OVERHEATING STUDY

—

12 KEATS GROVE
HAMPSTEAD
LONDON
NW3 2RN

—

PREPARED FOR:
PRIVATE CLIENTS

—

25 OCTOBER 2019
REVISION 1

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0	24.10.2019	LC	DRAFT	First draft issued to Chris Dyson Architects for review and comment.
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EXECUTIVE SUMMARY

12 Keats Grove is a Grade II listed detached villa, understood to have been constructed in the early 19th century. Accommodation is arranged across a semi-basement (lower ground), upper ground floor, first floor and second floor, with attic. All three bedrooms on the second (top) floor of the house experience the effects of overheating in summer. This was found to be the combined effect of solar heat gains through the glazing and conduction heat gains through the building fabric.

The objective of this study was to ascertain whether passive measures could be introduced to reduce the risk of overheating, whilst eliminating the need to provide comfort cooling. A number of passive mitigation measures have been tested and explored using dynamic thermal simulation, each of which varied in effectiveness. Overall, some of the passive mitigation measures were generally found to be effective, but only insofar as the indoor temperature aligns more closely with the outdoor air temperature during very warm weather. This is an improvement over the existing conditions under which the indoor air temperature significantly *exceeds* the outdoor air temperature.

As the passive measures are of limited effectiveness, and therefore of little direct improvement in terms of significantly reducing overheating in summer, it is likely that the client will still wish to introduce comfort cooling so that the bedrooms can all be maintained at a comfortable temperature, regardless of the prevailing weather conditions. Although the passive measures are of limited direct benefit, they would still be beneficial in reducing the running cost of a comfort cooling system (if installed) and would also result in worthwhile saving in winter heating costs. The reduction in running cost is representative of a corresponding reduction of energy consumption and carbon footprint.

In summary, if it is important for the client to have a high degree of confidence that the bedrooms can always be maintained at a comfortable temperature, then comfort cooling will need to be introduced.

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1 INTRODUCTION

.01 PURPOSE OF THIS DOCUMENT

An overheating assessment has been performed on the second floor of 12 Keats Grove, London. The second floor has been assessed due to the anticipated higher solar gains and conduction gains, with passive measures assessed in order to mitigate against the risk of overheating.

.02 BUILDING DESCRIPTION

12 Keats Grove is a Grade II listed detached villa, understood to have been constructed in the early 19th century. Accommodation is arranged across a semi-basement (lower ground), upper ground floor, first floor and second floor, with attic.

Openable glazing is installed to the south and east façade of the living room, with little or no external shading and obstructions. The living room features a large roof lantern, thus solar gains are expected to be higher towards the summer solstice (high solar altitude). Additionally, there will be internal gains arising from occupants, lighting and equipment.

.03 PRE-PLANNING APPLICATION FEEDBACK

The pre-application identified one aspect of feedback relating specifically to the second-floor overheating element of the project as follows:

> *10.2 Second Floor - The proposed comfort cooling is considered acceptable in principle. However, details similar to the information required for additional services and related fixtures will be needed at application stage.*

The purpose of the overheating study is to: i) establish the maximum temperatures reached during extreme summer conditions, and ii) propose mitigation measures (preferably passive) that can be undertaken to reduce the risk of overheating.

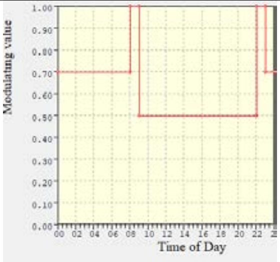
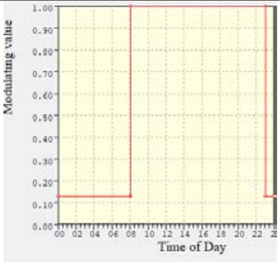
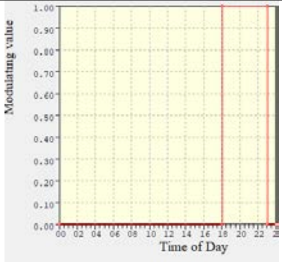
Therefore, whilst a comfortable temperature can be achieved with the introduction of comfort cooling to the second floor, the focus of this report will be to analyse alternative measures which can be undertaken in order to achieve compliance with CIBSE TM-52, the methodology of which is described in more detail in Section 3 of this report.

2 SCOPE

.01 ASSUMPTIONS

Certain assumptions have been made relating to the overheating analysis, which are detailed below. Reasonable assumptions have been made where i) specific information is unavailable, or ii) the methodology requires assumptions to be made.

.01 INTERNAL HEAT GAIN PROFILES

	Occupancy	Equipment	Lighting
Gain Profiles			
Peak Gains	75W/person (sensible) 55W/person (latent) Maximum 2 people	Maximum 80 Watts	Maximum 2.0W/m^2

.02 WEATHER DATA

Setting	Variable
Suncast Location (solar shading)	London/Heathrow
Simulation Weather File	London_LHR_DSY1.epw
Overheating Months	01 May – 30 Sep
Peak Solar Radiation (May – September)	Peak 913W/m^2 (direct), 537W/m^2 (diffuse)

.02 LIMITATIONS

As with any dynamic simulation analysis, the output data (results) are limited by the accuracy of input data. As such, reasonable care has been taken to include as accurate information as possible. Where assumptions have been made, these have been stated. Input data based on design information has also been stated. The dynamic simulation model represents a simplified model of the physical reality, in order to reduce simulation times and the potential for input errors. This accords with the CIBSE AM11 'Abstraction' approach to thermal modelling.

.03 EXCLUSIONS

Whilst this can be considered a comprehensive overheating strategy for the second floor at 12 Keats Grove, London, certain exclusions have been made and the reasons are provided below:

- The focus of the study is second floor bedrooms, as this area has been identified as experiencing high heat gains, thus other residential areas of the building have been excluded.
- The shading effect of trees to the south of the property has been excluded, as this will effectively only provide shading outside of peak months, when the sun is not as high in the sky and solar gain is less of a concern.
- Whilst the geometry of the second floor has been developed in sufficient detail to undertake the study accurately, the lower floors need only be modelled to allow the accurate simulation of an adjacency. As such, it is not intended to be an accurate model of the whole building.

3 METHOD

.01 OVERHEATING ANALYSIS – DYNAMIC SIMULATION MODELLING

The overheating analysis has been performed using the IES-VE software suite, including the APACHE-SIM, MACROFLO and SUNCAST applications. This generates a set of internal temperature results over the summer months (May to September). The weather data set implemented for the simulation is the 'London Heathrow Design Summer Year' file (London_LHR_DSY1.epw).

The software then has the option of implementing the CIBSE TM-52 Adaptive Comfort criteria, which is detailed in Figure 2 below.

TM-52 is designed for analysis of occupied spaces. The principle of 'adaptive comfort' theorises that an occupant's comfort is linked to the ongoing external weather patterns, rather than a fixed internal temperature setpoint.

.02 CIBSE TM-52 ADAPTIVE COMFORT CRITERIA

The following three criteria, taken together, are used to assess the risk of overheating of buildings in the UK and Europe. A room or building that fails any two of the three criteria is classed as overheating.

1. The first criterion sets a limit for the number of hours that the operative temperature can exceed the threshold comfort temperature (upper limit of the range of comfort temperature) by 1°K or more during the occupied hours of a typical non-heating season (1st May to 30th September).

2. The second criterion deals with the severity of overheating within any one day, which can be as important as its frequency, the level of which is a function of both temperature rise and its duration. This criterion sets a daily limit for acceptability.

3. The third criterion sets an absolute maximum daily temperature for a room, beyond which the level of overheating is unacceptable.

   Further information on these criteria can be found in TM52 – 2013, section 6.1.2.

.01 HOURS OF EXCEEDANCE

The number of hours during which ΔT is greater than or equal to one degree (°K) during the period May to September inclusive shall not be more than 3% of occupied hours. ΔT is defined as operative temperature less the maximum acceptable temperature. ΔT is rounded to the nearest whole degree.

If data is not available for the whole period (or if occupancy is only for a part of the period) then 3% of available hours should be used. It may be seen that educational NCM occupancy profiles are inappropriate due to prolonged unoccupied periods in these profiles. The user should assess the appropriate profiles for their models.

.02 DAILY WEIGHTED EXCEEDANCE.

To allow for the severity of overheating, the weighted exceedance shall be less than or equal to 6 in any one day.

.03 UPPER LIMIT TEMPERATURE

To set an absolute maximum value for the indoor operative temperature the value of ΔT shall not exceed 4 °K.

.03 INPUT DATA

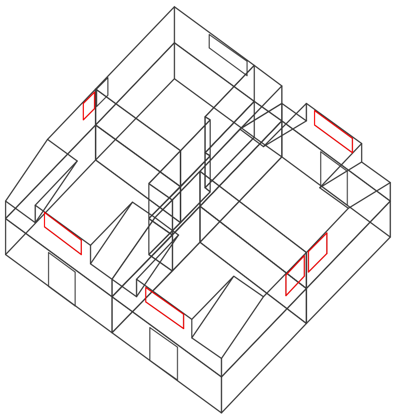
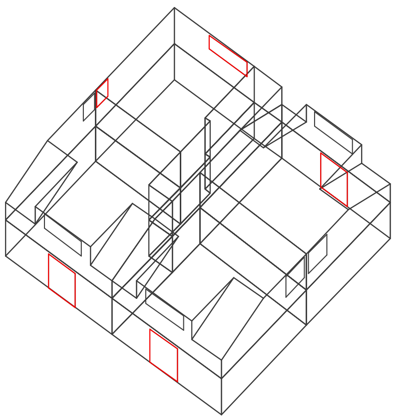
.01 FABRIC PERFORMANCE DETAILS

The following fabric U-values have been included in the design model (second floor), based on information provided by the architect:

Envelope Element	U-Value (W/m^{2}K)	Thermal Capacity
External Wall	1.45	Lightweight
Internal Floor/Ceiling	1.63	V. Lightweight
Roof	1.81	V. Lightweight
Existing windows	5.2 (g-value 0.82)	N/A

.02 VENTILATION AND OVERHEATING STRATEGY

For the purposes of the TM-52 overheating analysis, it has been assumed that the lower floor windows are closed, with passive airflow via windows to second floor only, in addition to infiltration airflow of 0.25 air changes per hour. Internal doors are assumed to be closed. Thus the following assumptions have been made with regards to openings in the building:

Opening Location and Image	Degree of opening
Second floor bedroom windows 	Assumed openable windows Degree of Opening - 60% openable area - 45° max angle open (fully opening) - 10° max angle open (slight opening) U-value (incl. frame) - 5.2 W/m^{2}K g-value (clear) - 0.82 g-value (solar film) - 0.40 Opening threshold – fully open 22°C (with 6°C band from 0-100% open)
Other Windows 	Assumed fixed (closed) for the overheating simulation. In reality, these may be opened from time to time, which would further assist with overheating mitigation.

.04 MITIGATION MEASURES

Numerous options have been considered in order to reduce the risk of overheating through passive measures (without the implementation of comfort cooling). These include improvements to the glazing specifications and introducing internal/external shading, along with various options for achieving airflow through the overheating zones by means of opening windows or introducing purge ventilation. The lower level windows of the property will be considered closed during the day, as these windows are unlikely to be left open during the day, for security reasons.

.05 SIMULATIONS PERFORMED

The simulations have been performed for the period 21 April to 30 September (including a 10-day preconditioning period), with the overheating period defined as 1 May to 30 September.

The following simulations have been performed:

1. Initial simulation (N/A)
2. Windows closed, no passive measures
3. Windows fully opening
4. Lower windows closed
5. Detailed conduction results (N/A)
6. Windows closed, solar control film applied to glazing (g-value = 0.4) / external shading
7. Windows slightly open with solar film
8. Windows fully open with solar film
9. Windows closed, purge ventilation (extract fan) = 140l/s
10. Windows open, venetian blind

The external dry-bulb temperature reaches 33.6°C on 22 July. Solar gains are based on glazing orientation, weather location and predicted weather conditions (Solar Latitude/Longitude: London Heathrow Airport; London Heathrow DSY1 weather file). At best, we can expect the internal temperatures to closely match the external dry-bulb temperature (due to the relatively low thermal mass of the exposed fabric within the assessed zones).

4 FINDINGS

The initial simulations indicated that the habitable spaces would not pass the TM-52 criteria, unless the windows are allowed to be fully open in order to mitigate against overheating. This is understandably impractical and may pose a security risk, thus further simulations have been performed with the windows modelled as slightly open, and with purge ventilation installed.

Mitigation measures have been introduced into the model systematically. The glazing g-value has been reduced to a proposed figure of 0.4 (which can be achieved by introducing a solar control film to the glazing), which reduced the solar gain entering the building. However, it did not enable a TM-52 pass for the second-floor bedrooms with windows closed.

Investigation was then performed into windows being partially opened (i.e. with restrictors) and g-value reduced, which resulted in a TM-52 pass. Thereafter a test was performed with windows closed, and mechanical purge ventilation introduced, which passed TM-52. Finally, a proposed venetian blind option installed internally to the second-floor bedroom windows was tested. The results are similar to the option of introducing a solar control film to the glazing.

These options have been tested, along with the assumed fabric U-values, against the TM-52 criteria (final results overleaf).

.01 HEAT GAINS

The building experiences three principal gains:

- Solar gain – the east, south, and west facing windows experience direct solar gain, particularly during mid to late summer when the sun remains at a reasonably high altitude in the afternoon and is not shaded by nearby trees.
- Internal gains due to lighting, equipment and occupants – whilst efficient LED lighting will be installed, these gains still contribute towards heat gains (combination of radiant and convective gains). Sensible and latent energy from people will also contribute to temperature and comfort levels.
- Conduction gains – although comparatively low in relation to other heat gains, thermal energy can be conducted through the fabric of the building, in particular the roof of the building which may reach high surface temperatures during mid-summer conditions.

Occasionally, the external dry bulb temperature will exceed the internal air temperature. To prevent unwanted heat gains during these periods of extreme weather, the windows will be assumed to closed under this scenario. The thermal mass of the building will instead be relied upon to prevent overheating, during these periods.

.02 OVERHEATING RESULTS

The TM-52 results for each simulation are presented below, with the maximum temperature shown additionally in each case (this is not a criterion of TM-52). A fail in a single category will still constitute an overall pass:

Simulation 2: Windows closed, no passive measures

Zone	Overheating % of occupied hrs	Severity of Overheating (ΔT x hrs)	Upper Limit (ΔT, °C)	Max Operative Temperature (°C)
2-04 BEDROOM 3	11.1	69	6	36.41
2-05 BEDROOM 4	13	75	7	36.75
2-03 BEDROOM 2	8	58	5	35.31

Simulation 3: Windows fully opening

Zone	Overheating % of occupied hrs	Severity of Overheating (ΔT x hrs)	Upper Limit (ΔT, °C)	Max Operative Temperature (°C)
2-04 BEDROOM 3	1	24	3	33.23
2-05 BEDROOM 4	0.9	23	3	33.22
2-03 BEDROOM 2	0.5	20	3	32.66

Simulation 4: Lower windows closed

Zone	Overheating % of occupied hrs	Severity of Overheating (ΔT x hrs)	Upper Limit (ΔT, °C)	Max Operative Temperature (°C)
2-04 BEDROOM 3	1.1	28	4	33.36
2-05 BEDROOM 4	0.9	25	4	33.28
2-03 BEDROOM 2	0.5	20	3	32.81

Simulation 6: Windows closed, solar control film applied to glazing (g-value = 0.4)

Zone	Overheating % of occupied hrs	Severity of Overheating (ΔT x hrs)	Upper Limit (ΔT, °C)	Max Operative Temperature (°C)
2-04 BEDROOM 3	5.3	49	5	34.72
2-05 BEDROOM 4	5.9	50	5	34.96
2-03 BEDROOM 2	3.9	37	4	33.96

Simulation 7: Windows slightly open with solar film

Zone	Overheating % of occupied hrs	Severity of Overheating (ΔT x hrs)	Upper Limit (ΔT, °C)	Max Operative Temperature (°C)
2-04 BEDROOM 3	1.7	31	4	33.44
2-05 BEDROOM 4	1.3	29	4	33.37
2-03 BEDROOM 2	0.9	23	3	32.67

Simulation 8: Windows fully open with solar film

Zone	Overheating % of occupied hrs	Severity of Overheating (ΔT x hrs)	Upper Limit (ΔT, °C)	Max Operative Temperature (°C)
2-04 BEDROOM 3	0.5	23	3	32.63
2-05 BEDROOM 4	0.5	20	3	32.79
2-03 BEDROOM 2	0.4	14	2	32.01

Simulation 9: Windows closed, purge ventilation (extract fan) = 140l/s

Zone	Overheating % of occupied hrs	Severity of Overheating (ΔT x hrs)	Upper Limit (ΔT, °C)	Max Operative Temperature (°C)
2-04 BEDROOM 3	0.8	23	3	32.74
2-05 BEDROOM 4	0.8	24	3	32.98
2-03 BEDROOM 2	0.5	18	3	32.24

Simulation 10: Windows open, venetian blind

Zone	Overheating % of occupied hrs	Severity of Overheating (ΔT x hrs)	Upper Limit (ΔT, °C)	Max Operative Temperature (°C)
2-04 BEDROOM 3	0.6	22	3	32.99
2-05 BEDROOM 4	0.6	21	3	33.05
2-03 BEDROOM 2	0.4	18	3	32.55

5 ANALYSIS

.01 IMPACT OF GLAZING G-VALUE

The results indicate that the glazing g-value has a significant impact on the peak temperatures reached, with a reduction of approximately 1.5°C achievable with a lower g-value (0.82 reduced to 0.4). This is due to the other internal gains (lighting; equipment and occupancy gains) remaining relatively constant, whilst the solar gain is directly related to the glazing g-value. Where glazing is to be replaced, it is recommended to implement replacement glazing with a g-value of no higher than 0.4 (or alternatively, a solar control film can be retrospectively applied to the existing glass).

Below is a graph demonstrating the impact of glazing g-value on room temperature:

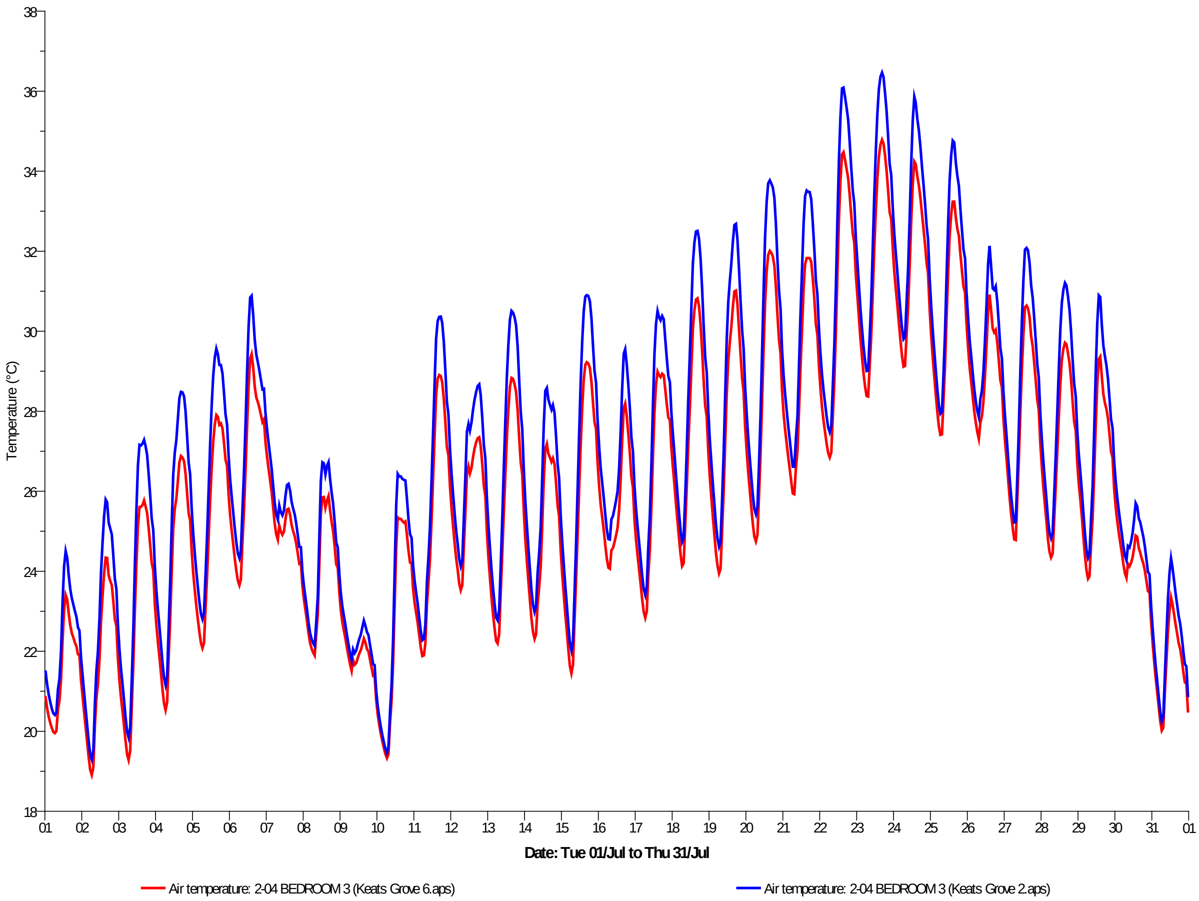


Figure 2: Impact of g-value on temperature: 0.82 (blue) vs 0.4 (red), Bedroom 3

.02 COMMENT ON OPENABLE WINDOWS

Further mitigation of overheating will be achieved by enabling opening of the second-floor windows; however, it is understood that this is not always feasible during the daytime (or night-time) for security reasons. It would be advisable to allow for opening of all other windows when possible, should this be acceptable, to allow for sufficient air changes to achieve mitigation of overheating. Alternatively, window restrictors can be installed which provide an increased level of security whilst still allowing for airflow through the building.

.03 COMMENT ON VENETIAN BLINDS

The effect of installing internal venetian blinds has been tested, which would be assumed to be angled in such a manner as to reflect a proportion of the direct shortwave radiation from the sun back through glass. The results are similar to the option of introducing a solar control film to the glazing, although the reduction in solar gain is not quite as effective.

Figure 3: Example of venetian blinds angled downwards to reduce solar gain

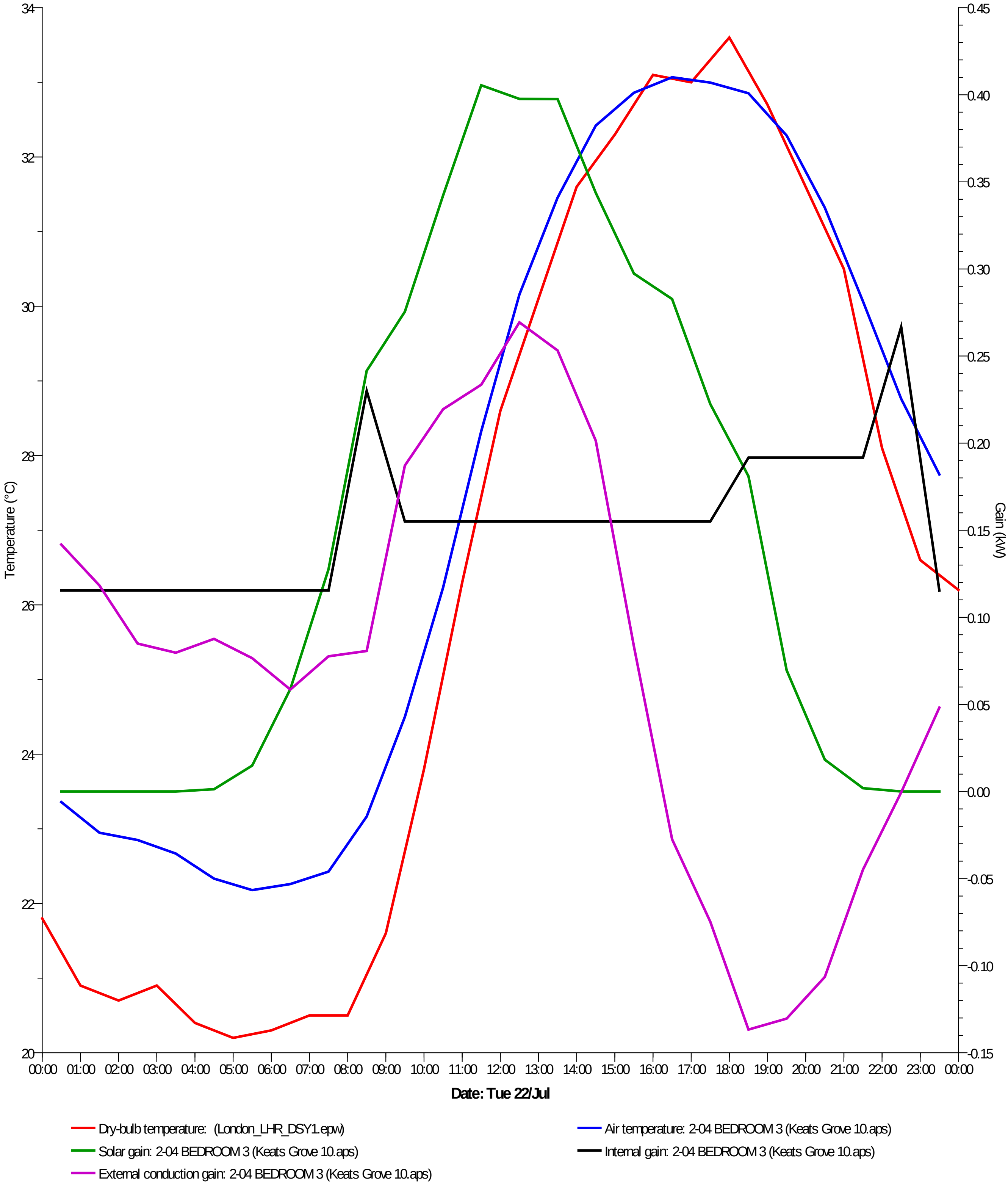
6 CONCLUSIONS

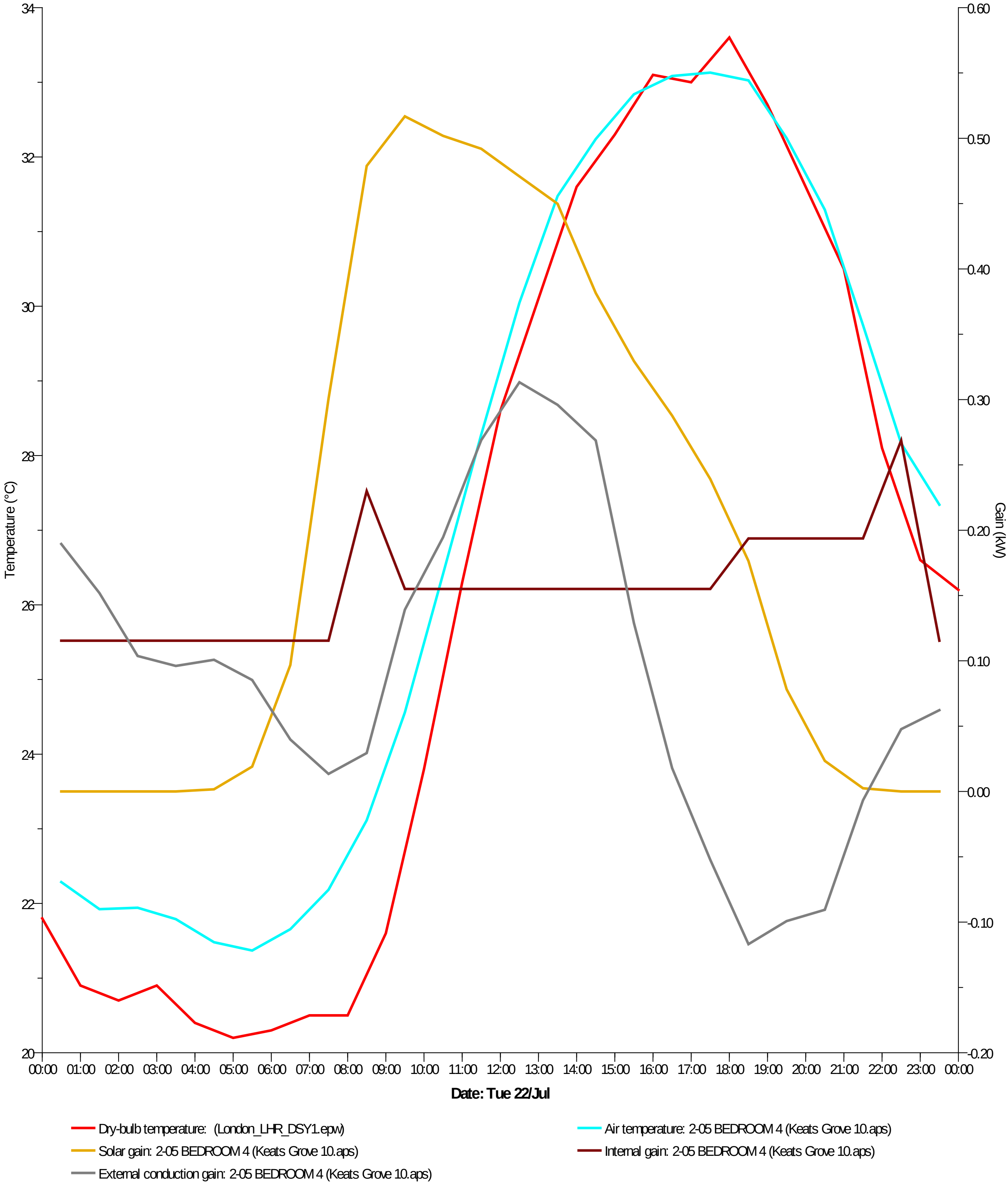
With the existing glazing, windows closed and no other means of overheating mitigation, the second-floor bedrooms would tend to overheat, with operative temperatures approaching 37°C during July.

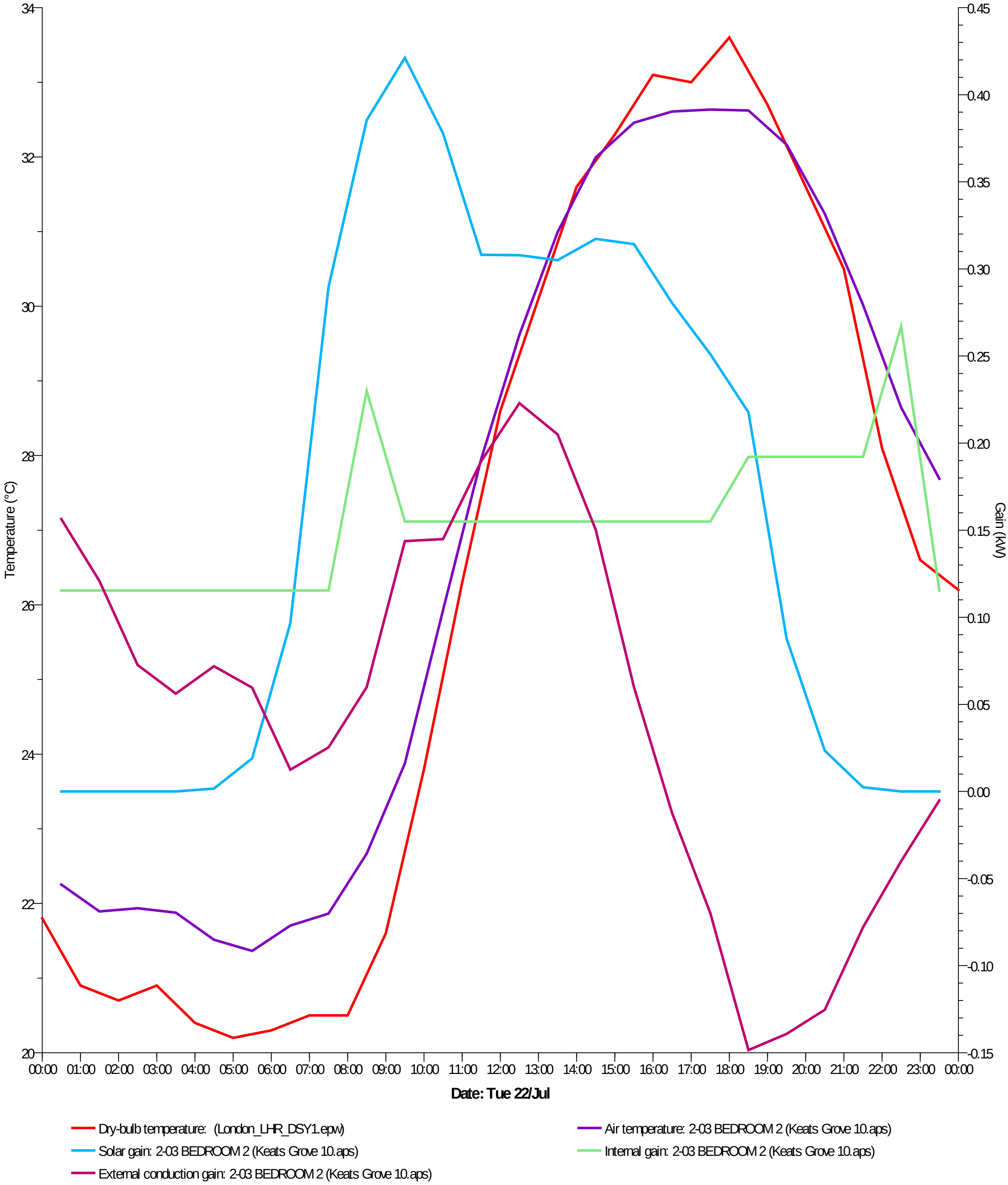
The results indicate that the glazing g-value has a considerable impact on the peak temperatures reached, with a reduction of approximately 1.5°C achievable with a lower g-value (reduced from the assumed existing value of 0.82 to a high-performance value of 0.4 for the second-floor windows). This can be achieved by retrospectively applying a solar control film to the windows or replacing the clear glass with solar control glass. With a lower g-value (0.4) assigned to the glazing in the model, solar gain to the building is reduced. Alternatively, external shutters or internal venetian blinds could be installed, though not quite as effective, would have a similar benefit.

Other options which could be considered include mechanical ventilation and/or active cooling measures. With mechanical purge ventilation installed, the results would closely match that of the full window opening scenario. Comfort cooling would be sized to enable a constant temperature setpoint to be achieved, irrespective of external dry bulb temperature.

APPENDIX 1: PEAK DAYS ANALYSIS (SIM. 10)




Temperature (°C)
Gain (kW)
34
32
30
28
26
24
22
20
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00
Date: Tue 22/Jul
Dry-bulb temperature: (London_LHR_DSY1.epw)
Air temperature: 2-05 BEDROOM 4 (Keats Grove 10.aps)
Solar gain: 2-05 BEDROOM 4 (Keats Grove 10.aps)
Internal gain: 2-05 BEDROOM 4 (Keats Grove 10.aps)
External conduction gain: 2-05 BEDROOM 4 (Keats Grove 10.aps)


34
32
30
28
26
24
22
20
Temperature (°C)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
Gain (kW)
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00
Date: Tue 22/Jul
Dry-bulb temperature: (London_LHR_DSY1.epw)
Air temperature: 2-03 BEDROOM 2 (Keats Grove 10.aps)
Solar gain: 2-03 BEDROOM 2 (Keats Grove 10.aps)
Internal gain: 2-03 BEDROOM 2 (Keats Grove 10.aps)
External conduction gain: 2-03 BEDROOM 2 (Keats Grove 10.aps)