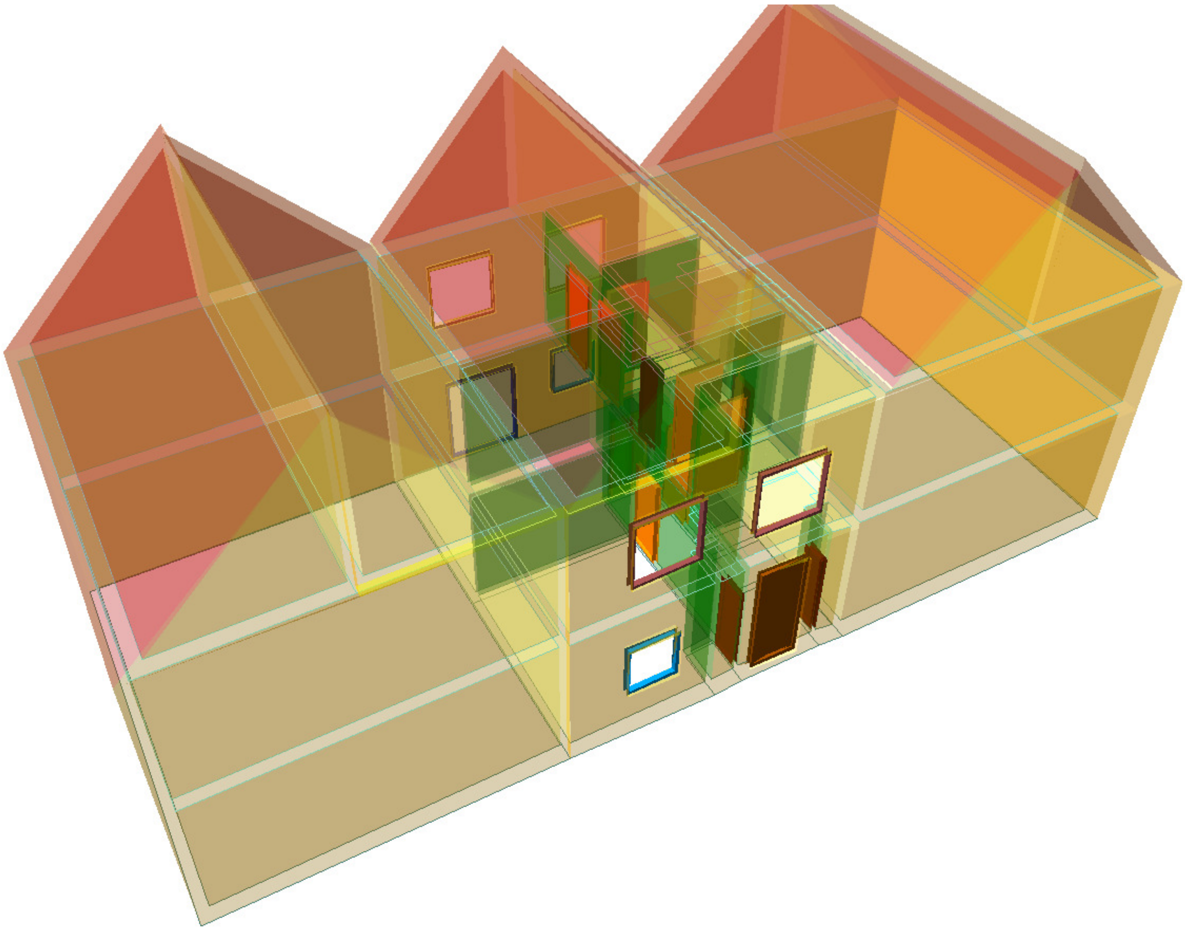
Bicester Eco-Town,
Oxfordshire

Overheating Analysis and Climate Change Mitigation



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PRP

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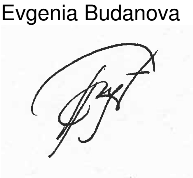
Signature		
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1 INTRODUCTION

PRP Environmental was commissioned by A2 Dominion Housing Group to carry out overheating analysis on worst-case scenario units within Phase 1 of Bicester Ecotown, Oxfordshire development. In addition, the sample units were tested against two climate change projection scenarios 2030 and 2050.

Given the changing climate to a warmer climate, one of the key aims of this study is to investigate the impact of climate change on Bicester and examine any potential risk of summer overheating that the buildings on Phase 1 may suffer from in the future.

The aim of this study is to assess summer overheating risks for the current weather scenario and three more future weather projections (2030, 2040 and 2050). In this analysis, maximum indoor temperatures and overheating hours (the number of hours that exceed 28ºC and 26ºC) are typically used as criteria for assessing summer overheating risk. Cumulative overheating hours are considered because human thermal comfort depends not only on temperature levels, but also on how long uncomfortable temperature levels occur.

In addition, this assessment aims to identify how the changes proposed on the earlier stages of design impact the internal temperatures up to 2050. It will also highlight measures of the design that have more significant impact on the mitigation of the overheating hours.

Two sample units were selected as they represent the worst-case scenario of each category, affordable and private housing. They are described below:

Affordable house, Type 3, House 357 - End terrace, 2 bedrooms
Private house, Type 5, House 386 - Mid terrace, 2 bedrooms

It is important to note that with any modelling exercise there are assumptions and approximations that have to be made. As far as possible, details of all assumptions made, and approximations used are supplied as part of this report. These should be read carefully.

All results are based on the output from computer modelling software and should be taken as an indication of the likely final situation, but these conditions cannot be guaranteed.

2 METHODOLOGY AND OVERHEATING CRITERIA

2.1 Criteria

This study assesses summer overheating risks for the current weather scenario and three more future weather projections (2030, 2040 and 2050).

In this analysis, maximum indoor temperatures and overheating hours (the number of hours that exceed 28ºC and 26ºC) are typically used as criteria for assessing summer overheating risk. Cumulative overheating hours are considered because human thermal comfort depends not only on temperature levels, but also on how long uncomfortable temperature levels occur.

The benchmark temperatures set for dwellings by the Chartered Institute of Building Service Engineers in CIBSE Guide A (2006) have been used. In addition, CIBSE Guide A 2006 sets out methodologies for analysing overheating in buildings and numerical guidelines and benchmarks for suggested maximum acceptable internal dry bulb temperatures in dwellings.

According to CIBSE Guide A - benchmarks for summer temperatures for dwellings, the annual number of hours of internal temperatures greater than 26ºC in bedrooms and 28ºC in living areas should not be greater than 1% of the total annual occupied hours. Please refer to the table below:

Table 1. CIBSE Benchmarks for annual overheating and comfort analysis.

Building Type:	Room type:	Benchmark Summer Peak Temperature C°	Overheating Criterion
Dwellings	Bedrooms	26°C	Maximum 1% annual occupied hours over operative temperature of 26 °C
	Living areas *(inc. Kitchen, Living and Dining rooms)*	28°C	Maximum 1% annual occupied hours over operative temperature of 28 °C

It has been assumed that the dwellings will be occupied from 4:00pm to 9:00am in weekdays and 24 hours weekends.

2.2 Methodology

2.2.1 Desktop assessment

The methodology used for this analysis follow an initial desktop assessment that determined the worst-case scenario units in Phase 1 of Bicester Ecotown development. The selection criteria were based on the following:

- Orientation – South facing dwellings will suffer from the high altitude mid-afternoon solar radiation and are considered high risk
- Shading by the surroundings elements – Dwellings that are not sheltered have been selected, as they will have higher solar heat gains
- Exposed walls – dwellings with more exposed walls will have high solar heat gains conducted through the building envelope into the dwelling
- Less Heat loses - dwellings with high air tightness have less opportunity to release the heat
- Category - private and affordable were divided for this analysis

As a result, seven units were classified as the worst case scenario, these are shown in Figure 1 and detailed as follows. They were then assessed following SAP (standard Assessment Procedure) methodology:

- Affordable: Type 1(304); Type 3 (357), marked in dark red Figure 1
- Private: Type 1 (312 & 363); Type 3 (368); Type 5 (326 & 386), marked in dark blue in Figure 1

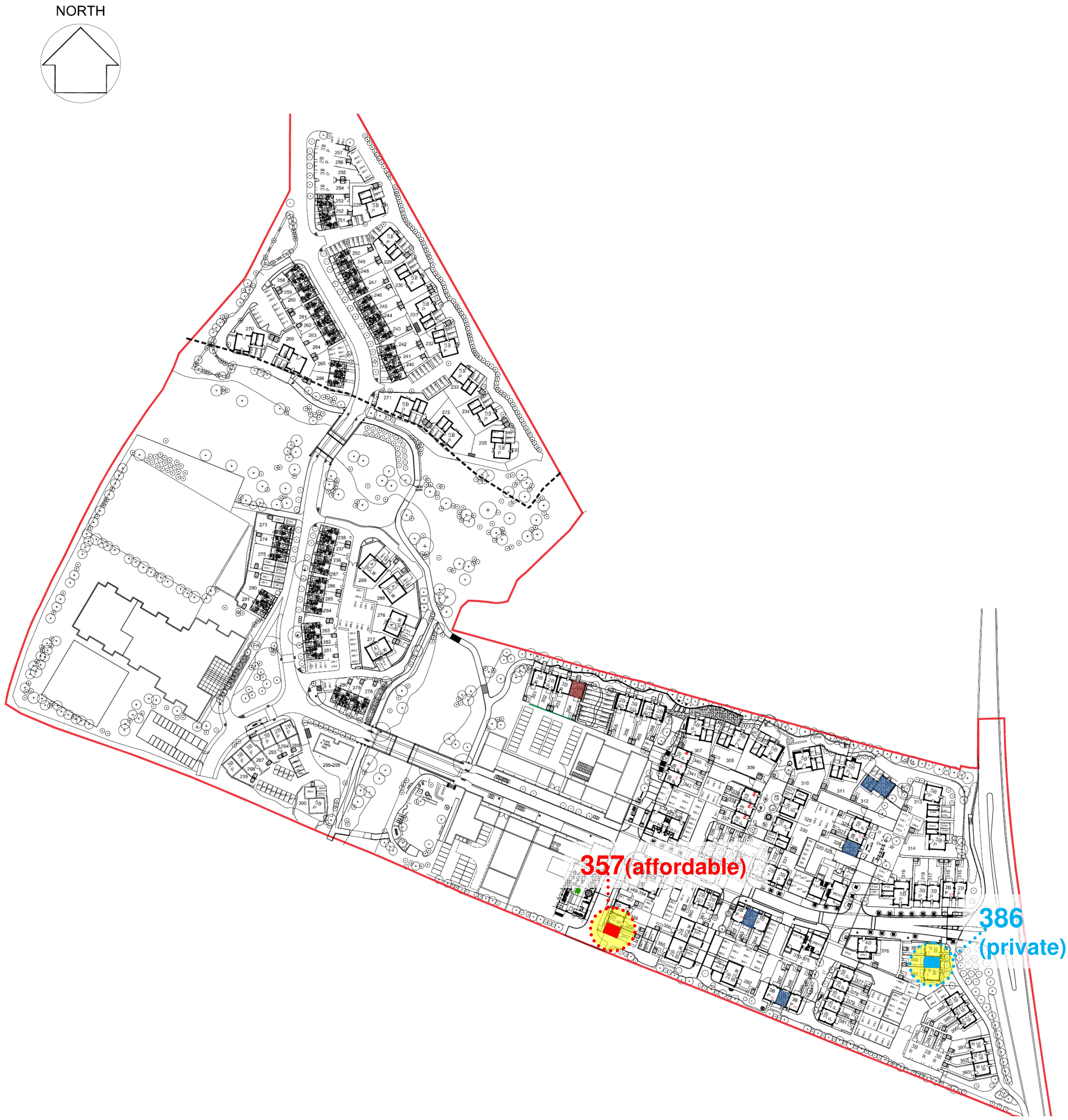


Figure 1. Location of units assessed in SAP (NHER). Phase 1 of Bicester Ecotown

2.2.2 SAP Assessment

The selected seven units were assessed in NHER Plan assessor software version 5.4.1, which is based on the SAP 2009 methodology, to test their compliance with Part L1A (2010) Criterion 3-Summer overheating risk.

Seven dwellings have been modelled under five different scenarios, using the current weather data, to assess their potential summer overheating risk. The five-modelled different scenarios are:

- Scenario 1: All windows are assumed fully open half the time
- Scenario 2: All windows are assumed slightly open; i.e. 50mm open
- Scenario 3: Mechanical ventilation system with an air change rate of 2ach
- Scenario 4: Mechanical ventilation system with an increased air change rate of 2.5 ach
- Scenario 5: Threshold air change rate required to overcome the overheating risk

SAP Modelling Assumptions

The following energy specification assumptions have been used in the SAP (2009) modelling:

- U-value of ground floors 0.15 W/m^{2}K
- U-value of heat loss upper floors above unheated areas 0.15 W/m^{2}KU-value of all external walls 0.15 W/m^{2}K
- Cavity party walls – 0.0 W/m^{2}K-(All exposed edges are effectively sealed and cavity is fully filled to prevent heat loss through the cavity)
- U-value of heat loss wall adjacent to unheated communal areas 0.15 W/m^{2}K
- U-value of all roof types 0.13 W/m^{2}K
- Whole window U-value 0.80 W/m^{2}K SAP default *'g'* factor 0.57 - timber frame windows-(triple glazed with low soft e-coating, 16mm or more argon filled cavity)
- U-value of external front doors 0.8 W/m^{2}K (now it is 1.1 W/m^{2}K)
- Low thermal mass has been assumed, given the proposed nature of construction and specification of the development
- Thermal bridges to Accredited Construction Details (ACDs) in all possible junction types
- Air permeability: 3 m^3/m^2.h (All dwellings to be tested in the As-Built Stage)
- Whole House Mechanical ^{V}en^{t}ilation system MVHR with insulated rigid ductwork (SFP of no more than 0.50 W/l/s & heat exchanger efficiency of no less than 90.0%)
- Gas CHP and communal heating to meet the base heat load of the development with back up communal gas boilers to meet the rest of the demand
- Pre-insulated heat distribution system with low temperature and variable flow (1991 or later)
- Charging system linked to community use, programmer and TRV's as controls
- Emitters: radiators
- Water Heating: from the communal heating system with a plate heat exchanger in each dwelling; i.e. no HWC within the dwelling
- Water use - less than 125 litres p/person p/day
- No air conditioning
- 100% low energy lightings

The SAP assessments undertaken have clearly demonstrated that the assessed dwellings have shown some risk of overheating in some of the scenarios listed above using the current weather conditions.

The following tables below list the SAP modelling results of the selected dwellings based on new plans from 30 October 2012:

Table 2 Results from SAP (NHER) assessment, showing the overheating risk in June, July and August

LEGEND	
H	High
M	Medium
S	Slight
NS	Not Significant

Risk of Overheating																					
Plot	304 - Affordable			312 - Private			326 - Private			357 - Affordable			363 - Private			368 - Private			386 - Private		
	Type 1 3B ET			Type 1 5B ET			Type 5 3B ET			Type 3 2B ET			Type 1 2B MT			Type 3 2B MT			Type 5 2B MT		
	Jun	*Jul*	*Aug*	*Jun*	*Jul*	*Aug*	*Jun*	*Jul*	*Aug*	*Jun*	*Jul*	*Aug*	*Jun*	*Jul*	*Aug*	*Jun*	*Jul*	*Aug*	*Jun*	*Jul*	*Aug*
Windows fully open half the time	N	S	S	N	S	S	N	S	S	N	S	S	N	S	S	N	S	S	N	S	S
Windows slightly open	M	H	H	S	H	H	M	H	H	M	H	H	M	H	H	M	H	H	H	H	H
Air change rate 2	N	M	M	N	M	M	N	M	M	S	M	M	S	M	M	S	M	M	S	M	M
Air change rate 2.5	N	M	M	N	S	S	N	M	S	N	M	M	N	M	M	N	M	M	N	M	M
Air change rate threshold for overheating	1.6			1.2			1.5			1.8			1.8			1.8			1.8		

2.2.3 Thermal Modelling

As a result the worst performing from SAP assessment units were further analysed, these units are:

- Affordable, Type 3, House 357 End terrace
- Private, Type 5, House 386 Mid terrace

These units were further assessed using the dynamic thermal simulation software EDSL-TAS (v.9.2.1.1.). The software has been used to calculate the annual number of overheating hours in the habitable rooms of the units stated above.

For the current weather year analysis, the Design Summer Years (DSY) weather data for the London area, which is based on an urban environment, has been used.

The projected weather years data used in this analysis was provided by the Low Carbon Building Group of Oxford Brookes University. The report "Future Climate changes projections for NW Bicester" explains how these climate projections were calculated.

These future weather scenarios were tested following the climate change adaptation of the Planning Policy Statement for eco-towns (**PPS1**) that states the following:

"*ET 8.1 Eco-towns should be sustainable communities that are resilient to and appropriate for the climate change now accepted as inevitable. They should be planned to minimise future vulnerability in a changing climate, and with both mitigation and adaptation in mind.*

ET 8.2 Developments should be designed to take account of the climate they are likely to experience, using, for example, the most recent climate change scenarios available from the UK Climate Change Impacts Programme. Eco-towns should deliver a high quality local environment and meet the standards on water, flooding, green infrastructure and biodiversity set out in this PPS, taking into account a changing climate for these, as well incorporating wider best practice on tackling overheating and impacts of a changing climate for the natural and built environment."

Internal heat gains from occupants, lighting, electrical and cooking equipment as well as the range of activities that take place in habitable rooms were included within the simulation as they have a significant impact on the internal temperatures and were scheduled following the same occupancy patterns.

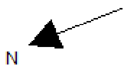
The assumptions described in Section 3 have been made with regard to the occupancy patterns, electrical lighting, electrical equipment, cooking, ventilation strategy and the building fabric specification.

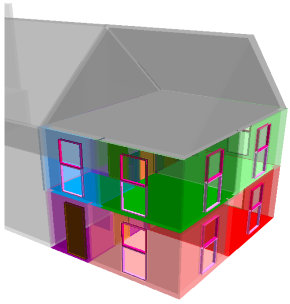
BASE CASE MODEL ASSUMPTIONS

2.3 **UNIT 357 - Worst Case Scenario Affordable**

Figure 3 below shows plans of the house 357, which was determined to be the worst case scenario of the affordable units. This two bedroom house (Type 3) was modelled in TAS. The orientation and immediate surrounding buildings were also included within the 3D model to account for any shading that may result from those buildings.

Type 3, Affordable house 357





Ground floor *First floor*

Figure 2 Floor plans of house 357 (Type 3). Rooms analysed are highlighted

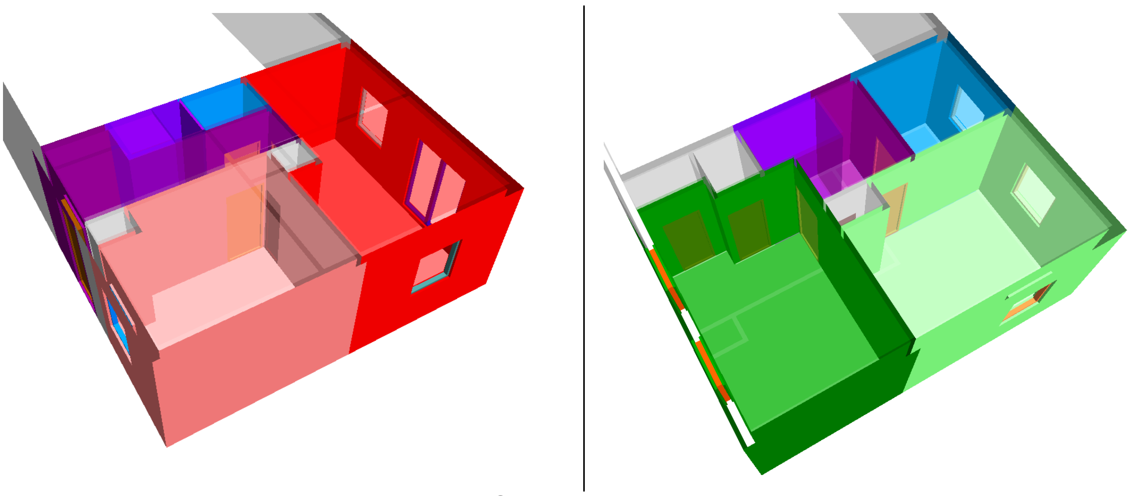


Figure 3 Type 3 - Unit 357 (End terrace). South West view: Zones Displayed

2.4 **UNIT 386 - Worst Case Scenario Private**

Figure 4 below shows plans of the house 386 that was modelled in TAS. The orientation and immediate surrounding buildings were also included within the 3D model to account for any shading that may result from those buildings.

Figure 4 Floor plans of house 386 (Type 5). Rooms analysed are highlighted

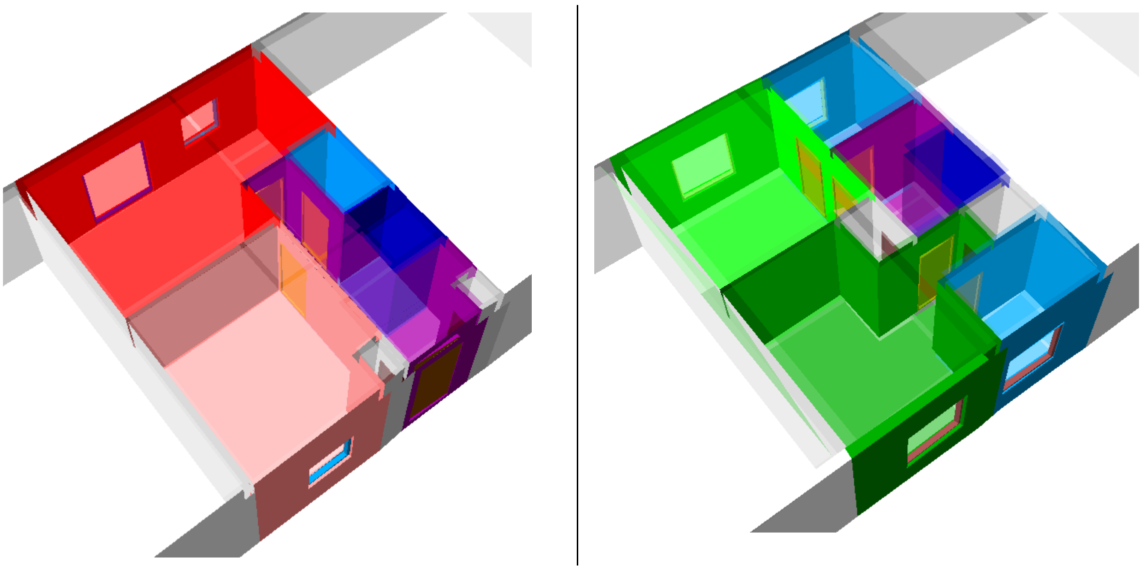


Figure 5 Type 5 - Unit 386 (Mid terrace). South East view: Zone Display

2.5 **Building Elements**

The following building elements were used for the base case model.

Table 3 Building elements. Base Case

<table>
<tr><th colspan="2">Building Elements</th><th>Construction / Materials</th><th>U-value W/m² ºC</th></tr>
<tr><td rowspan="4">WALLS</td><td>External</td><td>Timber frame superstructure with 103mm facing brickwork to outer leaf</td><td>0.15</td></tr>
<tr><td>Internal</td><td>• Plasterboard
• Timber Studwork
• Plasterboard</td><td>-</td></tr>
<tr><td>Ground</td><td>• Vinyl finish
• Insulation (50mm)
• Flooring screed
• EPS Insulated Block flooring system (90mm)
• Brick slips</td><td>0.15</td></tr>
<tr><td>Intermediate floor / Slabs</td><td>• C5 moisture resistant chipboard
• open metal web floor joists
• Fireline plasterboard</td><td>-</td></tr>
<tr><td>ROOF</td><td>Roof / ceiling</td><td>• Plasterboard
• Fully insulated OSB
• softwood saturated bitumen felt
• treated sw battens
• Unventilated cavity
• PV solar panels</td><td>0.13</td></tr>
<tr><td rowspan="3">OPENINGS</td><td>Windows</td><td>• Triple glazing (6mm)
• 16mm Argon filled cavity</td><td>0.80
G-value= 0.27</td></tr>
<tr><td>Main Door</td><td>• Softwood
• Insulation
• Plywood</td><td>1.1</td></tr>
<tr><td>Internal doors</td><td>• Wood</td><td>2.30</td></tr>
</table>

2.6 Internal Gains

- **Occupancy, lighting and equipment gains**

Initially based on NCM (National Calculation Methodology) for domestic properties using schedules accordingly

Table 4 Internal gains

Space	NCM condition	Lighting Gain (W/m²)	Occupancy gains (W/m²)		Equipment gains (W/m²)	
			Sensible	Latent	Sensible	Latent
Dining/ Kitchen	Dwell_DomDining_v3.5	7.8	1.34	0.86	5.0	0.0
Living rooms	Dwell_DomLounge_v3.5	7.8	1.34	0.86	5.0	0.0
Bathroom	Dwell_DomBath_v 3.5	7.8	1.2	1.2	2	11.25
Bedroom	Dwell_DomBed_v 3.5	5.2	1.35(single) 2.7(double)	0.45 (single) 1(double)	4.05	0.95
SCHEDULE USED		Lighting &Equipment: **5-9am & 7-11pm**	Profile Selected is **MEDIUM HIGH (0-9am & 5-0pm)**		Lighting &Equipment: **5-9am & 7-11pm** with setback of 0.01 W/m²	

2.7 Ventilation

Natural ventilation has been possible via openable windows and doors.

Table 5 Aperture schedule and profile

APERTURES	Room	Profile	
		Starts opening when adjacent zone at:	Fully opened adjacent zone at:
Windows	Living area (90% openable)	19ºC	22ºC
	Wetrooms (90% openable)	19ºC	22ºC
	Other Rooms (90% openable)	19ºC	22ºC
	Night Cooling (When Applicable)	Open 95% of the window while Night-time (6pm-8am) **NOTE: During Occupied hrs**	
Due to the security reasons, all the windows on the Ground floor can be only opened while occupied hours and they are completely closed at night.			
Doors	Main	Opened 10min of occupied hours, equivalent to 1%	
	Internal	100% opened while day time and 10%during night	

It is assumed that the occupants will open their windows when the internal temperatures exceed 19ºC to 22℃ (see table above). Occupants will have full control of their windows openings system and can manually open the windows when they experience warm temperatures inside. There is no intention to install automatic opening systems. Natural ventilation is introduced in order to mitigate summer overheating, in addition, both of the houses have mechanical ventilation meant to remove moisture and provide background ventilation while the summer.

- **House 386** (Private unit) has MEV, which is mechanical ventilation with extract only and trickle vents are available in all the windows.

- **House 357** (Affordable unit) has MVHR, which is mechanical vent with extract and intake, no trickle vents in windows.

2.8 Infiltration

An air infiltration rate of 0.155ACH is equivalent to air tightness of 3.0m³/hr/m²@50Pa has been used in this analysis.

2.9 Weather data

- **Current weather year file:** CIBSE *London DSY* (Design Summer Year) weather data, which is 2005.
- **Projected weather files.** MEDIUM Emissions Scenario; these files were provided by Oxford Brooks University

UK_WM_Oxford_2030_a1b_90Percentil; where a1b corresponds to a medium emissions scenario

UK_WM_Oxford_2050_a1b_90Percentil; where a1b corresponds to a medium emissions scenario

and *2040: An interpolation of the results of years 2030 & 2050 will determine the results of year 2040*

2.10 Occupancy Profiles

MEDIUM HIGH Occupancy used as it was considered the closest to reality**:**
- Weekdays: *Working Hours (4pm to 9am)*
- Weekends: *24 hours*

Base case models of both houses are based on modelling assumptions described above.

3 ITERATIONS

4.1 Single

- **New U-values (Walls - 0.12/ Windows - 1.2)**

Alternative U-values for the external walls and windows were considered in the overheating test in order to see how they will affect summer overheating. Walls improve the U-value to 0.12 W/m² ºC and windows lessen the U-value to 1.2.

- **Solar Shading (Shutters)**

Solar shading in the form of temporary shutters was incorporated to all the windows of the units. They are placed from 11am to 6pm to protect the internal spaces from solar gains.

- **Night Cooling (NC)**

The model was re-run with windows opened during nigh time (7pm to 9am). This allows the building fabric to cool as external temperatures drop down and the heat gains absorbed during the day can be naturally removed from the internal spaces. This measure does not require any additional cost or material production at the same time it brings significant reduction in overheating hours. Due to the security reasons, this iteration applied only to the windows of the First floors in both houses. As all the windows of the Ground floor can be only opened while occupied, hours and they have to be completely closed during the night - time.

Each of the above iteration is predicted to reduce overheating hours. Nevertheless, aiming to achieve even lower internal temperatures combined iterations were introduced, it is can be explained as follows:

4.2 Combined

- **Combining Night Cooling (NC) and Solar Shading (Shutters)**

This iteration combines night time cooling, opening all windows from 7pm to 9am and shutters during the day when solar gains are higher. In this way, the sun access is prevented during the day and the excess heat is realised in the night. As mentioned previously, this combination is the most effective measure, when two variables are applied.

5 RESULTS AND DISCUSSIONS

The Tables below show the results by the year analysed, future projections are for Medium Emissions 90 Percentil scenario. Values that are not highlighted show no risk of overheating, values highlighted in light blue have minor risk of overheating and values in dark blue demonstrate risk of overheating:

5.1 Current DSY 2005

House 357 (Affordable Unit) - CURRENT DSY (2005)						
Occupancy	Room	Single Iterations				Combined iterations
		Base case	Wdw 1.2/ walls 0.12	Shutter	NC	NC+shutter
MEDIUM HIGH Week Work Hrs (4pm-9am) & Wknd 24hr	*Living*	0.30%	0.26%	0.16%	0.00%	0.00%
	Dining	0.14%	0.07%	0.00%	0.00%	0.00%
	Bedroom1	0.74%	0.62%	0.56%	0.22%	0.04%
	Bedroom2	0.71%	0.65%	0.46%	0.23%	0.07%

NOTE: 1% of occupied hours are 69.3 hours - See Table 1

5.2 Projection 2030 Medium Emissions

House 357 - 2030 Medium Emissions Scenario						
Occupancy	Room	Single Iterations				Combined iterations
		Base case	Wdw 1.2/ walls 0.12	Shutter	NC	NC+shutter
MEDIUM HIGH Week Work Hrs (4pm-9am) & Wknd 24hr	*Living*	0.30%	0.23%	0.03%	0.00%	0.00%
	Dining	0.13%	0.09%	0.00%	0.00%	0.00%
	Bedroom1	**1.93%**	**1.69%**	**1.08%**	0.20%	0.03%
	Bedroom2	**1.90%**	**1.64%**	0.91%	0.29%	0.06%

5.3 Interpolation 2040 Medium Emissions

House 357 - 2040 Medium Emissions Scenario						
Occupancy	Room	Single Iterations				Combined iterations
		Base case	Wdw 1.2/ walls 0.12	Shutter	NC	NC+shutter
MEDIUM HIGH Week Work Hrs (4pm-9am) & Wknd 24hr	*Living*	0.95%	0.82%	0.50%	0.25%	0.06%
	Dining	0.69%	0.60%	0.42%	0.09%	0.04%
	Bedroom1	**2.98%**	**2.81%**	**1.97%**	0.78%	0.37%
	Bedroom2	**3.00%**	**2.79%**	**2.07%**	0.88%	0.41%

5.4 Projection 2050 Medium Emissions

House 357 - 2050 Medium Emissions						
Occupancy	**Room**	**Single Iterations**				**Combined iterations**
		Base case	**Wdw 1.2/ walls 0.12**	**Shutter**	**NC**	**NC+shutter**
MEDIUM HIGH Week Work Hrs (4pm-9am) & Wknd 24hr	*Living*	**1.60%**	**1.41%**	0.97%	0.50%	0.12%
	Dining	**1.25%**	**1.11%**	0.84%	0.17%	0.07%
	Bedroom1	**4.02%**	**3.92%**	**2.86%**	**1.36%**	0.71%
	Bedroom2	**4.10%**	**3.94%**	**3.22%**	**1.47%**	0.75%

5.5 Current DSY 2005

House 386 (Private Unit) - CURRENT DSY (2005)						
Occupancy	**Room**	**Single Iterations**				**Combined iterations**
		Base case	**Wdw 1.2/ walls 0.12**	**Shutter**	**NC**	**NC+shutter**
MEDIUM HIGH Week Work Hrs (4pm-9am) & Wknd 24hr	*Living*	0.16%	0.16%	0.03%	0.10%	0.00%
	Dining	0.07%	0.07%	0.04%	0.04%	0.01%
	Bedroom1	0.52%	0.53%	0.20%	0.29%	0.06%
	Bedroom2	0.46%	0.46%	0.20%	0.25%	0.07%

NOTE: 1% of occupied hours are 69.3 hours.

5.6 Projection 2030 Medium Emissions

House 386 (Private Unit) - 2030 Medium Emissions						
Occupancy	**Room**	**Single Iterations**				**Combined iterations**
		Base case	**Wdw 1.2/ walls 0.12**	**Shutter**	**NC**	**NC+shutter**
MEDIUM HIGH Week Work Hrs (4pm-9am) & Wknd 24hr	*Living*	0.30%	0.32%	0.00%	0.07%	0.00%
	Dining	0.00%	0.00%	0.00%	0.00%	0.00%
	Bedroom1	0.82%	0.85%	0.22%	0.36%	0.04%
	Bedroom2	0.53%	0.55%	0.17%	0.13%	0.03%

5.7 Interpolation 2040 Medium Emissions

House 386 (Private Unit) - 2040 Medium Emissions						
Occupancy	**Room**	**Single Iterations**				**Combined iterations**
		Base case	**Wdw 1.2/ walls 0.12**	**Shutter**	**NC**	**NC+shutter**
MEDIUM HIGH Week Work Hrs (4pm-9am) & Wknd 24hr	*Living*	0.83%	0.85%	0.22%	0.54%	0.13%
	Dining	0.23%	0.23%	0.10%	0.11%	0.05%
	Bedroom1	**1.85%**	**1.87%**	0.64%	**1.07%**	0.08%
	Bedroom2	**1.44%**	**1.47%**	0.58%	0.76%	0.05%

5.8 Projection 2050 Medium Emissions

House 386 (Private Unit) - 2050 Medium Emissions						
Occupancy	**Room**	**Single Iterations**				**Combined iterations**
		Base case	**Wdw 1.2/ walls 0.12**	**Shutter**	**NC**	**NC+shutter**
MEDIUM HIGH Week Work Hrs (4pm-9am) & Wknd 24hr	*Living*	**1.36%**	**1.38%**	0.43%	**1.00%**	0.26%
	Dining	0.46%	0.46%	0.19%	0.22%	0.09%
	Bedroom1	**2.87%**	**2.88%**	**1.05%**	**1.77%**	0.12%
	Bedroom2	**2.35%**	**2.39%**	0.98%	**1.38%**	0.07%

6 CONCLUSIONS:

Houses are designed following the advice on the early stages of design in order to demonstrate no overheating within the first 20 years of occupation. Any overheating post this period will be the responsibility of the homeowners. The affordable units will remain in the ownership of the client but can be retrofitted post the 20-year period which is not required in the base design.

6.1 House 357

Currently there is no risk of overheating in the spaces analysed for unit 357. In 2030, both of the bedrooms in the base case and with alternative U-values tend to overheat. Single iterations significantly improved the temperatures in all the spaces of this property and combined iteration completely mitigated overheating. In 2040, the night cooling iteration and combined iterations are the most efficient in terms of overheating reduction. All of the spaces of the base case model in 2050 have internal temperatures above the CIBSE benchmark and single iterations improve the overheating only in living and dining rooms, while the combined iteration causes significant temperatures drop.

6.2 House 386

In this dwelling there was no overheating observed in the years 2005 and 2030. In 2050, both bedrooms have internal temperatures above the CIBSE benchmark in the base case and with alternative U-values. There is a marginal overheating in the Bedroom 1 under night cooling iteration in the year of 2040. Additionally, this room was tested with reduced lighting and internal gains following an assumption that within next 20 years lighting and equipment will become more energy efficient. The result for Bedroom 1 in 2040 is 0.96% of the total annual occupied hours (with 20% more efficient lighting and equipment), which is below CIBSE benchmark.

The performances of both houses significantly improved due to the design advice followed by measures undertaken on the early stages of design. In both cases night cooling seems like the more efficient measure for reducing summer overheating, as it doesn’t require any additional cost or material production.

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Overheating Analysis

Carolina Caneva. PRP Environmental.

PRP

Why Overheating is an issue?

Climate change
warmer and drier summertime conditions and wetter winters

Energy prices
dwindling fossil fuel supplies mean that energy is likely to become more costly

Demographic change
UK's aging population elderly are more vulnerable to temperature extremes, more likely to suffer from fuel poverty, and tend to stay at home longer

Why Overheating is an issue?

Existing housing stock

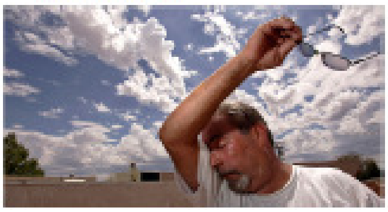
- inherently air leaky and thermally massive
- Will operate adequately at higher external temperatures
- needs to improve performance in winter months

New housing

- Highly insulated
- Often very little thermal mass
- May overheat internally to uncomfortable levels
- Problem has already been experienced in some 'energy efficient' developments

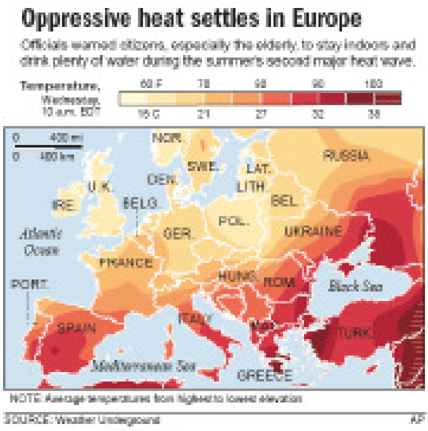
Who will Overheating affect?

- **sick/disabled**
  - from cardiovascular disease
  - respiratory disease
  - hypothermia
  - certain medication
  - those confined to their beds
- **elderly**
- **very young**
- **overweight**
- **poor**
- **outdoor workers**
- **living in properties prone to overheating**



Mortality: Heat Waves

- Can have deadly effects
- Elderly, children are particularly vulnerable
- Summer 2003 – around 30,000 heat-related deaths across Western Europe



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Why would our future homes tend to overheat?

Rising temperatures

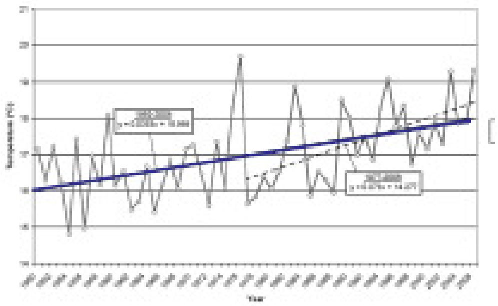
Global surface temperature is likely to rise a further 1.1 to 6.4 °C during the 21st century

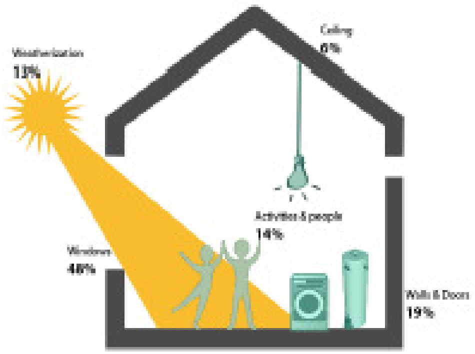
Changing lifestyle

- More gadgets and appliances
- Increased internal heat gains
- Working home
- Older population

Stricter building regulations

- Better insulation and airtightness
- Modern dwellings - less able to lose heat naturally, more reliant on mechanical ventilation
- Part L 2010 requires overheating calculations



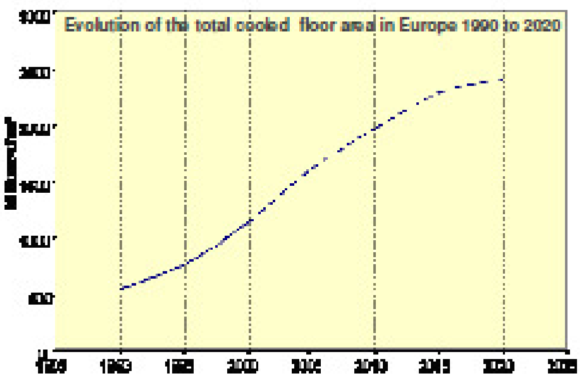


What happens if we don't design for overheating?

People will always just take matters into their own hands….
…or complain a lot!

Increases in CO_2 and Energy Demand

- Increased air conditioning use during summer
- > overall energy use of the property, > CO2 emissions
- 'Without careful management, the UK could soon emit more CO2 in summer than in winter in the future as the need for cooling increases'



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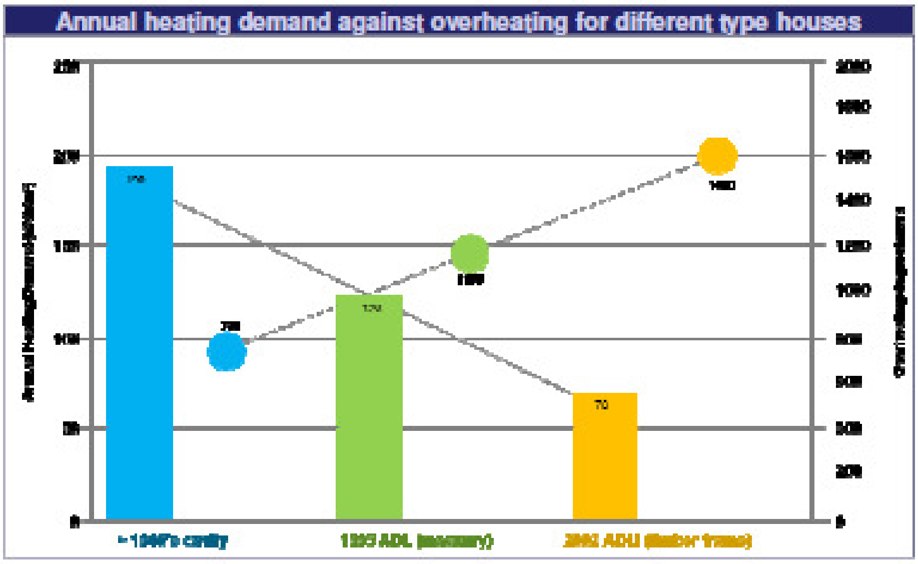
House Types and Overheating



Strategies - Overheating

High thermal mass

- likely to be central to creating sustainable buildings in the future.
- prevents increased energy demand for cooling
- allows a building to support a more comfortable temperature over a 24 hour period
- Stable indoor temperatures
- 'sponge' - absorbing surplus heat during the day, releasing the heat during the evening
- BUT to work effectively needs to be coupled with night-time ventilation or cooling

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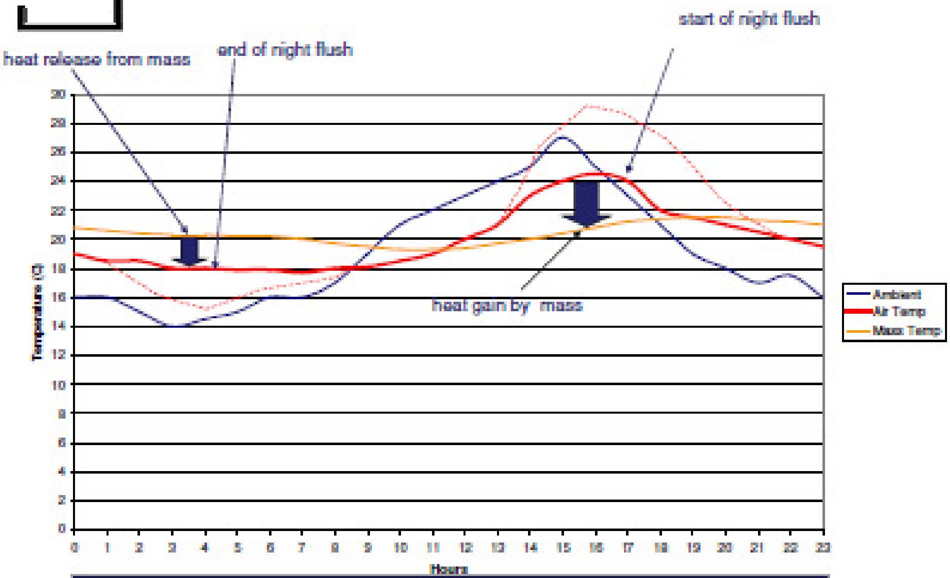
Strategies - Overheating

High thermal mass



Temperature profile of a thermally massive building with night-time ventilation

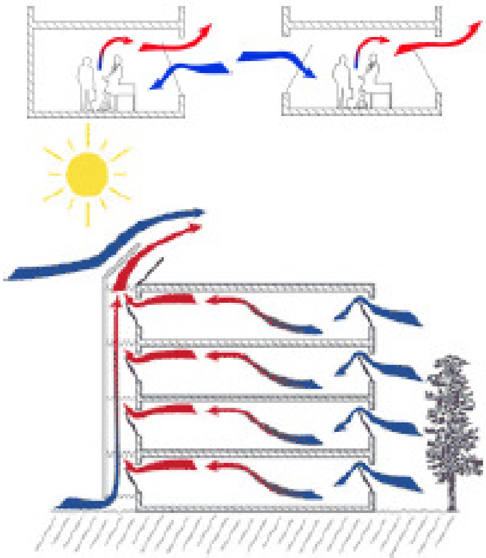
Strategies - Overheating

Natural Ventilation

- OPEN when outside is cooler than the inside
- CLOSED when outside is warmer than the inside

driven by wind pressure and density variations

- single sided ventilation (density driven)
- stack ventilation (density driven)
- cross flow ventilation (wind driven)



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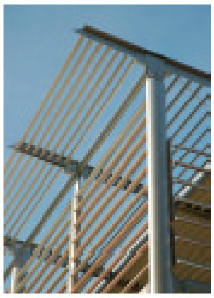
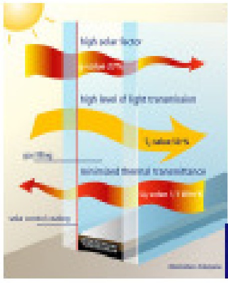
Strategies - Overheating

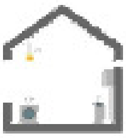
Reduce solar gain

- External solar shading (natural features & external devices on south facing windows)
- Optimised orientation (avoid large west-facing openings)
- Blinds (external/internal/interstitial)
- Shutters
- Tints and Coatings – tinted, reflective, glass, fritting
- Smart Glazing - photochromic, thermochromic glass
- High roof albedo (reflect solar radiation)



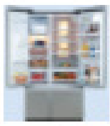


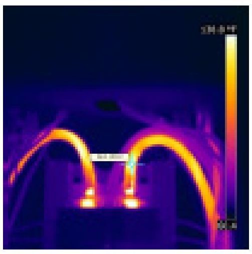
Strategies - Overheating

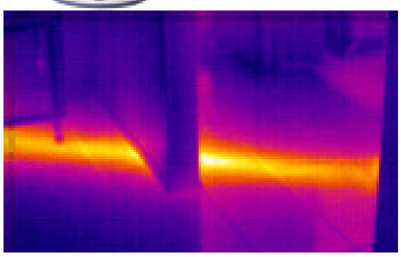


Reduce internal gains

- Daylight design (reduce gains from electric lighting)
- Controls (sensors and timers)
- Insulation (hot water systems)
- Energy efficient appliances







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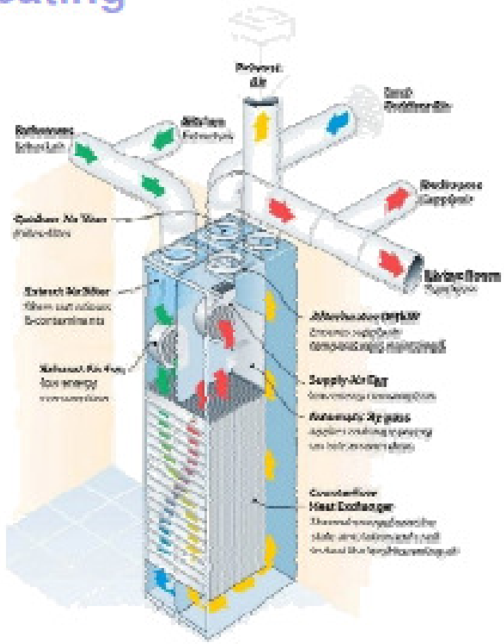
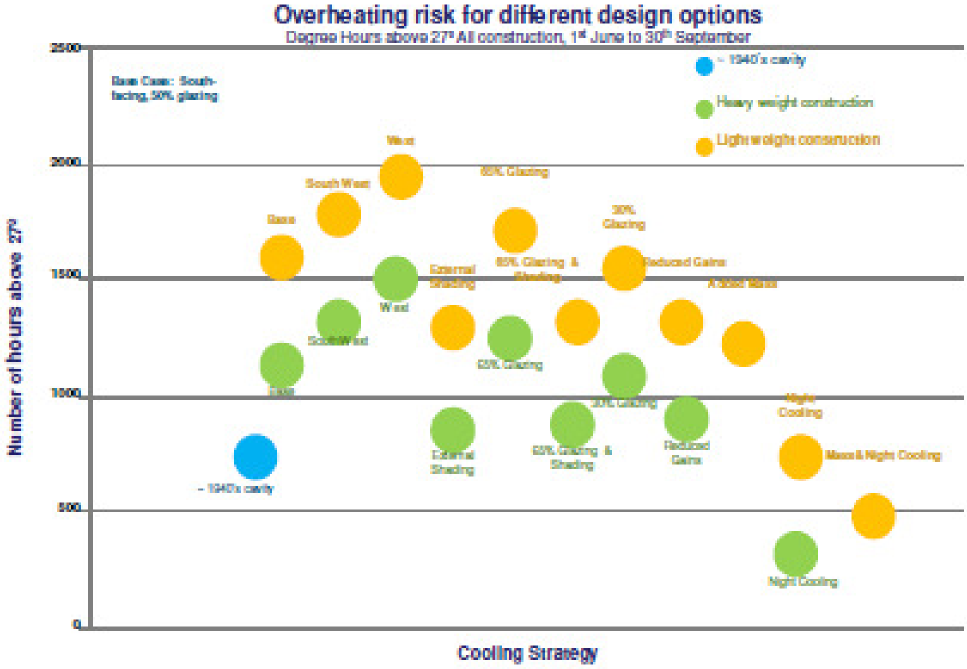
Strategies - Overheating

MVHR with summer bypass system

- Winter – used for heat recovery (heat from outgoing stale air pre-heats fresh incoming air). Also reduces humidity and condensation risk.
- Summer – summer bypass block enables system to bypass the heat exchanger, allowing a greater flow of cooler, fresh filtered air during warmer months



The most effective strategy?



7

Overheating Standards

CIBSE 2006

Overheating occurs if:

in any one year 1% of occupied hours exceed 28 °C for living areas and 26 °C for bedrooms.

[illegible]

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]		
— [illegible]	[illegible]	[illegible]
— [illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Table 1.8 Benchmark summer peak temperatures and overheating criteria

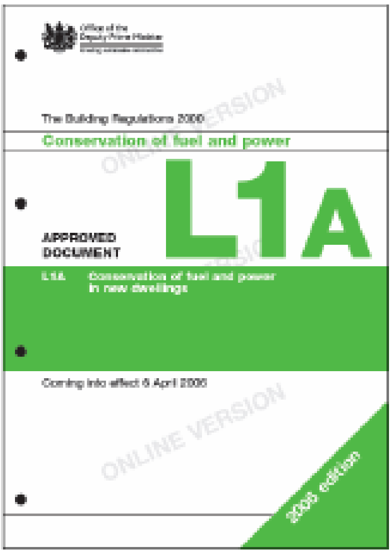
Building	Benchmark summer peak temp. / °C	Overheating criterion
Offices	28	1% annual occupied hours over operative temp. of 28 °C
Schools	28	1% annual occupied hours over operative temp. of 28 °C
Dwellings:		
— living areas	28	1% annual occupied hours over operative temp. of 28 °C
— bedrooms	26	1% annual occupied hours over operative temp. of 26 °C

* DfES Building Bulletin BB87[28] recommends an allowable overheating criterion of 80 occupied hours in a year over an air temperature of 28 °C.

Overheating Standards

Part L: The Five Criteria

1. Meet CO2 performance target
2. Minimum standards for fabric and building services efficiency
3. **Passive control features to limit overheating**
4. Demonstrate that actual performance is consistent with design predictions
5. Show suitable information is provided to users



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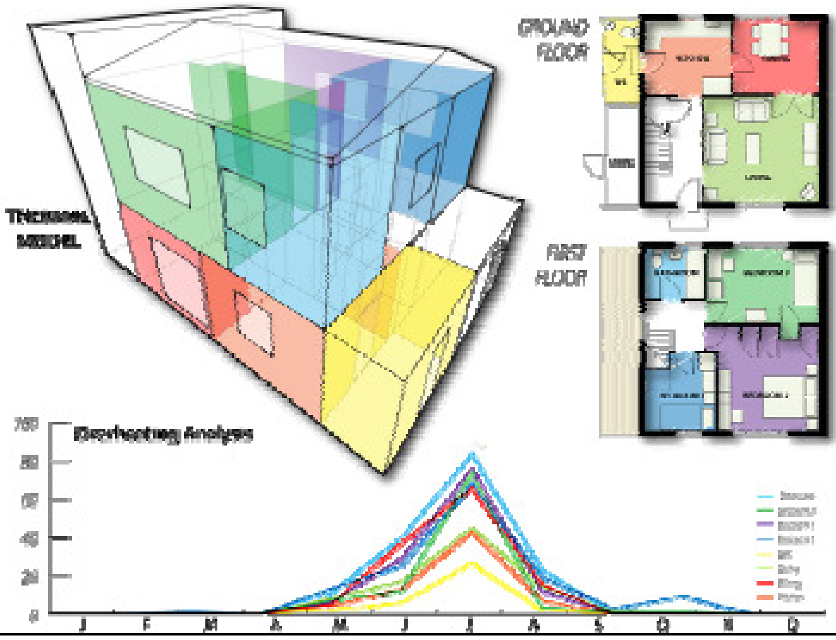
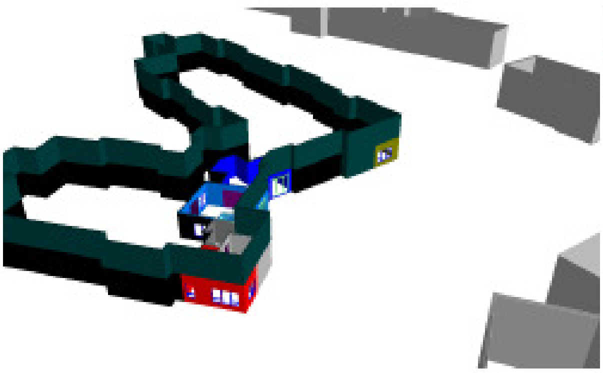
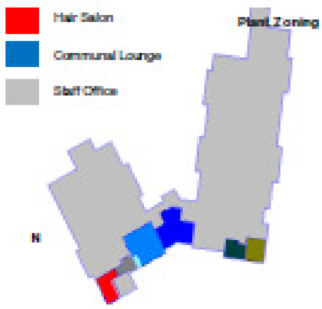
Case Studies – Retrofit for the future



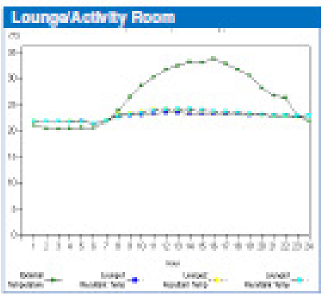
Case Studies – Lealands Court



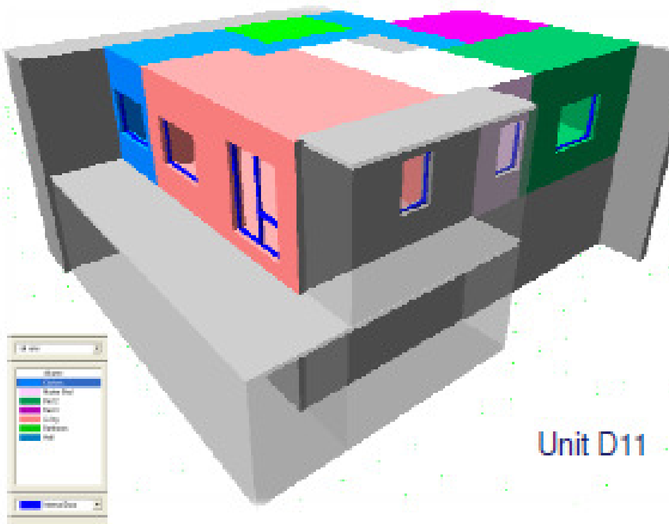


Conclusions

- No risk of overheating if care home is built as proposed.
- Controlling ventilation: Opening windows, mechanical extracts in kitchen and bathrooms (source of internal gain)
- The 'G' factor of the glazing to be 0.534 or less is specified.
- If the worst case scenario rooms will not have overheating, the whole building will comply with the criteria.



Case Studies – Site 11 - South Kilburn



No overheating if constructed as per pre-assessment (blockwork)

Change of material to lightweight construction: overheating problem in most of the units

Mitigation Measures:
- Reduce 'G' factor of glass
- Increase ventilation rates
- Use night time ventilation
- Apply thermal mass to some constructions

Case Studies – Site 11 - South Kilburn

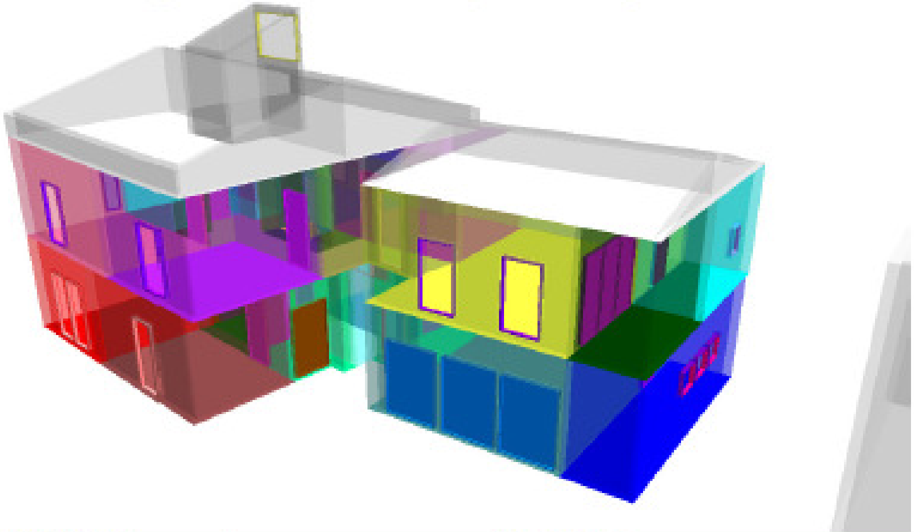
Results

PLOT D11 4th floor (S - W)	0. Base specification	Option 1		Option 2	Option 3		Option 4: Increase Ventilation			Option 4: Night Vent	
Iterations tested	Base Spec	Block Partition	Block partition Low 'G'	All blockwork: - Ext wall - Party wall - Partitions Low 'G'	Blockwork: - Ext wall - Party wall (wet plaster)	Blockwork: - Ext wall - Party wall (wet plaster) Low 'G'	Base Spec Increase Vent	Base Spec Increase Vent Low 'G'	Base Spec Increase Vent Low 'G' Ceiling: Energain	Base Spec Increase Vent Night Vent	Base Spec Increase Vent Night Vent Low 'G'
External - London DSY	1.47%										
Master Bed	[illegible]	[illegible]	0.75%	[illegible]	[illegible]	[illegible]	[illegible]	1.26%	1.21%	[illegible]	[illegible]
Bed 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bed 3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.21%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
External - London DSY	[illegible]										
Kitchen	0.78%			[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Living	0.78%			[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Key: Failed / minor problem / passed

10

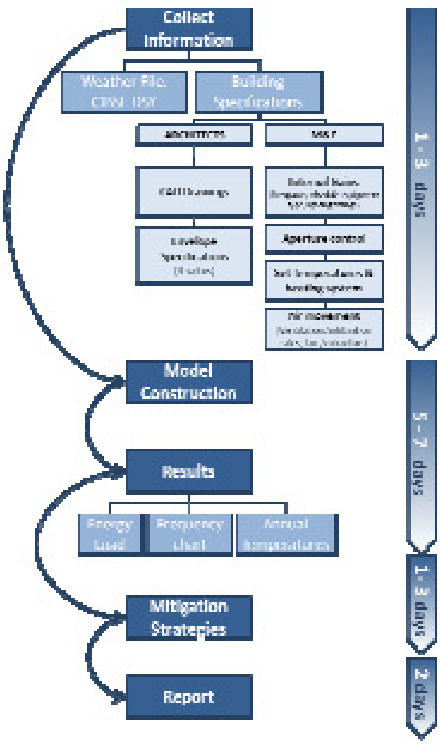
Case Studies – Bicester Ecotown



ENRICHED	Original Spec		
Band (°C)	Enriched 2005	Enriched 2030	Enriched 2050
Living	0.04%	0.07%	0.49%
Dining	0.04%	0.05%	0.53%
Office	0.05%	0.05%	0.47%
Bed3	0.35%	1.04%	2.43%
Bed4	0.35%	0.99%	2.14%
Bed Office	0.49%	1.28%	2.63%

Process

- Inputs
  - Weather Data
  - Plans, Elevations, Sections
  - Specifications: Materials, U-values, Occupancy Schedules, Equipment type, lighting fittings, aperture control, Set temperatures
- Process
  - Building the Model (TAS)
  - Running the Simulation (TAS)
- Outputs
  - Thermal Comfort Percentages and Graphs, Overheating Risk
  - Energy Consumption and CO_2 emissions



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