The investigation of Spatial Delight and Environmental Performance of Modernist Architecture in London – Golden Lane Estate

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This is an electronic version of a paper presented at the *16th International Conference on Sustainable Energy Technologies,* Bologna, 17 to 20 July 2017.

The investigation of Spatial Delight and Environmental Performance of Modernist Architecture in London – Golden Lane Estate

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Abstract: This paper investigated the spatial delight and environmental performance of two selected apartments in the modernist buildings at Golden Lane Estate built after the 2nd World War. This estate is a Grade II listed, high density, low cost housing complex designed by three young architects: Peter Chamberlin, Geoffrey Powell and Christof Bon *and it was built over a bombed site, and well embraced the post-war modern architecture ethos, environmental considerations and inclusion of social facilities and landscaped communal spaces.*

Two apartments in different building blocks with similar size, orientation, internal layout, use of materials and building elements were chosen for this study. However, one apartment has been refurbished with internal insulation and secondary glazing for improving the comfort conditions. Through fieldwork, which included on-site monitoring and interview of the building occupants, first-hand information on the environmental and comfort conditions inside the apartments were obtained. Through performance based theoretical analysis, the comfort conditions in the apartments and energy consumption were critically assessed.

The research findings indicate that through selective enhancement of the thermal property of the building envelopes by internal insulation, introduction of secondary glazing over the original single glazed windows and the improvement on the air tightness in the apartments, the original naturally ventilated and well day-lit living environments were maintained while the overall comfort level was significantly improved. This paper presents the feasible strategies to deal with the environmental challenges in the post-war Grade II listed residential buildings in the UK.

Keywords: Modernist Architecture, Environmental Performance, Spatial Delight, Selective Environmental Interventions, Occupants' Comfort.

1. INTRODUCTION

2017 marks 63 years since the architects Chamberlin, Powell and Bon were first approached by the City of London Corporation to act as consultants on the reconstruction of the Golden Lane and Barbican Estate. Their Practice, also known as CP&B was founded in 1952 during a period of energetic optimism for architecture. All three architects were in their early thirties, but they landed the ambitious commission to build what was to become a truly utopian piece of urban planning and a radical reimagining of a heavily bombed site in central London. The end of the 2nd World War in 1945 had seen a wide and heartfelt belief that there was an opportunity to build a better Britain, with greater opportunities for ordinary people than before.

CP&B adopted a design approach that embraced site, space and urbanism as three key elements central to architecture. One of their principal interests was the creation of places – not just buildings (Powell, 1957). The design of the Golden Lane Estate displayed strong influence from Le Corbusier. Mies van der Rohe, Frank Lloyd Wright and Ludwig Hilberseimer were other influences. They considered the design of a group of buildings in close proximity to each other as if they were a single problem in design, and experimented with aesthetic and composition (Penoyre, 2012).

This paper explored the spatial delight and environmental performance of selected apartments in the modernist buildings at the Golden Lane Estate, this estate is a Grade II listed, high density, low cost housing complex built over a heavily destroyed site, and it was one of CP&B's key competition winning schemes which well embraced the post-war modern architecture ethos, environmental concerns and inclusion of social facilities and landscaped communal spaces. It was built at a period when the local authorities, through a comprehensive recovery and re-building strategy, provided housing for single people and couples rather than large families. It marked the major commitment of British Government in providing social and affordable council housing that responded to new aspirations of post-war Britain and Europe to improve the living conditions of working people.

Two two-bed apartments in different building blocks on the estate with the same orientation, internal layout, use of materials and building elements were selected for this study. The environmental performance of the chosen apartments with a split-level internal layout (one in Bayer House and the other one in Basterfield House), different ventilation strategies, internal insulation, selective secondary glazing to windows (except the front movable glazed sliding doors) were analysed. In addition, this study also aimed to explore how life style and behavioural changes have impacted on the use of the domestic spaces and the demands on environmental comfort through sensible building modifications by the building occupants.

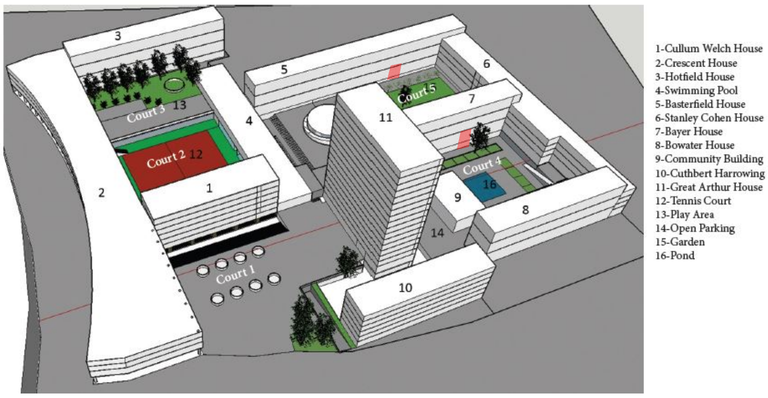


Figure 1: Overall view of the site showing the units being studied (highlighted in red)

Through fieldwork, which included on-site monitoring and interview of the building occupants, first-hand information on the environmental and comfort conditions inside the apartments and the occupants' subjective views on the architectural experience and comfort conditions were obtained.

2. RESEARCH METHODOLOGY

The research started with a discussion on the climatic conditions of London and this was related to the architects' environmental design considerations of the two residence blocks during the design development. The building massing and layout were evaluated against solar control, sun penetration and daylighting which were critical at the era when the estate was constructed. Two two-bed flats were further assessed by subjective interview, on-site monitoring and static and dynamic thermal simulation to compare the performance improvements that the selective retrofitting through internal insulation and secondary glazing had contributed to one flat against the other, which is in the most original state. This study attempts to reveal the spatial and environmental considerations applied in the design process, and also discusses the environmental benefits in terms of comfort and energy saving can be brought to the Grade II listed Estate.

2.1. Climate Study

London is located at Latitude 51.5 N, Longitude 0.1 W and is at 100 m to 245 m above sea level. It is characterised by oceanic climate with a warm season from May to September with average daily temperatures between 14°C and 19°C and mean maxima above 20°C. The predominant wind direction in London is from South East (SE) to West North West (WNW). The Design Sky illuminance for UK is about 4500lux and the dominant sky type is overcast (Meteonorm, 2014).

2.2. Apartment Studies

Two two-bed apartments were studied and evaluated for its original architectural design intent underpinned with environmental considerations in terms of planning, spatial layout and the choice of material. The flats are similar in orientation, size, spatial planning and building elements but one is retrofitted (Basterfield House) while the other is in its closest original design stage (Bayer House).

Both apartments are maisonettes with North-South orientation and a deep plan accessed from the ground floor. The house has thick solid brick masonry on the North side with a balcony while the south side has large single glazed windows. A large glazed sash door in the living room on the southern façade of the flat opens to the communal garden. The lower floor consists of living cum dining room and a kitchen. The upper floor has two bedrooms, a bathroom cum toilet and a balcony.

Figure 2: Photo of North side and South side facade (left to right)

Bayer House

An old couple of over 70 years have been living in the house for more than 20 years and developed a deep sentimental attachment to the original design. The interview findings show that the occupants are generally very happy with the thermal and visual comfort in all rooms except the bedroom on the north. The North Bedroom is considerably colder than the other rooms and heating is required for most of the year.

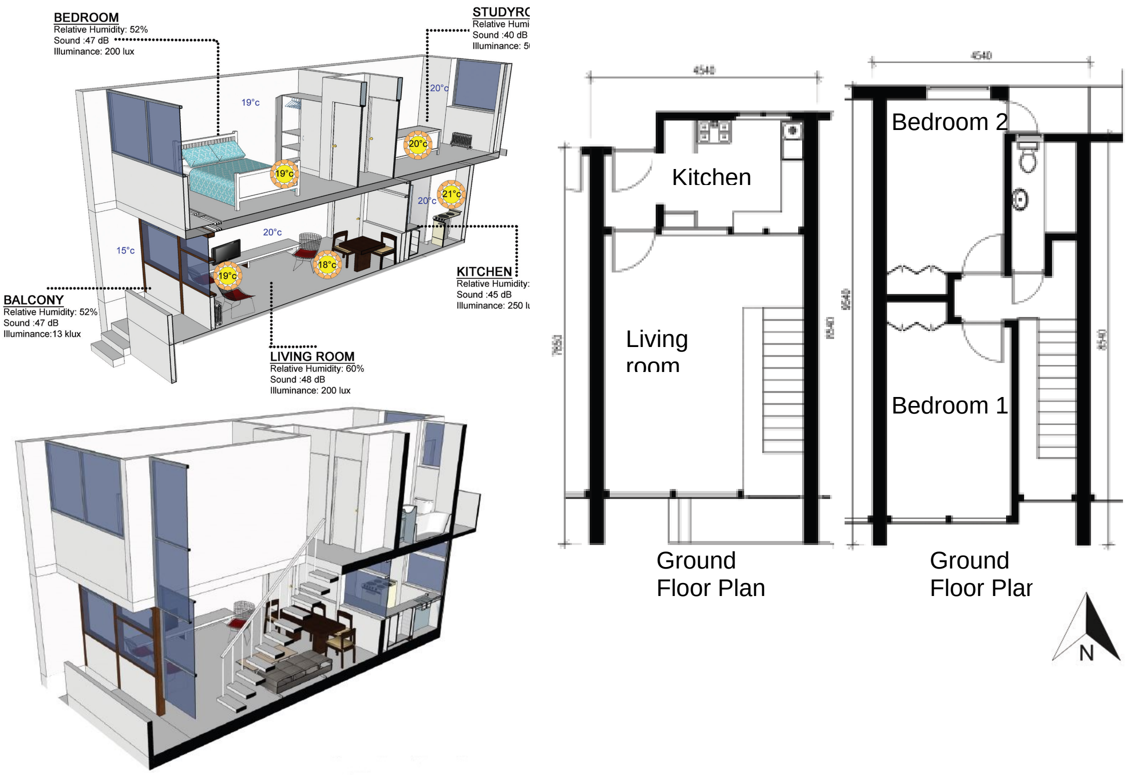
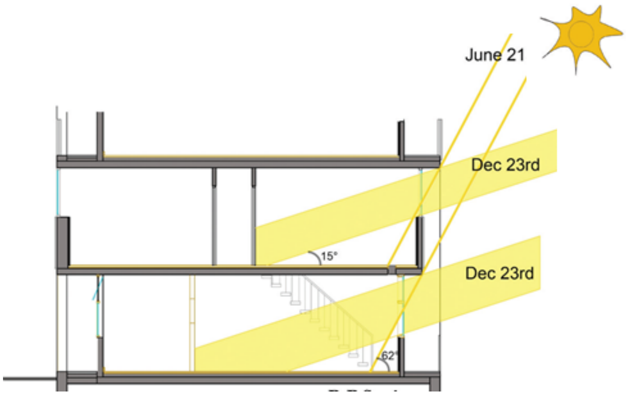


Figure 3: Internal cross sectional views with spot measurement and floor plans

Figure 3 shows the overall spatial arrangement and the spot measurements that were taken during the study period in October. The total floor area of the flat is 56m^2. The upper floor is accessed via an internal stairway. The living room and the main bedroom are located on the South side. There are large glazed areas on the south elevation (Figure 2). The floor projection in the bedroom to the south helps to provide shading to the glazed facade during summer as well as shelters from the rain. This also acts as a transitional space before one gets out to the open green lawn.

The overhang projection of 0.29m has been carefully designed by the architects to allow the sun to penetrate deep into the flat during winter months. This unique façade design gives high importance to sunlight availability especially during the cold season. The Vertical Sky Component measured 23° while is well within the threshold of 27 ° for UK for ensuring the Annual Sun Probability hours are met (BRE report: Site layout planning to daylight and Sunlight). Figure 4 below illustrates how the slab projection serves its purpose of ensuring restricted solar ingress during summer, but deep sunlight penetration during winter when heat gain is required.



Window to wall ratio			
Orientation	Window area (m2)	Wall area (m2)	WWR (%)
South facing	12.4	20.3	61%
North facing	3.8	20.3	19%

Table 1: Window to Wall Ratio

Figure 4: Illustration of Sun Penetration at differnt times of year at noon

Table 1 above shows the window to wall ratio in the flat. It is clear that there is a deliberate design intent to have less glazing elements in the North façade to reduce the heat loss. However the high window to wall ratio on the south elevation indicates the desire to welcome the solar gain from the south.

Bayer House						
Month	Correction factor	Transmitted radiation (kWh/m²)	Fraction unobstructed	Glass area (m²)	Fraction retained	Net solar gain (kWh/m²)
December	1	15.2	0.894	12.24	0.869	145
June	1	36	0.894	12.24	0.869	342
September	1	56	0.894	12.24	0.869	533

Table 2: Solar gain from South Windows

Table 2 summarizes the findings to demonstrate the impacts of the overhang on solar radiation with respect to the sun angles compared with the net solar gain and the transmitted radiation from the window surface. When the Sun is at its highest angle in June, it is expected that there might be chances of overheating from the large glazed elevation. However, this facade is well shielded most of the time, allowing an average transmitted radiation of only 36kWh/m² for the entire month in June. In September when the temperature drops to about 16°C, the irradiation received by the windows averages to about 56kWh/m². This indicates that the depth of the overhang allows more solar ingress in the colder months of year, however, given the fewer hours of sunlight in winter (December) the irradiance received on the window surface still reaches 15.2 kWh/m².

The recommended glazing ratio is normally between 25-35% (BRE). In the case of the chosen flats, the high Window to Wall ratio (above 25%) ensures good daylighting for the apartments, this ratio also potentially leads to extreme heat loss from the windows during winter and excessive heat gain in summer, particularly for buildings that were built in the 60's as the glazing at the time was mostly single glazed. This implies that considerable amount of heat loss from the building façade will contribute to the building heat loss coefficient of 400W/K and 25% of the total heat loss in the building, which equates to 4000 kWh/year.

This observation highlights the need to strike the right balance between good daylighting and thermal performance so that environmental comfort can be provided throughout the year. Figure 5 shows the average daylight factor in the living room is about 8%, indicating a well day lit space without the need for artificial lighting for most of the time. However, the desirable daylighting performance also leads to potential heat loss by conduction through the single glazed windows with U value of 5W/m²K.

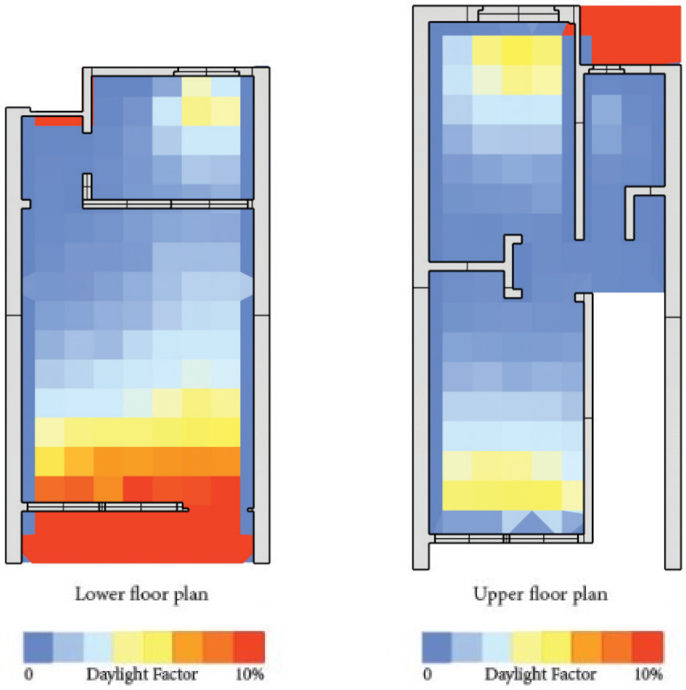


Figure 5: Daylighting analysis in the chosen apartment

Figure 6 shows the correlated temperature profiles of all rooms within the flat in September. Apart from the data shown in the bedroom 1 which is also used as the office, the other data show a linear relationship to the temperatures at different positions within the house. The graphs also show that the worst performing room, in terms of heat retention, is bedroom 1 where a sharp increase and as well as decrease in the temperature is observed, however the thick wall helps to maintain a relatively steady temperature of 17°C - 18°C despite it being on the north side.

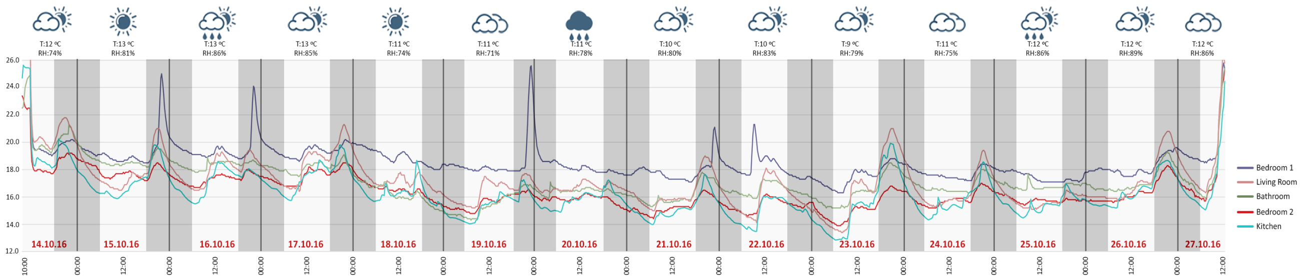


Figure 6: On-site monitoring temperature data recorded from data loggers (Apartment in the Bayer House)

The energy index is calculated with an operative temperature of 17.3 ˚C and an infiltration rate of 0.7 air changes per hour (ACH). The operative temperature was derived from the findings from the data loggers by averaging the temperature of the rooms. The ACH is derived from the CIBSE guide based on the time the house was constructed and the state of the house at present.

The Gain to Loss ratio is calculated against the average temperature in London which is 12˚C. A Gain to Loss ratio (GLR) of 0.502 implies that the losses are high in the house and it is primarily due to the wall with a total loss of 140W/K. Hence the conductance of the construction material plays an important role in determining the GLR despite the huge solar gain from windows of 5697kWh. This also indicates the need to have insulation on the building envelope.

Basterfield House

Another identical apartment at Basterfield house, a replica of the flat at the Bayer house was selected for comparative studies. This flat had been retrofitted with internal wall insulation and additional secondary glazing over the existing single glazed windows. In this flat, although subjective interview with the occupants had not been carried out due to the time constraint, on-site monitoring and theoretical performance simulation were undertaken to quantify the environmental improvements the intervention has contributed to.

In 2010, the house was retrofitted and the following changes were made;

1. Secondary glazing were introduced to the existing single glazed windows with sliding arrangement on aluminium channels.

2. The walls on the ground floor and the upper floor on the south side were insulated internally.

3. The bedroom wall facing north, the kitchen and the toilet walls were also internally insulated.

There are 3 radiators in the Living room and one each in all other rooms. According to the occupant, the thermostat in his apartment is all set to 21°C. Data loggers were installed in his residence to get an average indoor temperature range irrespective of the set thermostat setting. The external ambient temperature at the time of the measurement was between 3°C to 6°C in December.

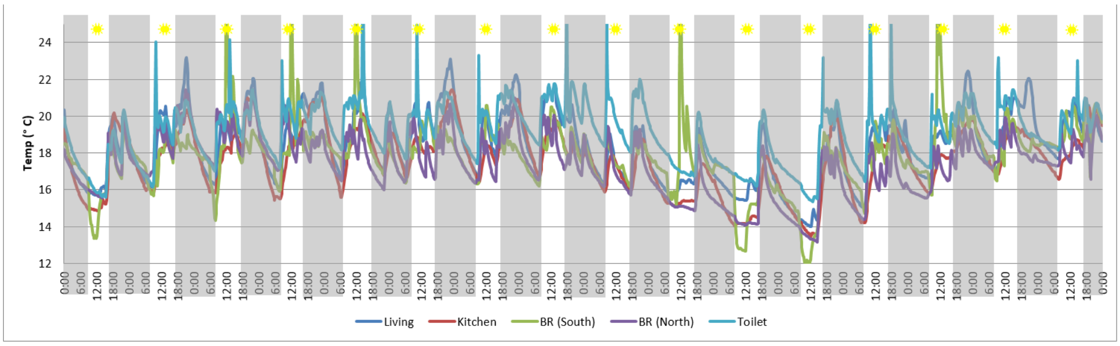


Figure 7: Temperature profiles recorded by logger data during January 2017 (Basterfield residence)

Figure 7 shows that for over 80% in January 2017, the temperature profiles were within the range between 16°C to 21°C, except for some abnormalities in Bedroom south on some of the days. The south wall shows a relationship between solar gain and the loss which is dependent on the radiation falling on its surface and the outside air temperature.

The energy index is calculated on the basis of a hypothetical calculation of the total internal gains from equipment, lighting and occupancy. The equipment in place and the finding from the informal interviews is the source for the data. The result shows a continuous heating of 11537kWh per year which is equivalent to 206 kWh/m2. This achieves D1 rating in the Building Energy Rating Standard used for domestic buildings in the UK (E2 rating is considered as the minimum energy rating required for domestic buildings in London as per Part L 1A 2016).

2.3. Comparative Analysis

A comparison on the Energy Index between Bayer House and Basterfield House shows that overall heat loss coefficient is reduced by 20%, a clear indication that the retrofitted building envelope is a significant improvement in energy conservation. The solar gain in general is reduced by introducing the secondary glazing but it greatly helps to achieve the overall 26% reduction in heating demand annually.

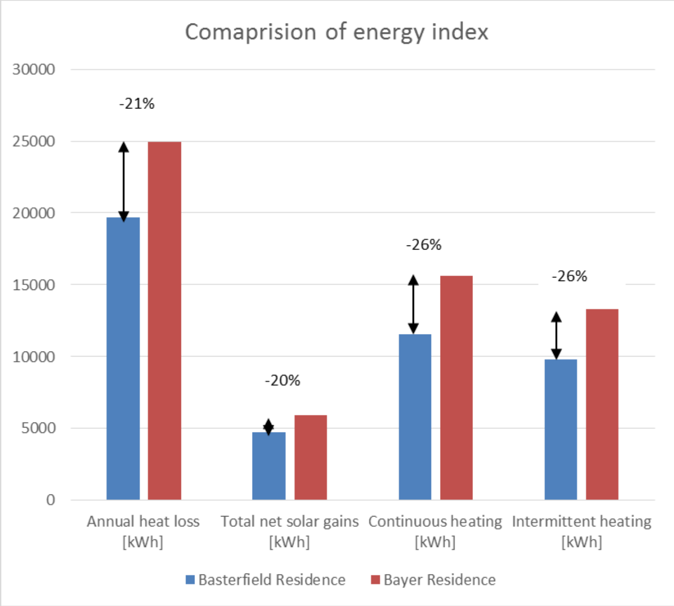


Figure 2: Comparison of Energy Index

Dynamic thermal simulation results show how the resultant temperature in the living room of the apartment in the Bayer House is directly related to the availability of sun and the outdoor temperature. It is a clear indication of the poor performing building fabric that contributes to high heat losses during winter. So despite having same condition for heating the room there is a difference in the indoor thermal environment. The resultant temperature in the Basterfield residence case is almost constant. This has direct implication on the heating demand, and the difference is about 30% reduction.

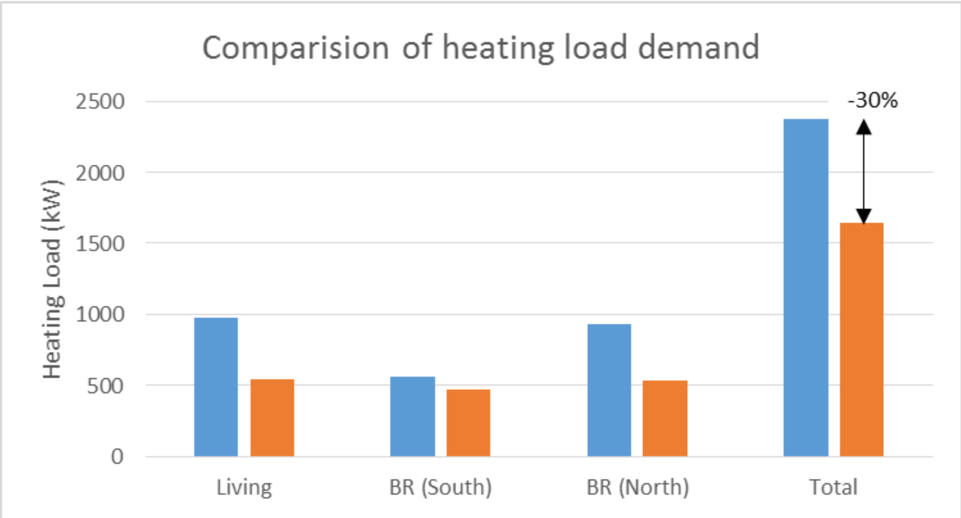


Figure 3: Comparison of Heating load demand

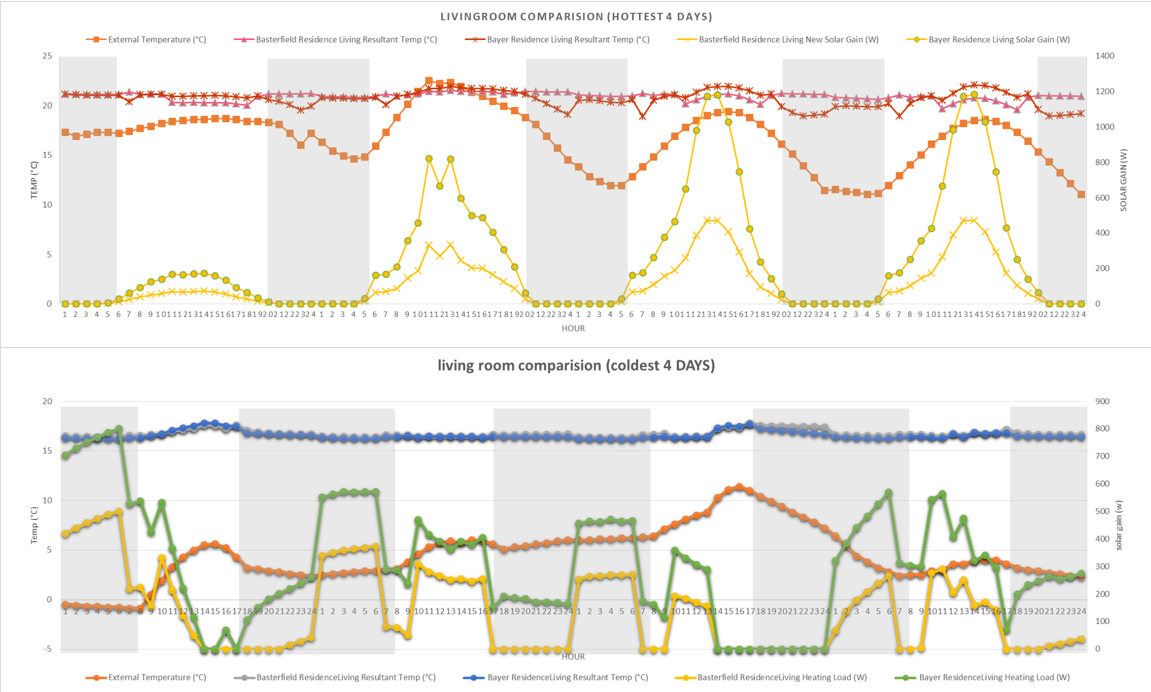


Figure 4: Comparison of performance during typical summer and winter days

Figure 8 shows the relationship between the resultant temperature in the living space and the outdoor temperature and the solar gain from the windows during summer. Given the retrofitting windows with low U value of 2.0W/m2K in Basterfield residence compared to original windows at the Bayer residence (U value = 5.0W/m2K), the indoor resultant temperatures in Basterfiled residence is much more stable than the Bayer residence on the hot days. The temperature profiles on cold days show similar constant trend but when compared against heating load, the Bayer residence requires a relatively much higher heating load throughout the year due to the poor averaged U value of 2.95 W/m2K of the original construction.

3. CONCLUSION

The significant difference in the energy consumption between the two chosen flats is mainly due to the improved thermal property of the building envelope with an overall improvement in weighted average U value by 17%. The Architects designed the building to best suit the climate and followed the basic principles of having high glazed area on the south to receive solar gain and with minimal glazing and thick walls on the north to reduce heat loss during the cold winters. The dynamics of thermal performance works beyond the simple logical interpretation to drawing up interrelations with the intensity of the radiation and the hours it benefits.

Given the low sun angles in winter, the solar radiation on a vertical surface is high (up to 2kW at 15 hours) for the Bayer House, however owing to extreme cold outdoor temperature, the resultant temperature in the interior is a function of the heating by the appliances in the rooms and the high glazing ratio which results in higher heat loss in cold months. The solar gain on the glazed façade is affected by the property of the glass (high transmittance for single glazed compared to low transmittance for secondary glazed) thus a difference of 750 W at 14 hours during winter months is observed.

Although theoretically the heating demand in the flat at Bayer House seems quite large, this is a subjective issue. The couple living in the flat at Bayer house practice adaptive comfort and put on more clothing to keep themselves warm while reducing the use of heating, their heating set point is also lower by 2% compared to the occupants at the Basterfield house apartment. As a result, life style and occupants' behaviour can make a substantial difference to the overall energy consumption.

The choice of material and its implication on the visual and the thermal comfort should not be overlooked or investigated in isolation. The visible transmittance and the G value of the glazing system have a significant role in enhancing the physical well-being of the occupants. In this case the solar gain reduction from 2kW to 1kW at 14 hours on a typical winter day indicates that higher internal heating demand is required while the same solar gain reduction in summer would mean less cooling is needed.

The energy consumption in domestic sector of UK has increased by 3.6%, with the majority being contributed by gas consumption, 5.1% higher, reflecting additional heating requirement (Department for Business, Energy and Industrial Strategy, 2016). Between 2014 and 2015 the consumption of energy per household has increased by

2.6%, owing to the changing expected level of comfort from individuals (Department for Business, Energy and Industrial Strategy, 2016).
While accepting that life style is subject to change further, the majority of the energy conservation has to come from retrofitting the existing homes as new housing being built currently stands at less than 1% (Yorke, 2014). So it is important that existing homes are selectively retrofitted in the best way possible to ensure reaching lower energy consumption while addressing the need for environmental comfort.

The feasible solutions for achieving better thermal performance of existing dwellings are by reducing heat loss through ventilation (leaky windows and doors), improving building fabric performance with better insulation and upgrading windows with higher glazing specifications (Roberts, 2008).

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