Compliance with the overheating criteria in Purpose Built Student Accommodation (PBSA): How accurate is the TM59 method in those buildings

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Abstract

This paper examines the effectiveness of the Dynamic Thermal Modelling Method (DTMM) under TM59 and Approved Document O (Part O) in assessing overheating risks for Purpose Built Student Accommodation (PBSA) in pre-construction. With Part O mandate for residential overheating assessments, this explores whether TM59's standard methodology reliably ensures occupant comfort or inadvertently promotes over-engineering and excessive mechanical cooling, contributing to increased carbon emissions. The research compares standard simulation inputs with modified numbers and evaluates their performance against the appropriate TM59 criterion. Findings are based on real project data used for planning and compliance assessments.

Keywords

DTMM – Dynamic Thermal Modelling Method

PBSA – Purpose Built Student Accommodation

TM59 standard – Technical Memorandum 59

PMVH – Predominantly Mechanically Ventilated Homes

GLA – Greater London Authority

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1. Introduction

Since the introduction of the Approved Document O (Part O) on 15 June 2022, all new residential buildings need to be assessed for overheating risk in the pre-construction stages of development. One of the ways to do so is the use of the Dynamic Thermal Modelling Method (DTMM), following the guidance described in (Bonfigli, et al. 2017) ((2010) 2021) ((2010) 2021)Technical Memorandum (TM) 59, which was developed by the Chartered Institution of Building Services Engineers (CIBSE), along with additional limitations introduced in the Part O. This paper aims to research the impact of modelling inputs on the final overheating strategy. The intention is to establish whether some current standards are leading to over-engineering of the buildings, hence the increase of the carbon emissions in Purpose Built Student Accommodation (PBSA) buildings, such as to inform further research as to how they could be modified.

The findings of this report are based on a single case study used for analysis. The modifications made to the modelling to do this analysis are based on authors' experience of assessing a significant number of similar PBSA schemes. This paper evaluates the TM59 standard modelling inputs, analyses them with a case study, and demonstrates how they might be modified to lead to more carbon-efficient strategies. It is considered the first step in an attempt to encourage the competent authorities to update the modelling inputs that can be used in early-stage overheating assessments.

2. Criteria

Compliance with TM59 can be achieved by passing either the "Criteria for homes predominantly naturally ventilated" or the "Criteria for homes predominantly mechanically ventilated". Since the implementation of Part O (2022) (7), buildings in sites with potential external noise issues might need to be modelled with bedroom windows completely or partially closed during sleeping hours. Moreover, PBSA occupied rooms' windows need to be restricted for safety reasons in line with Part K (8), limiting that way the amount of fresh air passing through them. According to Part O (7) only the portion of the windows' free area that can safely remain open can be used in the overheating mitigation strategy. As a result, the majority of fresh air supply is provided via mechanical ventilation, hence the "Criteria for homes predominantly mechanically ventilated" seems more appropriate in those cases. The requirements as outlined in the TM59 guide are:

- *All occupied rooms should not exceed an operative temperature of 26°C for more than 3% of the annual occupied hours.*

Compliance with this requirement is directly influenced by the building use profile used for the assessed spaces. No PBSA specific user profile exists within the TM59 methodology. As a result, outcomes of TM59 assessments carried out on these building types may include inherent inaccuracies as shown in Section 3.

3. Modelling inputs

3.1 Heat gain profiles

TM59 introduces specific profiles for internal gains resulting from occupancy, equipment, and lighting. The accuracy of these profiles is crucial, as it directly impacts simulation results. Utilising profiles that over or under-estimate these internal gains can lead to over-engineering, unnecessary active cooling installations, or indoor conditions that may be uncomfortable or even hazardous to occupants' health (1). In a PBSA, the primary spaces assessed for overheating risk are bedrooms (ensuites), studios, and communal kitchens. The TM59 standard profiles best suited for these areas are the single bedroom and studio profiles. However, as there is no specific TM59 profile for communal kitchens, the 3-bedroom living/kitchen profile will be used as the closest fit for analysis.

Assessing standard heat gain profiles is crucial for determining overheating risks in such building types. TM59 offers a foundational methodology that allows for necessary adjustments. Nonetheless, due to limited information available in early development phases, clear guidance is essential for effective overheating mitigation strategies.

3.2 Occupancy profiles

The variations in occupancy profiles across simulations can significantly impact the results, potentially leading design teams to implement unsuitable or unnecessary mitigation measures (2). The TM59 profiles for single-bedroom and studio apartments suggest these rooms are occupied continuously throughout the day, with no differentiation between weekdays and weekends. This assumption overlooks the time students spend attending classes or engaging in activities outside their rooms. Similarly, the living/kitchen area profile assumes continuous occupancy from 10 am to 10 pm, without day-to-day variation (3).

The precision of these occupancy profiles influences not only the increase in internal temperatures due to sensible and latent gains from occupants but also impacts the hours assessed under the criteria for PMVH, which will be discussed further in section 4.

3.3 Equipment and Lighting profiles

The assessed rooms include electrical appliances and luminaires, which vary depending on the room type. The equipment gains in TM59 are based on values from the Household Electricity Survey (4) and the Electrical Appliances at Home reports (5). Both reports monitor households across England from 2010 to 2011. The average age of the monitored appliances is a few years old e.g. 8.4 years for fridge-freezers (5), which implies these were purchased in the early 2000s.

The energy consumption of refrigerators fell more than 30 per cent between 2000 and 2013 due to increases in their efficiency and other factors (6). The TM59 standard was released in 2017, by which point far more efficient appliances were on the market, resulting in less electrical energy use and thus less heating emissions into the local environment. Similarly, lighting electricity usage has dropped by 24% over the past decade.

The operational equipment profile of single bedrooms shows that all the appliances in the assessed room are in use every day of the year between 8 am and 11 pm. In addition, the lighting operational profile has set peak energy use from 6 pm to 11 pm. The lighting operational profile seems not to include the extended daylight hours in different months, the effect of this is especially pronounced in summer when overheating is more likely to occur. This is compounded by the fact that equipment operational profiles do not account for the hours that the student rooms are unoccupied.

The study will include a comparison between the standard and the modified values, which use modern electrical and lighting information to demonstrate the impact of internal gains on the thermal comfort of the occupants.

3.4 Natural and Mechanical ventilation

The operational profiles that both TM59 and Part O require for simulation use two factors to determine the time windows can open - internal temperature and occupancy.

Research conducted in the UK indicates that people are more likely to open windows as the indoor temperature increases (2). This behaviour is also reflected in the profiles recommended by TM59 and Part O. A key observation here is the lack of guidance on scenarios where active cooling is present in a room but is insufficient to maintain indoor temperatures consistently below the target threshold in the profiles. It is advised that windows remain closed when mechanical cooling is active, to prevent outdoor heat from entering the space. For this reason, it may be more effective to assess the above system using a window operational profile that will keep the windows closed when the system is operating.

In GLA-referable PBSA buildings, such a system may need to be installed to achieve compliance with overheating criteria whilst maintaining low enough carbon emissions to achieve compliance with other sustainability criteria.

The window operational profile presented here could be used in all projects that fall under Part O and have to implement low-power active cooling systems to achieve compliance with the overheating regulations.

4. Case Study

The study case is a PBSA building in London, which was granted planning permission in 2023. The weather file used for the completion of the simulation is London Heathrow (London_LHR_DSY1_2020High50). The building comprises **414** bedrooms (Levels 2-25), with the assessed ones being all the bedrooms (90 rooms) on the top 5 floors (Level 21-25) with varied orientations (25 south-facing, 35 north-facing, 20 west-facing, and 10 east-facing) and 10 communal kitchens serving the same floors (east-facing). This approach was chosen as all of the 24 floors have similar layouts and the rooms located on the higher floors are at high risk of overheating (3).

Table 4.1 below shows the standard TM59 values and the modified values that have been implemented in the study case. The changes in the peak loads are explained in the sections above, although the changes in the operational profiles arise from the different use of student accommodations from traditional dwellings. The numbers presented are a suggestion by the authors, based on their collaboration with student accommodation operators and design team members in PBSA projects, and further studies need to take place before being used in other compliance assessments.

Input Types	TM59 Standard templates	TM59 Modified templates	
Studio			
Equipment Peak Load (W)	450	200	
Equipment Operational profile	19% : 00:00-08:00 24% : 08:00-18:00 100% : 18:00-20:00 44% : 20:00-22:00 24% : 22:00-24:00	19% : 00:00-08:00 24% : 08:00-18:00 100% : 18:00-19:00 44% : 19:00-24:00 24% : 22:00-24:00	
Lighting Peak Load (W/m²)	2	1	
Lighting Operational Profile	0% : 00:00-18:00 100% : 18:00-23:00 0% : 23:00-24:00	Winter months 0% : 00:00-18:00 100% : 18:00-23:00 0% : 23:00-24:00	Summer months 0% : 00:00-20:00 100% : 20:00-23:00 0% : 23:00-24:00
Occupancy Operational Profile	70% : 00:00-08:00 100% : 08:00-23:00 70% : 23:00-24:00	70% : 00:00-08:00 100% : 08:00-09:00 50% : 09:00-15:00 100% : 15:00-23:00 70% : 23:00-24:00	
Bedrooms (Ensuites)			
Equipment Peak Load (W)	80	80	
Equipment Operational profile	13% : 00:00-08:00 100% : 08:00-23:00 13% : 23:00-24:00	13% : 00:00-11:00 100% : 11:00-23:00 13% : 23:00-24:00	
Lighting Peak Load (W/m²)	2	1	
Lighting Operational Profile	0% : 00:00-18:00 100% : 18:00-23:00 0% : 23:00-24:00	Winter months 0% : 00:00-18:00 100% :18:00-23:00 0% : 23:00-24:00	Summer months 0% : 00:00-20:00 100% : 20:00-23:00 0% 23:00-24:00
Occupancy Operational Profile	70% : 00:00-08:00 100% : 08:00-23:00 70% : 23:00-24:00	70% : 00:00-08:00 100% : 08:00-09:00 50% : 09:00-15:00	

<table>
<tr><td></td><td></td><td colspan="2">100% : 15:00-23:00
70% : 23:00-24:00</td></tr>
<tr><td colspan="4">Communal kitchens/ 3 bed Living/Kitchen</td></tr>
<tr><td>Equipment Peak Load (W)</td><td>450</td><td colspan="2">350</td></tr>
<tr><td>Equipment Operational profile</td><td>19% : 00:00-09:00
24% : 09:00-18:00
100% : 18:00-20:00
44% : 20:00-22:00
24% : 22:00-24:00</td><td colspan="2">18% : 00:00-09:00
22% :09:00-18:00
100% : 18:00-20:00
34% : 20:00-22:00
22% : 22:00-24:00</td></tr>
<tr><td>Lighting Peak Load (W/m^2)</td><td>2</td><td colspan="2">1</td></tr>
<tr><td>Lighting Operational Profile</td><td>0% : 00:00-18:00
100% : 18:00-23:00
0% : 23:00-24:00</td><td><u>Winter months</u>
0% : 00:00-18:00
100% :18:00-23:00
0% : 23:00-24:00</td><td><u>Summer months</u>
0% : 00:00-20:00
100% : 20:00-23:00
0% : 23:00-24:00</td></tr>
<tr><td>Occupancy Operational Profile</td><td>0% : 00:00-09:00
100% : 09:00-22:00
0% : 22:00-24:00</td><td colspan="2">0% : 00:00-09:00
60% : 09:00-22:00
0% : 22:00-24:00</td></tr>
</table>

Table 4.1 - Internal Gains

The modified templates are suggested by the authors as an initiative for future studies, that would lead to the creation of dedicated TM59 templates for all the different types of residential buildings. Although the lighting peak load can standardised for all overheating assessments, the occupancy and equipment peak loads and operational profiles should be used just for PBSA buildings as their use differs significantly from normal dwellings.

5. Results and Conclusion

The results of the modified templates demonstrate important differences from those produced using the standard TM59 templates. As shown in Figure 5.1the modified loads of internal heat gains for the assessed rooms are constantly lower than their equivalent standards. The most significant differences are spotted in the communal kitchens, followed by the studios. That can also be seen in Figure 5.2, which shows the total compliance rate for the three room types.

- Communal Kitchen
- Single bed
- Studio

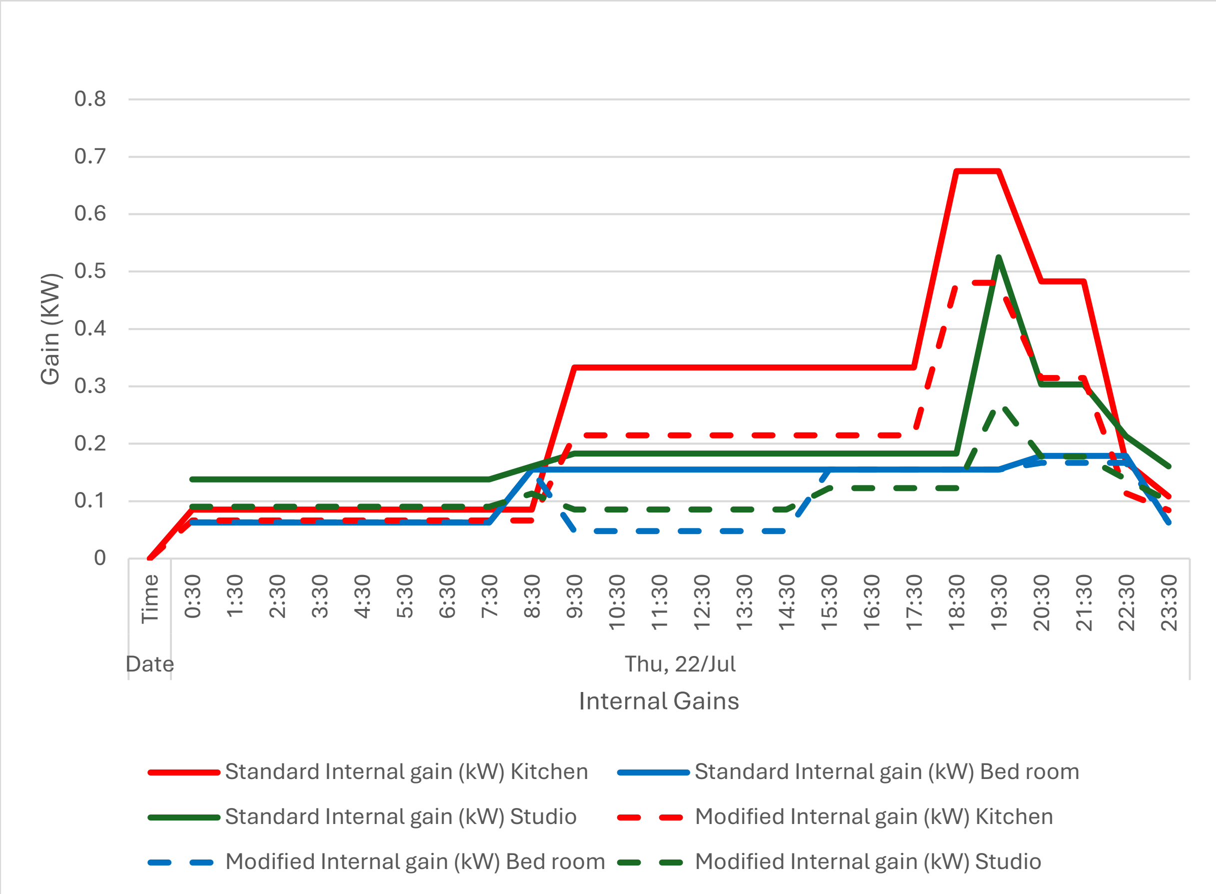

Figure 5.1 - Standard vs Modified templates

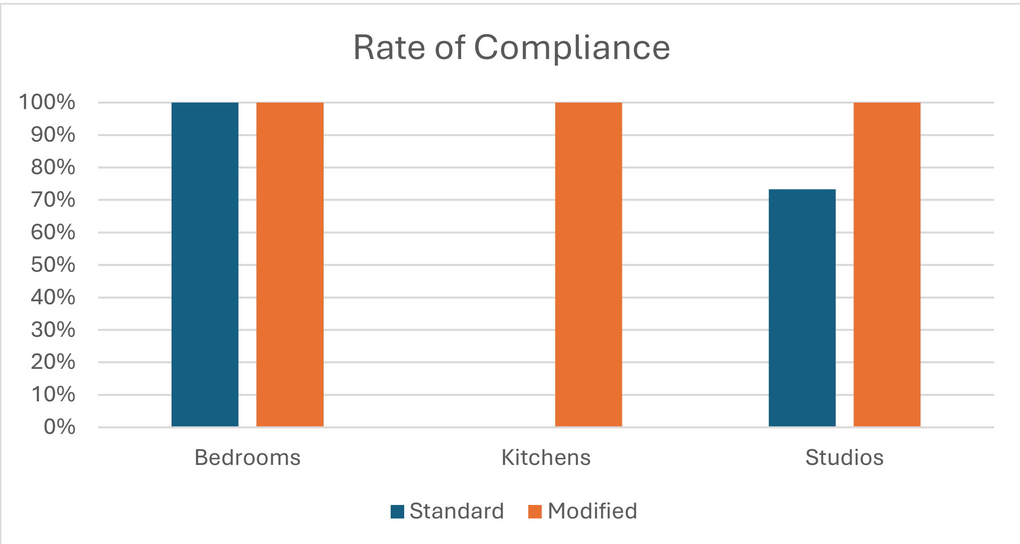

Figure 5.2 – Rate of Compliance

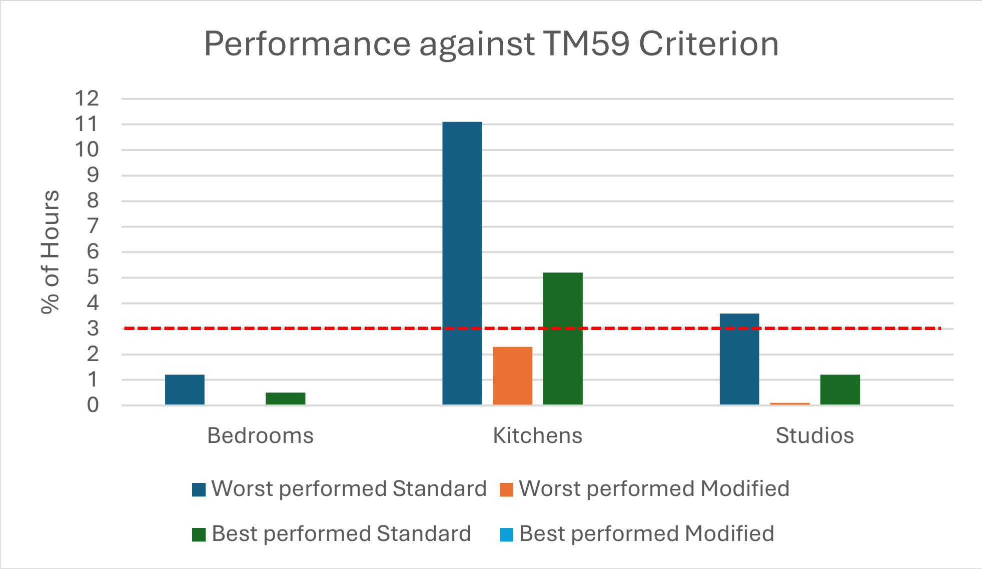

Figure 5.3 – Performance against TM59 Criterion

Even though in Figure 5.2 it is shown that the bedrooms have the same percentage of compliance, the kitchens and studio demonstrate significant differences. Figure 5.3 compliments the results of Figure 5.2 by showing the significant differences between the worst and best-performed rooms against the TM59 Criterion, which is represented by the red line.

The findings indicate that a shift towards customised, data-driven profiles that reflect actual building use more accurately than TM59 defaults, may provide occupant comfort and more energy-efficient overheating strategies, in line with contemporary building performance expectations.

References

1. Mourkos K, McLeod RS, Hopfe CJ, Goodier CI, Swainson M. Assessing the application and limitations of a standardised overheating risk-assessment methodology in a real-world context. Building and Environment [Internet]. 2020 Aug 15;181:107070. Available from: https://www.sciencedirect.com/science/article/pii/S0360132320304509

2. Elsharkawy H, Zahiri S. The significance of occupancy profiles in determining post retrofit indoor thermal comfort, overheating risk and building energy performance. Building and Environment [Internet]. 2020 Apr 1;172:106676. Available from: https://repository.uel.ac.uk/item/87817

3. CIBSE, Design Methodology for the Assessment of Overheating Risk in Homes, CIBSE, London, 2017. TM59

4. Zimmermann J-P. Household Electricity Survey, a study of domestic electrical product usage. Intertek [Internet]. 2012 May

5. Parker J, Terry N, Kane T, Firth S, Hughes M, Pope P, Young J, Knight D, Godoy-Shimizu D. Electrical appliances at home: tuning in to energy savings. Cambridge Architectural Research Limited [Internet]. 2013 November

6. Khan S, Wilkes E. Energy Consumption in the UK. Department of Energy & Climate Change 2014 July

7. Building Regulations (2010). Approved Document O: Overheating. 2021

8. Building Regulations (2010). “Approved Document K: Protection from falling, collision and impact”. 2013