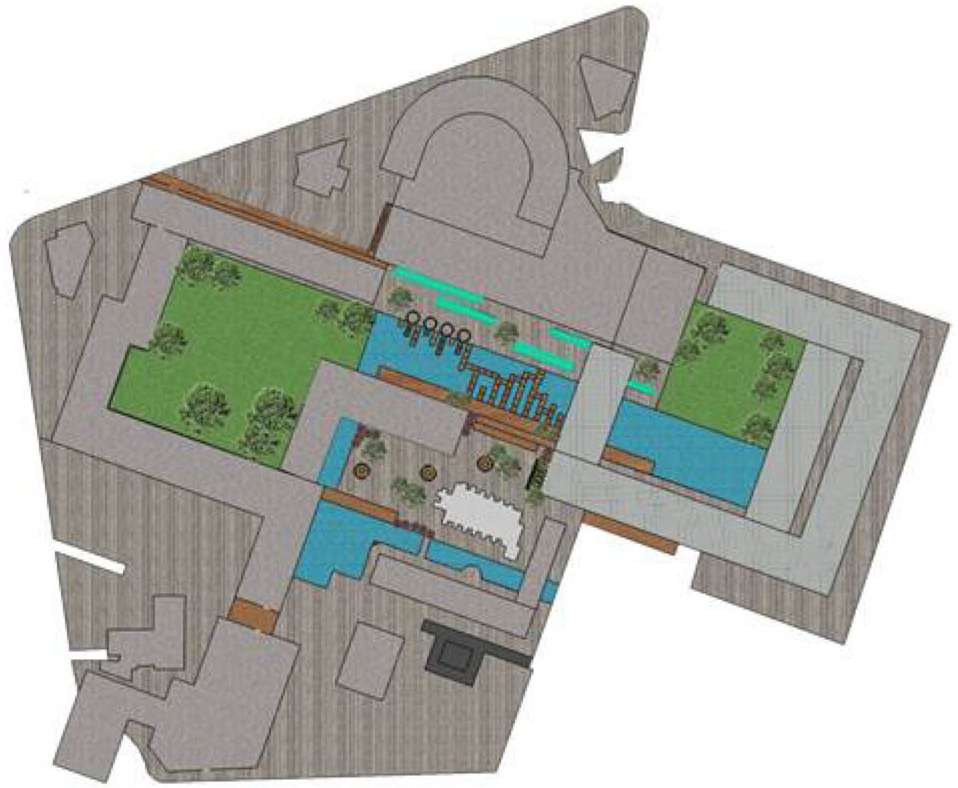


Figure 6.4: proposed master plan with voids


Figure 6.5: view from barbican promenade


Figure 6.6: view overlooking the water body

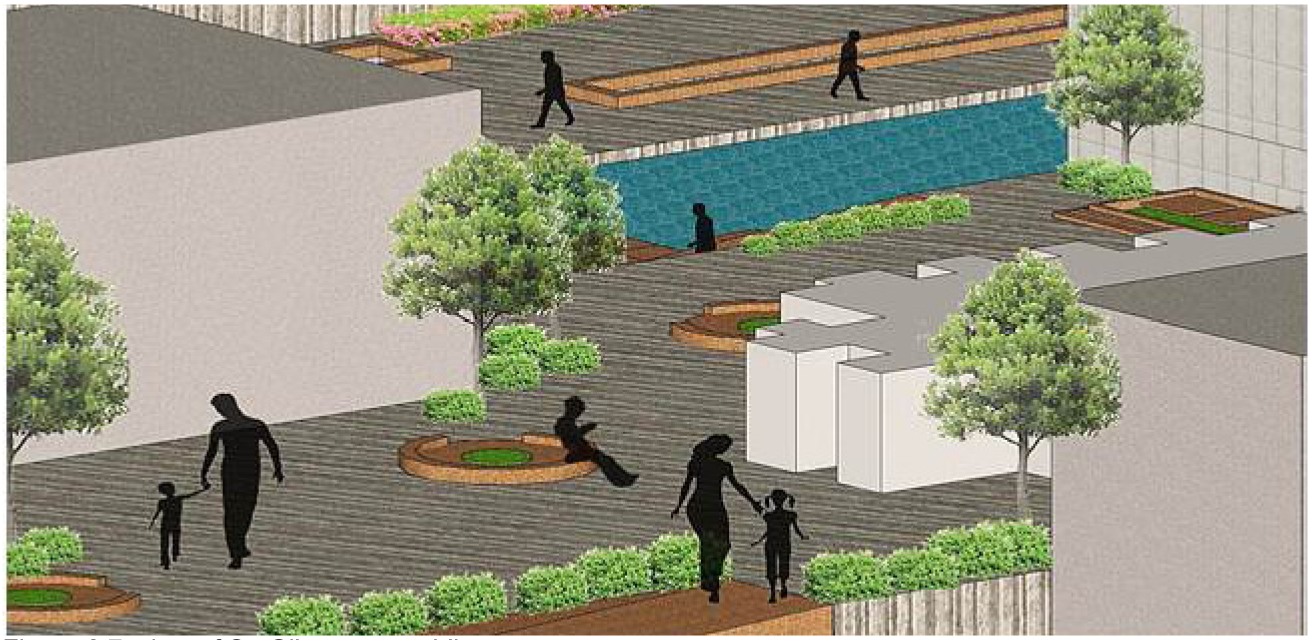


Figure 6.7: view of St. Giles open public space

Figure 6.4 shows the openings made within the slab to allow penetration of daylight to the lower floors of the estate. This strategy was mainly used to improve the daylight quality in order to reduce the energy loads to artificial lighting.

The overall concept for the master plan was to cater to the improve the quality of space based on the occupants usability by increasing the amenities provide within the public spaces, like seating, car park, accessibility between two areas of the estate. The most important aspect was to keep the private areas private. keeping in mind the residents usage to the usage of the residents as well as the public.

Section 7.1 Conclusion

The design proposal for the Barbican estate Term 2 project led the team to understand and learn a number of important aspects of retrofitting, listed residential buildings. Some of the most important aspects were the importance of construction types and materials which is essential for a good building performance. The materials used in the Barbican estate were beneficial from the era it was built, and through the team's analytical work showed that it would work 50 years from now especially with the increase in temperature and climate change. One of the other aspects of the building was its extensive use of concrete, which comprises to a highly substantial thermal mass within the complex.

Through the design interventions made for future scenarios it was possible to reconfigure the apartment layout without actually increasing its energy loads. This was an important aspect that was learnt as it was built post war. One of the main conclusions made and learnt from this project was that the buildings from this era would work better in terms of performance than the newly constructed buildings both architecturally and environmentally with very subtle alterations and interventions. As a team it was important for us to understand the significance of a refurbished building and preserving its aesthetics. As it is, being a refurbished project and a listed building, the guidelines were not occupant sensitive and it was important through this proposal for design strategies to achieve that balance.

All the strategies can be incorporated into western side of the Barbican estate. All the design proposals obtained for the Southern block and the Eastern block can be used in the Barbican estate can be used throughout in the same orientation. Another strong element for the strategies used for the design proposal the elements used in one block can cater to the reduce the energy loads and demands, even if the orientations are different as the construction type and the layout of these flats are similar.

Section 7.2 Refrences

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Section 8.1 Appendix

SENSITIVE ANALYSIS OF SUMMER SUNNY OPENING WINDOWS

A sensitive analysis was made to understand what would happen to each room, the bedroom and the living, if the occupants open the windows during summer period. The figures 7.1 and 7.2 in the appendix show the behaviour of each room. The open able area considered for each room is around 3 m2. It can be seen that the inside temperature gets closer to the outside temperature as the windows open more widely. At 10% open the temperature still remains at comfort levels while at 50% the temperature already crossed 28 oC. This means that if the occupant opens the windows in the hottest period of the day the room would get warmer. The hot air from outside will enter the room mixing with the internal air thus elevating its temperature. The opening of windows at 10% the bedroom provided an average of 2-3 Ach while the living was around 1Ach. At 50% windows opened, the bedroom stayed at an average of 5 Ach with peaks of almost 10 Ach, while the living remained at 3 Ach.

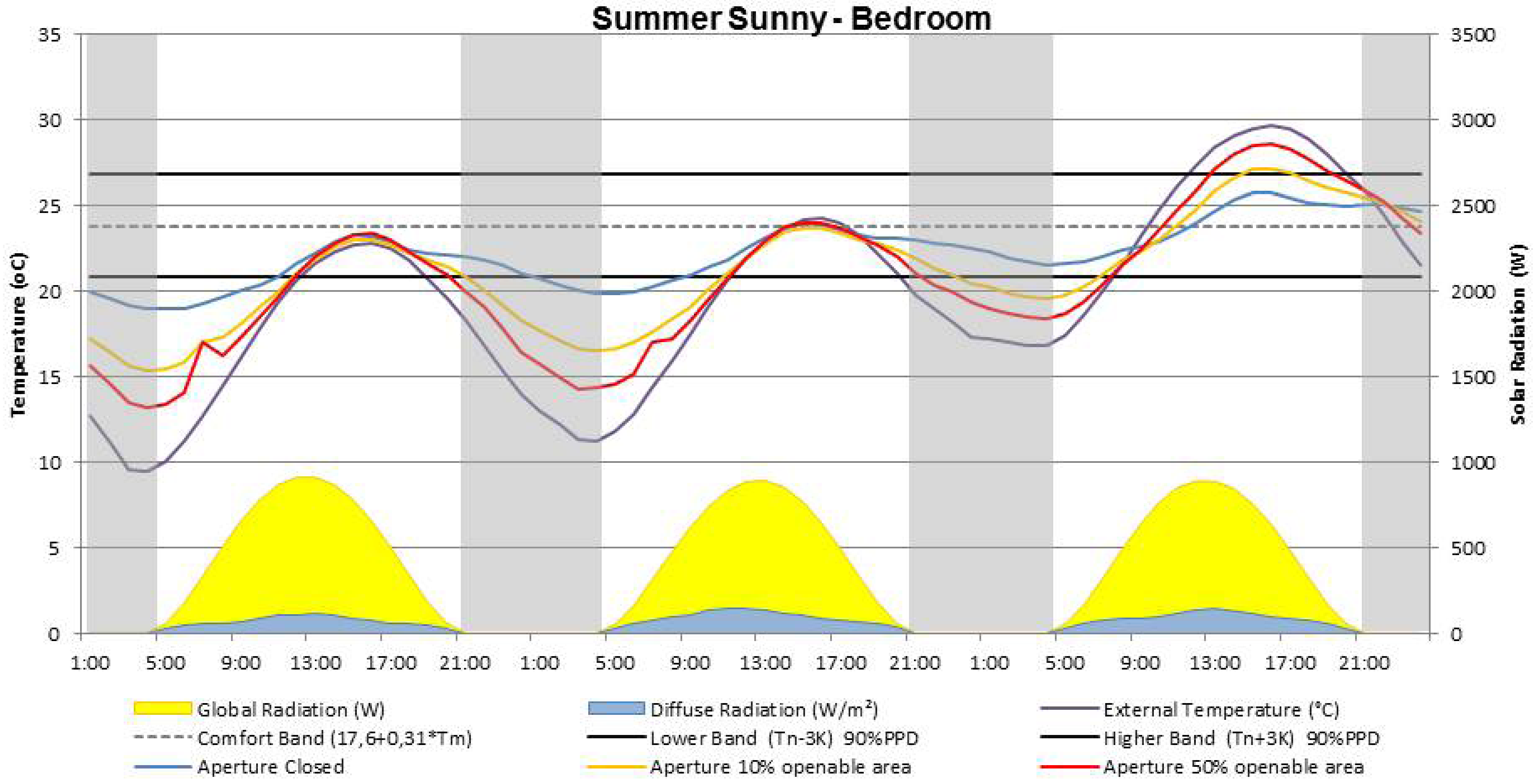

Figure 7.1: aperture sensitive analysis andrewes

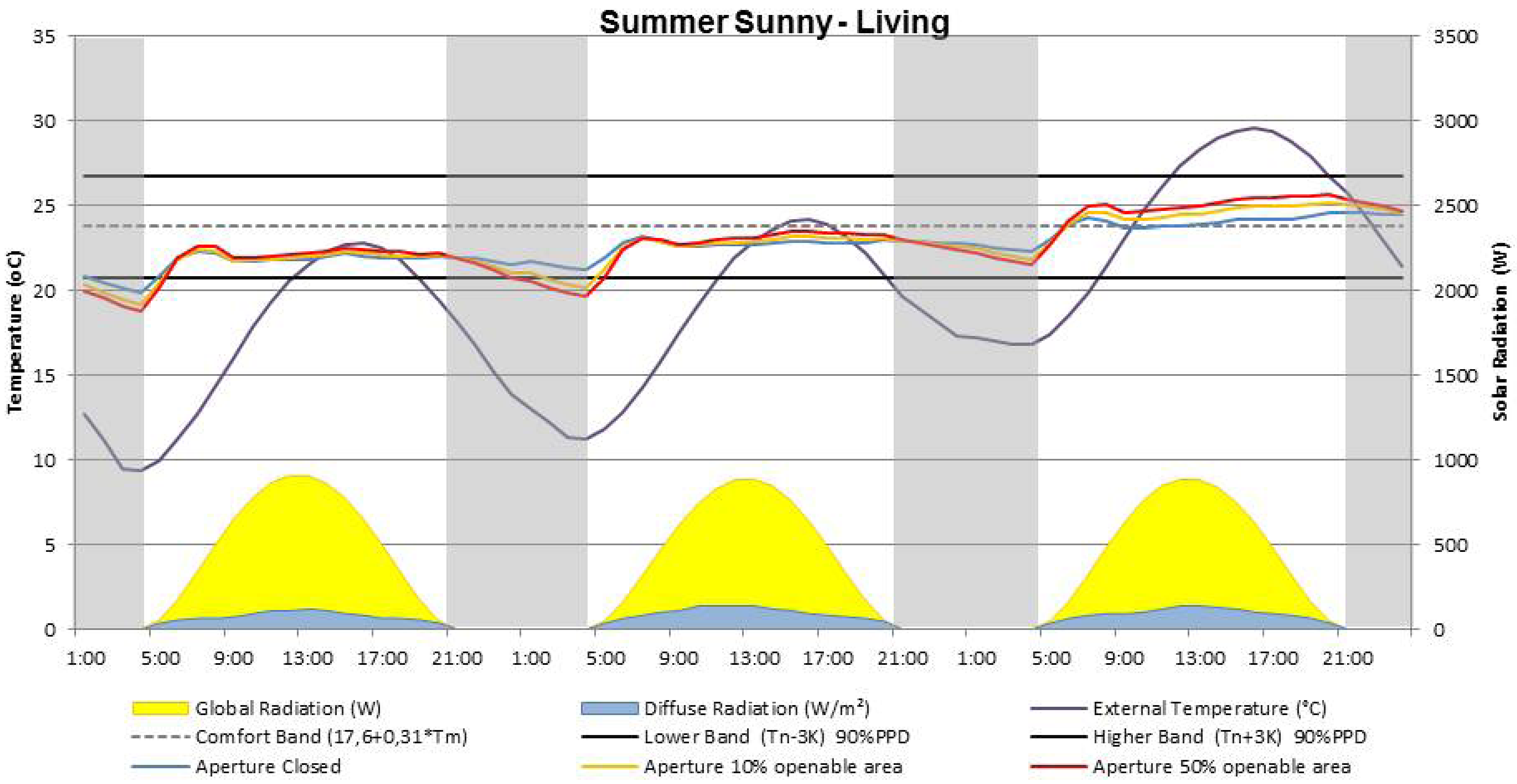

Figure 7.2: aperture sensitive analysis andrewes

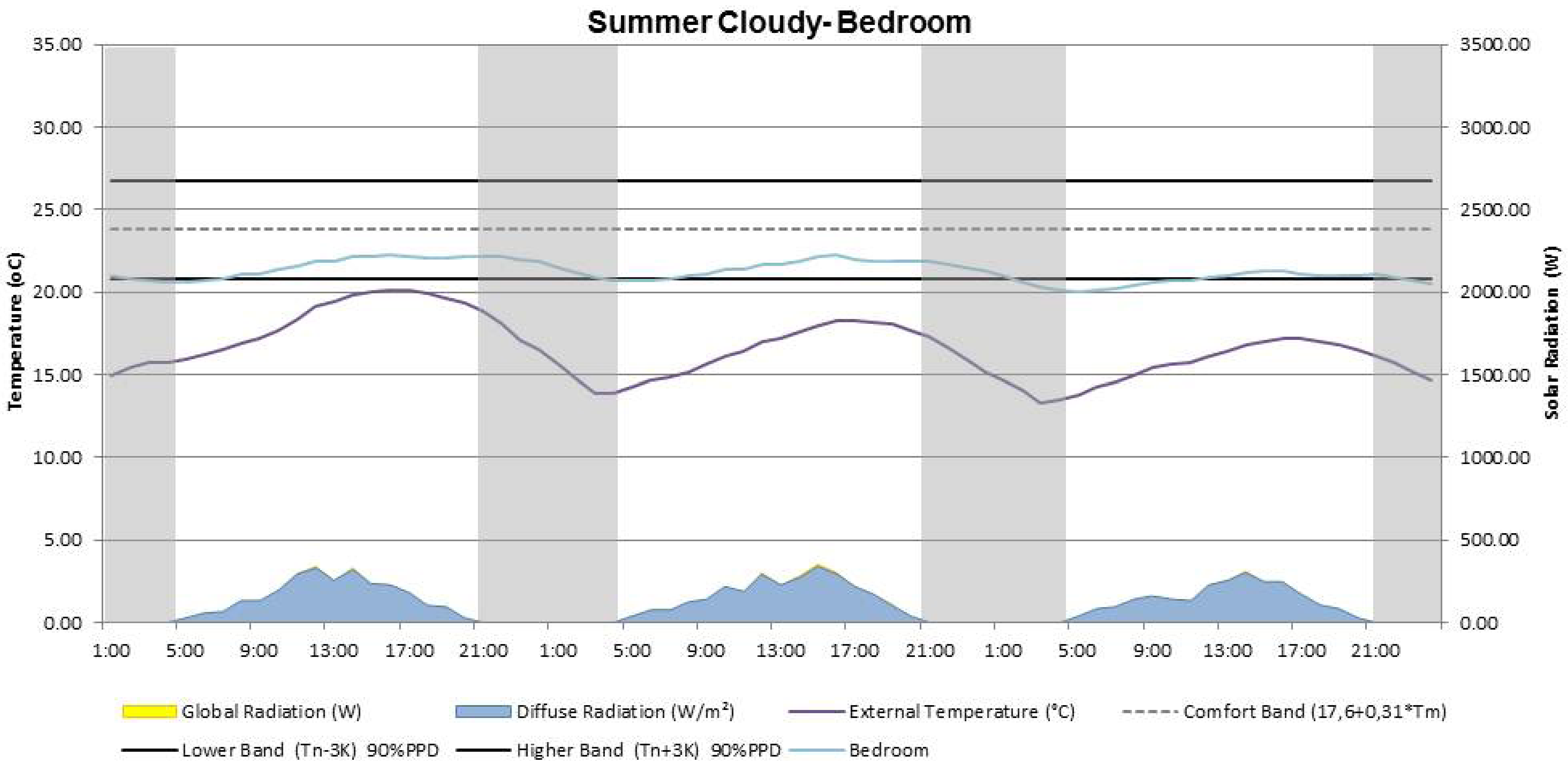

Figure 7.3: aperture sensitive analysis andrewes

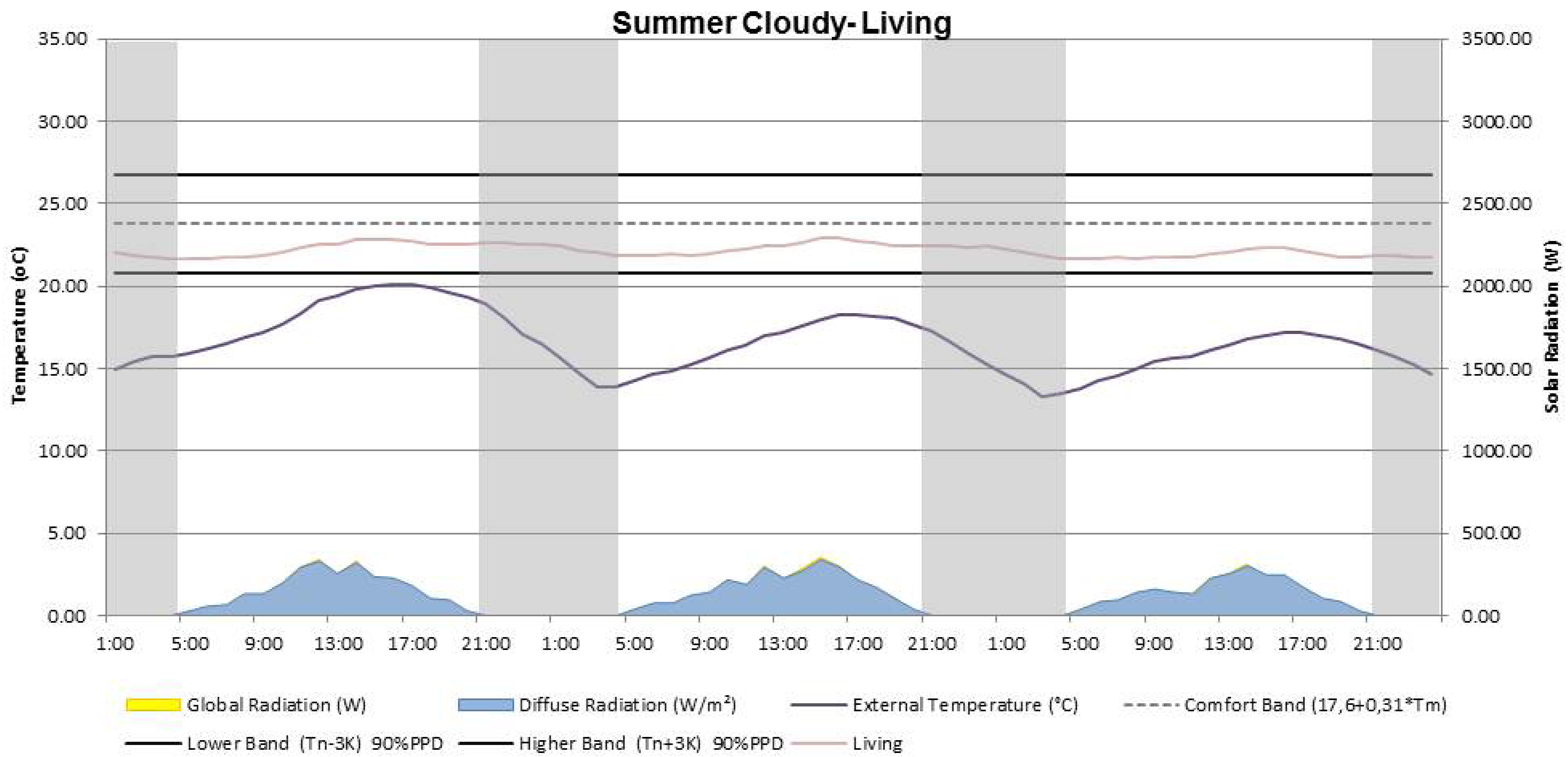

Figure 7.4: aperture sensitive analysis andrewes

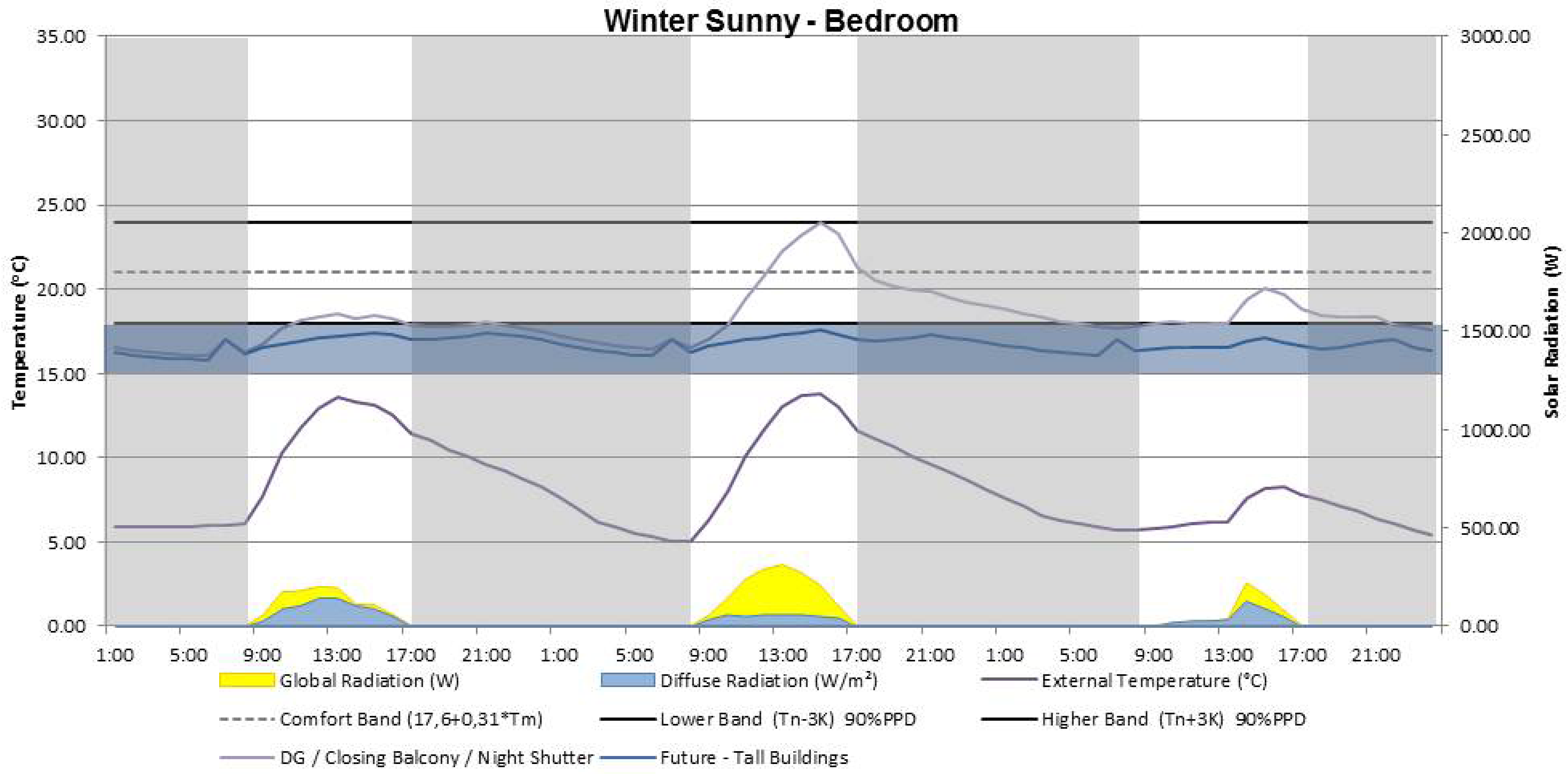

Figure 7.5: temperature simulations andrewes

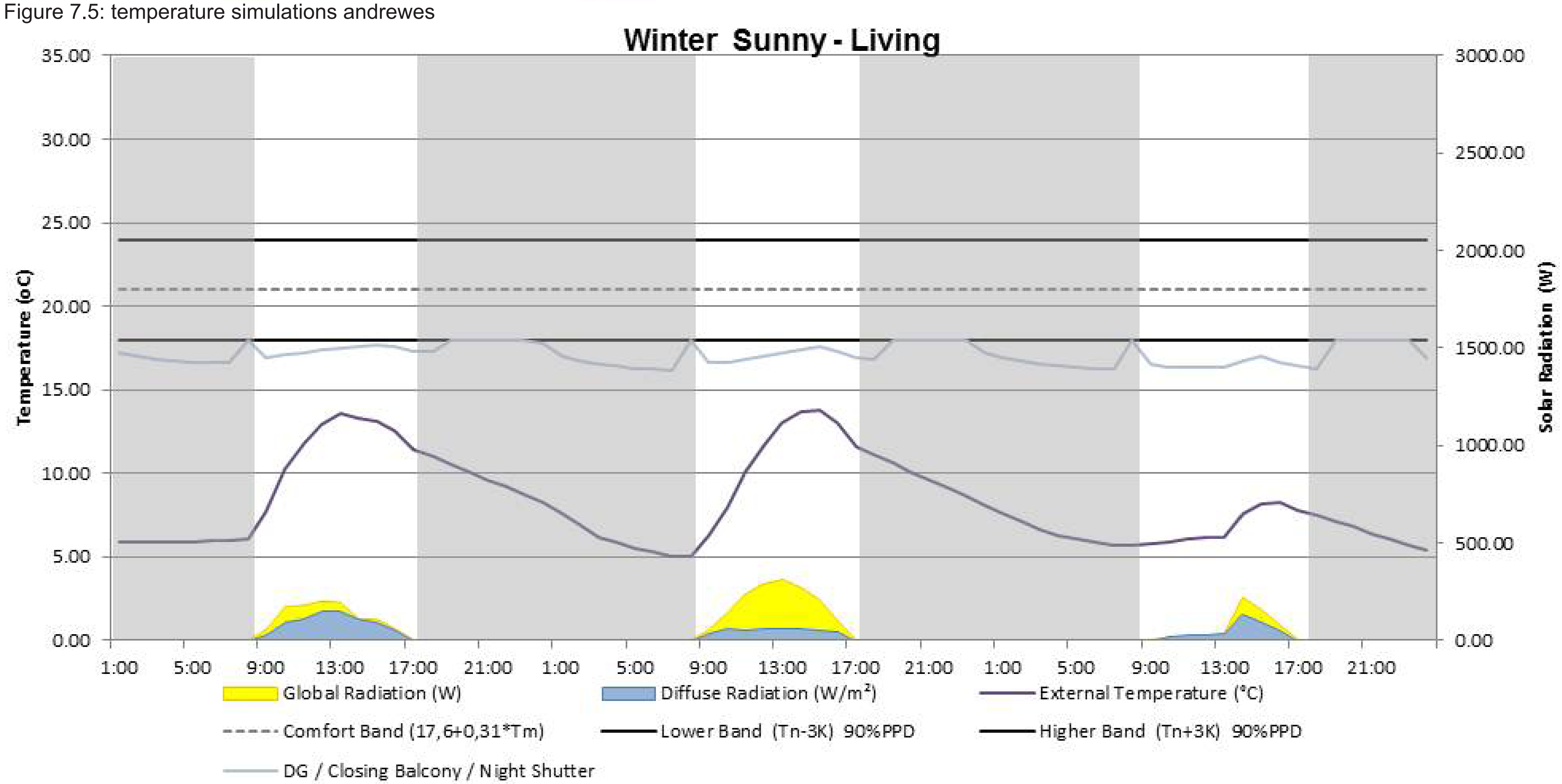

Figure 7.6: temperature simulations andrewes

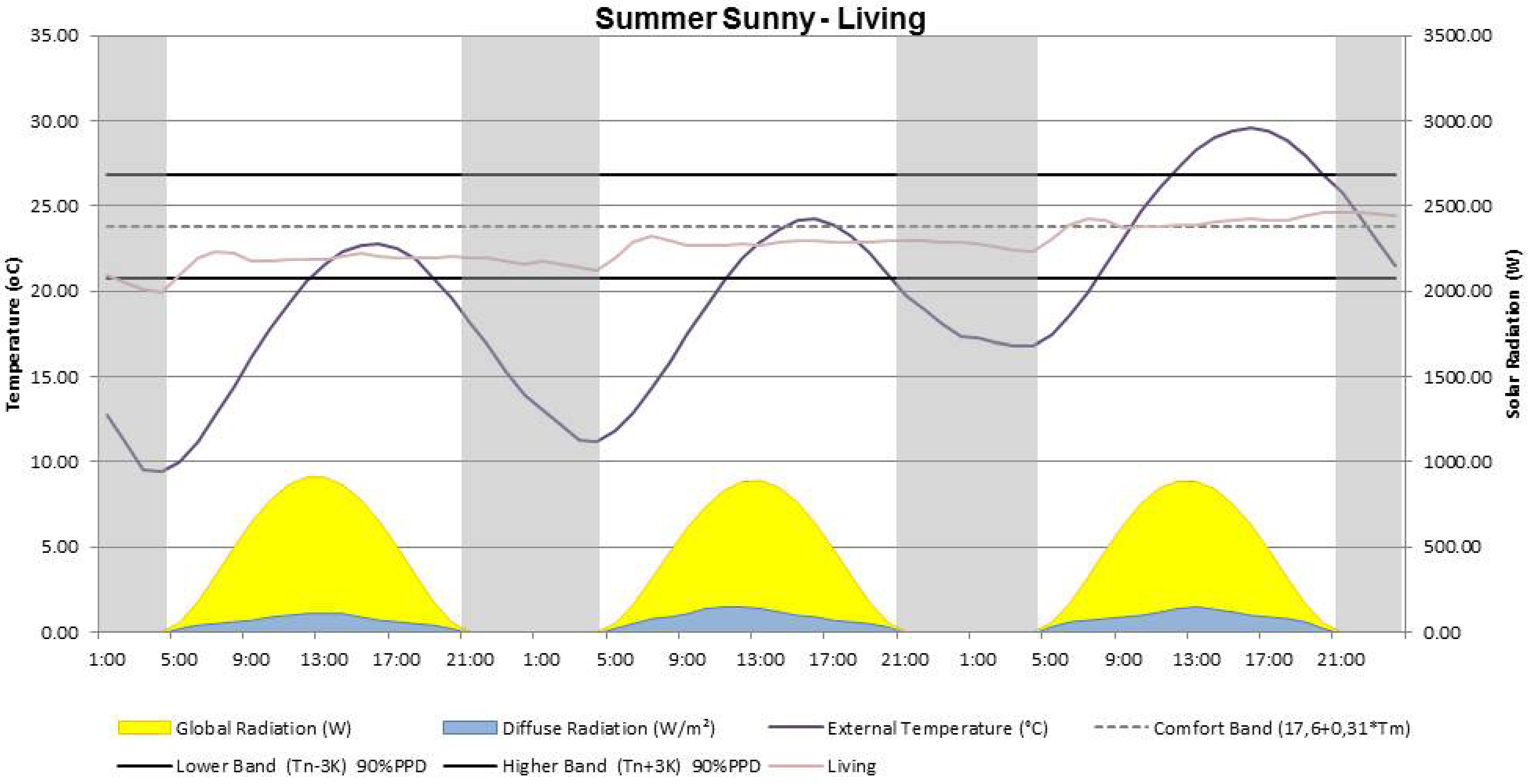

Figure 7.7: temperature simulations andrewes

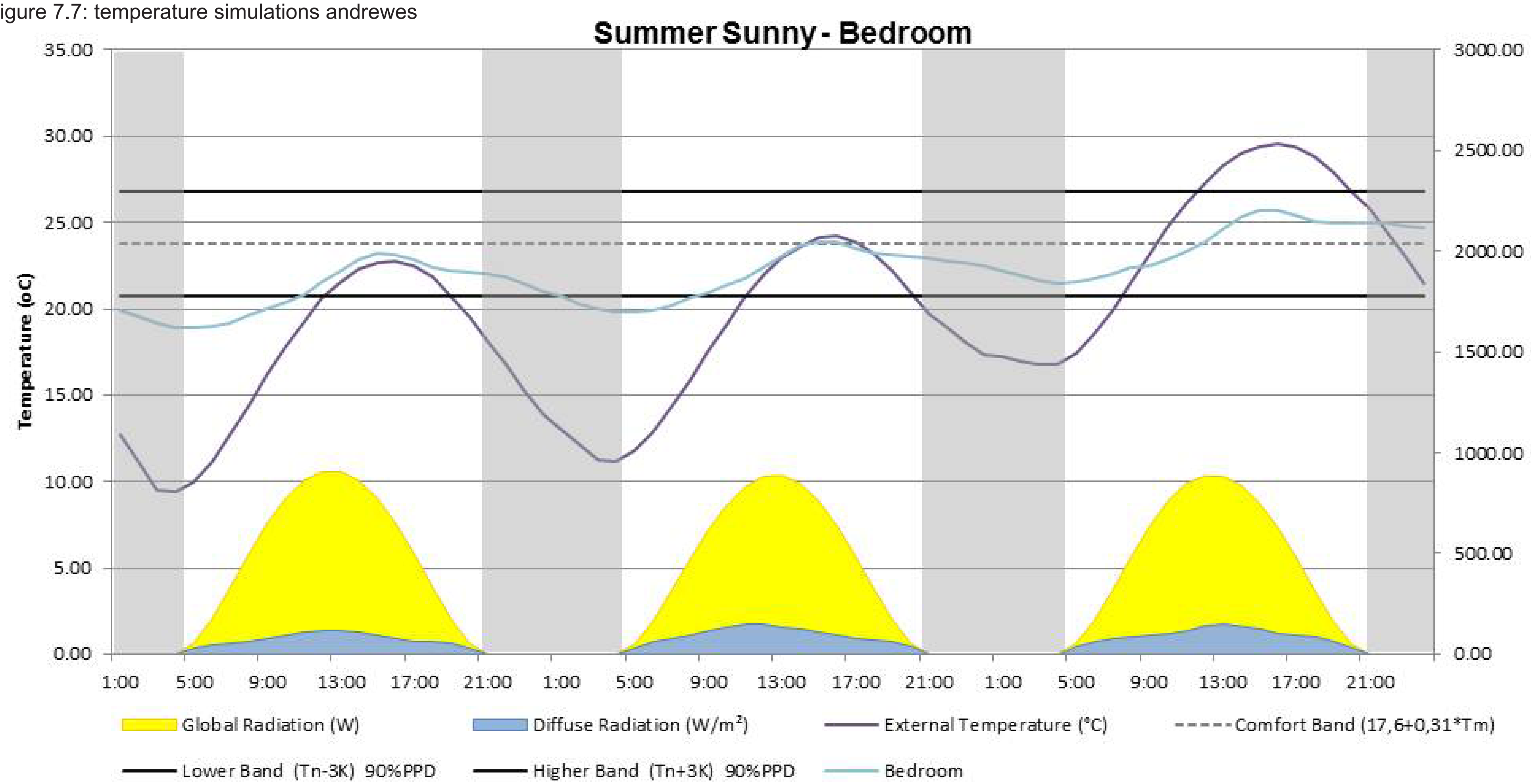

Figure 7.8: temperature simulations andrewes

SUMMER SUNNY- LIVING

During the summer period the figure 7.7 shows that the room responds well to hot days. The thermal mass of the building helps stabilizing the temperature throughout the day. Also the balcony works as a shading device during the summer period when the sun has a higher angle. It is important to make sure that the balcony remains open throughout the summer months, in order to increase ventilation and not act as a buffer space like during the winter periods. The temperature doesn't cross the limit set of 28 oC even with the outside temperature is at 30 oC.

SUMMER SUNNY- BEDROOM

The figure 7.8 shows the temperature in a typical sunny winter day. It can be seen it is possible to heat the room using only passive strategies. With solar heat gains and the refurbishment of window areas the internal temperature could reach 24 oC. However this situation has limitations. The future prospect of the area sees an increase in height and density of the buildings surrounding the Barbican estate. A future scenario was simulated with higher buildings which overshadowed the blocks with the complex and thus resulting in changes within the flats.

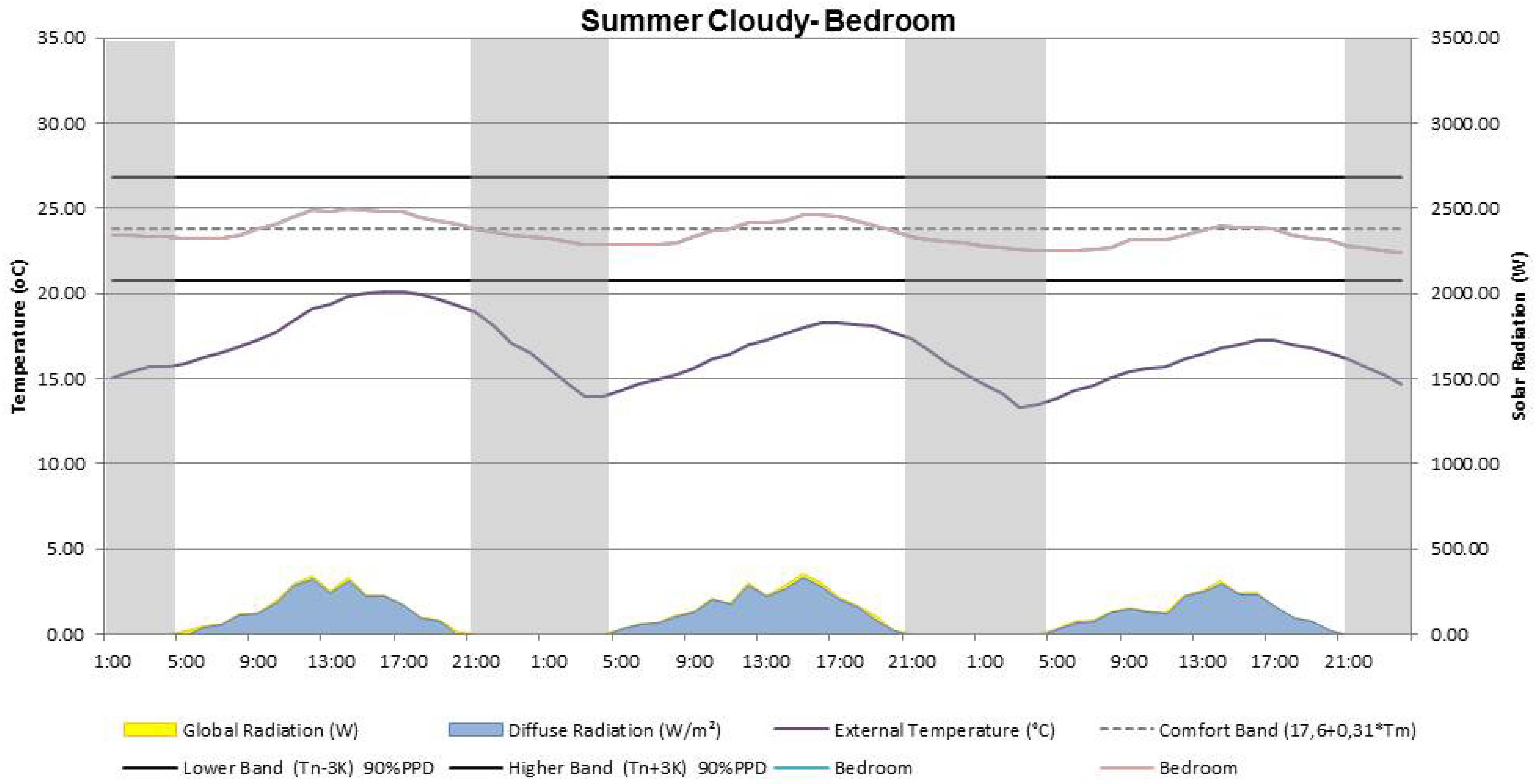

Figure 7.9: temperature simulations andrewes

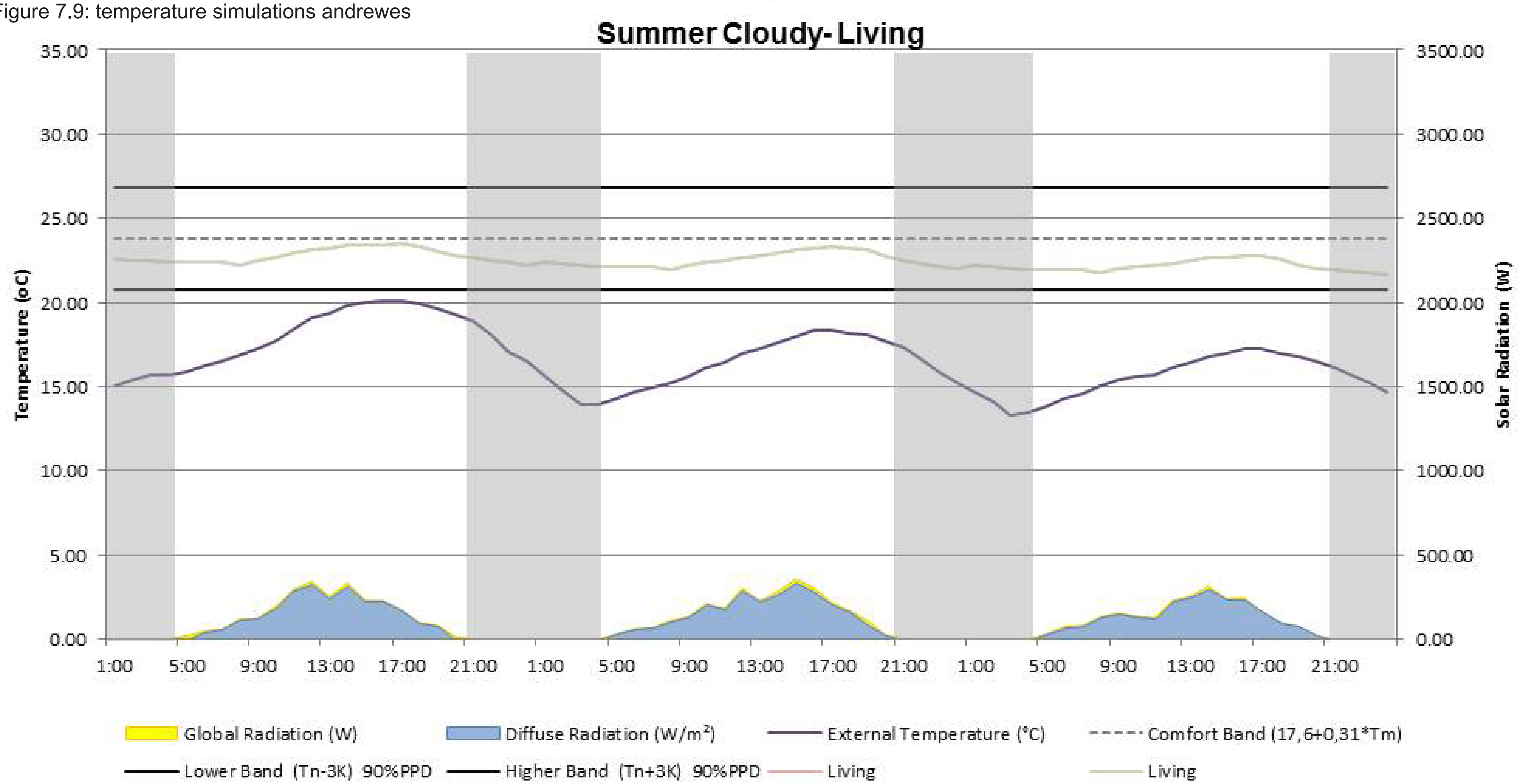

Figure 7.10: temperature simulations andrewes

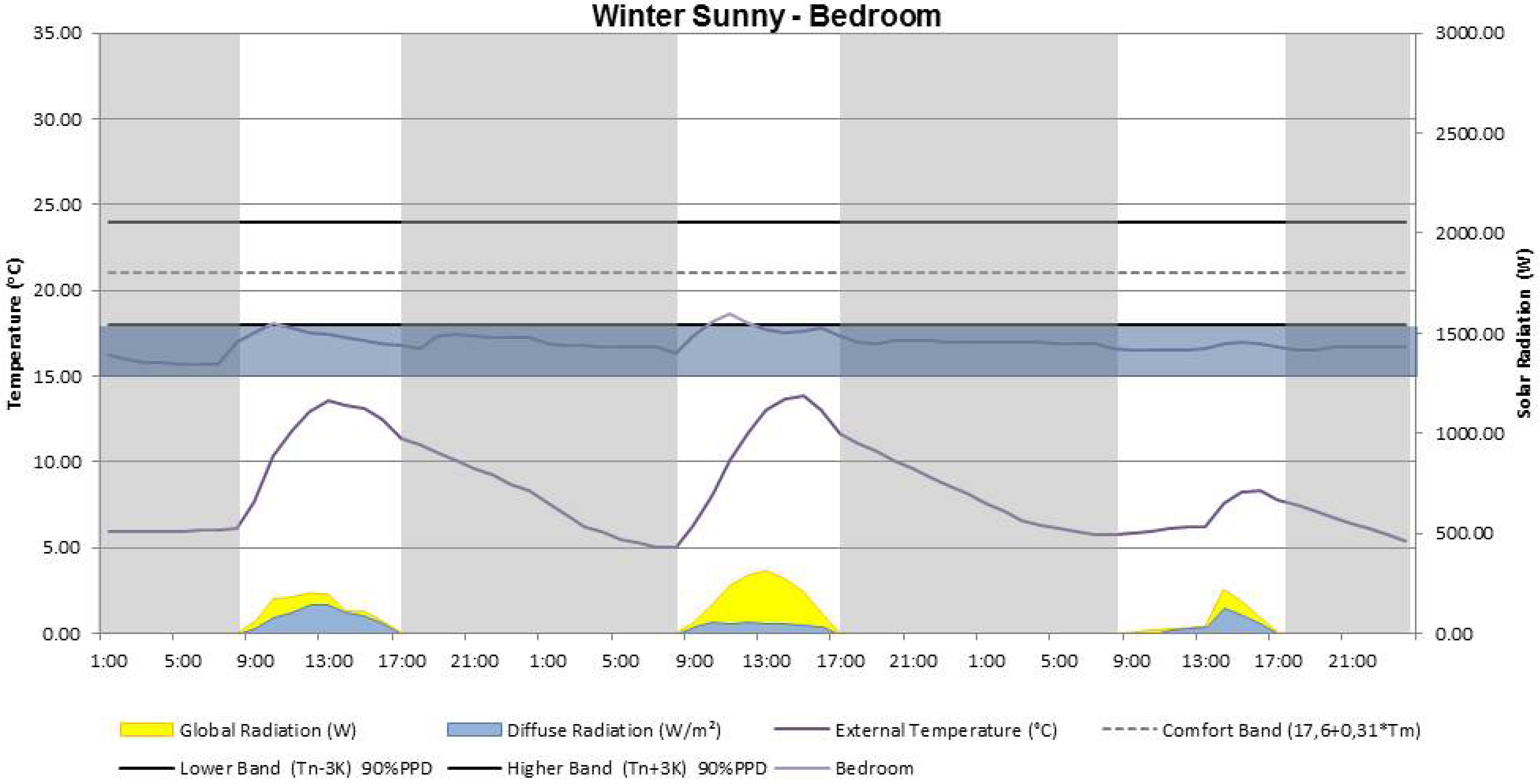

Figure 7.11: temperature simulations andrewes

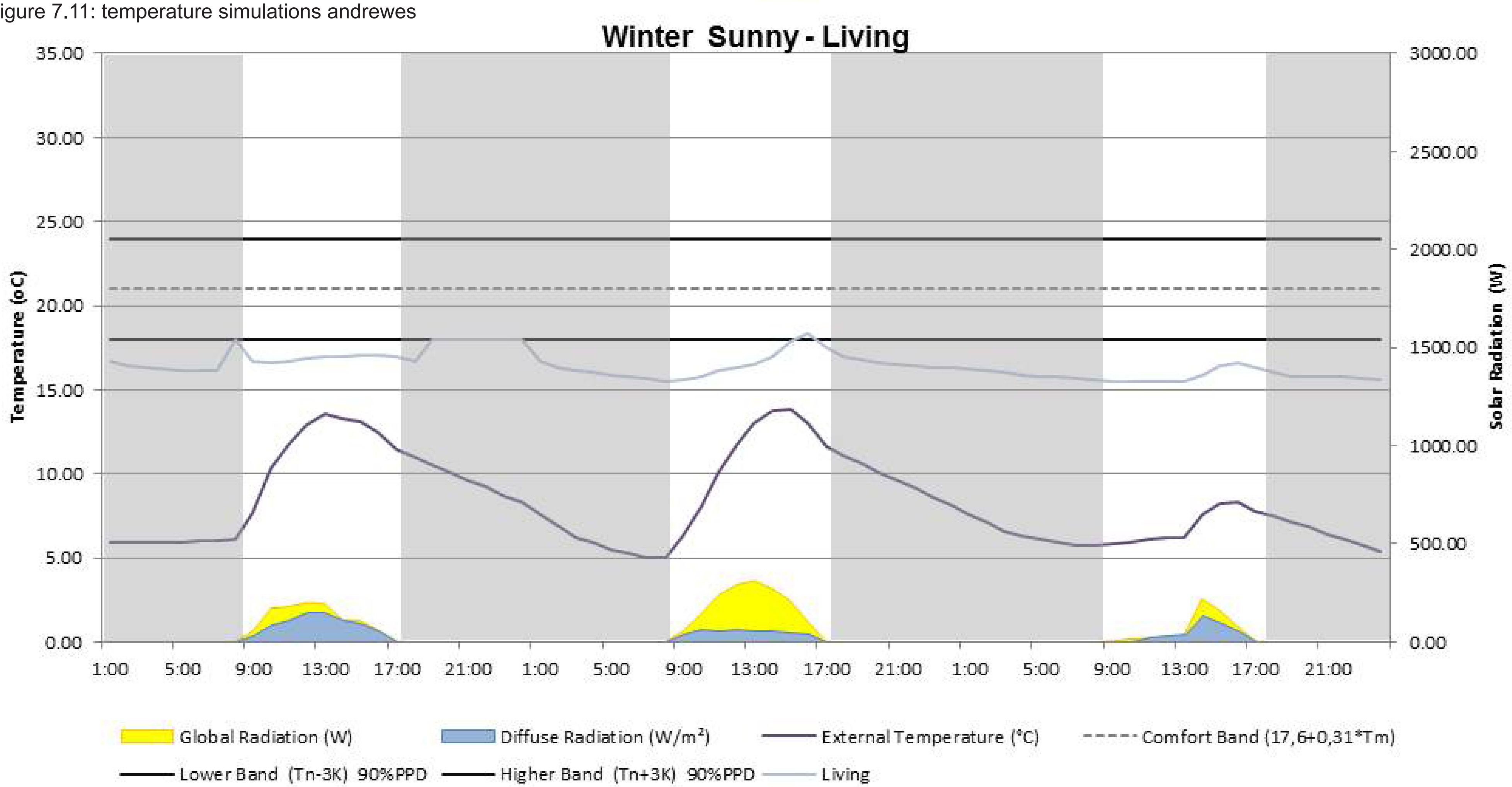

Figure 7.12: temperature simulations andrewes

WINTER SUNNY - BEDROOM

Similarly to the living, the bedroom's temperature remained between 15 oC to 17 oC . However, this temperature is still comfortable to sleep if blankets or other sets of clothing and layers were used to sleep. This comfort is dependent on the function and use of this space figure 7.11.

WINTER SUNNY - LIVING

The figure 7.12 shows the living temperature in a period of three consecutive days of a typical winter sunny week. Although the external temperature has increased to 14 oC, the temperature of the living room fluctuated between 15 to 17 oC, stating the need for heating to reach the comfort temperature of 18 oC.

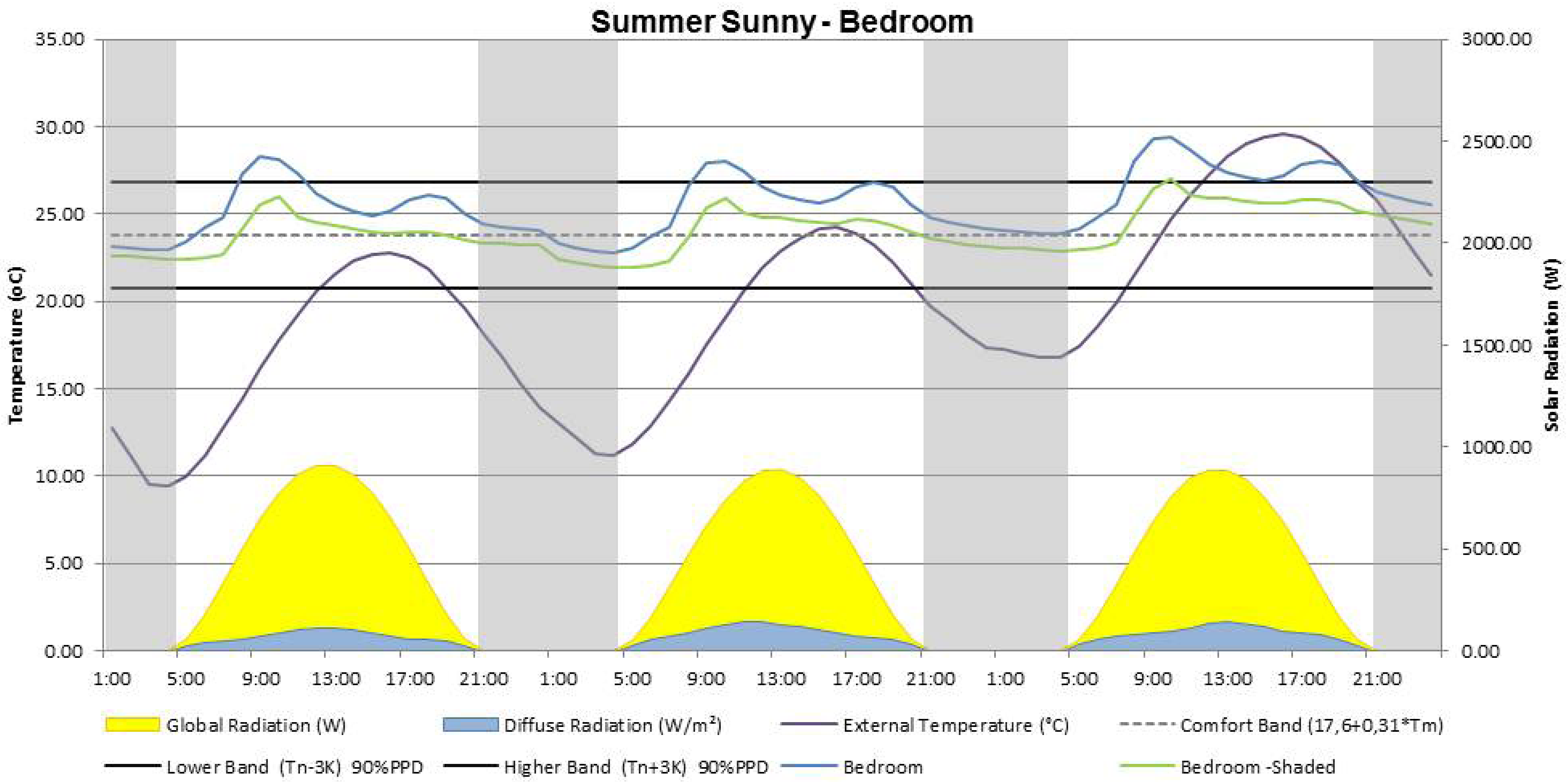

Figure 7.13: temperature simulations andrewes

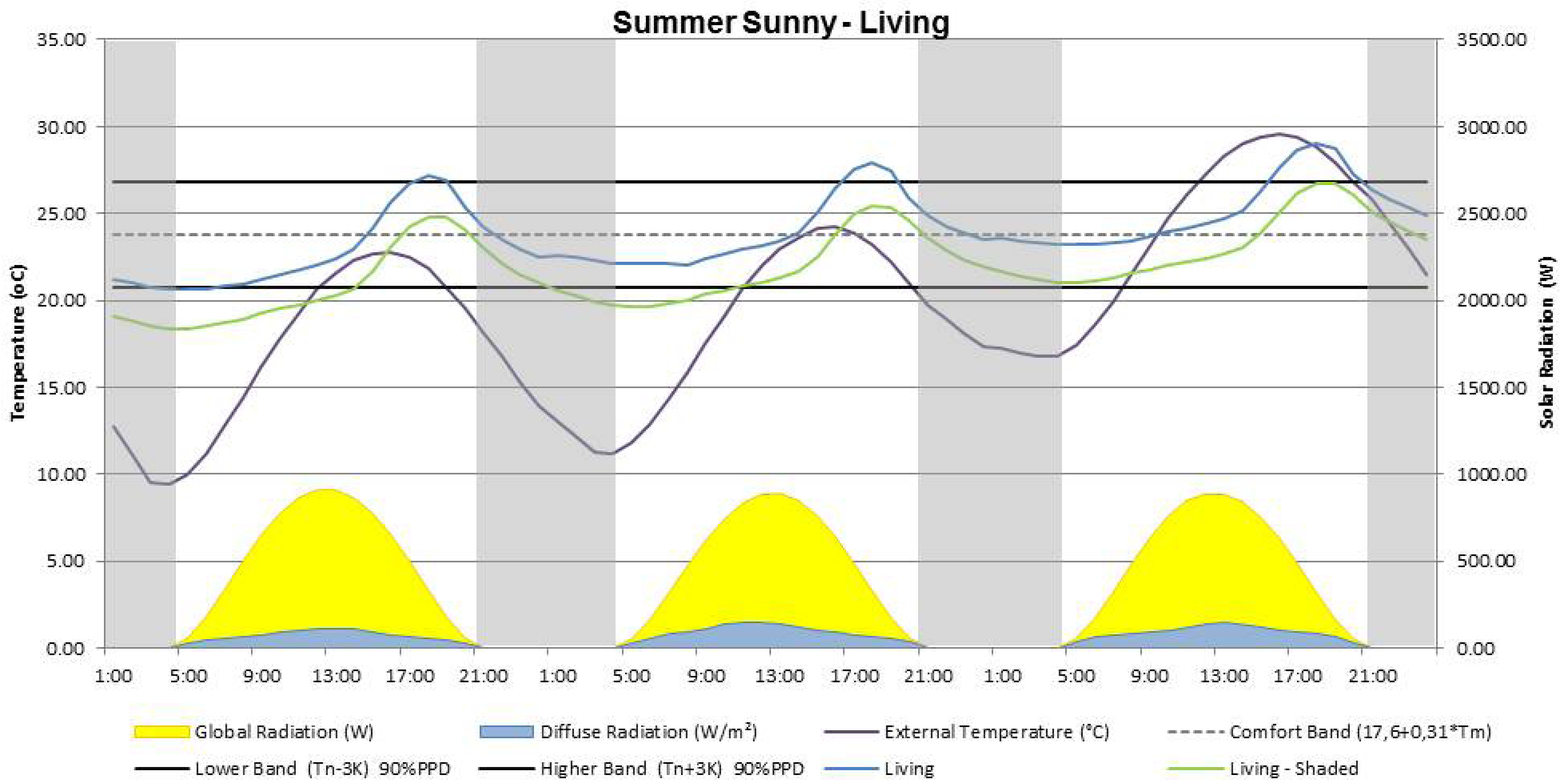

Figure 7.14: temperature simulations andrewes

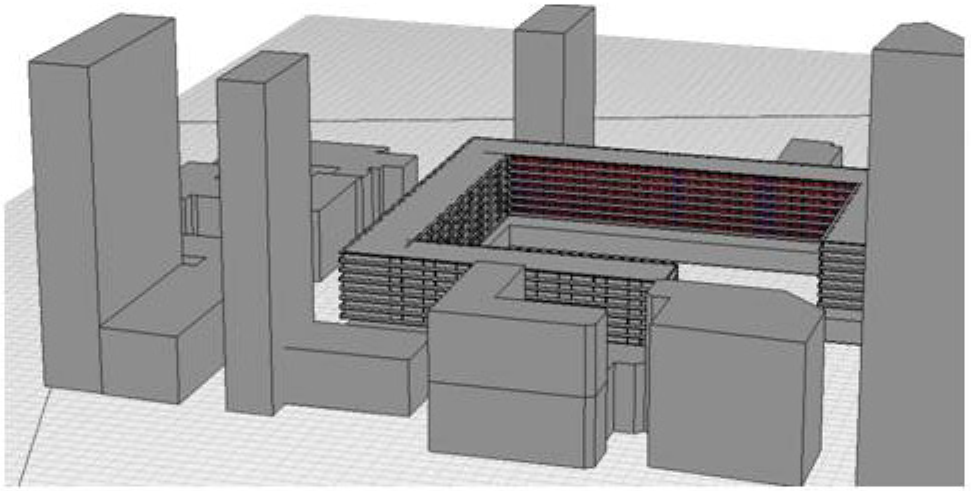

Figure 8.2: solar radiations 3d view

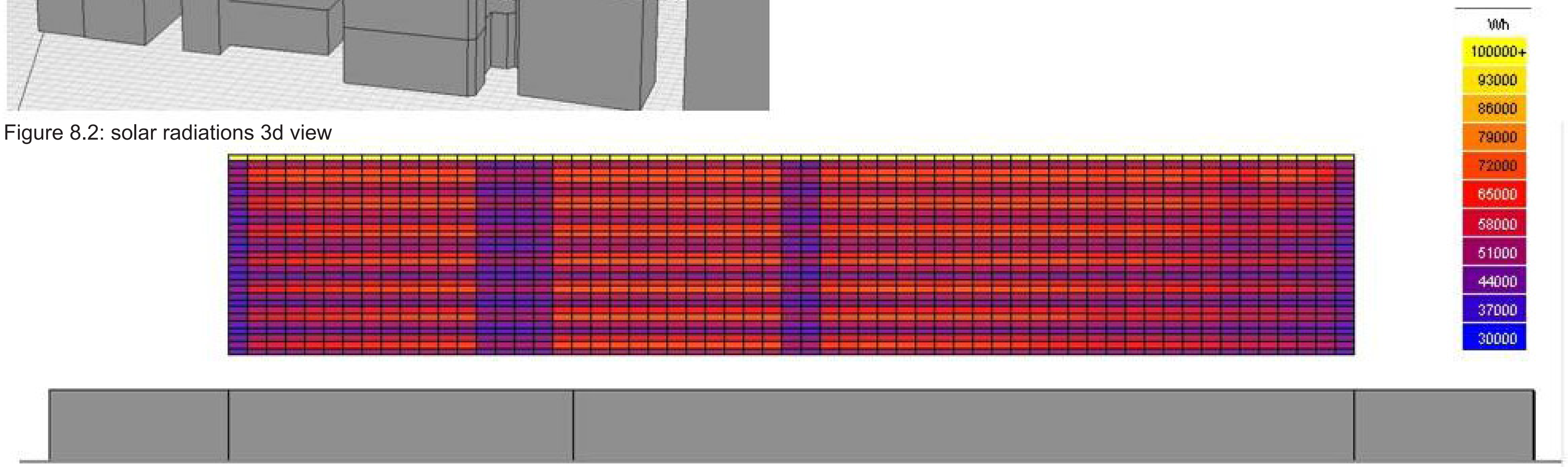

Figure 8.3: solar radiations facade winter

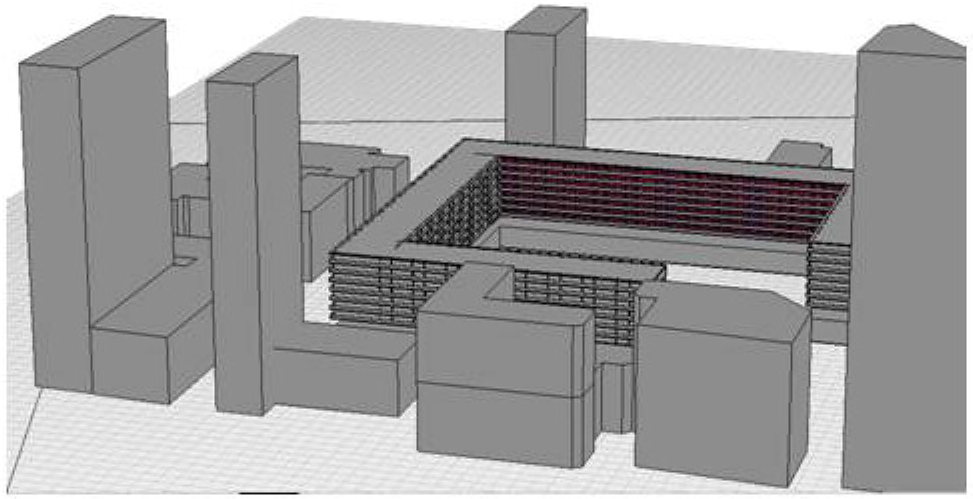

Figure 8.4: solar radiations 3d view

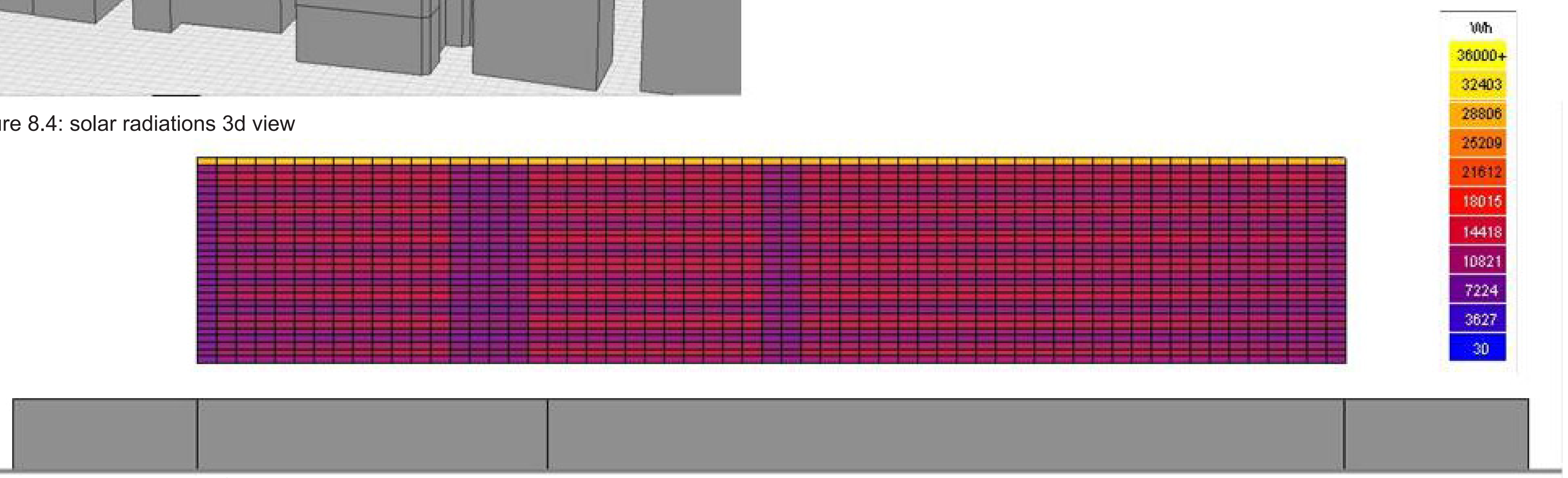

Figure 8.5: solar radiations facade summer

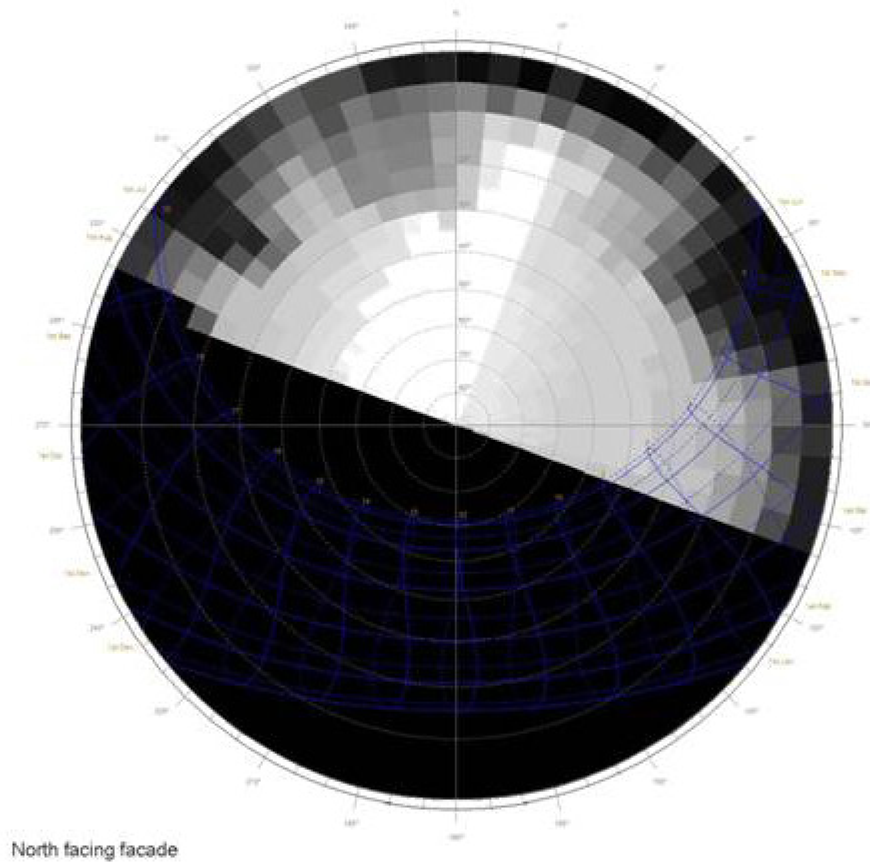

Figure 8.1: sky view factor andrewes

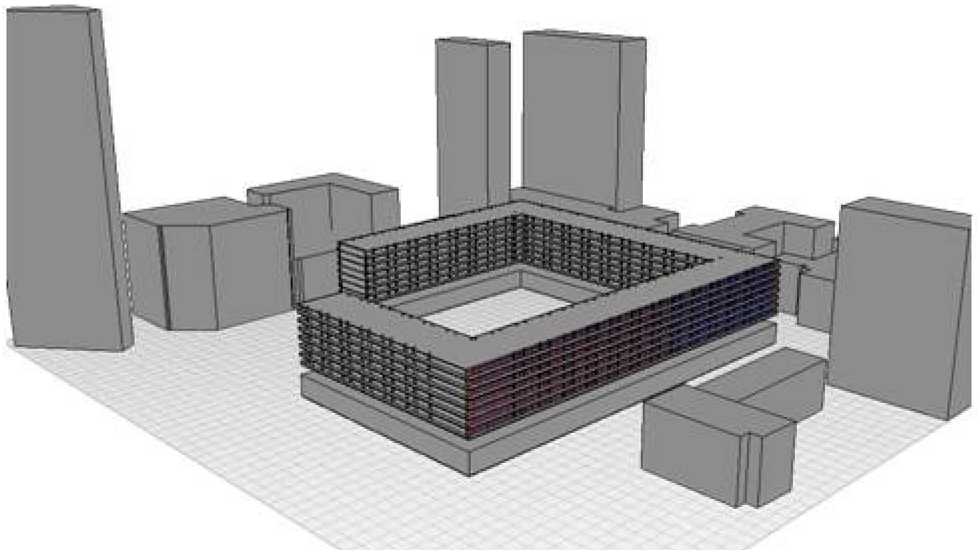

Figure 8.7: solar radiations 3d view

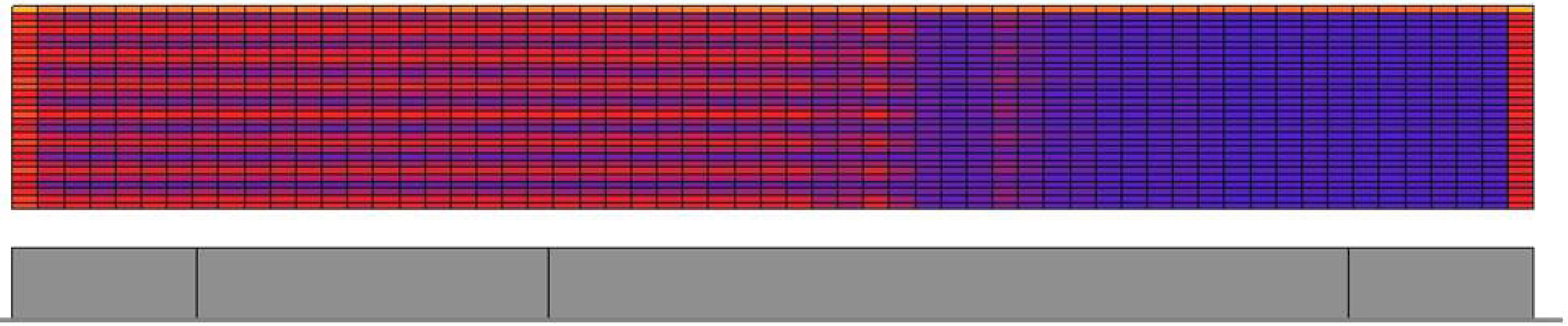

Figure 8.8: solar radiations facade winter

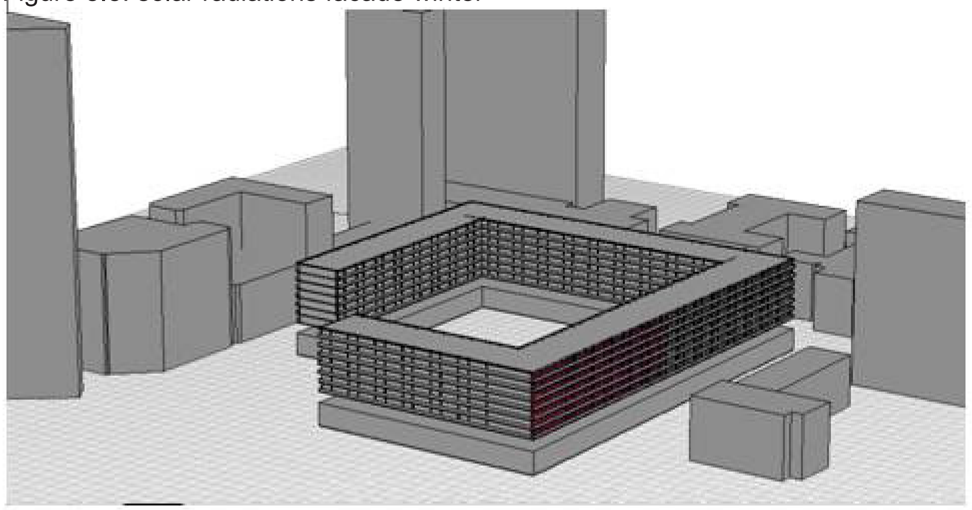

Figure 8.9: solar radiations 3d view

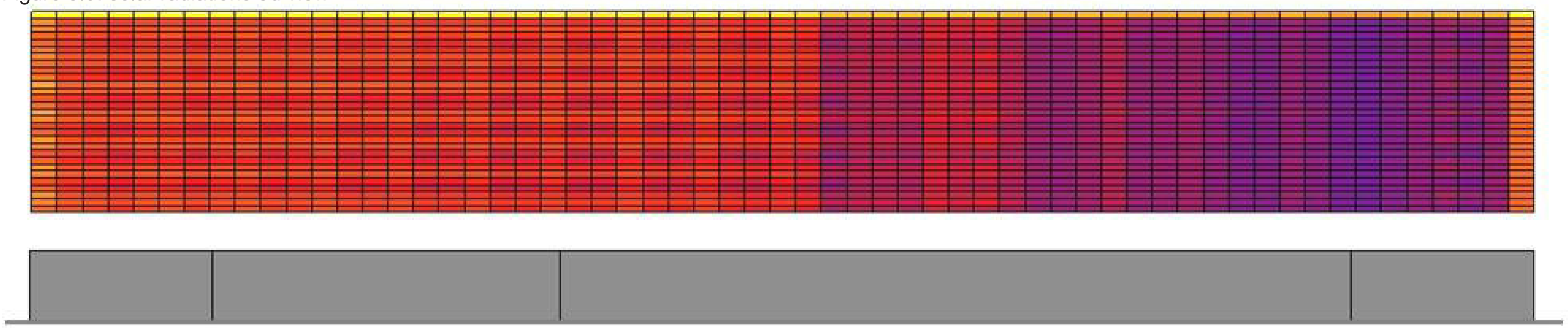

Figure 8.10: solar radiations facade summer

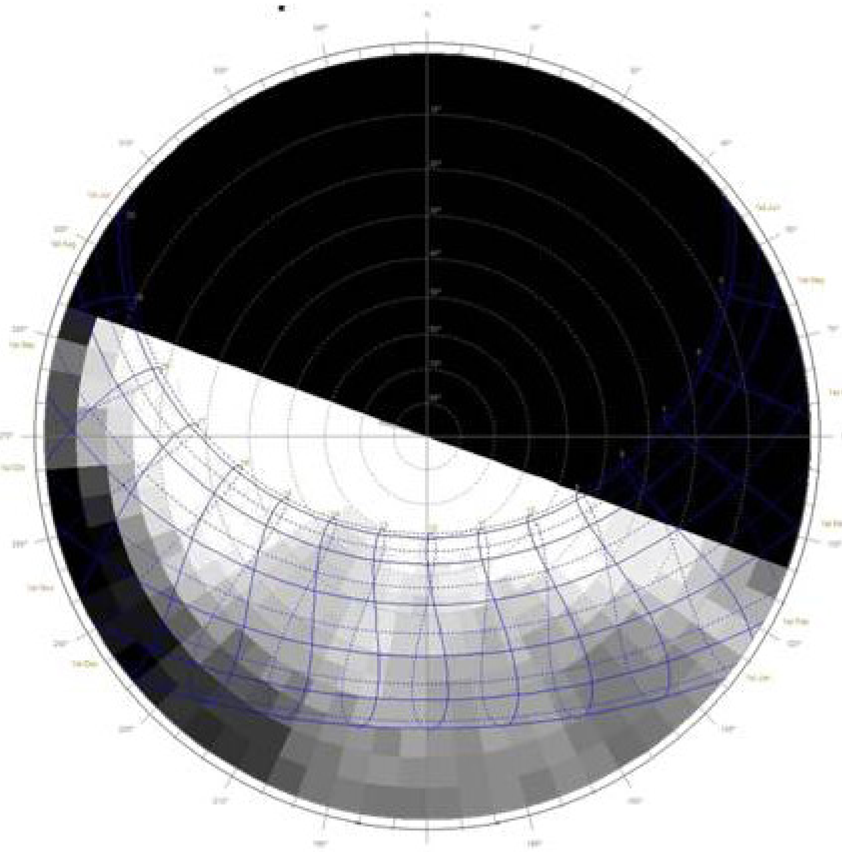

Figure 8.6: sky view factor andrewes south

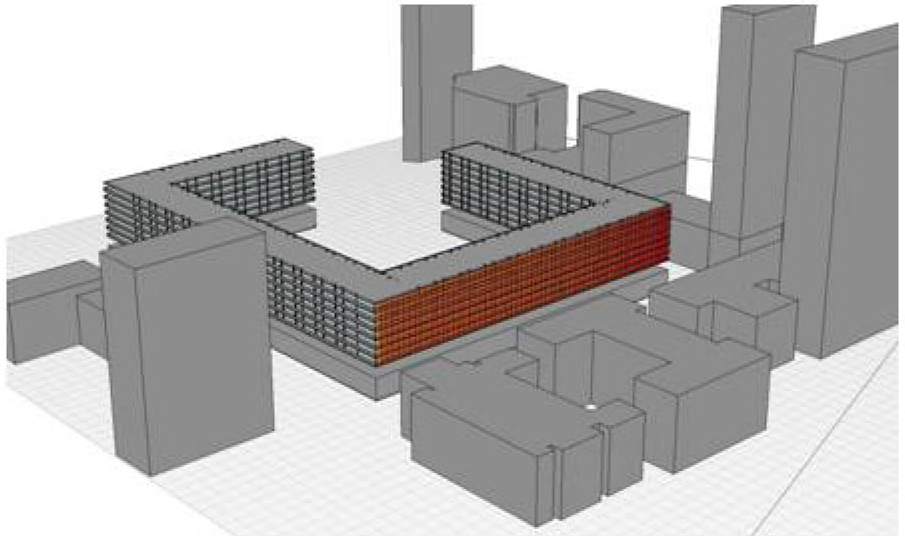

Figure 8.12: solar radiations 3d view

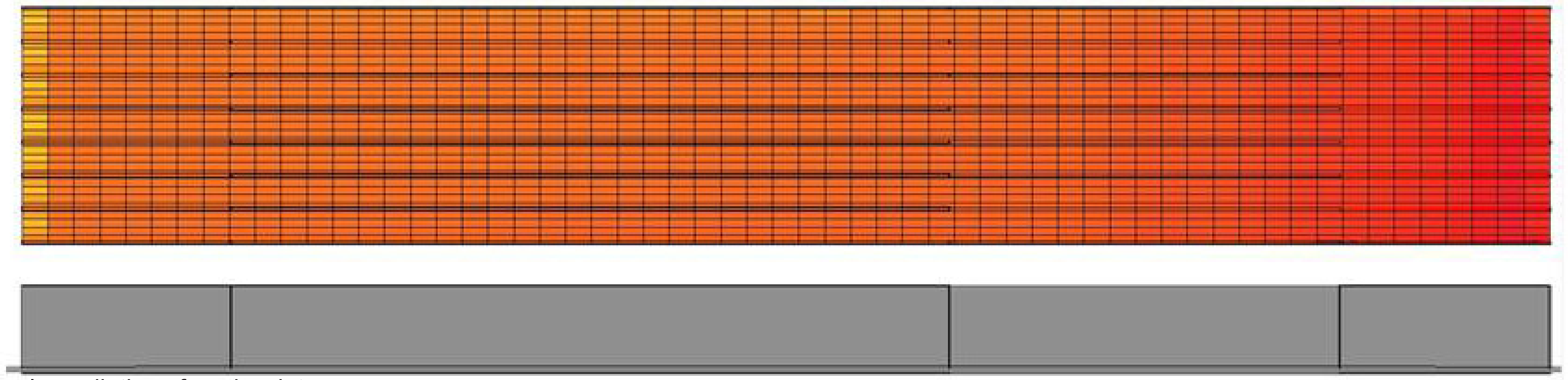

Figure 8.13: solar radiations facade winter

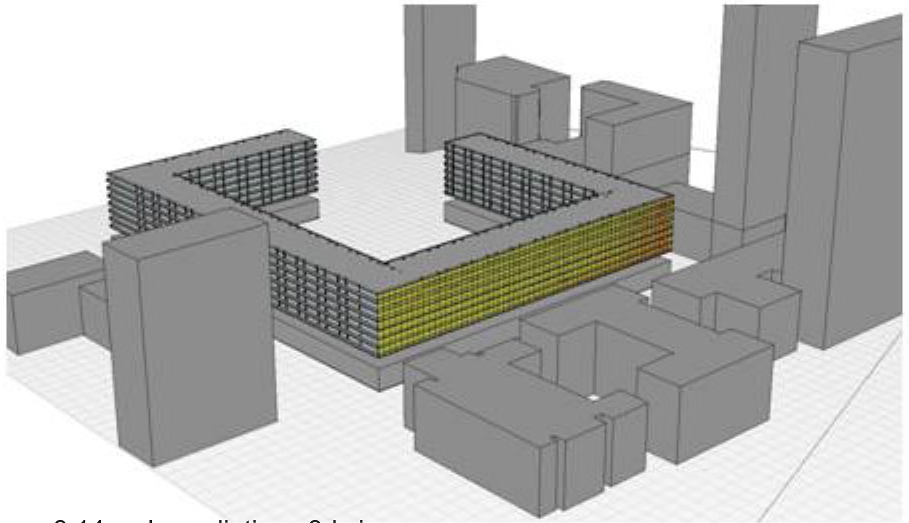

Figure 8.14: solar radiations 3d view

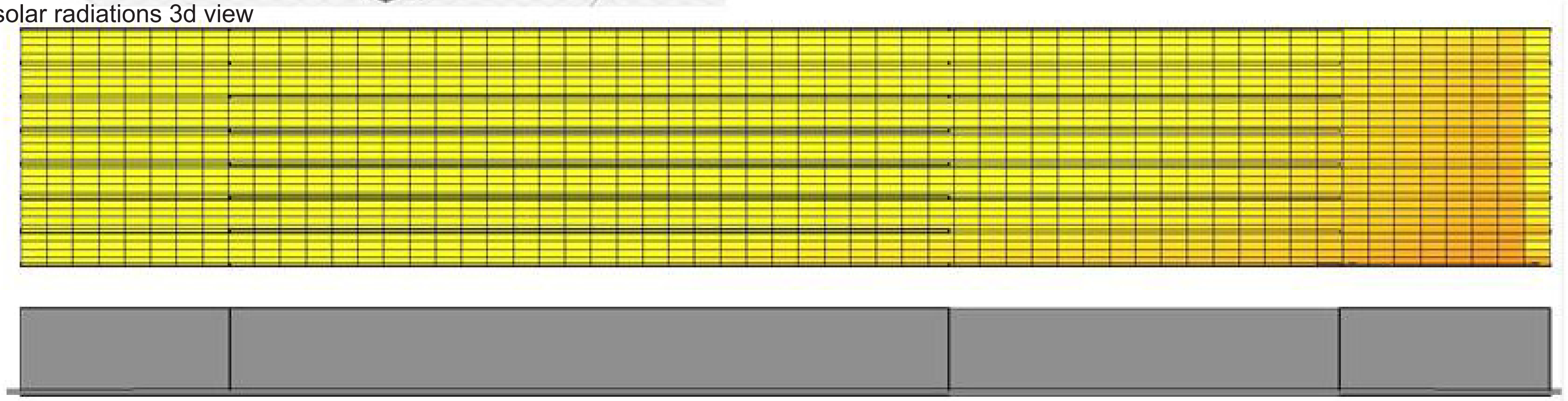

Figure 8.15: solar radiations facade summer

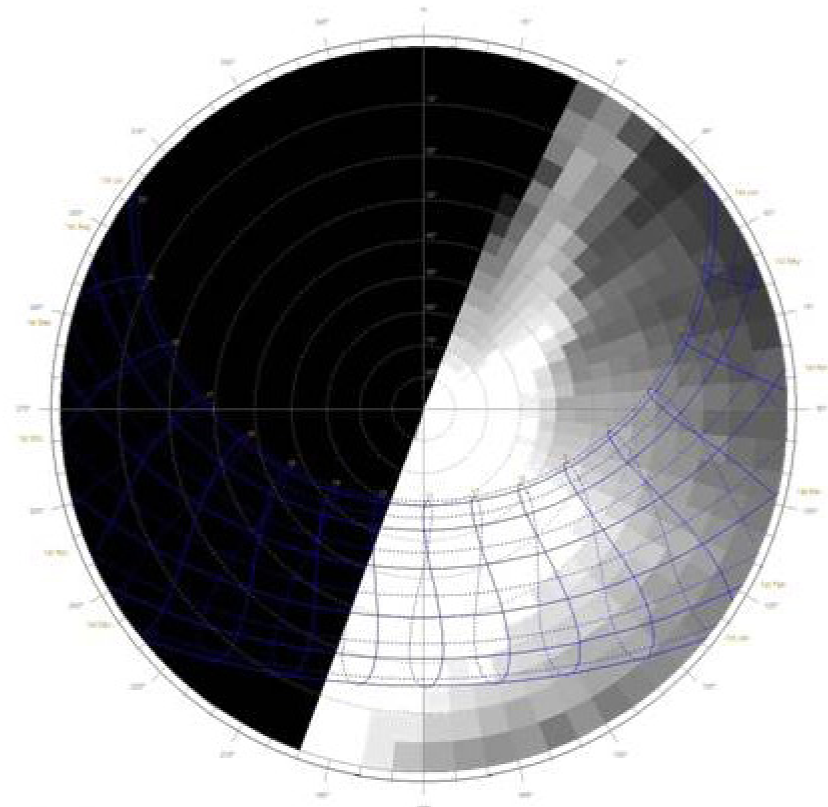

Figure 8.11: sky view factor willoughby east

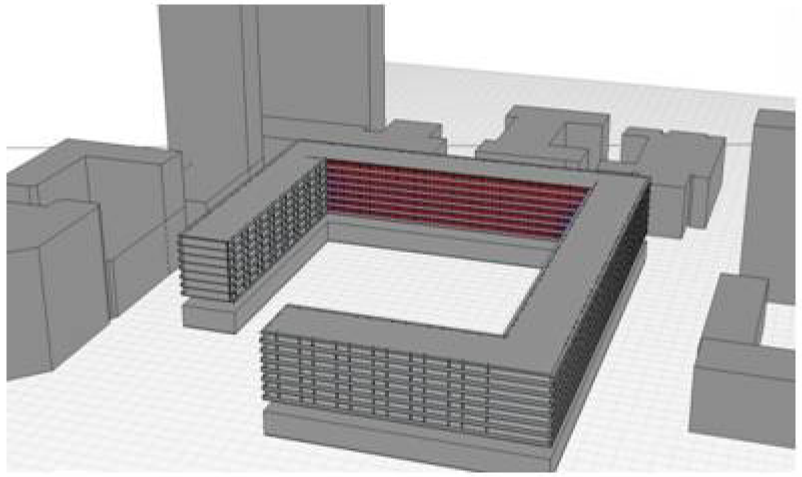

Figure 8.17: solar radiations 3d view

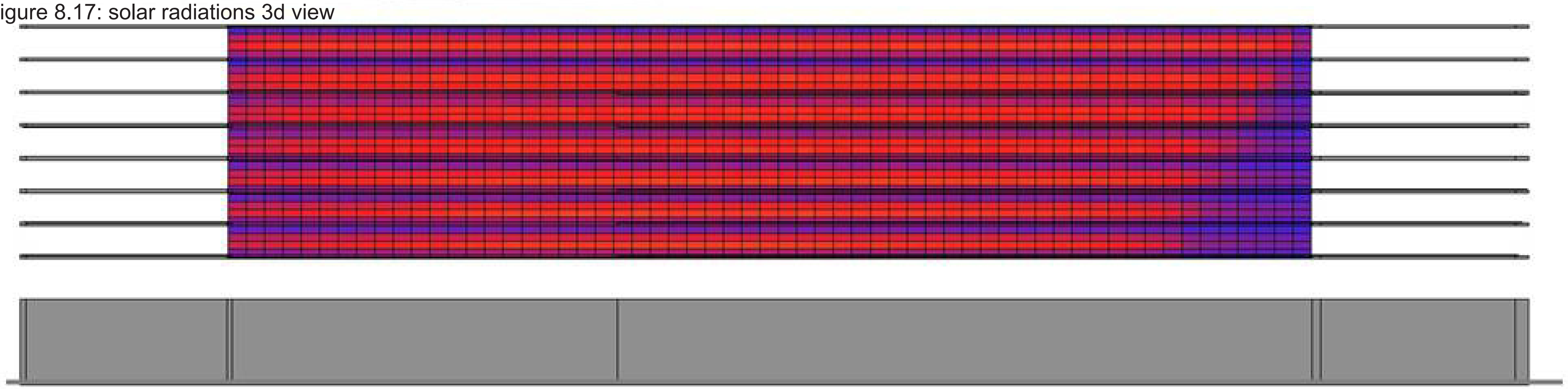

Figure 8.18: solar radiations facade winter

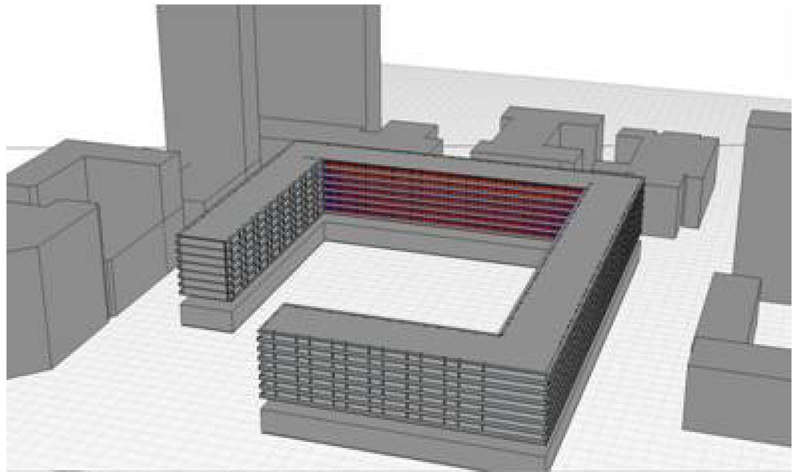

Figure 8.19: solar radiations 3d view

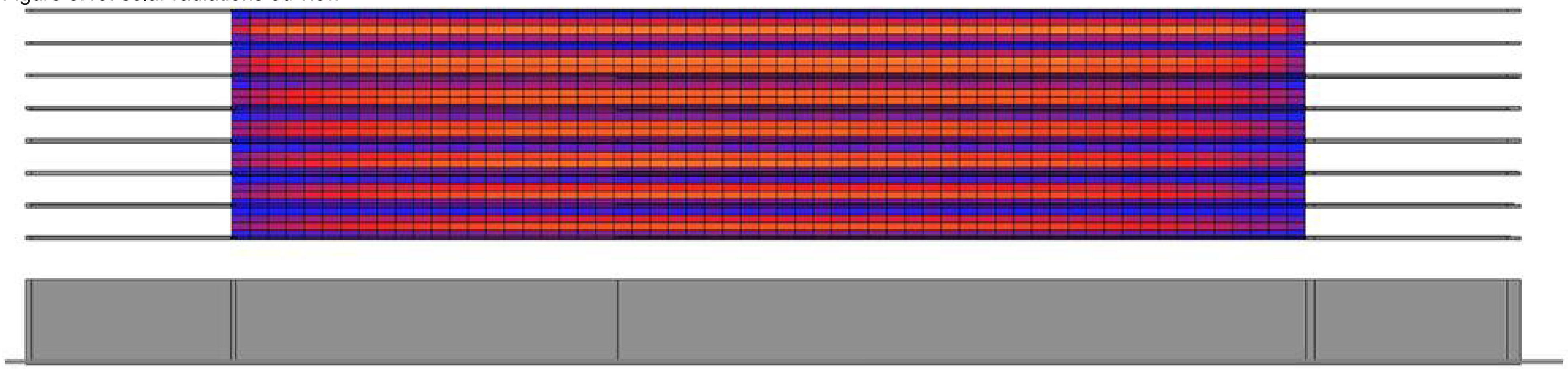

Figure 8.20: solar radiations facade summer

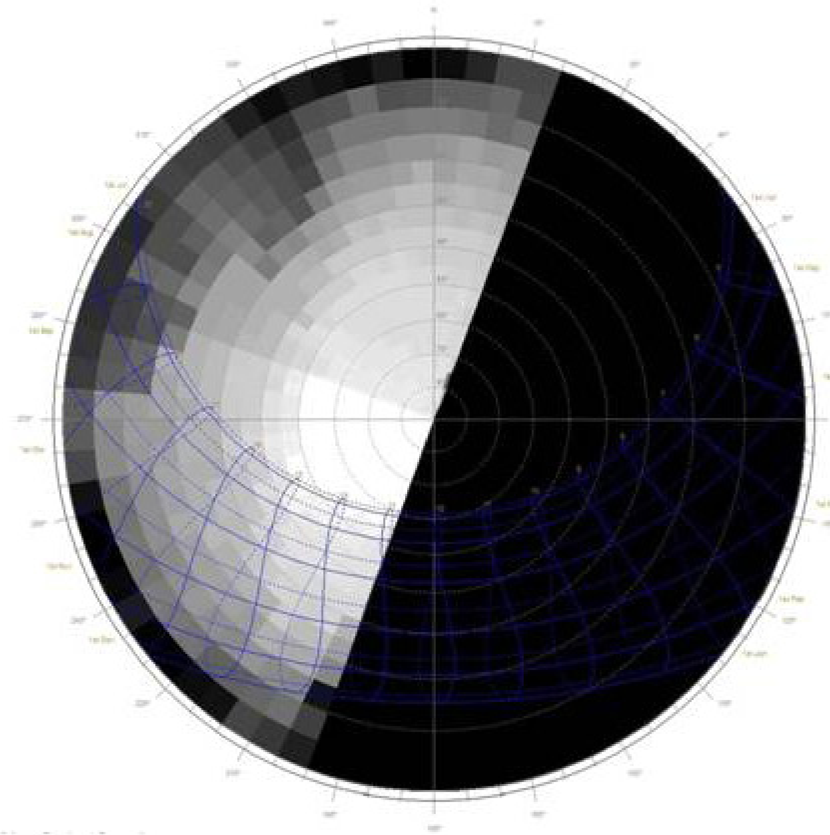

Figure 8.16: sky view factor willoughby west