TM-52 OVERHEATING ASSESSMENT - KITCHEN

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12 KEATS GROVE
HAMPSTEAD
LONDON
NW3 2RN

—

PREPARED FOR:
PRIVATE CLIENTS

—

20 DECEMBER 2019
REVISION 1

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ISSUE SCHEDULE

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REVISION	DATE	BY	STATUS	DETAILS
0	04.12.2019	CC	DRAFT	First draft issued to Chris Dyson Architects for review and comment.
1	20.12.2019	CC		Incorporating comments by Chris Dyson Architects.

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. A kitchen extension is proposed at upper ground floor, with laundry/ancillary spaces at lower ground. An overheating assessment has been performed on the proposed kitchen extension at upper ground floor. The kitchen has been assessed due to the anticipated high solar gains from two types of roof lighting (referred to as 'central' and 'curved' roof lighting in this report) and vertical south-facing windows, with passive measures analysed in order to mitigate against the risk of overheating.

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, with varying effectiveness. Overall, some of the passive mitigation measures were generally found to be effective. However, due to the relatively low thermal mass of the kitchen fabric, at best the indoor temperature aligns closely with the outdoor air temperature during very warm weather. This is an improvement over conditions which could be expected without any passive measures, under which the indoor air temperature would significantly exceed the outdoor air temperature.

Whilst the passive measures are effective in mitigating against the risk of summertime overheating, it is possible that the client may still wish to introduce comfort cooling so that the kitchen can be maintained at a setpoint temperature, regardless of the prevailing weather conditions. Under this scenario, the passive measures would still be beneficial in reducing the running cost of a comfort cooling system (if installed). The reduction in running cost is representative of a corresponding reduction of energy consumption and carbon footprint.

There are two scenarios which can be derived from the results of this analysis:

<u>Comfort Cooling Provided</u>

The client may wish to introduce comfort cooling to the proposed kitchen extension, for the following reasons:

- Greater flexibility – with regards to glazing specification (colour and solar factor), and glazing opening requirements
- Maintaining a setpoint temperature – if a setpoint temperature is desirable, regardless of external air temperature

<u>No Comfort Cooling Provided</u>

The client can avoid the need for comfort cooling, by allowing for the following compromises:

- Glazing specification – a very high-performing solar factor glass would be required, which may compromise the colour/appearance of the glass (this would apply mainly to the central roof lighting)
- Window and rooflight opening – in order to achieve the required air flows for overheating mitigation, the rear windows and central roof lighting would need to remain slightly open during periods of warm weather.

In summary, the kitchen is able to comply with the CIBSE TM-52 methodology for assessment of overheating through passive measures alone, however if it is important for the client to have a high degree of confidence that the kitchen can always be maintained at a certain setpoint temperature, then comfort cooling will need to be introduced to the kitchen.

CONTENTS

1 INTRODUCTION

.01 PURPOSE OF THIS DOCUMENT

An overheating assessment has been performed on the proposed kitchen extension at 12 Keats Grove, London. The kitchen has been assessed due to the anticipated higher solar gains from vertical glazing in addition to roof lighting, 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.

A kitchen extension is proposed at upper ground floor, (along with lower ground ancillary spaces), located to the east side of the main house. The kitchen extension features dual aspect north and south facing glazing, in addition to a large proportion of roof lighting, thus solar gains are expected to be high during the morning around the summer solstice (high solar altitude). Additionally, there will be internal gains arising from occupants, lighting and equipment.

.03 PRE-APPLICATION FEEDBACK

The pre-application identified one aspect of feedback relating specifically to the implementation of comfort cooling as follows (this refers to the second floor, however the principal of mechanical cooling is the same and would entail a similar outdoor unit):

> *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) to reduce the risk of overheating.

Therefore, whilst a comfortable temperature can be achieved with the introduction of comfort cooling to the kitchen, 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 Section 3.

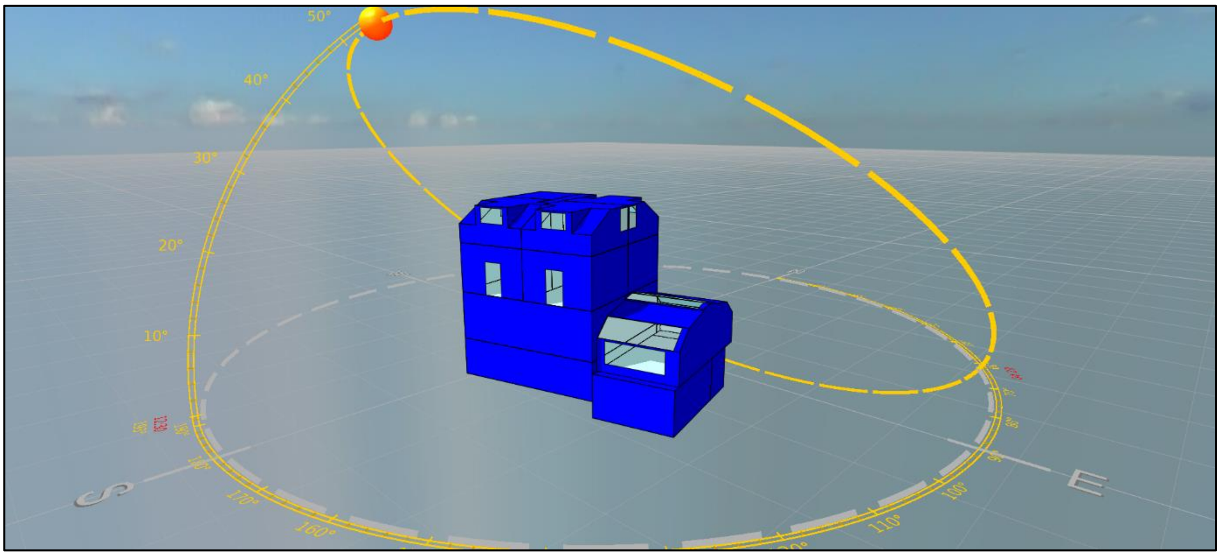


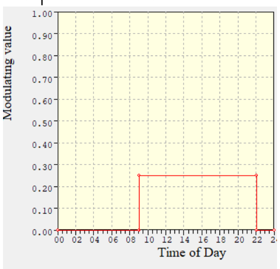
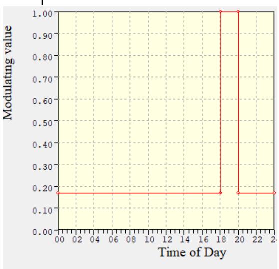
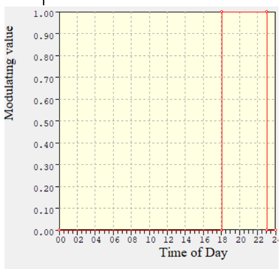
Figure 1: Kitchen 3D engineering model - Peak Solar Gain - May 07 12h30 (view from south-east)

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 GAIN PROFILES

Zone: Kitchen	Occupancy	Equipment	Lighting
Gain Profiles	As per TM-59  	As per TM-59  	As per TM-59 
Peak Gains	75W/person (sensible) 55W/person (latent) Maximum 3 people	Maximum 300 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 reduce 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 proposed kitchen extension at 12 Keats Grove, London, certain exclusions have been made and the reasons are provided below:

- The focus of the study is the upper ground kitchen, 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 and north of the property have been excluded, along with the neighbouring property to the east, as these will mainly provide shading outside of peak times, when solar gain is less of a concern.
- Whilst the geometry of the kitchen extension has been modelled accurately, the curved roof lighting has been modelled as planar in order to reduce simulation times. This accords with the CIBSE AM11 'Abstraction' approach to thermal modelling.

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 in 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

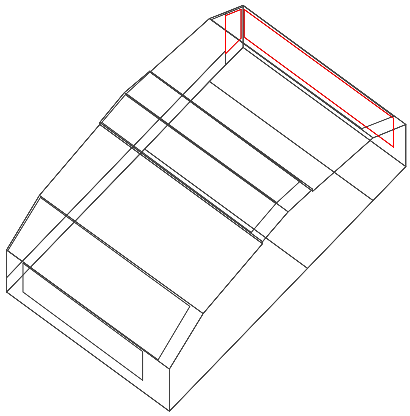
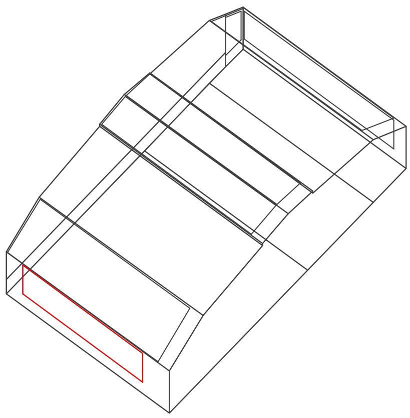
.01 FABRIC PERFORMANCE DETAILS

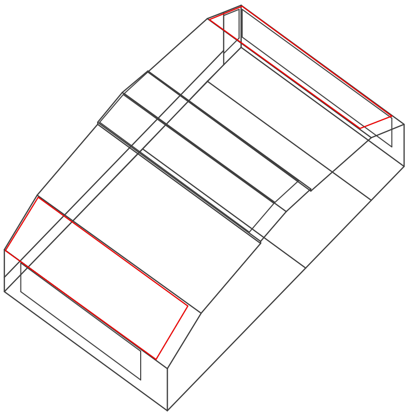
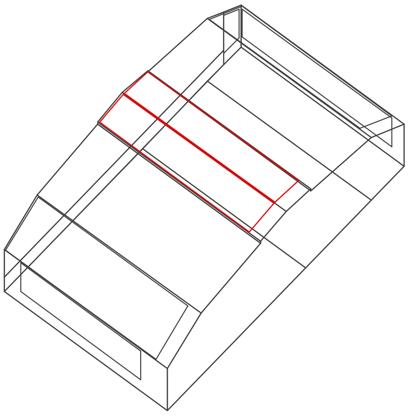
The following fabric U-values have been included in the design model for the kitchen, based on information provided by the architect and glazing supplier:

Envelope Element	U-Value (W/m²K)	Thermal Capacity
External Wall – front and rear	0.19	V. Lightweight
External Wall – side	0.26	V. Lightweight
Ground Floor	0.22	V. Lightweight
Roof	0.23	V. Lightweight
Windows	1.6 (g-value 0.28)	N/A
Rooflight (central)	2.3 (g-value 0.18)	N/A
Rooflight (curved)	2.3 (g-value 0.28)	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
Kitchen rear windows 	Assumed openable windows Degree of Opening (60% openable area): FULL - 60° max angle open - 56% equiv area SLIGHT - 10° max angle open - 10% equiv area U-value (incl. frame) - 1.6 W/m²K g-value (solar control) - 0.28 Opening threshold – fully open 22°C (with 6°C band from 0-100% open)
Kitchen front windows 	Assumed fixed (closed) for the overheating simulation. U-value (incl. frame) - 1.6 W/m²K g-value (solar control) - 0.28

Curved Rooflight Windows 	Assumed fixed (closed) for the overheating simulation. Modelled as planar windows to reduce simulation time. U-value (incl. frame) - 2.3 W/m^{2}K g-value (solar control) - 0.28
Central Rooflight Windows 	Assumed openable windows Degree of Opening (60% openable area): FULL - 30° max angle open - 35% equiv area SLIGHT - 10° max angle open - 10% equiv area U-value (incl. frame) - 2.3 W/m^{2}K g-value (solar control) - 0.18 Opening threshold – fully open 22°C (with 6°C band from 0-100% open)

.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 front windows of the kitchen extension will be considered closed during the day and night, as these windows are unlikely to be left open, for security reasons.

.05 SIMULATIONS PERFORMED

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

The following simulations (overleaf) have been performed:

Filename	Description
Keats Grove 2.1.aps	Kitchen windows closed
Keats Grove 2.2.aps	Kitchen centre rooflight slight opening (10 deg)
Keats Grove 2.3.aps	Kitchen rear side window also slight opening
Keats Grove 2.4.aps	Kitchen rear side window also full (60deg) opening
Keats Grove 2.5.aps	Kitchen rear main window also slight opening
Keats Grove 2.6.aps	Kitchen rear main window also full opening
Keats Grove 2.7.aps	Kitchen centre rooflight full opening (30 deg)
Keats Grove 2.8.aps	Kitchen centre rooflight g 0.18, other glazing g 0.28
Keats Grove 2.9.aps	Kitchen centre rooflight slight, rear window slight

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).

The simulation has been performed initially with all windows and rooflights closed (Simulation 2.1), thereafter incrementally increasing the number of openings and maximum angle opened.

Further simulations (Simulation 2.8 & 2.9) have been performed with reduced g-value to windows and roof lighting, to enable a TM-52 'pass' to be achieved.

The purpose of the initial analysis is to gauge the impact of:

i) having all windows closed during the day, for example when the house is unoccupied
ii) allowing the centre rooflights to be slightly open to allow some of the heat to dissipate, and
iii) to determine the extent of window and rooflight opening required in order to closely match the external dry bulb temperature.

.06 OBSTRUCTIONS EXCLUDED FROM ANALYSIS

A tree survey has identified a large Lime tree to the north of the proposed kitchen. The location of the Lime tree has been reviewed, in addition to the existing neighbouring property to the east.

Given the positions of these structures in relation to the kitchen glazing, there will be very little impact on shading at the times of peak solar gain (around midday and late afternoon - see solar gain & air temperature charts in Appendix 1). The shading would be in the morning only, when solar gain and room temperatures are not significantly high.

Therefore, including these structures in the analysis would not affect the outcome of the results by a significant degree, and the requirements in terms of g-value and window/rooflight opening areas are unlikely to change.

Performing further simulations with these structures included would therefore not be necessary and would not affect the results.

4 FINDINGS

.01 OVERVIEW

The initial simulations (2.1 – 2.7) indicated that the habitable spaces would not pass the TM-52 criteria, if assessed under 'Category II' (new buildings). With windows fully open the kitchen comes close to passing TM-52, however, 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 reduced g-value to windows and roof lighting.

Mitigation measures have been introduced into the model systematically. The glazing g-value has been reduced from an initial value of 0.4 (which represents a standard specification of solar control glazing), to a value of 0.28 (windows and curved rooflights) and 0.18 (central rooflights). This has the effect of reducing the solar gain entering the building, and enabled a TM-52 pass for the kitchen with windows modelled as fully open, as well as slightly open.

A similar result could be anticipated with the introduction of internal shading and/or external shutters, which would have a similar effect as reducing the g-value of the glass. However, it may be impractical to implement internal shading to rooflight glass curvature. External shading/blinds may also be cumbersome on a roof of this shape.

.02 HEAT GAINS

The building experiences three principal gains:

- Solar gain – the south-facing windows and rooflights experience direct solar gain, particularly during mid to late summer when the sun remains at a reasonably high altitude in the afternoon
- Internal gains due to lighting 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 can also contribute to temperature and comfort levels.
- Internal gains due to equipment – maximum 300W, modelled as peak during the hours of 6pm to 8pm, these gains primarily result from cooking activities in the evening, and can contribute to discomfort around the summer solstice as external dry-bulb temperatures peak during the late afternoon.

Occasionally, the external dry bulb temperature will exceed the internal air temperature on the warmest days. To prevent unwanted heat gains during these periods of extreme weather, the windows will be assumed to be closed under this scenario. The thermal mass of the building (in particular, the adjacent solid brick wall of the main building) will instead be relied upon to prevent overheating, during these periods.

.03 OVERHEATING RESULTS

The maximum and mean summer temperature results for each simulation are presented below, along with a description of the incremental measures implemented:

Filename	Description	Type	Max. Val.	Max. Time	Mean
Keats Grove 2.1.aps	Kitchen windows closed	Temperature (°C)	44.64	20/06/2019 13:30	27.32
Keats Grove 2.2.aps	Kitchen centre rooflight slight opening (10 deg)	Temperature (°C)	37.63	22/07/2019 13:30	22.63
Keats Grove 2.3.aps	Kitchen rear side window also slight opening	Temperature (°C)	36.89	22/07/2019 13:30	22.1
Keats Grove 2.4.aps	Kitchen rear side window also full (60deg) opening	Temperature (°C)	34.99	22/07/2019 14:30	20.79
Keats Grove 2.5.aps	Kitchen rear main window also slight opening	Temperature (°C)	34.1	22/07/2019 14:30	20.36

Keats Grove 2.6.aps	Kitchen rear main window also full opening	Temperature (°C)	33.48	22/07/2019 18:30	19.93
Keats Grove 2.7.aps	Kitchen centre rooflight full opening (30 deg)	Temperature (°C)	33.38	22/07/2019 17:30	19.49
Keats Grove 2.8.aps	Kitchen centre rooflight g 0.18, other glazing g 0.28	Temperature (°C)	32.31	22/07/2019 15:30	19.29
Keats Grove 2.9.aps	Kitchen centre rooflight slight, rear window slight	Temperature (°C)	32.82	22/07/2019 14:30	20.12
Ext. Dry Bulb Temperature			33.6	22/07/2019 18:00	17.47

In terms of assessing against TM-52, there are three building categories which relate to the leniency of the targets. Category I applies to buildings for young/infirm (for example, nursing home), Category II applies to new build properties, whilst Category III applies to existing properties. For the purposes of demonstrating compliance against the relevant building category, 'new build' (Category II) has been deemed the most appropriate. The results are presented overleaf for simulation 2.7 (fully open windows, standard solar control glass), simulation 2.8 (improved performance solar control glass) and simulation 2.9 (slightly open windows, improved performance solar control glass):

The TM-52 results for simulations 2.7-2.9 are presented below, with the maximum operative 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 2.7: All glazing g 0.4, Rear windows fully open, centre rooflight fully open

Zone	Overheating % of occupied hrs	Severity of Overheating (ΔT x hrs)	Upper Limit (ΔT, °C)	Max Operative Temperature (°C)
KITCHEN	3.5	37	5	33.39

Simulation 2.8: Kitchen centre rooflight g 0.18, other glazing g 0.28, fully open

Zone	Overheating % of occupied hrs	Severity of Overheating (ΔT x hrs)	Upper Limit (ΔT, °C)	Max Operative Temperature (°C)
KITCHEN	1.5	26	4	32.27

Simulation 2.9: Kitchen centre rooflight g 0.18, other glazing g 0.28, slightly open

Zone	Overheating % of occupied hrs	Severity of Overheating (ΔT x hrs)	Upper Limit (ΔT, °C)	Max Operative Temperature (°C)
KITCHEN	3	33	4	32.92

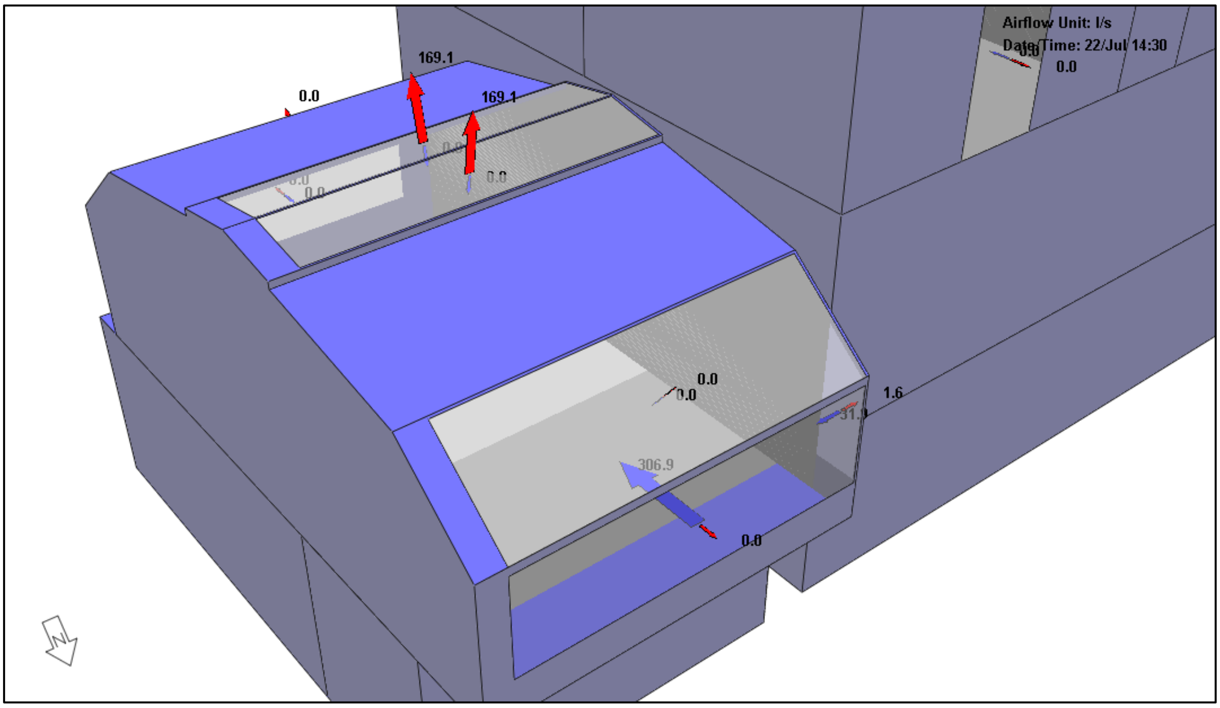


Figure 2: IES-VE MacroFlo (natural ventilation in L/s) arrows - July 22 14h30 (view from north)

5 ANALYSIS

.01 IMPACT OF GLAZING G-VALUE

The initial analyses (simulation 2.1 to 2.7) has been performed with a proposed g-value of 0.4, which represents a reasonable specification of solar control glass.

Further simulations have been performed with a proposed g-value as follows:

Windows, curved rooflight: G-value: 0.28
Central rooflight: G-value: 0.18

The results indicate that the glazing g-value has a significant impact on the peak temperatures reached, with a reduction of approximately 1.0°C achievable with a lower g-value (0.4 reduced to 0.28/0.18). 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. It is recommended to implement glazing with a g-value of no higher than 0.28 (with central rooflight glazing no higher than 0.18). Under this scenario, the kitchen complies with CIBSE TM-52, with central rooflight and rear windows slightly open.

A similar result could be anticipated with the introduction of external shutters, which would have the same effect as reducing the g-value of the glass.

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

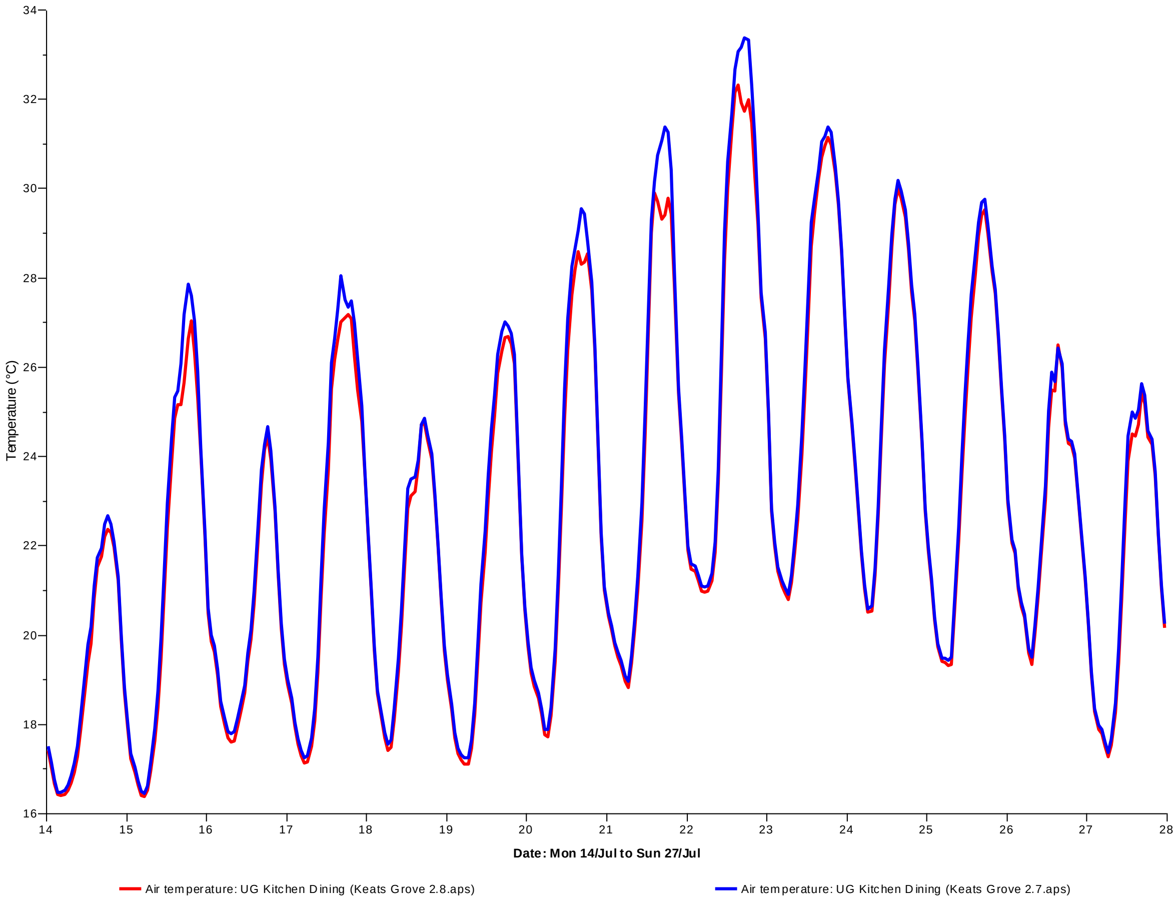


Figure 3: Impact of g-value on temperature: 0.4 (blue) vs 0.28/0.18 (red), Kitchen

.02 COMMENT ON OPENABLE WINDOWS

Passive mitigation of overheating has been demonstrated to be achievable by enabling opening of the central rooflight windows in addition to the rear kitchen windows. However, it is understood that this is not always feasible during the day-time (or night-time) for security reasons. It would be advisable to allow for opening of these windows when possible, should this be acceptable, to allow for sufficient air changes to achieve mitigation of overheating. Additionally, window restrictors can be installed which provide an increased level of security whilst still allowing for airflow through the building.

An alternative approach to opening windows would be the use of louvres/vents, installed at low level, with a free area equivalent to rear windows being 'slightly open'. This equates to a free area requirement of at least 0.80m^2 for low level make-up air vents (if rear windows are to remain closed). The central rooflight would be opened to an angle of 10 degrees under this scenario (which equates to a free area of circa 0.92m^2) to allow warm air to escape at high level.

6 CONCLUSIONS

.01 RESULTS ANALYSIS

The results indicate that it would be quite difficult to closely match the external dry bulb temperature within the kitchen space, unless significant proportions of the glazing can be left slightly open (10-degree opening angle for central rooflights and rear windows, curved rooflights remaining closed) throughout the day (and night). This is usually seen as impractical and can pose a security risk.

The results can be explained by the highly glazed area of the façade in relation to the volume of the kitchen and, whilst there is shading from direct sunlight in the afternoon due to the main house, the diffuse sunlight element still results in high solar gains, largely from the proposed roof lighting.

.02 PASSIVE MEASURES

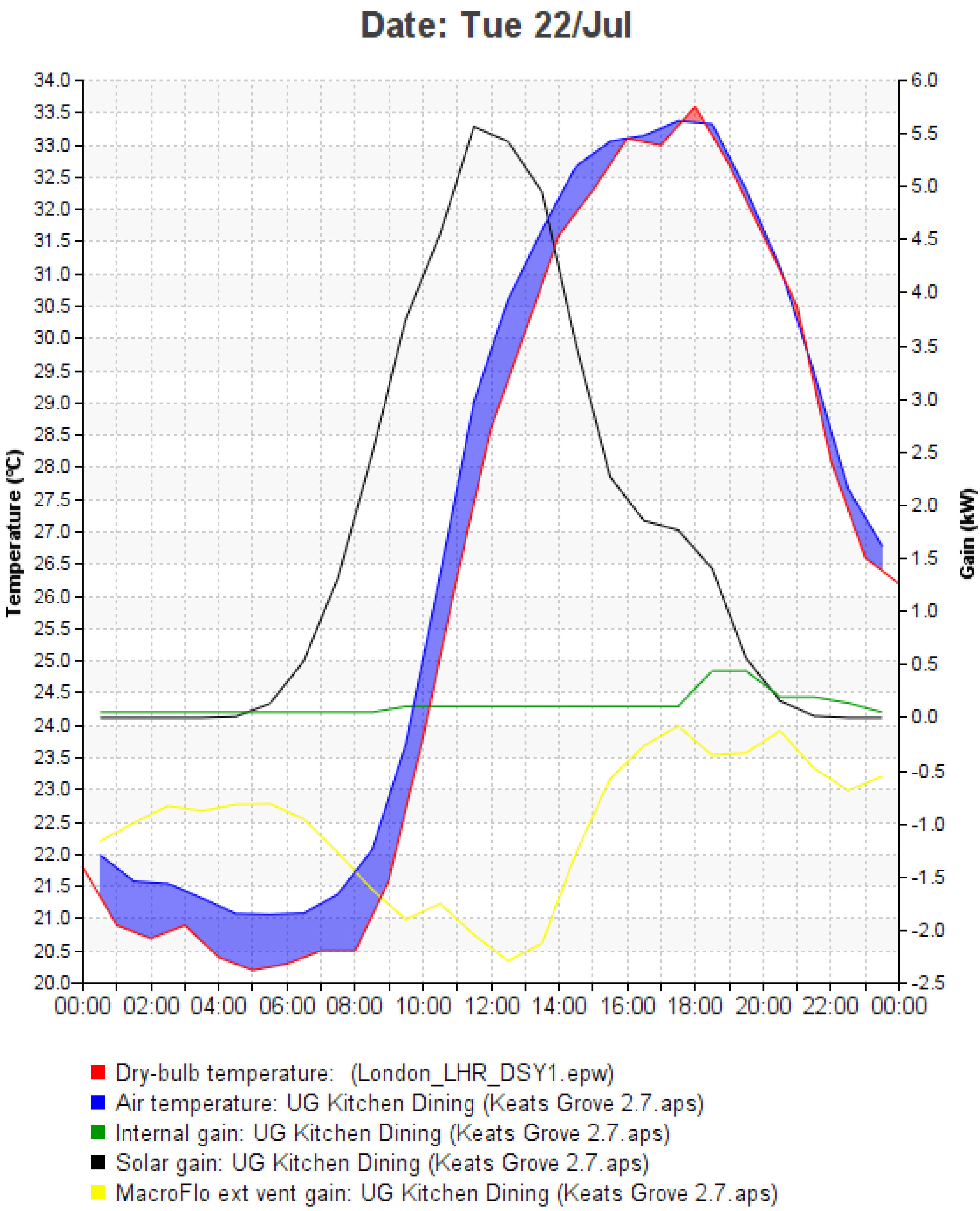
The initial results assume that a standard solar control glass is specified (g-value 0.4). Possible further passive measures which could be investigated include internal blinds for the roof lighting. However, deployment of such a system may prove difficult (in particular for the curved rooflights – it would be challenging to implement internal shading). External shading/blinds may also be cumbersome on a roof of this shape.

Further simulations have tested a very high performing solar control glass specification (g-value of 0.28 to windows and curved rooflights, 0.18 to central rooflights), although the visible light and appearance of the glass may be slightly compromised by opting for a very low g-value.

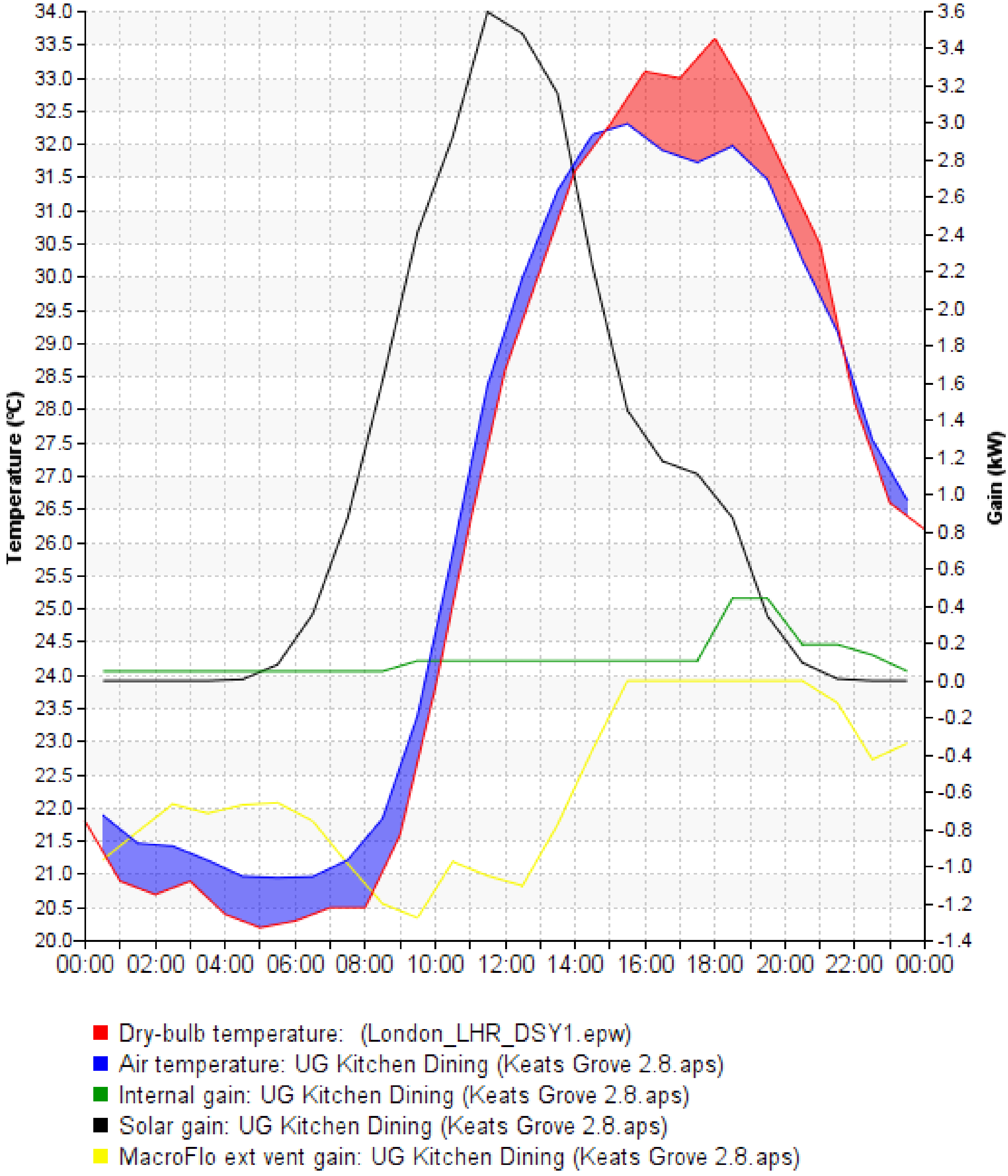
.03 ACTIVE MEASURES

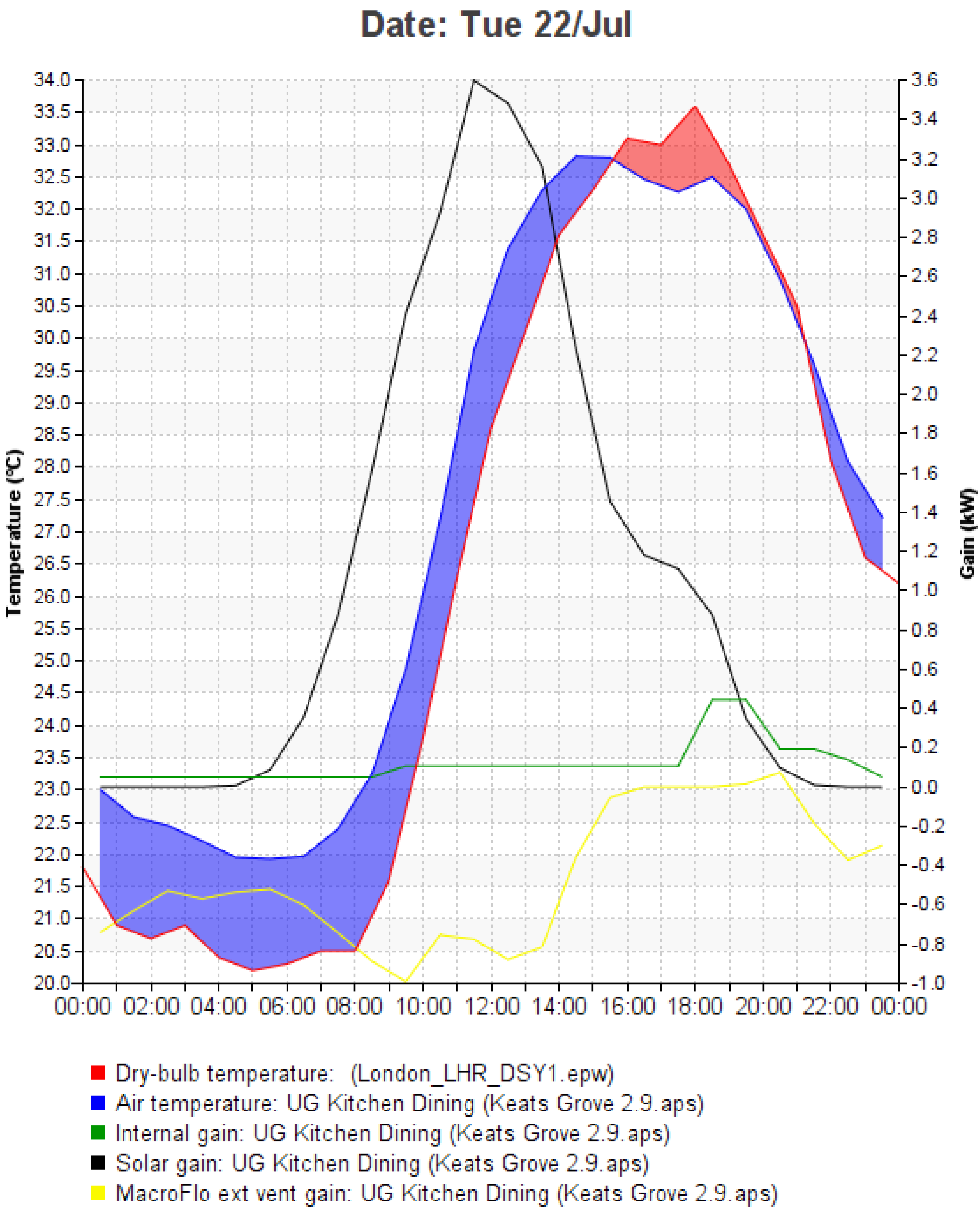
Due to the high volume of air changes required to bring the air temperature within close range of the external dry bulb temperature (up to 1000 L/s), a purge ventilation fan system is unlikely to be practical for the kitchen. However, active cooling could be specified to mitigate against the risk of overheating. It would still be worth pursuing certain passive measures to reduce the cooling loads, as total heat gains would peak around 7kW (assuming standard solar control glass, g-value = 0.4), which may result in more than one indoor unit being required. A reduction in glazing g-value has been recommended, which would result in a proportional reduction in solar gains to the kitchen, as demonstrated.

APPENDIX 1: PEAK DAYS ANALYSIS (SIM. 2.7 – 2.9)



Date: Tue 22/Jul




Date: Tue 22/Jul
Temperature (ºC)
Gain (kW)
34.0
33.5
33.0
32.5
32.0
31.5
31.0
30.5
30.0
29.5
29.0
28.5
28.0
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3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Dry-bulb temperature: (London_LHR_DSY1.epw)
Air temperature: UG Kitchen Dining (Keats Grove 2.9.aps)
Internal gain: UG Kitchen Dining (Keats Grove 2.9.aps)
Solar gain: UG Kitchen Dining (Keats Grove 2.9.aps)
MacroFlo ext vent gain: UG Kitchen Dining (Keats Grove 2.9.aps)