NW Bicester

An application for the exemplar phase of the
NW Bicester Eco Development proposals submitted by
P3Eco (Bicester) Limited **and the** A2Dominion Group

Daylight and Sunlight Analysis

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NW Bicester Eco Development

Daylight and Sunlight Analysis

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CONTENTS

1 SUMMARY

The consensus is that for planning purposes, the light levels to the plots are adequate for typical housing design when referring to the British standard for daylighting. Increasing the imposed level of daylight on a number of dwelling types would further reduce the need for artificial lighting and improve the sustainability of those dwellings.

Adjacent dwellings do not cast large shadows onto neighbouring plots. It is also noted that no shadows are cast on dwelling roofs, and so the proposed solar panels to dwellings should not be affected in their energy providence via overshadowing.

2 INTRODUCTION

Hyder Consulting UK Ltd were appointed to undertake overshadowing and daylighting works to the Exemplar site of the NW Bicester eco development. The daylighting and overshadowing studies included within this report have been formulated on the basis of the information supplied by the project architect. All models created and analysed are for option 1 of Exemplar scheme only.

2.1 Standards

The following standards and good practice guides have been used for the study:

Type	***Description***
BS 8206-2 (2008)	Lighting for Buildings Part 2: Code of practice for daylighting
BRE Report 209	Site layout planning for daylight and sunlight; A guide to good practice
CE292	Energy efficiency and the code for sustainable homes; Levels 5 & 6

Table.1 – Applied standards and good practice

2.2 3D Modelling

3D models have been constructed for the exemplar site based on the dwelling types provided by the project architect. At this stage there are currently ten types of dwelling identified to the scheme, which are as follows:

Type	***Description***
01	*2 Bed Private Terrace*
02	*3 Bed Private Terrace*
03	*2 Bed Social Terrace*
04	*3 Bed Social Terrace*
05	*3 Bed Private Semi-detached*
06	*4 Bed Social Detached*
07	*4 Bed Private Detached*
08	*2 Bed Bungalow*
09	*3 Bed Bungalow*
10	*5 Bed Private Detached*

Table.2 – Dwelling Types

No information is currently available for the 3 bed private semi-detached option (Type 05), however drawing information has been provided for the remaining types in the form of the following:

1. Site Layout Plan; providing a proposed master planning layout for the dwelling types. This has been used as a template for the overshadowing study

2. Building Elevations; providing the scope of typical window sizes and placements for the building front elevations. It is noted that given the early stages of design, window placements are not indicated for the rear or side walls to the building types.

3. Floor Plan Layouts; providing indication of the space planning to the building plots. As with the building elevations, these drawings are not yet indicative of the placement of windows to the rooms.

For the purpose of this study, building types have been modelled in Google SketchUp for ease of creation and manipulation. The selection of SketchUp was primarily due to the surfaced based nature of its cad engine, which has been found to translate geometry into the selected environmental program with the highest level of accuracy, particularly in comparison to other modelling methods such as Autodesk Revit Architecture or other standard *.dxf or *.xml imports. Recent developments between the software packages in the form of a GUI plug-in have also strengthened the flexibility and accuracy of model translation. Baseline models were constructed for each of the building templates described in table.1 (with the exception of Type 05). These models were then exported to the environmental analysis software for addition of the reflectance and transmittance variables (see section 2.2). Habitable spaces were translated as bound rooms within the environmental analysis software, with occupiable areas extending from finished floor level to underside of ceiling. Intermediate floors and roof spaces were also created within the model geometry but have not been included within the analysis areas.

2.2.1 Assumptions made

In the absence of relevant data or information, the following assumptions have been made in order to expedite modelling works and analysis;

1. Given that no glazing is indicated to the rear of the buildings types, windows have been included in the rear walls in a configuration that mirrors the front elevation, using the same sizes and types. Some areas such as the bathrooms to dwellings will require windows to the external building envelope; these are likely to be smaller in size and as such not of dimensions indicated by the architect on the issued drawings.

2. All internal doors have been assumed as 900mm wide x 2100mm high to comply with building regulations.

3. For dwellings, the current cladding is not yet designed in detail, with external wall thicknesses proposed as 350mm thick and internal walls 100mm thick block or metal stud. The works being undertaken do not have any thermal transmittance requirements and so statement of U-Values is not included. As such all external and internal walls are assumed as fully opaque.

4. The glazing to the dwellings has been applied as per the specification in Table.3 in order to meet the target U-values in line with CSH level 5 dwellings. This configuration is influenced by reference data supplied within CE292 (refer to appendices) and also research within current sustainable buildings such as the PassiveHaus by Eco2h2o which denotes a specification of triple glazing with a krypton gas fill to the glazing cavities. These values in turn are indicative of the transmittance and reflectance values required for daylight calculation.

5. Neutral colours and finishes have been selected for the internal and external building surfaces such as white emulsion on render or crème carpets in order to calculate internal daylighting factors. The reflectance and transmittance properties of these finished are stated in Table.4.

Description	Process	Thick
1. Pilkington Suncool	Toughened	6mm
2. Cavity	Krypton fill (90%)	16mm
3. Pilkington Optifloat	Annealed	6mm
4. Cavity	Krypton fill (90%)	16mm
5. Pilkington Optilam	Laminated	6.4mm

U-Value	U	0.80	W/m^2k
Light Transmission	LT	62	%
	UV	1	%
Light Resistance Out	LR Out	13	%
Light Resistance In	LR In	17	%
Energy Transmitted	ET	32	%
Energy Reflected	ER	29	%
Energy Absorbed	EA	39	%
Total Transmittance	g	39	
Shading Coefficient	SC	0.45	

Table.3 – Typical Glazing Specification

Material	LR In	LR Out	LT
Carpet: Light Colour	45	0	0
External Wall; Light Grey Brick	40	40	0
Internal Wall; Plaster, White Emulsion	80	80	0
Door; Light Oak Timber	25	25	0
Ceiling; Plaster, White Emulsion	80	80	0
Roof; Slate / Timber	70	10	0

Table.4 – Materials Reflectance Properties

2.3 Environmental Analysis

For overshadowing and daylighting analysis, the housing types were imported from Google SketchUp into IES Virtual Environment. All geometrical elements were identified as either opaque or transparent, with no translucent materials applied at this stage. Window perimeter frames have been created within the models to accurately represent the intended areas of glazing coverage. The geographical location of the buildings was set as for Oxford, with local CIBSE DSY weather data for Brize Norton applied, being the nearest site for reference data.

Fig.1 – Typical SketchUp Model (Type 10)

Fig.2 – Typical IES Model (Type 10)

2.3.1 Overshadowing Study

For the overshadowing study, all building types modelled and imported were applied to sample areas of the site location plan in order to populate typical areas. The models were then subject to Suncast analysis to track solar patterns and account for any localised shading impacts from surrounding buildings. Images were captured for particular areas of interest, with results stated in section 3.1.

2.3.2 Daylighting Study

Building types were analysed individually, with multiple cases investigated for the varying orientations of the building types, indicated by placement on the site layout plan provided by the project architect. IES FlucsPro software was then used to establish daylighting factors within building plots. Daylighting calculations were made for a midseason day of 21st March at midday, with a CIE standard overcast sky applied to all calculations to allow an onerous case for the internal lighting levels. Contour plots were taken for the ground and first floor areas of the proposed buildings, with a working plane of 850mm above finished floor, being the standard as stated in BRE Report 209 (see fig.3). A maintenance factor for the glazing of 0.9 was assumed allowing for clean vertical glazing.

Methods proposed within the British Standard for daylighting (BS8206-2) indicate that daylight factors within properties should be no lesser than the values stated in Table.4 below for adequate task lighting in dwelling. Methods described by the BRE in Report 209 (P.J Littlefair, 1998) however state that for a predominantly day lit appearance, calculated daylight factors should ideally be 5% or more if there is to be no additional supplemented daylighting, with lesser factors requiring assistance from electric lighting to create suitable conditions.

Room Type	***Min. Average DF***
Bedrooms	*1%*
Living Rooms	*1.5%*
Kitchens	*2%*

Table.4 – Daylight Factors by British Standard

Given the high level of passive design imposed upon the proposed properties, investigation was made into mapping daylight factors against lower and upper limits of 2% and 5% accordingly to represent the effectiveness of the orientation of the building plots. An indication of this output can be seen in fig.4 overleaf; further results for these daylight factors are stated in section 3.2.

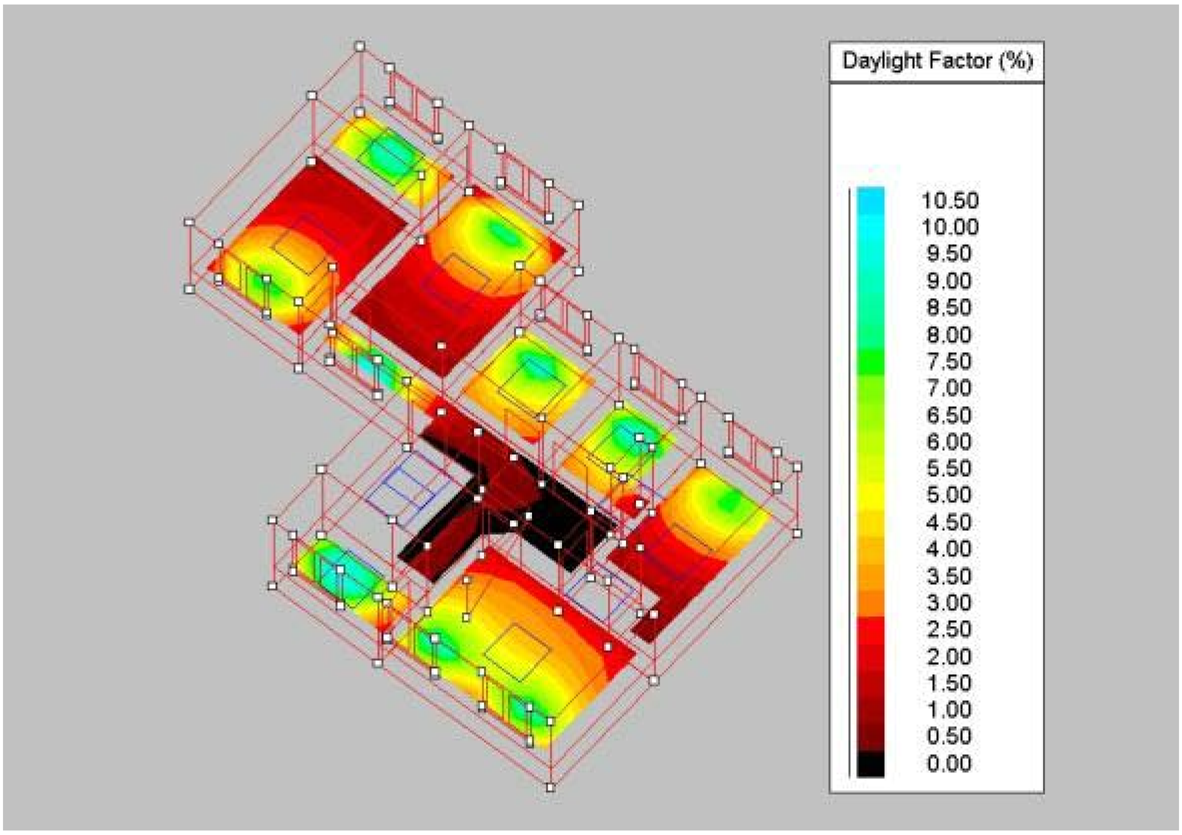


Fig.3 – Typical Daylighting Factor Contour Map

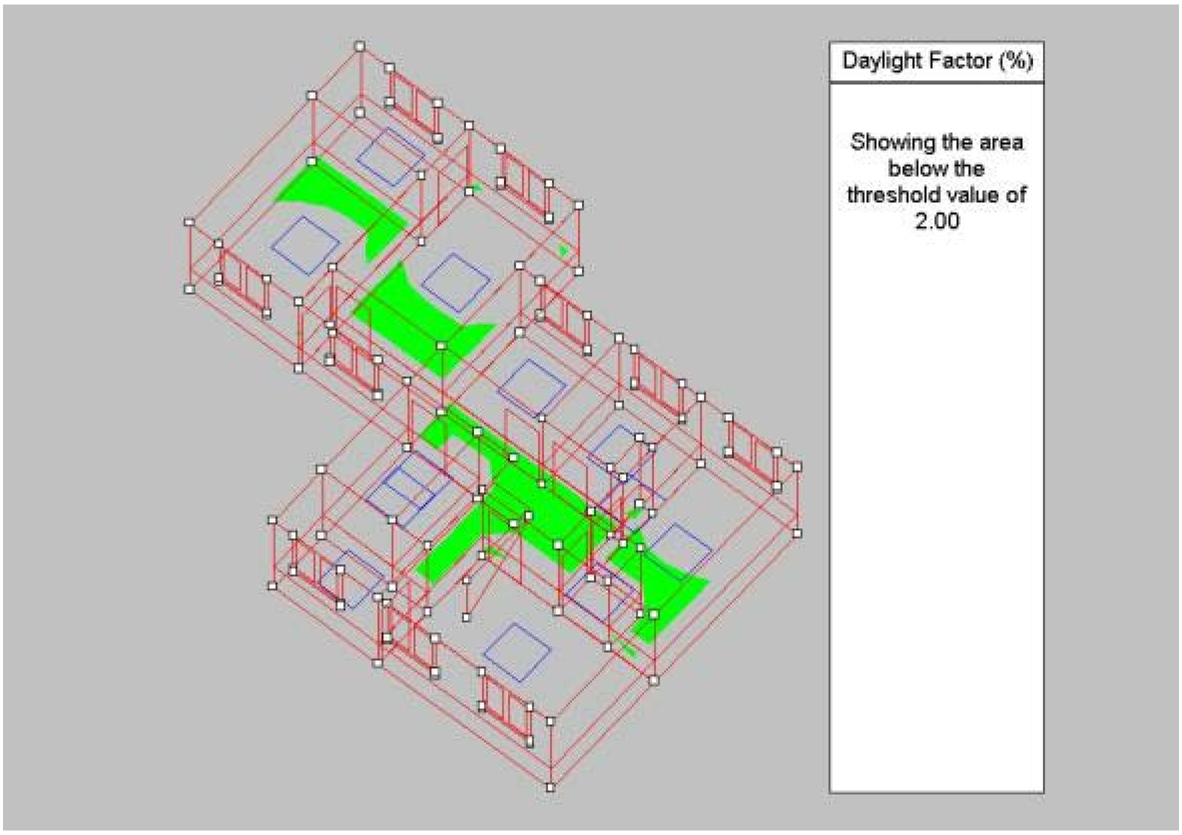


Fig.4 – Typical indication of areas below 2% Daylight Factor

3 RESULTS

3.1 Overshadowing Study

Fig.5 – Exemplar Site Layout Plan

As indicated previously in section 2.3.1, all building types modelled and imported were applied to sample areas of the site location plan in order to populate typical areas. The proposed site was split into four zones for further analysis; these areas have been denoted as zones 1 to 4 respectively, indicated in fig.5 above.

The models were then subject to Suncast analysis to track solar patterns and account for any localised shading impacts from surrounding buildings. For the purposes of this report, shadows were recorded for a typical winter day as an onerous case, where elongated shadows are more likely to extend to adjacent building plots. In this case the design day is 15th January for a typical CIBSE design year.

Suncast Images were captured for particular areas of interest and have been entered into the report for investigation of any possible issues (figs. 6 to 17 respectively). All Suncast images, along with some recorded videos for cast shadows, will be made available to the clients design team for further inspection. The site layout plan may have altered since appointment of the works due to the fluctuating nature of the scheme designs, however the configuration of many of the houses should still remain unaltered and the results yielded for the overshadowing and daylighting studies will remain valid, particularly with regards to orientation of the dwelling types.

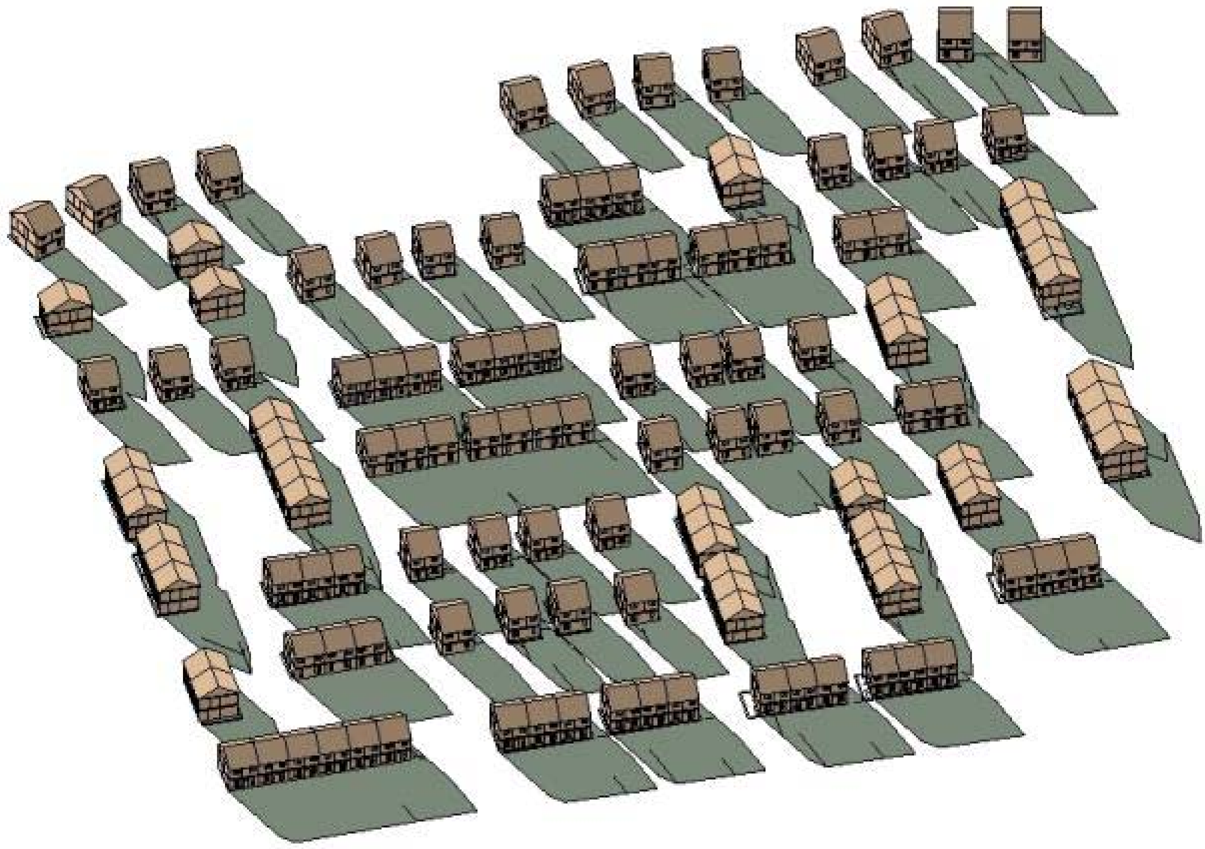


Fig.6 – Zone 1 - Critical Suncast

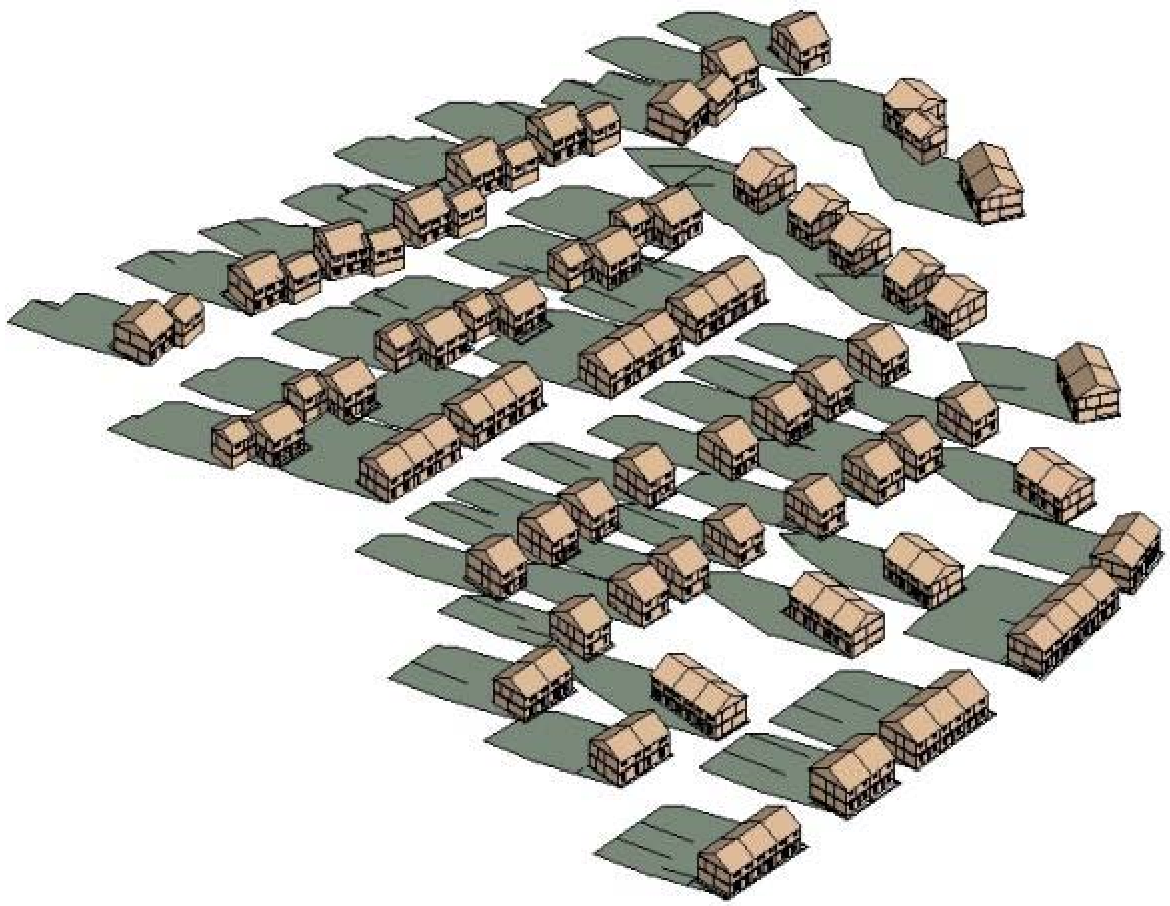


Fig.7 – Zone 2 - Critical Suncast

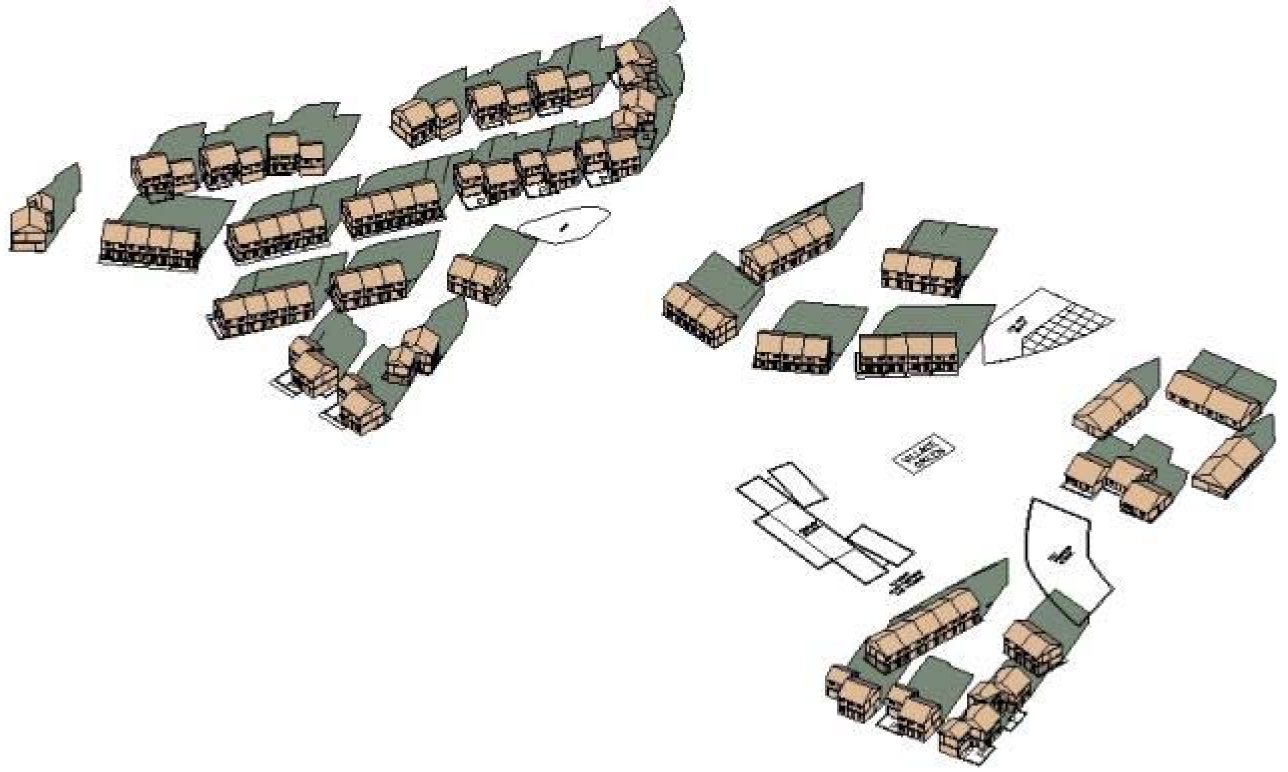


Fig.8 – Zone 3 - Critical Suncast

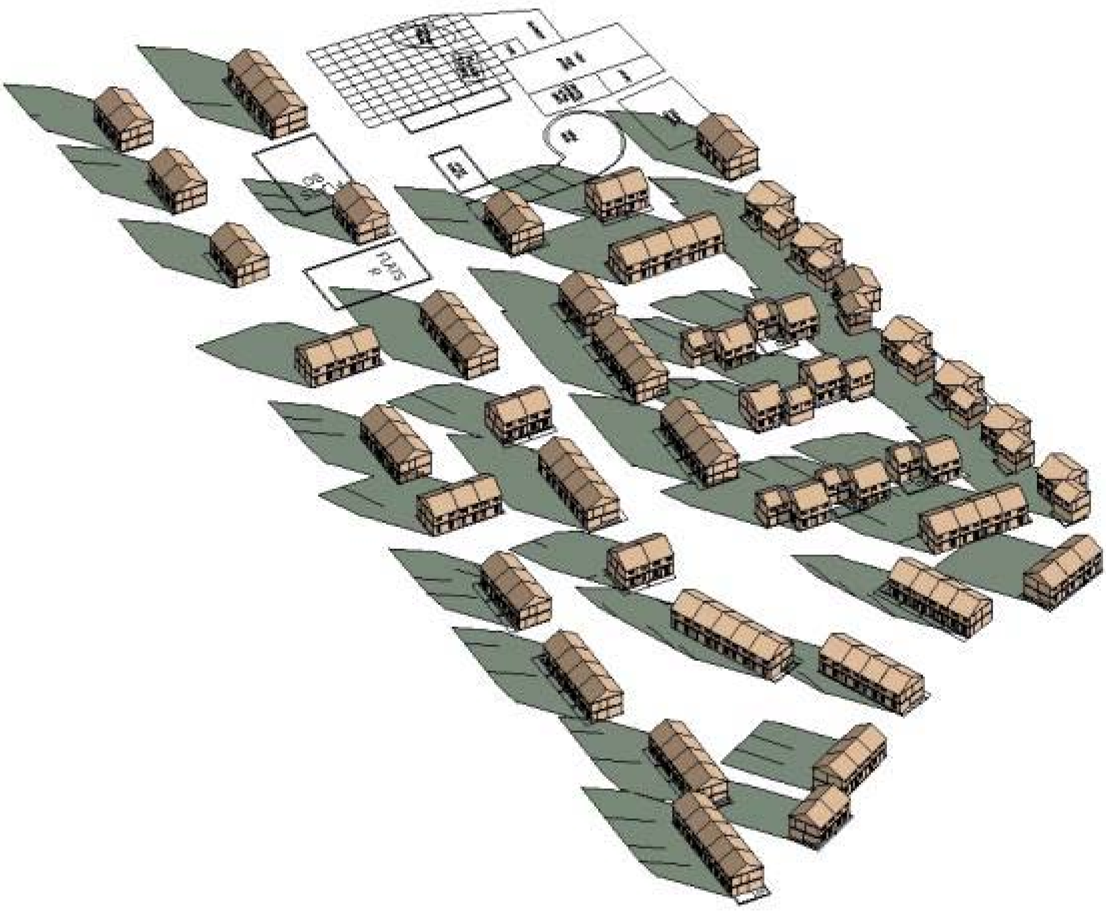


Fig.9 – Zone 4 - Critical Suncast

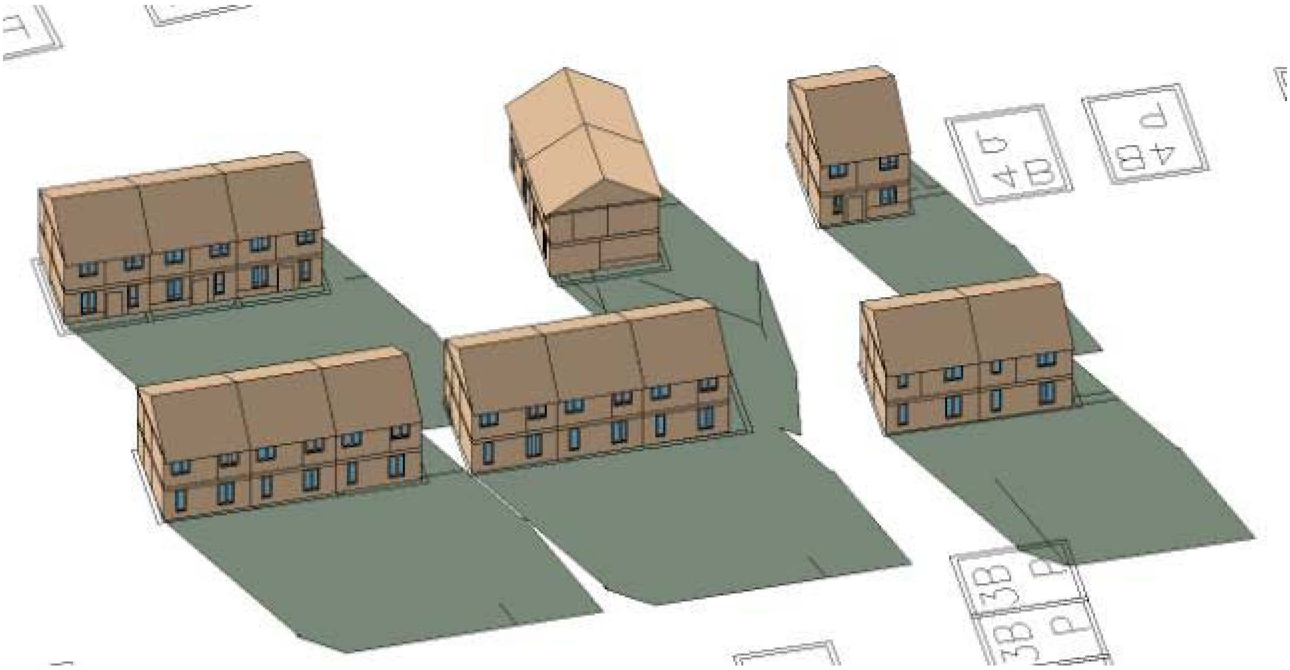


Fig.10 – Zone 1a - Critical Suncast

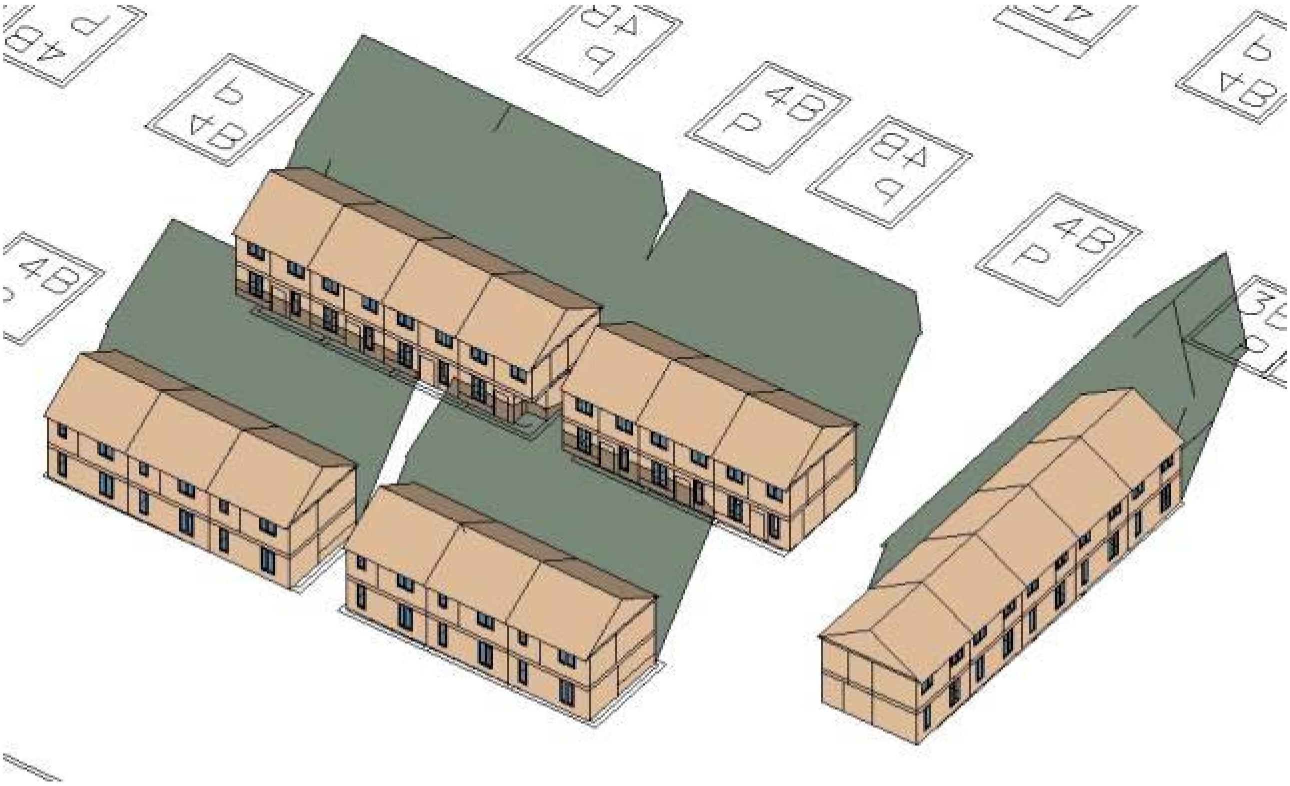


Fig.11 – Zone 1b - Critical Suncast

Fig.12 – Zone 2a - Critical Suncast

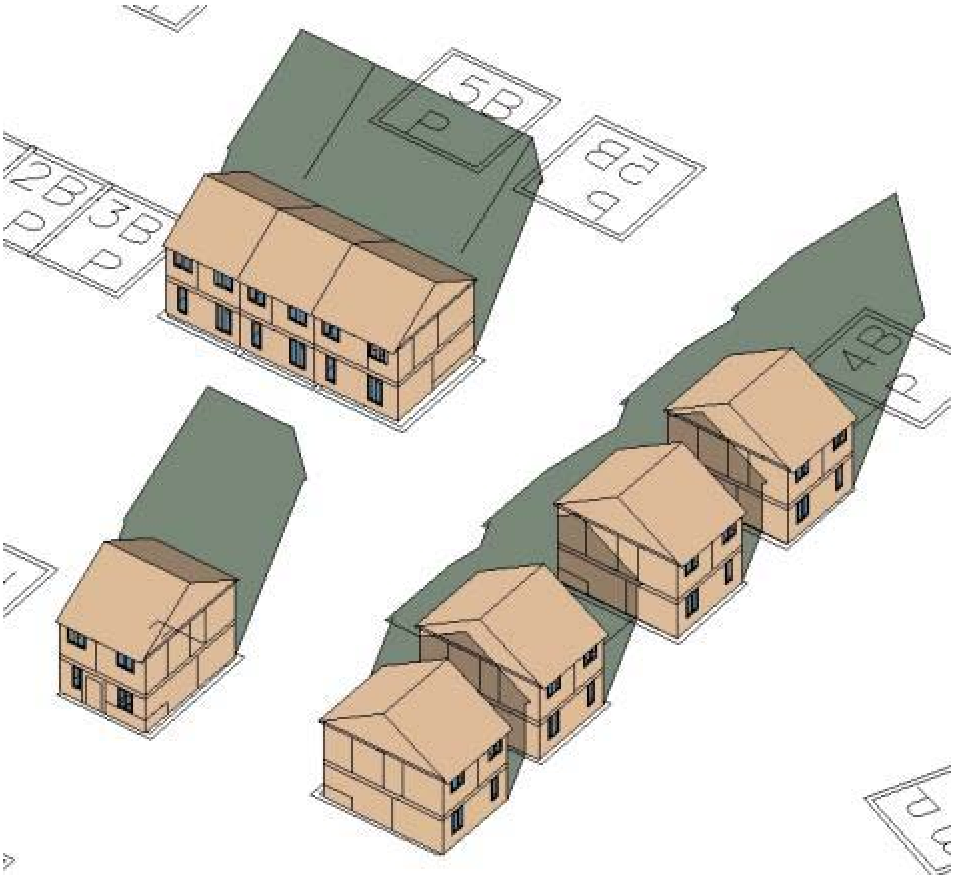


Fig.13 – Zone 2b - Critical Suncast

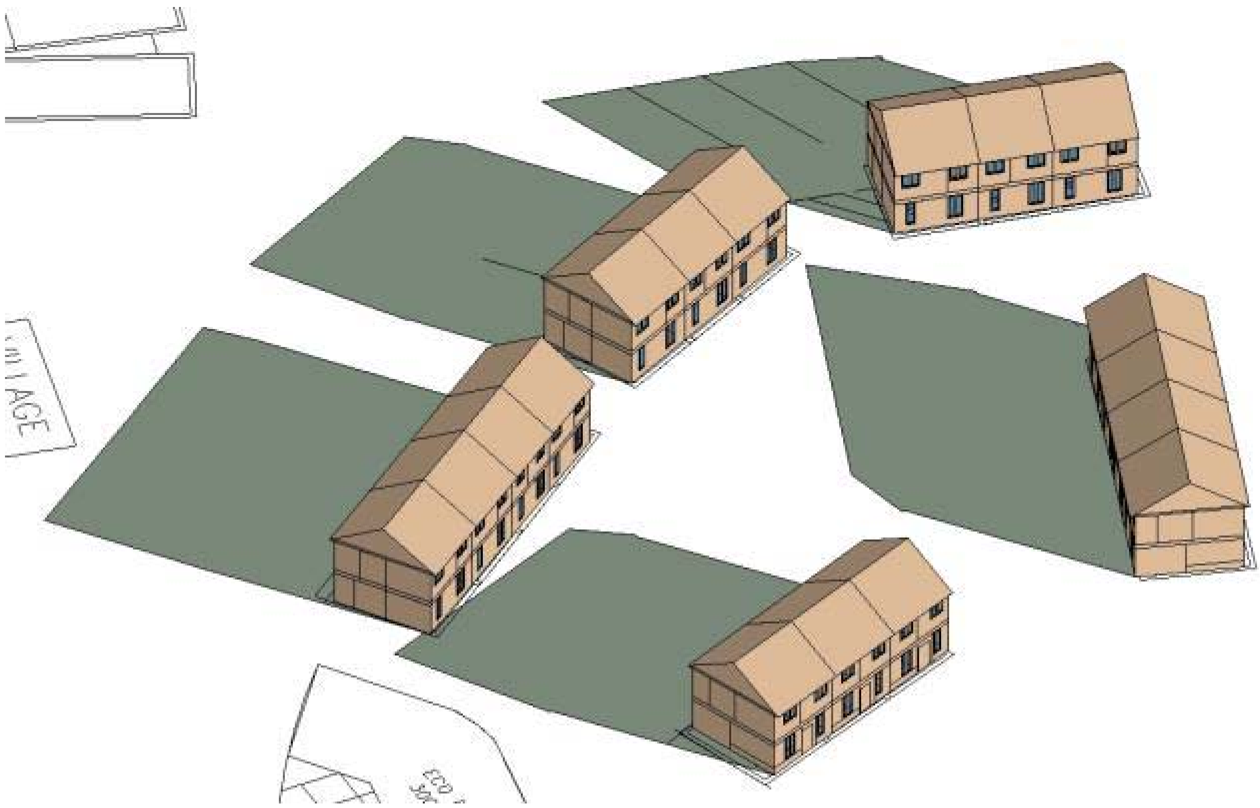


Fig.14 – Zone 3a - Critical Suncast

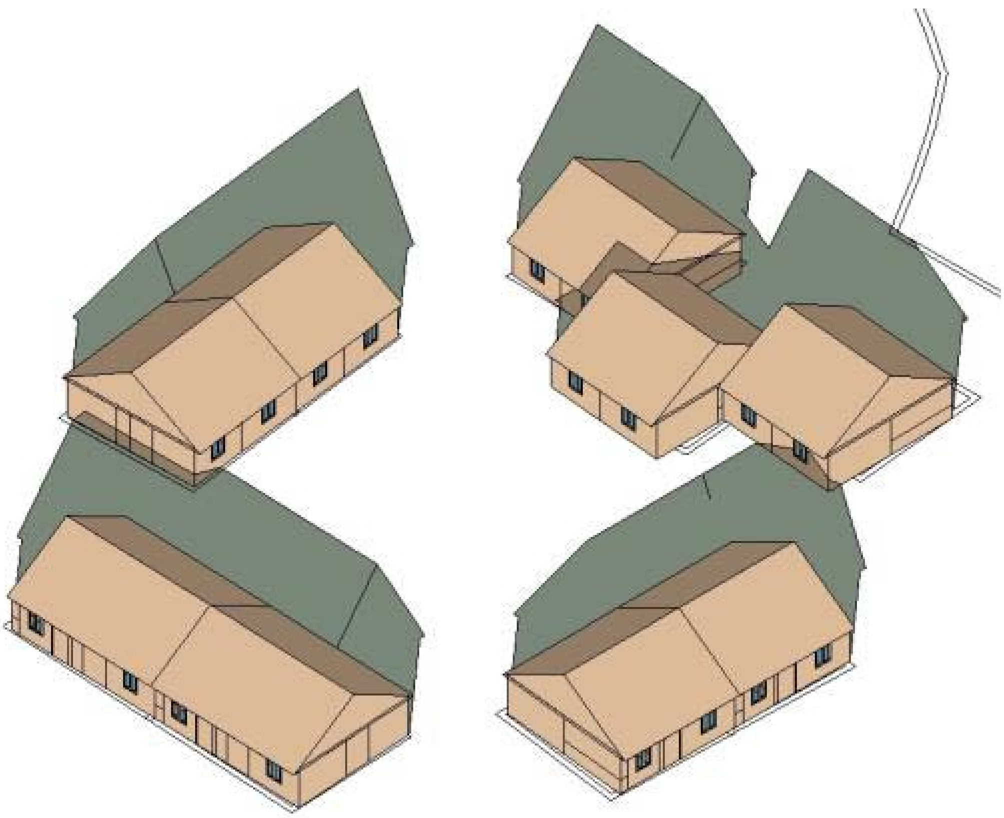


Fig.15 – Zone 3b - Critical Suncast

Fig.16 – Zone 4a - Critical Suncast

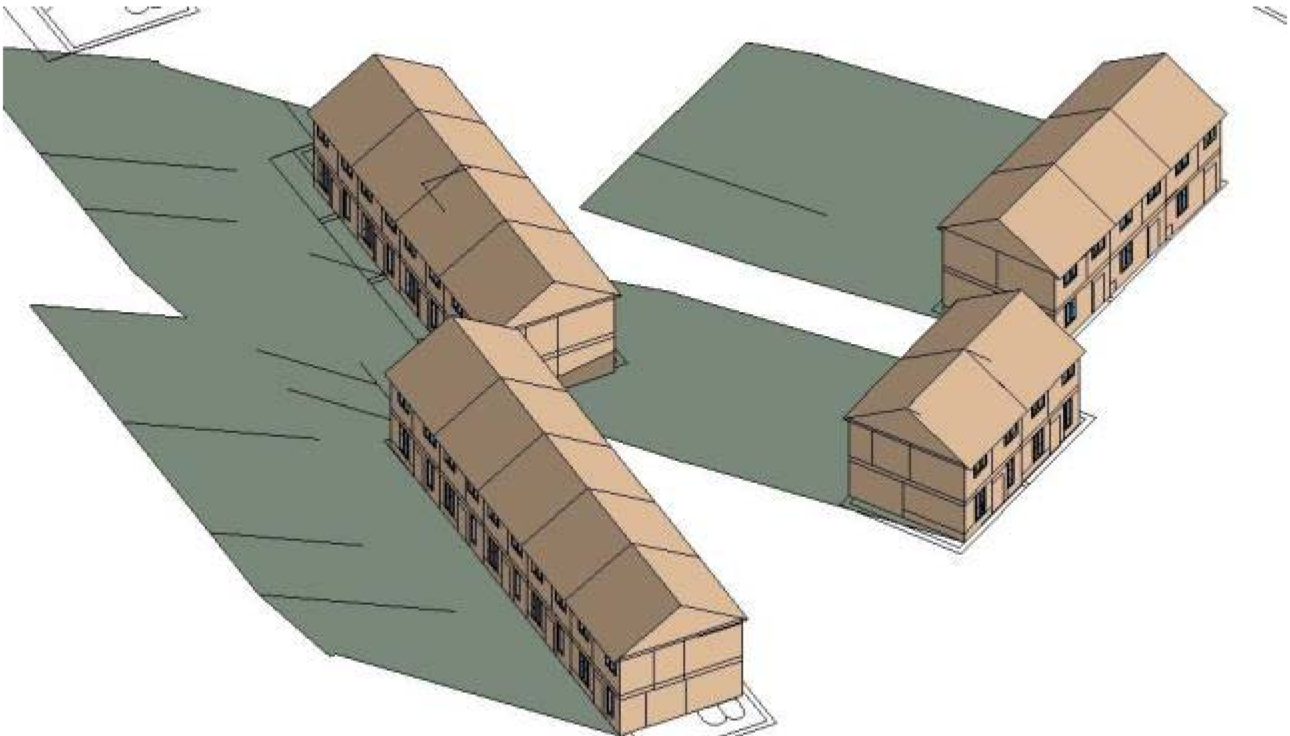


Fig.17 – Zone 4b - Critical Suncast

3.2 Daylighting Study

The following section contains a summary of daylighting conditions for each dwelling type for their respective orientations, as dictated by the site layout plan. The quality of the internal lighting has been noted for daylight factors for the upper and lower limits of 5% and 2% as noted inspection 2.3.2. More detailed information on the Lux levels for the dwelling room types, along with colour contour charts, is available upon request.

Fig.18 – Dwelling Type 01

Orientation	Floor	Quality @ 2%	Quality @ 5%
E	Ground	Average	Poor
E	1st	Good	Average
ESE	Ground	Good	Poor
ESE	1st	Good	Average
SE	Ground	Good	Poor
SE	1st	Good	Average
SW	Ground	Good	Average
SW	1st	Good	Average
NE	Ground	Good	Average
NE	1st	Good	Average

Table.5 – Type 01 Daylight Summary

Fig.19 - Dwelling Type 02

Orientation	Floor	Quality @ 2%	Quality @ 5%
N	Ground	Average	Poor
N	1st	Good	Average
SE	Ground	Poor	Poor
SE	1st	Good	Average
NE	Ground	Average	Poor
NE	1st	Good	Average
E	Ground	Average	Poor
E	1st	Good	Average
ESE	Ground	Average	Poor
ESE	1st	Good	Average
SSW	Ground	Average	Poor
SSW	1st	Good	Average
SW	Ground	Average	Poor
SW	1st	Good	Average
WNW	Ground	Average	Poor
WNW	1st	Good	Average
WSW	Ground	Average	Poor
WSW	1st	Good	Average

Table.6 – Type 02 Daylight Summary

Fig.20 – Dwelling Type 03

Orientation	Floor	Quality @ 2%	Quality @ 5%
E	Ground	Good	Average
E	1st	Good	Average
ENE	Ground	Average	Poor
ENE	1st	Good	Average
ESE	Ground	Good	Average
ESE	1st	Good	Average

Table.7 – Type 03 Daylight Summary

Fig.21 - Dwelling Type 04

Orientation	Floor	Quality @ 2%	Quality @ 5%
NW	Ground	Good	Average
NW	1st	Good	Good
NNE	Ground	Good	Average
NNE	1st	Good	Average

Table.8 – Type 04 Daylight Summary

Fig.22 - Dwelling Type 06

Orientation	Floor	Quality @ 2%	Quality @ 5%
E	Ground	Average	Poor
E	1st	Good	Average
N	Ground	Average	Poor
N	1st	Good	Average
S	Ground	Average	Poor
S	1st	Good	Average
W	Ground	Average	Poor
W	1st	Good	Average

Table.9 – Type 06 Daylight Summary

Fig.23 - Dwelling Type 07

Orientation	Floor	Quality @ 2%	Quality @ 5%
NE	Ground	Average	Poor
NE	1st	Good	Average
NNE	Ground	Average	Poor
NNE	1st	Good	Average
NNW	Ground	Average	Poor
NNW	1st	Good	Average
NW	Ground	Average	Poor
NW	1st	Good	Average
SE	Ground	Average	Poor
SE	1st	Good	Average

Table.10 – Type 07 Daylight Summary

Fig.24 - Dwelling Type 08

Orientation	Floor	Quality @ 2%	Quality @ 5%
NE	Ground	Good	Poor
SSW	Ground	Good	Poor
WNW	Ground	Good	Poor

Table.11 – Type 08 Daylight Summary

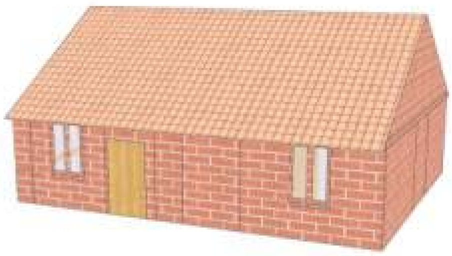


Fig.25 - Dwelling Type 09

Orientation	Floor	Quality @ 2%	Quality @ 5%
ESE	Ground	Good	Poor

Table.12 – Type 09 Daylight Summary

Fig.26 - Dwelling Type 10

Orientatio n	Floor	Quality @ 2%	Quality @ 5%
ENE	Ground	Good	Average
ENE	1st	Good	Average
ESE	Ground	Good	Average
ESE	1st	Good	Average
NE	Ground	Good	Average
NE	1st	Good	Average
SE	Ground	Good	Average
SE	1st	Good	Average
SW	Ground	Good	Average
SW	1st	Good	Average

Table.13 – Type 10 Daylight Summary

4 CONCLUSION;

Overshadowing;

With respect to any overshadowing risk, the proposed housing types appear well spaced apart, with adjacent dwellings not casting large shadows onto neighbouring plots. For some portions of the winter months there may be some overshadowing to ground floor livings rooms by buildings opposite, however this is likely to be for short periods at the end of the day when electric lighting will shortly be required. It is noted that no shadows are cast on dwelling roofs, and so the proposed solar panels to dwellings should not be affected in their energy providence.

Daylighting:

The consensus is that for planning purposes, the light levels to the plots are adequate for typical housing design. The lower limit Daylight Factor of 2% actually provides the onerous case for dwellings when referring to the British standard for daylighting, with lower requirements for bedrooms and living rooms during the daytime periods when natural light will be available. The results forecast are also for midseason overcast cases and so internal lighting conditions will typically be of better quality for a greater portion of the year.

Some areas within the dwellings had no levels of daylighting, such as bathrooms, corridors or landings. This is primarily due to an incomplete window schedule and elevation drawings upon appointment for the works; such areas may now have windows sized for these locations. Provision of these openings will increase internal lighting to the plots, both by direct light transmittance or by reflected light if the internal finishes are light in appearance and luminance.

Upon reviewing the results for the upper 5% Daylight Factor limit, the levels are average or poor. If further emphasis is placed upon the proposed dwellings to be sustainable, i.e. to reduce the requirement of supplemented electrical lighting (during the daytime hours), and then further allowance must be made to increase the imposed level of daylight. Light levels to the ground floor corridors may be increased by introductions of glazed fan lights and fixed lights to the surround of the entrances. Patio or French doors may also be considered to the rear of some dwellings which may further increase the lighting levels to living rooms or kitchen areas.

While the daylight levels may need to be increased for a more passive configuration, there will still be a requirement within the design to limit imposed large solar gains and prevent unwanted heat build-up, given the highly insulated nature of the intended building fabric. Internal glare into the dwelling spaces will also need to be considered, and so alteration of window glazing should considered carefully against thermal and visual comfort.

5 APPENDICES:

The following information has been obtained from the Energy Saving Trust document CE292 for CSH level 5 and 6 dwellings. The fabric U-values contained within have been used formulate a template for the building fabric used within the daylighting study.

Detached house (104m^2) scenarios

			Typical building regulations scenario	Energy Saving Trust 100% and zero carbon solutions							
				Gas boiler with solar water heating		Biomass boiler		Heat pump		Communal gas CHP	
				100%	Zero carbon	100%	Zero carbon	100%	Zero carbon	100%	Zero carbon
Fabric U-values W/m^2.K		Roof	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
		Walls	0.30	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
		Ground floor	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
		Windows	1.90	0.80	0.70	0.80	0.70	0.80	0.70	0.80	0.70
		Doors	2.00	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
		y-value	0.08 (accredited)	0.04		0.04		0.04		0.04	
Ventilation		Airtightness m^3/(hr.m^2)	7.0	3.0		3.0		3.0		3.0	
		Mechanical Ventilation	Extractor fans	MVHR 85% efficiency, 1W /(l.s) specific fan power		MVHR 85% efficiency, 1W /(l.s) specific fan power		MVHR 85% efficiency, 1W /(l.s) specific fan power		MVHR 85% efficiency, 1W /(l.s) specific fan power	
Heating		Boiler	Gas condensing 90%, boiler interlock	Gas condensing 90%, boiler interlock		Wood pellet, independent boiler 86%		Electric ground to water heat pump		Gas CHP, 75%	
		Controls	Programmer, room thermostat, thermostatic radiator valves	Programmer, room thermostat, thermostatic radiator valves, weather or load compensator		Programmer, room thermostat, thermostatic radiator valves		Programmer and at least 2 room thermostats		Flat rate charging, programmer, room thermostat and thermostatic radiator valves	
		Water heating	160 litre cylinder, 50mm insulation	160 litre cylinder, 80mm insulation		160 litre cylinder, 80mm insulation		160 litre cylinder, 80mm insulation		160 litre cylinder, 80mm insulation	
		Secondary heating	Electric heaters	Electric	n/a	Electric	n/a	Electric	n/a	Electric	n/a
Renewables		Solar water heating	n/a	Solar water heating 4m^2		n/a		n/a		Solar water heating 4m^2	
		Photovoltaic (kWp)	n/a	2.90	5.30	1.75	3.95	3.60	5.95	2.90	5.35
Lighting			30%	100%		100%		100%		100%	
CO_2	100% (Level 5)	TER	23.76	23.76		23.76		33.73*		23.76	
		DER	23.46	-0.12		-0.20		-0.10		-0.19	
		Improvement	**1.3%**	**100.00%**		**101.00%**		**100.00%**		**101.00%**	
	Level 6 only	**Actual emissions**		-1.65		-2.22		-1.82		-1.42	
		Level 6 offset		12.24		12.24		12.24		12.24	
		Final DER		-10.59		-10.02		-10.42		-10.82	
Energy efficiency rating			80 (C)	97 (A)	112 (A)	85 (B)	95 (A)	102 (A)	114 (A)	101 (A)	112 (A)
Environmental impact rating			79 (C)	99 (A)	112 (A)	102 (B)	112 (A)	102 (A)	112 (A)	101 (A)	112 (A)
Running costs (£/yr)			263	69	-107	210	98	4	-124	27	-108

*Here the TER has changed because the heating fuel for this option has different fuel factor in the building regulations

Fig.27 – CE292 Target for Detached Houses

Semi-detached house (89m²) scenarios

		Typical building regulations scenario	Energy Saving Trust 100% and zero carbon solutions							
			Gas boiler with solar water heating		Biomass boiler		Heat pump		Communal gas CHP	
			100%	Zero carbon	100%	Zero carbon	100%	Zero carbon	100%	Zero carbon
Fabric U-values $W/m^2.K$	Roof	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
	Walls	0.25	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	Ground floor	0.25	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	Windows	1.90	0.80	0.70	0.80	0.70	0.80	0.70	0.80	0.70
	Doors	2.00	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
	y-value	0.08 (accredited)	0.04		0.04		0.04		0.04	
Ventilation	Airtightness $m^3/(hr.m^2)$	7.0	3.0		3.0		3.0		3.0	
	Mechanical Ventilation	Extractor fans	MVHR 85% efficiency, 1W /(l.s) specific fan power		MVHR 85% efficiency, 1W /(l.s) specific fan power		MVHR 85% efficiency, 1W /(l.s) specific fan power		MVHR 85% efficiency, 1W /(l.s) specific fan power	
Heating	Boiler	Gas condensing 90%, boiler interlock	Gas condensing 90%, boiler interlock		Wood pellet, independent boiler 86%		Electric ground to water heat pump		Gas CHP, 75%	
	Controls	Programmer, room thermostat, thermostatic radiator valves	Programmer, room thermostat, thermostatic radiator valves, weather or load compensator		Programmer, room thermostat, thermostatic radiator valves		Programmer and at least 2 room thermostats		Flat rate charging, programmer, room thermostat and thermostatic radiator valves	
	Water heating	160 litre cylinder, 50mm insulation	160 litre cylinder, 80mm insulation		160 litre cylinder, 80mm insulation		160 litre cylinder, 80mm insulation		160 litre cylinder, 80mm insulation	
	Secondary heating	Electric heaters	Electric	n/a	Electric	n/a	Electric	n/a	Electric	n/a
Renewables	Solar water heating	n/a	Solar water heating 4m²		n/a		n/a		Solar water heating 4m²	
	Photovoltaic (kWp)	n/a	2.75	5.25	1.60	4.20	2.40	5.00	2.50	5.10
Lighting		30%	100%		100%		100%		100%	
CO_2 100% (Level 5)	TER	23.00	23.00		23.00		32.60*		23.00	
	DER	22.69	-0.19		-0.01		-0.03		-0.17	
	Improvement	**1.3%**	**101.00%**		**100.00%**		**101.00%**		**101.00%**	
CO_2 Level 6 only	**Actual emissions**		-1.68		-1.31		-1.28		-1.38	
	Level 6 offset		13.46		13.46		13.46		13.46	
	Final DER		-11.78		-12.15		-12.18		-12.08	
Energy efficiency rating			101 (A)	113	94 (A)	106	97 (A)	109	100 (A)	112
Environmental impact rating			102 (A)	112	101 (A)	112	101 (A)	112	101 (A)	112
Running costs (£/yr)			21	-98	99	-23	60	-64	32	-89

*Here the TER has changed because the heating fuel for this option has different fuel factor in the building regulations

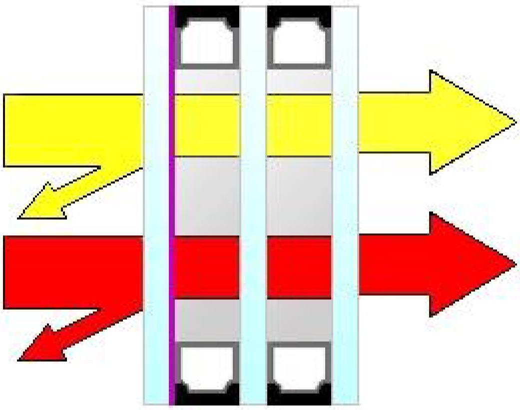
Fig.28– CE292 Target for Semi-Detached Houses

Mid-terrace house (79m²) scenarios

			Typical building regulations scenario	Energy Saving Trust 100% and zero carbon solutions							
				Gas boiler with solar water heating		Biomass boiler		Heat pump		Communal gas CHP	
				100%	Zero carbon	100%	Zero carbon	100%	Zero carbon	100%	Zero carbon
Fabric U-values W/m^2K		Roof	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
		Walls	0.30	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
		Ground floor	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
		Windows	1.90	0.80	0.70	0.80	0.70	0.80	0.70	0.80	0.70
		Doors	2.00	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
		y-value	0.08 (accredited)	0.04		0.04		0.04		0.04	
Ventilation		Airtightness $m^3/(hr.m^2)$	7.0	3.0		3.0		3.0		3.0	
		Mechanical Ventilation	Extractor fans	MVHR 85% efficiency, 1W /(l.s) specific fan power		MVHR 85% efficiency, 1W /(l.s) specific fan power		MVHR 85% efficiency, 1W /(l.s) specific fan power		MVHR 85% efficiency, 1W /(l.s) specific fan power	
Heating		Boiler	Gas condensing 90%, boiler interlock	Gas condensing 90%, boiler interlock		Wood pellet, independent boiler 86%		Electric ground to water heat pump		Gas CHP, 75%	
		Controls	Programmer, room thermostat, thermostatic radiator valves	Programmer, room thermostat, thermostatic radiator valves, weather or load compensator		Programmer, room thermostat, thermostatic radiator valves		Programmer and at least 2 room thermostats		Flat rate charging, programmer, room thermostat and thermostatic radiator valves	
		Water heating	140 litre cylinder, 50mm insulation	160 litre cylinder, 80mm insulation		160 litre cylinder, 80mm insulation		160 litre cylinder, 80mm insulation		160 litre cylinder, 80mm insulation	
		Secondary heating	Electric heaters	Electric	n/a	Electric	n/a	Electric	n/a	Electric	n/a
Renewables		Solar water heating	n/a	4m²		n/a		n/a		4m²	
		Photovoltaic (kWp)	n/a	2.35	4.75	1.45	3.75	2.25	4.65	2.25	4.65
Lighting			30%	100%		100%		100%		100%	
CO_2	100% (Level 5)	TER	21.32	21.32		21.32		30.13*		21.32	
		DER	21.04	-0.18		-0.18		-0.16		-0.19	
		Improvement	**1.3%**	**101.00%**		**101.00%**		**101.00%**		**101.00%**	
	Level 6 only	**Actual emissions**		-1.66		-1.97		-1.47		-1.47	
		Level 6 offset		14.28		14.28		14.28		14.28	
		Final DER		-12.62		-12.31		-12.81		-12.81	
Energy efficiency rating				101 (A)	113 (A)	88 (B)	99 (A)	97 (A)	109 (A)	101 (A)	113 (A)
Environmental impact rating				101 (A)	113 (A)	102	112 (A)	101 (A)	112 (A)	101 (A)	113 (A)
Running costs (£/yr)				24	-87	163	53	58	-57	28	-87

*Here the TER has changed because the heating fuel for this option has different fuel factor in the building regulations

Fig.29 – CE292 Target for Mid-Terrace Houses



Description

Position	Product	Process	Thickness (nominal) mm	Weight kg/m^2
Glass 1	Pilkington Suncool 70/40	Toughened	6	15
Cavity 1	Krypton (90%)		16	
Glass 2	Pilkington Optifloat Clear	Annealed	6	15
Cavity 2	Krypton (90%)		16	
Glass 3	Pilkington Optilam Clear	Laminated	6.4	15
Product Code	6C(74)-16Kr-6-16Kr-6.4L		50.4	46

Performance

Light		
Transmittance	LT	62%
	UV %	1%
Reflectance Out	LR out	13%
Reflectance In	LR in	17%

Energy		
Direct Transmittance	ET	32%
Reflectance	ER	29%
Absorptance	EA	39%
Total Transmittance	g	39%
Shading Coefficient Total		0.45
Shading Coefficient Shortwave		0.36

Sound Reduction	R_w dB $(C;C_{tr})$	NPD
Thermal Transmittance	W/m^2K	0.8

Performance Code

U-value/Light/Energy	0.8 / 62 / 39

The values of some of characteristics are displayed as NPD. This stands for No Performance Determined.

Fig.30 – Typical Triple IGU to meet CSH Level 5 requirements