Tallaght Innovation Centre

Belgard Square North,
Dublin 24

Comhairle Contae
Átha Cliath Theas
South Dublin County Council

Energy & Sustainability Report

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17/09/2020	00	Issued for Planning

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1.0 Executive Summary

This report compiles the Environmental and Building Services Engineering analysis and Concept Design undertaken for the proposed Tallaght Innovation Centre at Belgard Square North, Tallaght, Dublin 24.

A summary of the Daylight analysis which informed the design is described in Section 2.0. The analysis found that 88% of all applicable rooms achieved the BRE guidance best practice target average daylight factor for daylight spaces. The only rooms which did not achieve the target were generally found to be internal rooms at lower levels that are lit only through the atrium. These rooms are therefore allocated as meeting rooms which are unlikely to be occupied throughout the day.

Section 3.0 summarises the requirement for solar gain control in accordance with TGD Part L 2017 to minimise the need for excessive cooling and/ or allow natural ventilation strategies to be viable. Compliance was demonstrated by determining that maximum benchmark levels of solar gain were not exceeded for each room/façade in accordance with the Part L methodology. The results determined that all spaces meet building regulation requirements and are deemed compliant based on the advised glazing and shading criteria. The glazing g-value and framing factors are adjusted at each façade on a floor by floor basis to control the solar gain while maintaining consistent building massing and visual appearance.

The Natural Ventilation analysis is detailed within Section 4.0 which confirms this is a viable environmental strategy for all occupied areas and advises the extent of opening windows and vents to the atrium and occupied rooms. Based on these requirements all occupied spaces were deemed to comply with CIBSE TM52 guide to overheating risk for Naturally Ventilated buildings and the adaptive thermal comfort methodology. The performance results and required free opening areas for each occupied space are detailed in Appendix C, Tables C1.

Section 5.0 summarises the outcomes of building energy analysis, including the inclusion of a District Heating connection to provide a renewable energy source for the building. The energy analysis in this Section assessed the proposed building design and determined an environmental and servicing strategy to ensure compliance to Technical Guidance Document Part (TGD) L 2017 of the Building Regulations, in accordance with the Near Zero Energy Building (NZEB) Directive.

The energy analysis inputs and results are described for the building and a servicing strategy comprising of district heating using highly efficient air source heat pumps providing space and domestic hot water, as detailed in Table D1 of Appendix D

Compliance with TGD Part L was determined including the renewable contribution from the heat pumps, to ensure NZEB Target is achievable

The proposed Utilities strategy is outlined in Section 6.0. including the requirement for new ESB Power and Telecom connections and the utilisation of a local network District Heating connection from a neighbouring Data Centre.

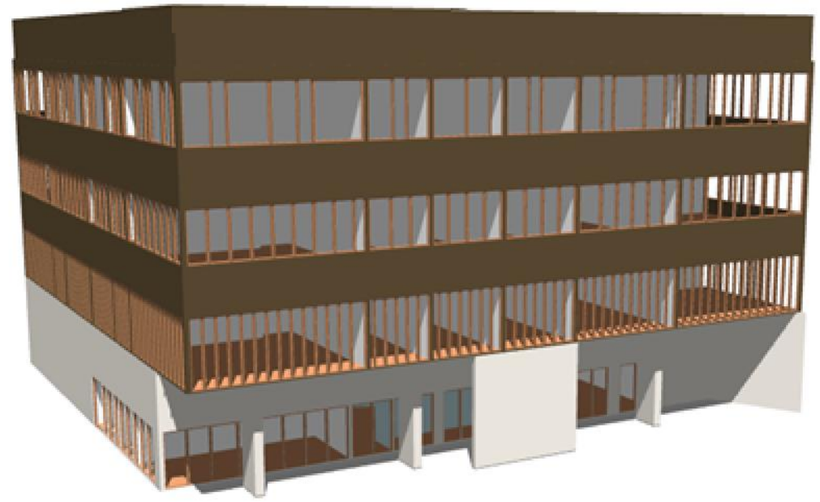


Fig 1.1– TAS 3D Dynamic Simulation Model of The Proposed Tallaght Innovation Hub

2.0 Daylight Analysis

2.1 Methodology

Daylighting analysis was undertaken using Tas Dynamic Simulation Modelling (DSM) to determine Average Daylight Factors (ADF's) for each individual room in accordance with best practice BRE guidelines.

ADF's were determined for a CIE Overcast Sky equivalent to providing an external, unobstructed illumination level of 10,000 Lux. CIE Overcast skies are theoretical sky models, with brightness highest at the zenith and reducing to the horizon, but also unidirectional (as illustrated in Figure 2.1), therefore ADF's do not differ for façade orientation, with North facing rooms achieving identical metric performance to South facing, all else being equal, with results accounting for diffuse natural light excluding any direct sunlight effects.

The daylight analysis accounted for all aspects that can potentially restrict natural light availability including adjacent buildings, along with explicitly modelling Building Details such as window frames, reveal and cill depth etc. in accordance with the architectural design drawings.

The daylighting models were calculated based on the following assumptions regarding transmittance and reflectance (based on measured manufacturer's test data):

- Glazing Transmission = 70%
- Ceilings: 82% reflectance (BS 00E55 White)
- Walls: 62% reflectance (BS 10C31 Ivory)
- Floors: 36% reflectance (BS 00A05 Platinum Grey)

Daylight Factors for each space were then calculated for a working plane height of 0.7m on a 0.1 x 0.1m grid basis to enable a detailed calculation within each room, the average of which was then determined to calculate ADF. The results are illustrated in Figures 2.1.1 to 2.1.8

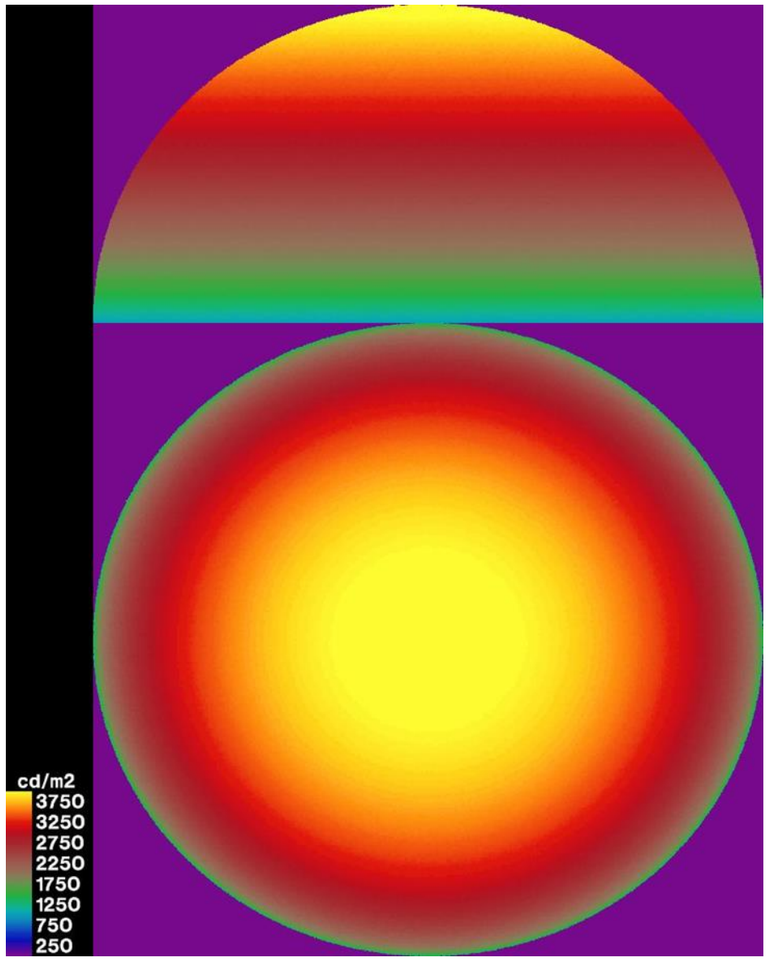


Fig 2.1 CIE Overcast sky as viewed in elevation and from below

2.2 Daylight Results

Figure 2.2 illustrates the Summary of daylight analysis undertaken, where over 85% of rooms analysed were found to achieve compliance with BRE best practice guidelines. (Average Daylight Factor (ADF) >2%).

However, where rooms were determined to be below target, this was generally found to be internal rooms at lower levels that are lit only through the atrium. Most of these rooms are meeting rooms at lower levels and are unlikely to be occupied throughout the day.

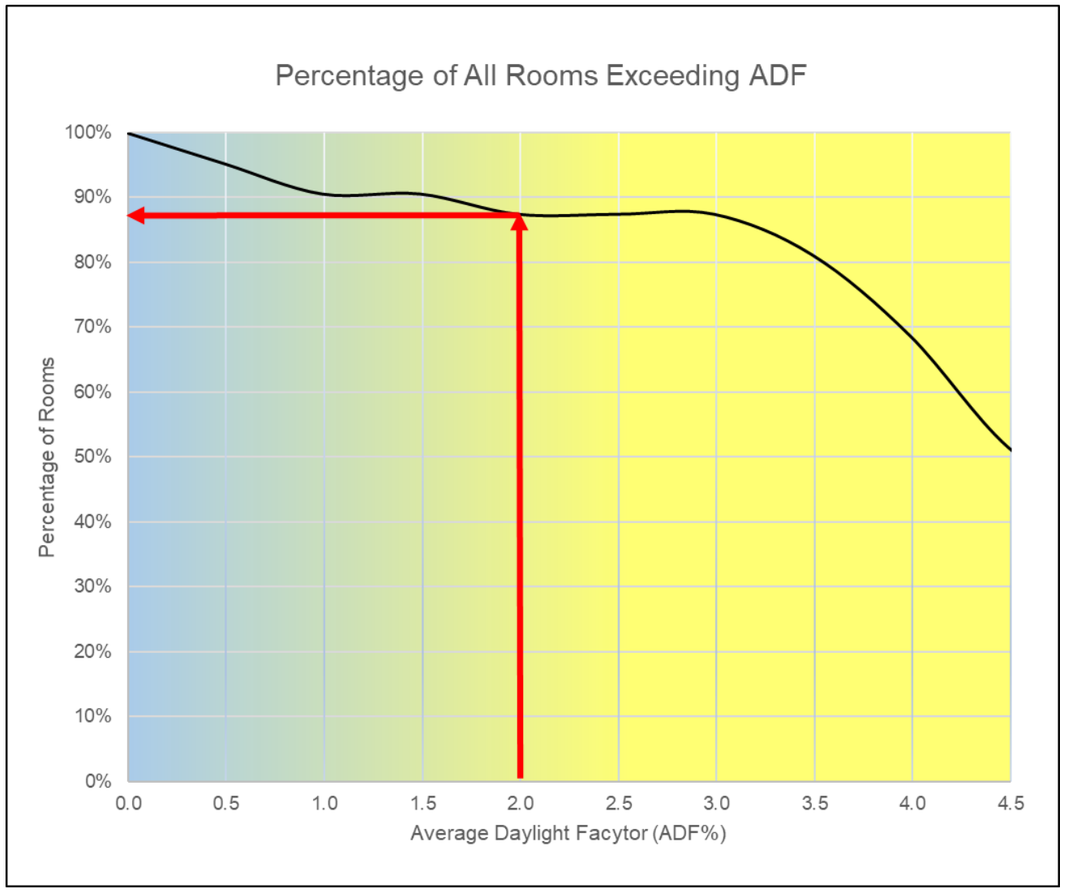
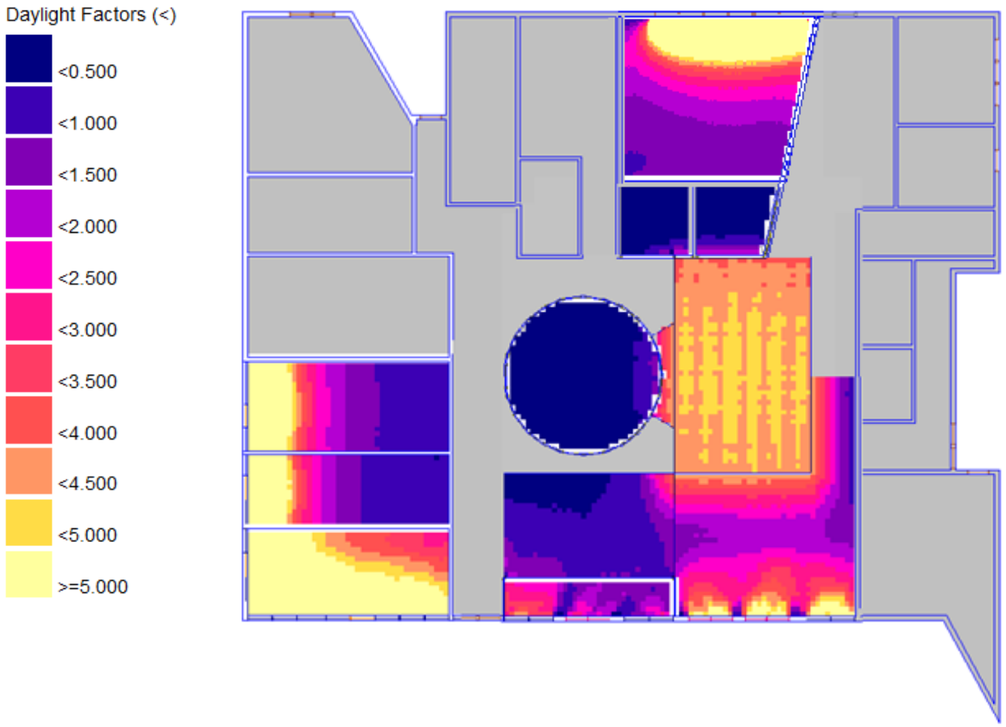


Fig 2.2 – Percentage of Occupied Rooms Exceeding 2% ADF

2.3 Results – Level 00

Daylighting Analysis as illustrated below, determined the following daylighting performance with associated Average Daylight Factors (ADF's).



> 2%	
1.5% > 2%	
< 1.5%	

Name	ADF %
0nd Atrium	4.4
0nd Cafe S	3.1
0nd Meet 1 SW 8p	7.4
0nd Meet 2 w 8p	3.4
0nd Meet 3 int 4p	0.2
0nd Meet 4 int 4p	0.4
0nd Meet 5 int 11p	0.3
0nd Off 1 W 6p	3.8
0nd Off 2 N 9p	4.0
0nd Reception S 3p	0.9

Fig 2.2.1 – Level 00 Daylighting Contours

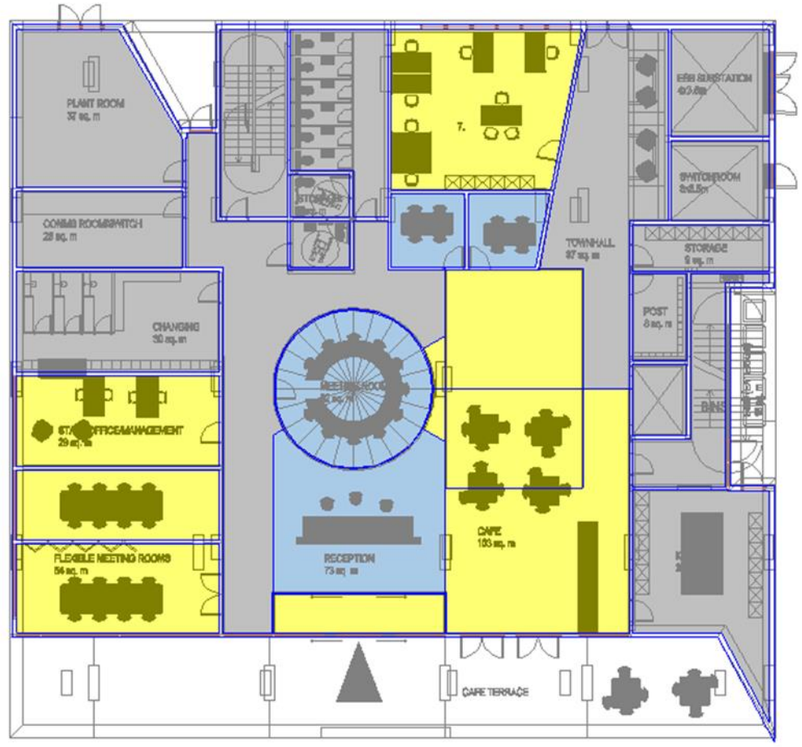
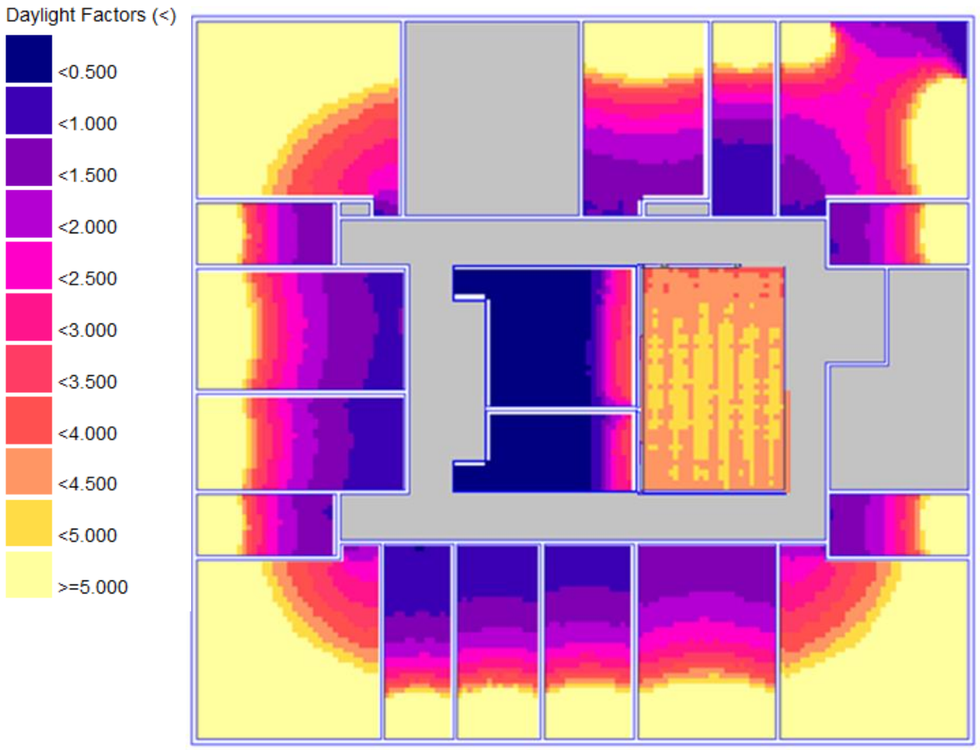


Fig 2.2.2 – Level 00 Daylighting Results

2.4 Results – Level 01

Daylighting Analysis as illustrated below, determined the following daylighting performance with associated Average Daylight Factors (ADF's).



> 2%	
1.5% > 2%	
< 1.5%	

Name	ADF %
1st Off 1 SW 8p	9.0
1st Off 10 E 2p	4.4
1st Off 11 E 2p	4.5
1st Off 12 SE 8p	8.8
1st Off 13 S 6p	4.2
1st Off 14 S 4P	3.9
1st Off 15 S 4p	3.7
1st Off 16 S 3p	3.4
1st Off 17 int 4p	0.7
1st Off 2 W 2p	4.7
1st Off 3 W 4p	3.7
1st Off 4 W 7p	3.9
1st Off 5 W 2p	4.6
1st Off 6 NW 8p	8.6
1st Off 7 N 6p	4.3
1st Off 8 N 3p	3.3
1st Off 9 NE 8p	4.0

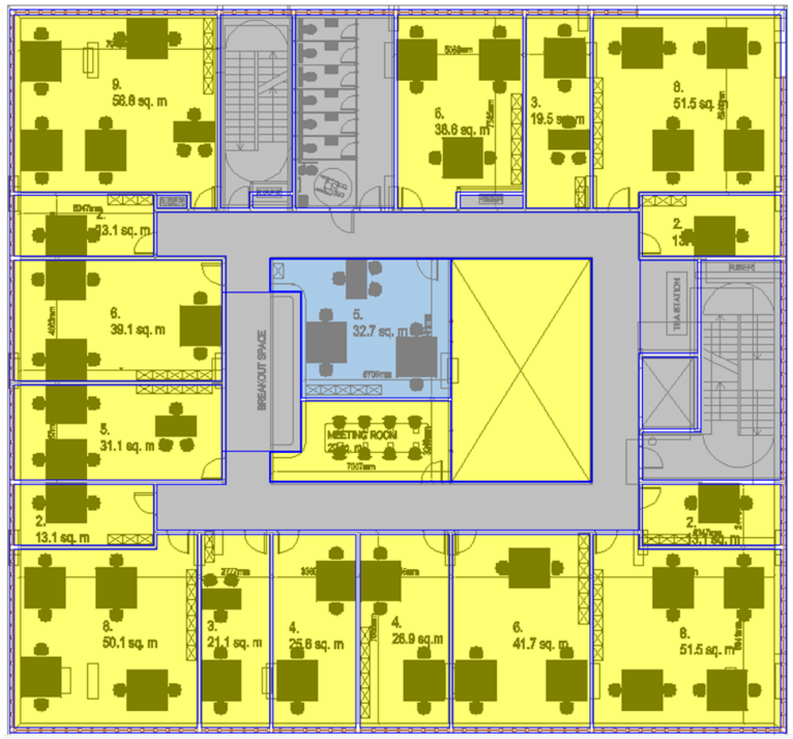


Fig 2.2.3– Level 01 Daylighting Contours

Fig 2.2.4 – Level 01 Daylighting Results

2.5 Results – Level 02

Daylighting Analysis as illustrated below, determined the following daylighting performance with associated Average Daylight Factors (ADF's).

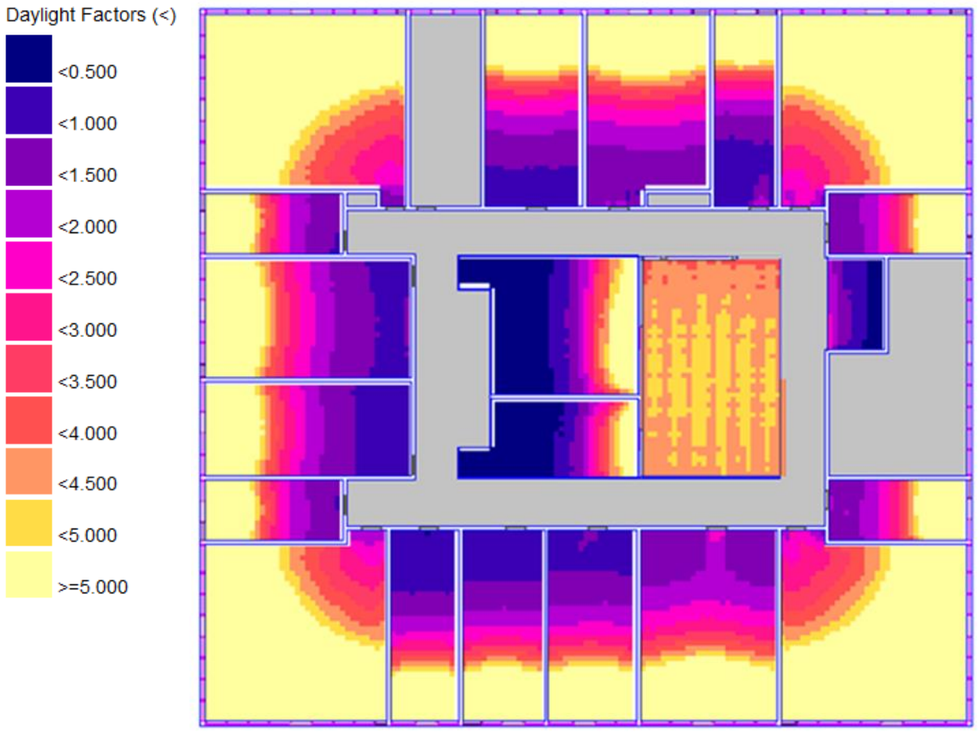


Fig 2.2.5– Level 02 Daylighting Contours

> 2%	
1.5% > 2%	
< 1.5%	

Name	ADF %
2nd Off 1 SW 8p	10.7
2nd Off 10 E 2p	5.2
2nd Off 11 E 2p	5.3
2nd Off 12 SW 8p	10.5
2nd Off 13 S 6p	5.1
2nd Off 14 S 4p	4.6
2nd Off 15 S 4p	4.5
2nd Off 16 S 3p	4.3
2nd Off 17 int 4p	1.9
2nd Off 18 int 3p	1.5
2nd Off 2 W 2p	5.6
2nd Off 3 W 4p	4.4
2nd Off 4 W 6p	4.6
2nd Off 5 W 2p	5.6
2nd Off 6 NW 8p	10.3
2nd Off 7 N 6p	5.0
2nd Off 8 N 3p	3.9
2nd Off 9 NE 8p	10.3

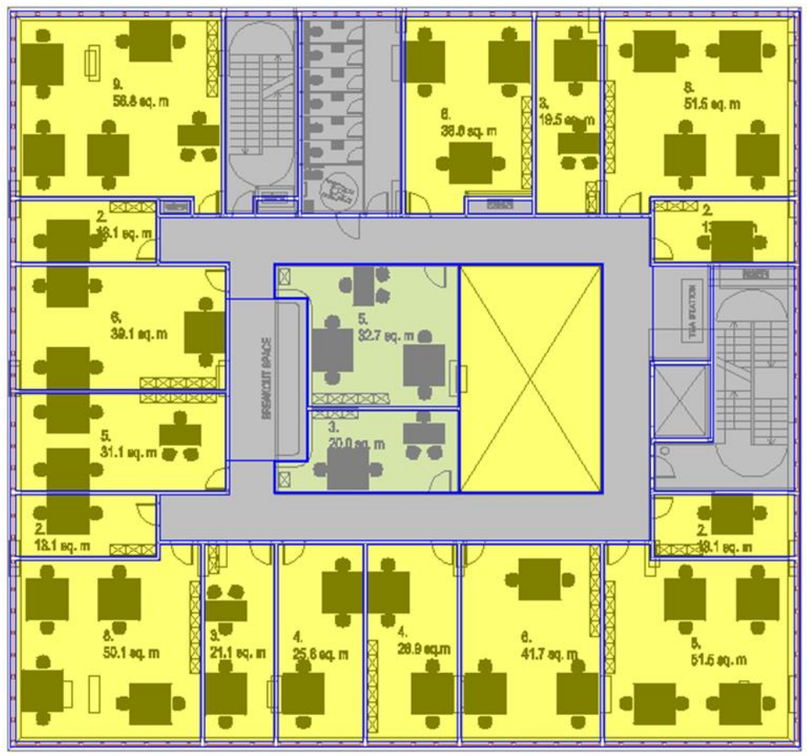
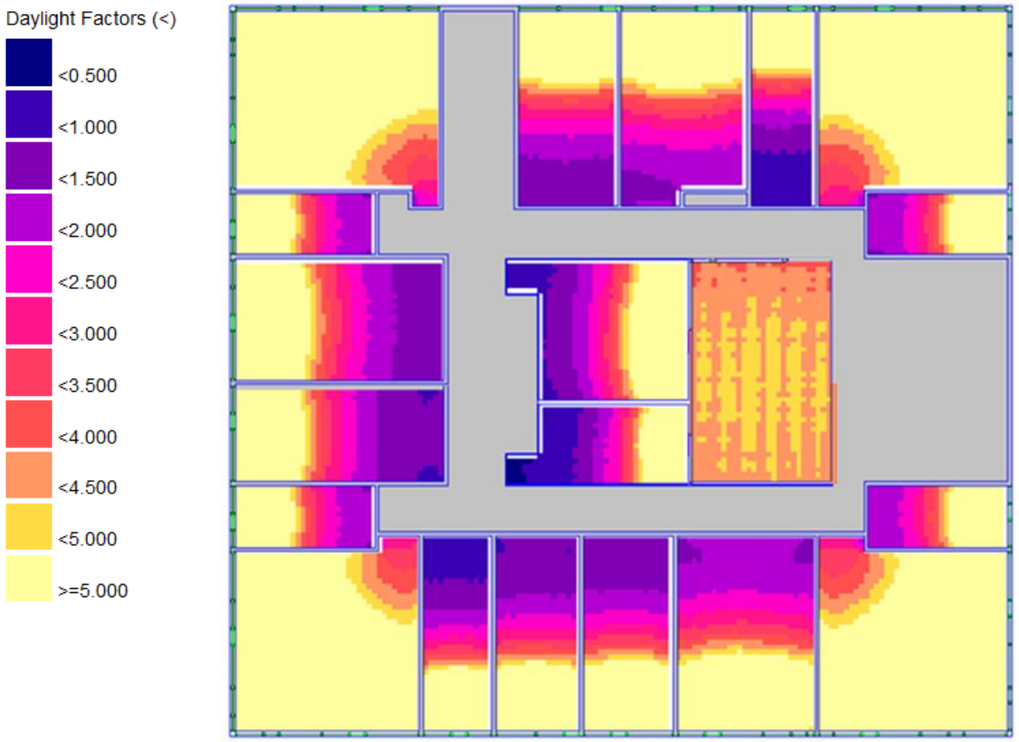


Fig 2.2.6 – Level 02 Daylighting Results

2.6 Results – Level 03

Daylighting Analysis as illustrated below, determined the following daylighting performance with associated Average Daylight Factors (ADF's).



> 2%
1.5% > 2%
< 1.5%

Name	ADF %
3rd Kitchen E	5.5
3rd Off 1 SW 8p	12.3
3rd Off 10 E 2p	5.7
3rd Off 11 SE 8p	12.0
3rd Off 12 S 6p	5.6
3rd Off 13 S 4p	5.2
3rd Off 14 S 4p	5.0
3rd Off 15 S 3p	4.5
3rd Off 16 int 4p	4.9
3rd Off 17 int 3p	3.6
3rd Off 2 W 2p	5.6
3rd Off 3 4p	4.9
3rd Off 4 6p	5.3
3rd Off 5 2p	5.6
3rd Off 6 NW 8p	11.9
3rd Off 7 N 6p	5.8
3rd Off 8 N 3p	4.2
3rd Off 9 NE 8p	11.9

Fig 2.2.7– Level 03 Daylighting Contours

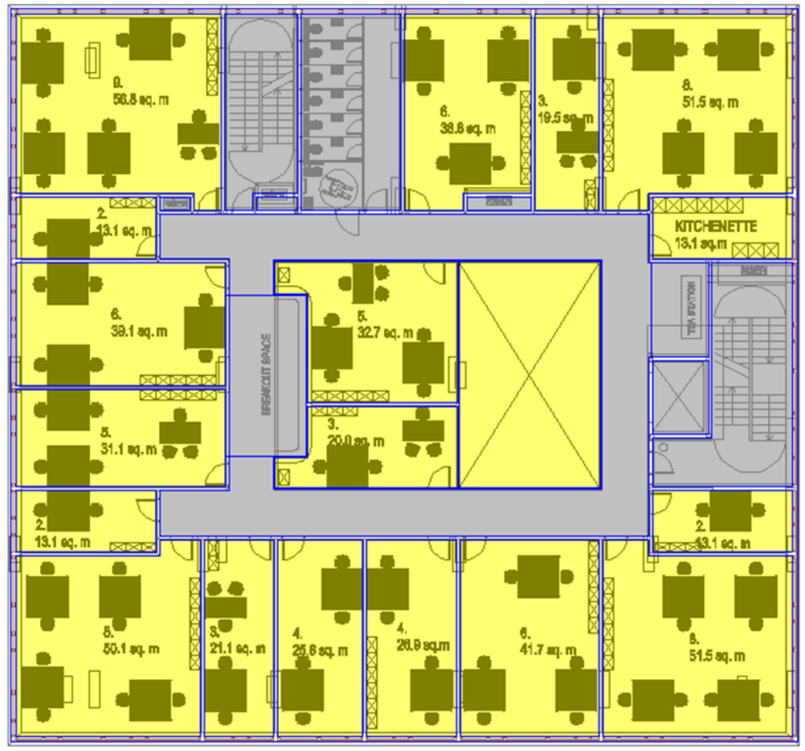


Fig 2.2.8 – Level 03 Daylighting Results

3.0 Solar Gain

3.1 Methodology

Part L of the Building regulations requires limitation of solar gain through the building fabric to minimise energy required for cooling.

Thermal analysis was undertaken for all occupied perimeter zones areas of the building using Dynamic Simulation Modelling (TAS software). This involved creating a 3D representational model of the building including its form, materials, and constructions, glazing and shading, both local and from neighbouring buildings.

Using the model, the annual predicted solar gain was calculated for each occupied space within the building and the result compared with the maximum allowable target. Each space was assessed based on the assumed solar performance values as indicated in Figures 3.1 to 3.4.

3.2 Results

The results determined that all spaces meet the building regulation requirements and are illustrated in Appendix B Tables B1 and B2.

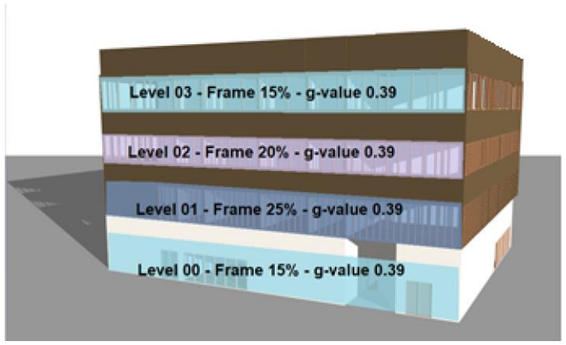


Fig 3.1 – North Elevation - Solar Performance of Glazing

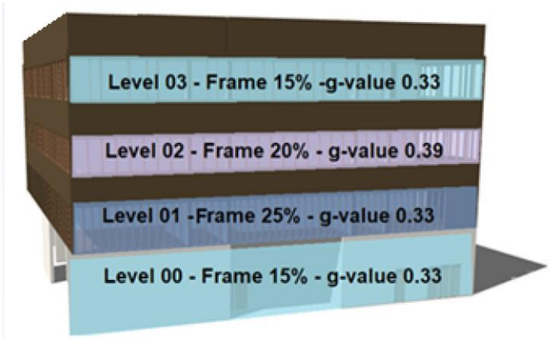


Fig 3.2 – East Elevation – Solar Performance of Glazing

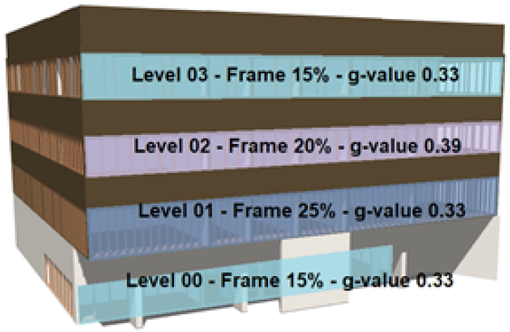


Fig 3.3 – South Elevation – Solar Performance of Glazing

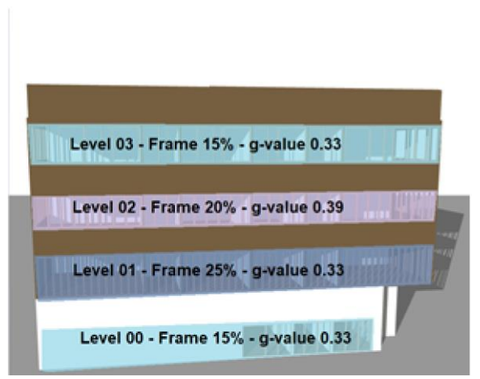


Fig 3.4 – West Elevation – Solar Performance of Glazing

4.0 Natural Ventilation

4.1 Methodology

Thermal analysis was undertaken for Block L using Dynamic Simulation Modelling (TAS software). This involved creating a 3D representational model of the building including its form, materials and constructions, glazing, occupancy profiles and operation (i.e. opening/closing windows / heating system control etc.)

In order to assess the predicted performance of the natural ventilation strategy, predicted internal conditions were attributed to each zone specifying values for infiltration, lighting, occupancy, equipment, heating emitter type and space design temperature.

The building model was then simulated against historic representational climate data for Dublin (Test Reference Year climate file) on an hour-by-hour basis, which includes data for Air Temperature, Relative Humidity, Solar Radiation (Direct and Diffuse) and Wind Speed / Direction.

The CIBSE design criteria for Naturally Ventilated spaces stipulates that predicted Dry Resultant Temperatures must not exceed 25°C for more than 5% of the annual occupied period, nor 28°C for more than 1% of this same period.

The building construction assumptions used to determine the natural ventilation strategy are detailed in Table C1 in Appendix C.

CIBSE Analysis of the building indicates that all areas comply with the CIBSE design criteria. The calculated minimum window opening free area to achieve compliance for key Public Areas are illustrated in Figures 4.1, to 4.4, with minimum free open areas for natural ventilation for all rooms summarised in Appendix C Table C1 of this report

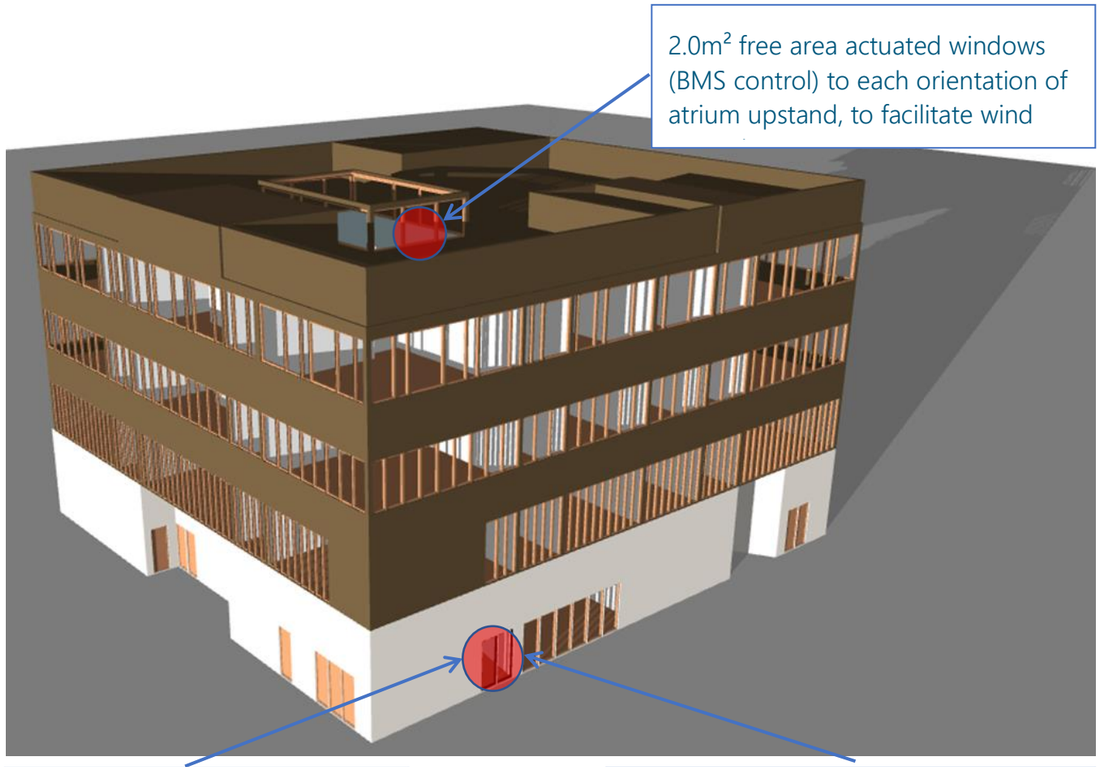


Fig 4.1 – Atrium – Tallaght Innovation Hub Free Opening Area Requirements

4.2 Results – 2nd Office 4W 6p

The Level 02 Office 4W 6p was assessed based on the following occupancy schedule and load assumptions:

4.2.1 Design Criteria

Occupancy Schedule																							
Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Weekday	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Occupancy	Diversity	Lighting Load	Equipment Load
6 No. Equivalent to 12W/m²	0.8	7.5 W/m²	19 W/m²

Total Free Opening Area	Openable Area as a % of Floor Area	Annual % Temp. Exceeding 25°C DRT
1.43m²	3.6%	2.9%

4.2.2 Simulation Results

The Level 02 Office 4W 6p was found to be compliant with the overheating criteria for Naturally Ventilated spaces, exceeding 25ºC for less than 5% or 28ºC for less than 1% of occupied time. Free Area of 1.43 m² or more is required to achieve compliance.

The required Free opening areas for each room assessed are included in Appendix C, Table C1 of this report.

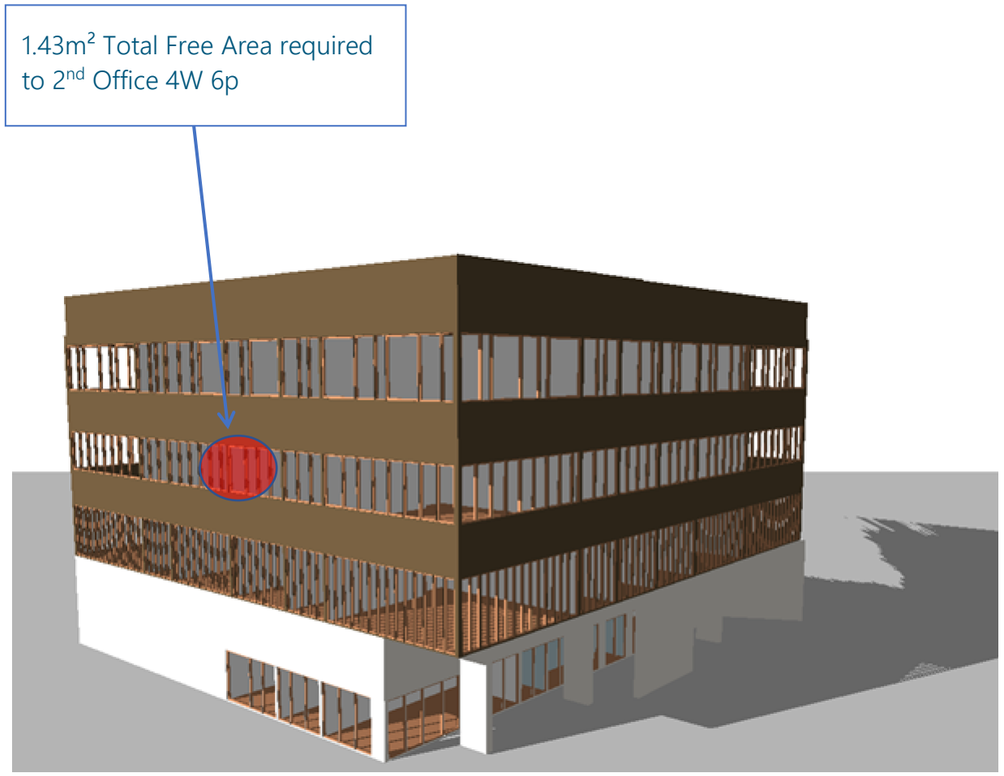


Fig 4.2 – Level 02 Office 4W 6p – Tallaght Innovation Hub

Free Area required for Openable windows

4.3 Results – 0nd Meet 1 SW8p

The Level 00 Meeting room was assessed based on the following occupancy schedule and load assumptions:

4.3.1 Design Criteria

Occupancy Schedule																							
Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Weekday	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0

Occupancy	Diversity	Lighting Load	Equipment Load
8 No. Equivalent to 24W/m²	0.8	7.5 W/m²	17 W/m²

Total Free Opening Area	Openable Area as a % of Floor Area	Annual % Temp. Exceeding 25°C DRT
1.48m²	5.0%	0.7%

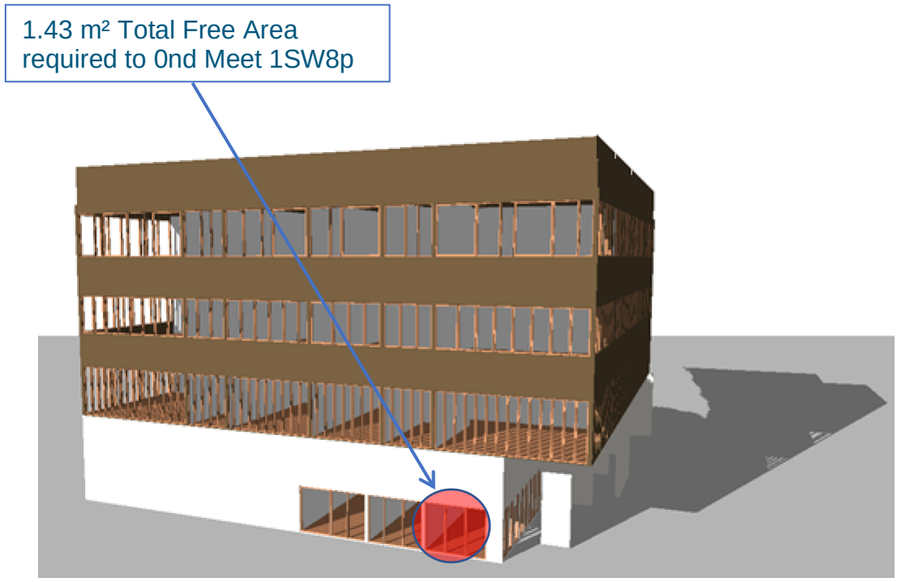


Fig 4.3 – 0nd Meet1SW8p- Tallaght Innovation Hub
Free Area required for openable windows

4.3.2 Simulation Results

0nd Meet 1 SW8p was found to be compliant with the overheating criteria for Naturally Ventilated spaces, exceeding 25ºC for less than 5% or 28ºC for less than 1% of occupied time. Free Area of 1.48m² or more is required to achieve compliance.

The required Free opening Areas for each rooms assessed are included in Appendix C, Table C1 of this report

4.4 Results – 3rd Off 16int 4p

3rdOff16 int 4p was assessed based on the following occupancy schedule and load assumptions:

4.4.1 Design Criteria

Occupancy Schedule																							
Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Weekday	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Occupancy	Diversity	Lighting Load	Equipment Load
4 No. Equivalent to 9 W/m²	0.8	7.5 W/m²	15 W/m²

Total Free Opening Area	Openable Area as a % of Floor Area	Annual % Temp. Exceeding 25°C DRT
2.0m²	5.9%	3.8%

4.4.2 Simulation Results

3rdOff16 int 4p was found to be compliant with the overheating criteria for Naturally Ventilated spaces, exceeding 25ºC for less than 5% or 28ºC for less than 1% of occupied time. Free Area of 2.0m² or more is required to achieve compliance.

The required Free opening Areas for each room assessed are included in Appendix C, Table C1 of this report

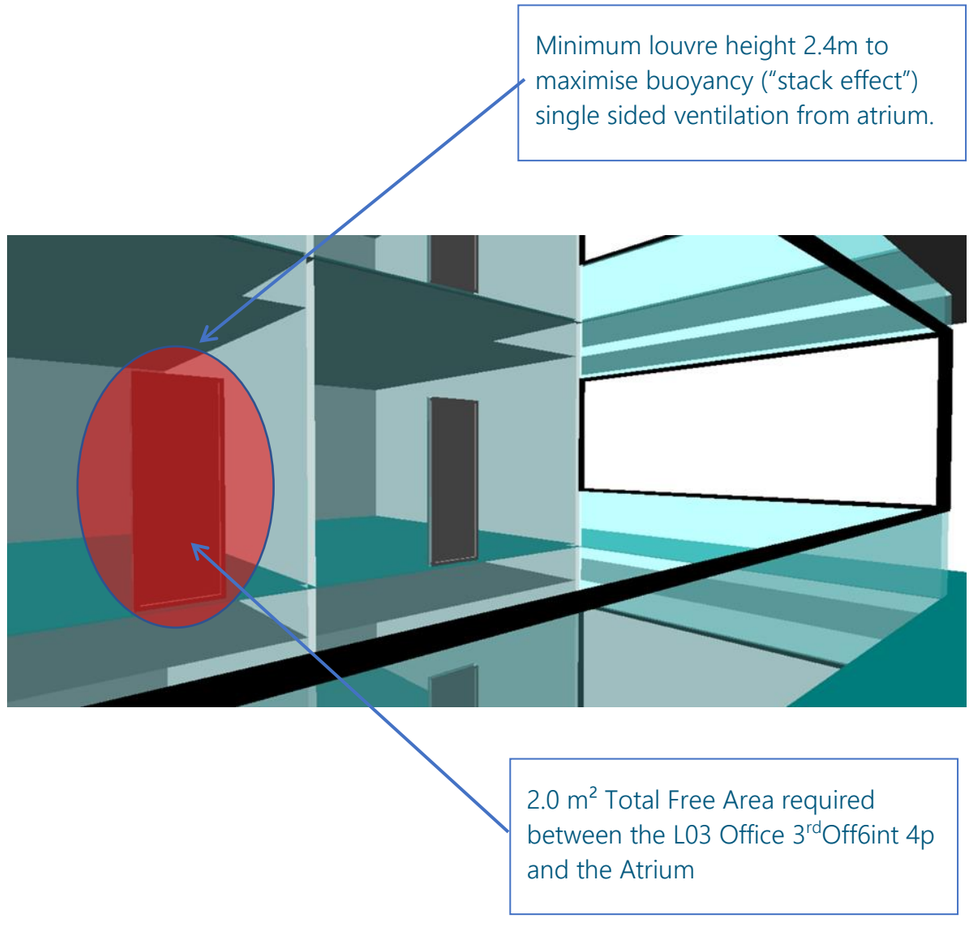


Fig 4.4 – 3rd Off 6 int 4p – Tallaght Innovation Hub

Free Area Required for opening vents

4.5 CIBSE TM52

TGD Part L 2017 of the Building Regulations requires compliance with CIBSE TM52 for Naturally ventilated buildings.

CIBSE TM52 is an adaptive thermal comfort methodology, in that it acknowledges that people will adapt to higher internal temperatures during continuous warm weather periods. Conversely, it accounts for that thermal discomfort will be experienced during cooler external conditions, or if hotter weather suddenly occurs. Figure 4.5.1 indicates the temperature profiles determined from the Belfast DSY and used for analysis. It can be that instead of having a fixed temperature for compliance (i.e. 25°C), this (Comfort Range Max (T max) in Figure 4.5.1) varies in accordance with the prevailing external weather conditions. Therefore, higher temperatures in the cooler earlier months (May/ June) and September are penalised more than during July/ August.

CIBSE TM52 includes categorisation of comfort in accordance with people's sensitivity or fragility. Figure 4.5.2 indicates how differing categories are used depending on this expectation.

Category II in CIBSE TM52 is defined as "Normal expectation (for new buildings and renovations)" and was therefore applied to all occupied spaces within the analysis.

The CIBSE TM52 methodology is a comprehensive thermal comfort assessment, in that three sub-criteria are checked for compliance. At least two of these three sub-criteria must then be demonstrated to be in accordance with the methodology for compliance to be gained, the three sub-criteria are: -

- Summertime Hours (similar to that outlined in Sections 4.1 above), but adjusting for prevailing weather so that higher temperatures are penalised during colder conditions etc.
- Peak Day: An assessment is made of how hot conditions would be throughout an extreme summer day (measured in degree-hours).
- Peak Hour: An absolute upper peak temperature must not be exceeded at any time of the year.

The assessment methodology therefore accounts for matters of thermal comfort not addressed in Sections 4.1 – 4.4, for example, conditions could be generally warm in a room throughout the year and deemed tolerable, but extreme hot conditions could be experienced on a particular day / hour which may deem natural ventilation unacceptable.

The CIBSE TM52 assessment was undertaken for all naturally ventilated spaces within the building, allowing for Category II assessment of these areas. This analysis determined that six rooms did not meet the Peak Day assessment exceeding the maximum degree-hours. However, each of these spaces achieved overall compliance as they perform within the requirement targets of the other two sub-categories. All naturally ventilated spaces are predicted to provide adaptive comfort in full compliance with TM52.The results are presented in Appendix C Table C2.

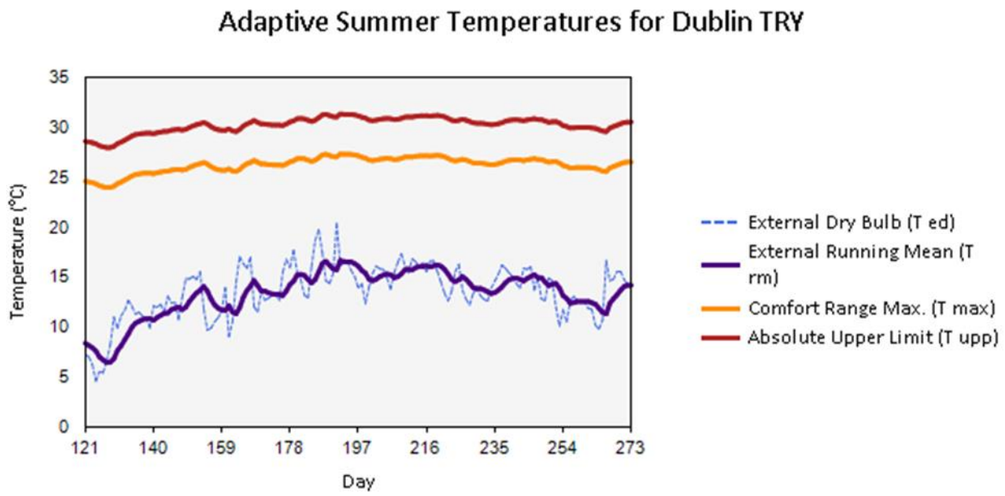


Figure 4.5.1: Adaptive Summer Temperatures profile from May to September

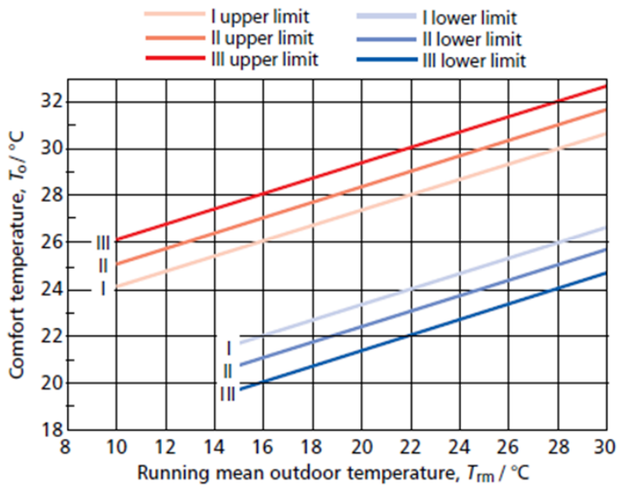


Figure 4.5.2: Comfort Range Adjustment (CIBSE TM52 Fig. 6)

5.0 Part L 2017 Compliance

The office development is designed to ensure a low-energy building be delivered, through maximising the use of passive design features supplemented by low-energy systems, with the following features incorporated:

- Connection into local District Heating Network for heating and domestic hot water production.
- Natural ventilation to perimeter Offices and Meeting Rooms for fresh air and cooling.
- Heat recovery ventilation to Wet rooms and Locker space.
- Low energy lighting: LED lamp based.
- Photocell based lighting controls to maximise utilisation of Daylighting within office plan areas.

The building is designed to comply with New Part-L 'NZEB' Regulations, with the necessary renewable contribution being provided from the local District Heating (DH) Network system. The source of heat is a heat pump connected to the data centre cooling system and is essentially a water to water system. Therefore, it simultaneously provides heat to the DH network and as a by-product of this heating also provides cooling back to the data centre.

The EU Energy Performance of Buildings Directive (EPBD) requires that all new developments be designed to be Near-Zero Energy Buildings (NZEB) from 2020.

This directive has been interpreted for Ireland as requiring both a substantial reduction in Primary Energy (of the order of 50-60% below the Part L 2008 benchmark), with significant proportion of that (10-20% of energy) being provided by Renewable Energy sources "either on-site or nearby (i.e. energy from district heating systems etc.)".

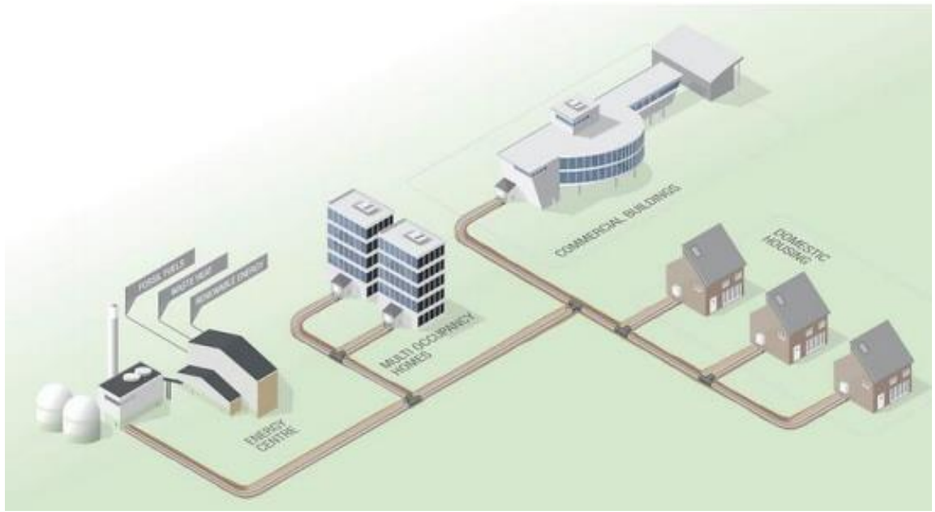


Figure 5.1: Indicative Diagram of a District Heating System

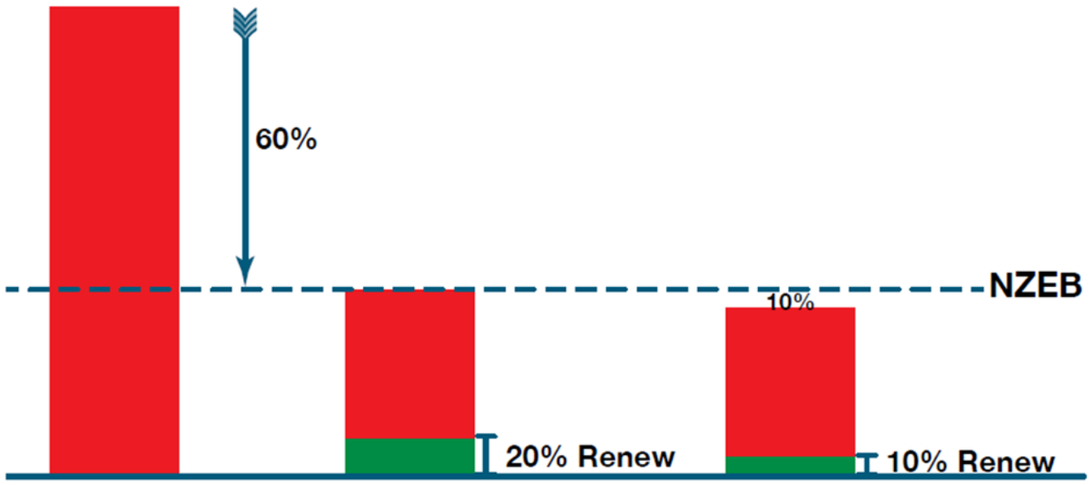


Fig 5.2 – Part L 2017 - NZEB Requirement

5.1 NZEB Methodology

The NZEB methodology involves comparing the “Actual Building” as proposed against a “Reference Building”, in a similar way to that of Section 3.2.

The NZEB “Reference Building” has been defined in the SEAI’s “Interim NZEB Performance Specification” document and is (essentially) a building of the same form and geometry as the “Actual” with 40% glazing and 10% framing factor applied to walls of each orientation and building insulation levels, mechanical/ electrical systems and renewable energy contribution in accordance with Appendix C of the Part L Technical Guidance Document.

Figure 5.1. illustrates the energy performance required to demonstrate compliance for Part L 2017: In addition to meeting the overall Primary Energy NZEB performance (which is 50-60% lower than Part L 2008 benchmark) , the Renewable Energy Ratio (RER) contribution must be either 20%; or, if an additional 10% reduction in overall Primary Energy against the benchmark is achieved, the RER contribution may be reduced to 10%.

In order to demonstrate NZEB compliance, the representative model as described in Section 4 was used to calculate the predicted Primary Energy usage for the “Actual” building as designed, based on the proposed fabric and HVAC service values as illustrated in Table D1 Appendix D.

The calculated primary energy consumption of the “Actual Building” is divided by that of the NZEB “Reference Building”, the result being the Energy Performance Coefficient (EPC) of the “Actual Building”.

The Renewable Energy Ratio (RER) is calculated by dividing the renewable energy contribution as a proportion of overall Primary Energy provided. To demonstrate that an acceptable Primary Energy consumption rate has been achieved, the calculated EPC of the building being assessed should be no greater than the Maximum Permitted Energy Performance Coefficient (MPEPC) as defined within Part L 2017 as illustrated in Figure 5.2

5.2 NZEB Results

The proposed Innovation Hub building as designed was found to comply with NZEB requirements. The results are displayed in Figure 5.4

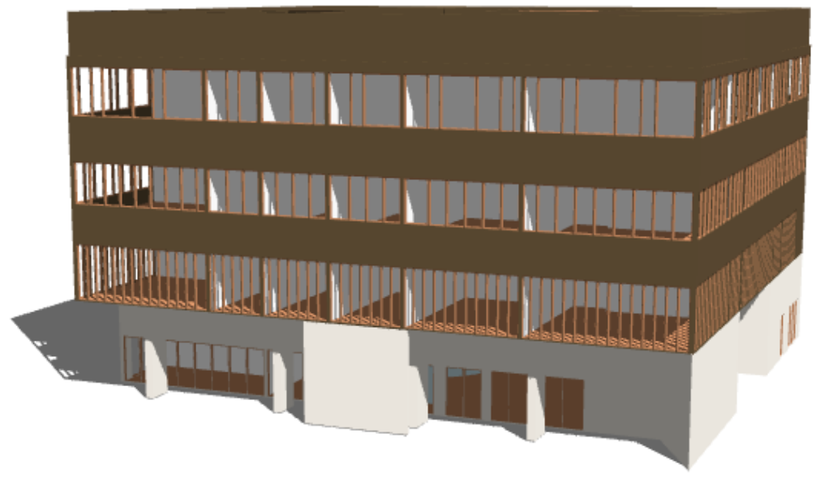


Fig 5.3 – 3D Simulation Model of Part L 2017 – Tallaght Innovation Hub

Primary Energy Consumption, CO2 Emissions, and Renewable Energy Ratio

The compliance criteria in the TGD-L have been met.

Calculated CO2 emission rate from Reference building	17.2 kgCO2/m2.annum
Calculated CO2 emission rate from Actual building	16.4 kgCO2/m2.annum
Carbon Performance Coefficient (CPC)	**0.95**
Maximum Permitted Carbon Performance Coefficient (MPCPC)	**1.15**
Calculated primary energy consumption rate from Reference building	91.1 kWh/m2.annum
Calculated primary energy consumption rate from Actual building	83.1 kWh/m2.annum
Energy Performance Coefficient (EPC)	**0.91**
Maximum Permitted Energy Performance Coefficient (MPEPC)	**1**
Renewable Energy Ratio (RER)	**0.33**
Minimum Renewable Energy Ratio	**0.2**

Fig 5.4 – Part L 2017 Results - NZEB Compliance

6.0 Utilities Infrastructure

6.1 District Heating Network

The Tallaght District Heating Scheme (TDHS) will utilise waste heat from a local data centre to provide low- carbon, low cost hot water and space heating to buildings in the Tallaght area. It will operate by taking the waste heat from the large-scale centralised heating source and redirecting it into underground insulated pipelines for it to be delivered into properties. is due to commence construction mid 2020.

6.2 Natural Gas

There is a natural gas in the vicinity of the development which serves the neighbouring Exchange Hall buildings. There is no intention to provide natural gas to the Tallaght Innovation Centre development.

6.3 ESB Networks

There is currently no existing ESB networks Electricity infrastructure on the Tallaght Innovation Centre development site.

The preliminary electrical load estimate calculates the load requirement for the new Tallaght Innovation Centre development as 240kVA.

The Tallaght Innovation Centre development shall have a dedicated ESB sub-station built-in the building at ground floor level with a client switch room located adjacent. The Substation shall be designed and installed to ESB standard specifications. The substation shall be provided with a 3-meter-wide vehicular access.

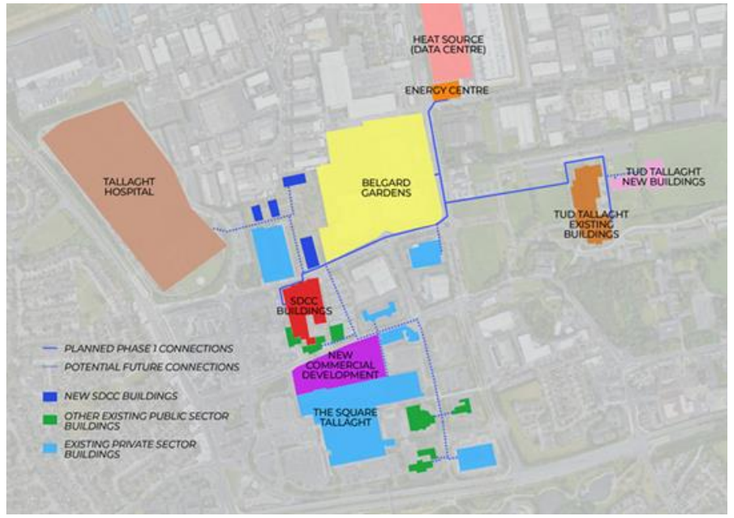


Figure 6.1: Tallaght District Heating Network Map

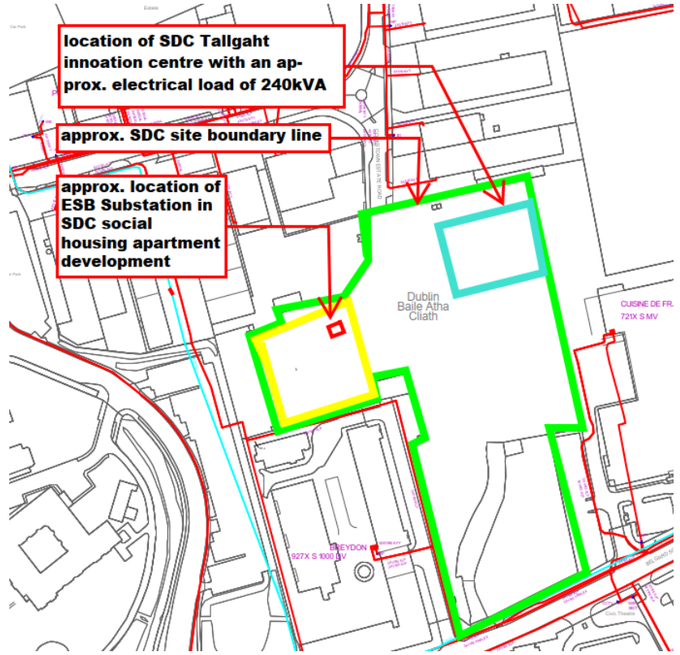


Figure 6.2: ESB Networks Local Area Map

6.4 Telecom Services

There is currently no existing EIR, Virgin Media or any other Telecom provider infrastructure on the proposed Tallaght Innovation Centre development site.

EIR and Virgin Media do appear to have networks in the vicinity of the site for future connections. New connections shall be required to the nearest relevant Telecom providers.

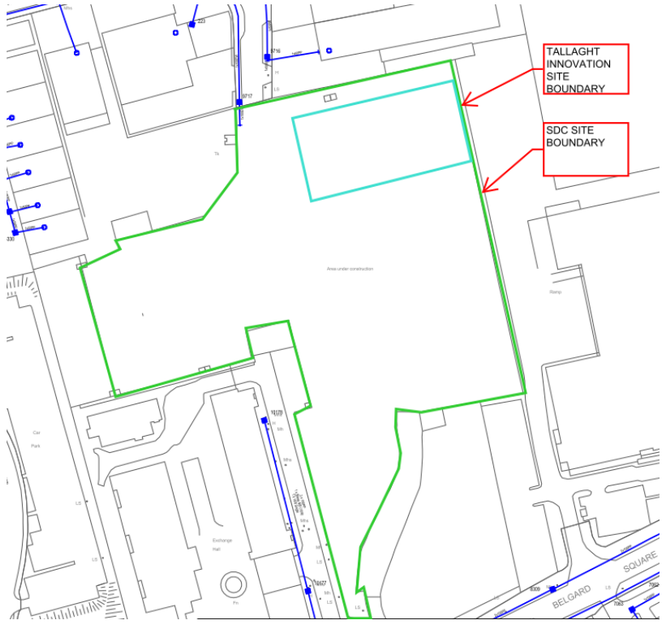


Figure 6.3: Eir Networks Local Area Map

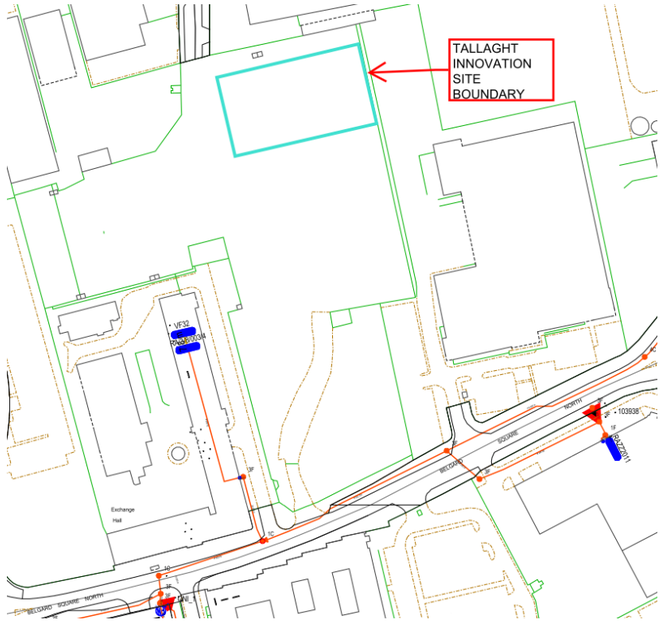


Figure 6.4: Virgin Media Networks Local Area Map

7.0 Appendix A

> 2%	
1.5% > 2%	
< 1.5%	

7.1 Table A1 - Average Daylight Factor (ADF %)- Results

Name	Daylight Factor %	Name	Daylight Factor %	Name	Daylight Factor %	Name	Daylight Factor %
0nd Atrium	4.4	1st Off 14 S 4P	3.9	2nd Off 13 S 6p	5.1	3rd Off 10 E 2p	5.7
0nd Cafe S	3.1	1st Off 15 S 4p	3.7	2nd Off 14 S 4p	4.6	3rd Off 11 SE 8p	12.0
0nd Meet 1 SW 8p	7.4	1st Off 16 S 3p	3.4	2nd Off 15 S 4p	4.5	3rd Off 12 S 6p	5.6
0nd Meet 2 w 8p	3.4	1st Off 17 int 4p	0.7	2nd Off 16 S 3p	4.3	3rd Off 13 S 4p	5.2
0nd Meet 3 int 4p	0.2	1st Off 2 W 2p	4.7	2nd Off 17 int 4p	1.9	3rd Off 14 S 4p	5.0
0nd Meet 4 int 4p	0.4	1st Off 3 W 4p	3.7	2nd Off 18 int 3p	1.5	3rd Off 15 S 3p	4.5
0nd Meet 5 int 11p	0.3	1st Off 4 W 7p	3.9	2nd Off 2 W 2p	5.6	3rd Off 16 int 4p	4.9
0nd Off 1 W 6p	3.8	1st Off 5 W 2p	4.6	2nd Off 3 W 4p	4.4	3rd Off 17 int 3p	3.6
0nd Off 2 N 9p	4.0	1st Off 6 NW 8p	8.6	2nd Off 4 W 6p	4.6	3rd Off 2 W 2p	5.6
0nd Reception S 3p	0.9	1st Off 7 N 6p	4.3	2nd Off 5 W 2p	5.6	3rd Off 3 4p	4.9
1st Meet 1 int 8p	0.6	1st Off 8 N 3p	3.3	2nd Off 6 NW 8p	10.3	3rd Off 4 6p	5.3
1st Off 1 SW 8p	9.0	1st Off 9 NE 8p	4.0	2nd Off 7 N 6p	5.0	3rd Off 5 2p	5.6
1st Off 10 E 2p	4.4	2nd Off 1 SW 8p	10.7	2nd Off 8 N 3p	3.9	3rd Off 6 NW 8p	11.9
1st Off 11 E 2p	4.5	2nd Off 10 E 2p	5.2	2nd Off 9 NE 8p	10.3	3rd Off 7 N 6p	5.8
1st Off 12 SE 8p	8.8	2nd Off 11 E 2p	5.3	3rd Kitchen E	5.5	3rd Off 8 N 3p	4.2

8.0 Appendix B

8.1 Table B1 – Solar Gain Results

Zone Name	Facade Length (m)	Floor Area (m²)	Actual Solar Gain (kWh)	Solar Gain Limit (kWh)	Solar Gain (%)
0nd Meet 1 SW 8p	11.8	29.5	1850	2840	-34.9
0nd Meet 2 w 8p	2.8	23.3	627	683	-8.2
0nd Off 1 W 6p	3.7	30.1	810	881	-8.0
0nd Off 2 N 9p	7.7	46.1	875	1854	-52.8
0nd Cafe S	7.4	74.4	783	1783	-56.1
0nd Reception S 3p	0.0	39.4	249	1274	-80.5
1st Off 1 SW 8p	14.3	52.4	2801	3450	-18.8
1st Off 2 W 2p	2.5	13.5	542	590	-8.1
1st Off 3 W 4p	3.8	31.2	843	911	-7.4
1st Off 4 W 7p	4.8	39.4	1064	1152	-7.6
1st Off 5 W 2p	2.4	13.3	535	582	-8.2
1st Off 6 NW 8p	15.1	57.3	2563	3628	-29.3
1st Off 7 N 6p	5.0	36.5	735	1198	-38.6
1st Off 8 N 3p	2.5	19.3	373	604	-38.2
1st Off 9 NE 8p	14.5	53.5	1181	3481	-66.1
1st Off 10 E 2p	2.4	13.3	491	582	-15.6
1st Off 11 E 2p	2.5	13.5	499	590	-15.4
1st Off 12 SE 8p	14.5	53.8	2730	3494	-21.9

Zone Name	Facade Length (m)	Floor Area (m²)	Actual Solar Gain (kWh)	Solar Gain Limit (kWh)	Solar Gain (%)
1st Off 13 S 6p	5.4	41.8	1085	1309	-17.1
1st Off 14 S 4P	3.5	27.3	710	854	-16.8
1st Off 15 S 4p	3.3	25.4	658	794	-17.1
1st Off 16 S 3p	2.7	20.9	544	654	-16.9
2nd Off 1 SW 8p	14.3	52.4	2906	3450	-15.8
2nd Off 2 W 2p	2.5	13.5	549	590	-7.0
2nd Off 3 W 4p	3.8	31.2	853	911	-6.3
2nd Off 4 W 6p	4.8	39.4	1076	1152	-6.6
2nd Off 5 W 2p	2.4	13.3	542	582	-7.0
2nd Off 6 NW 8p	15.1	57.3	2651	3628	-26.9
2nd Off 7 N 6p	5.0	36.5	753	1198	-37.1
2nd Off 8 N 3p	2.5	19.3	386	604	-36.2
2nd Off 9 NE 8p	14.5	53.5	2419	3481	-30.5
2nd Off 10 E 2p	2.4	13.3	495	582	-15.0
2nd Off 11 E 2p	2.5	13.5	503	590	-14.8
2nd Off 12 SW 8p	14.5	53.8	2836	3494	-18.8
2nd Off 13 S 6p	5.4	41.8	1117	1309	-14.6
2nd Off 14 S 4p	3.5	27.3	730	854	-14.6
2nd Off 15 S 4p	3.3	25.4	677	794	-14.7
2nd Off 16 S 3p	2.7	20.9	562	654	-14.1
3rd Off 1 SW 8p	14.3	52.4	2696	3450	-21.9

Zone Name	Facade Length (m)	Floor Area (m²)	Actual Solar Gain (kWh)	Solar Gain Limit (kWh)	Solar Gain (%)
3rd Off 2 W 2p	2.5	13.5	524	590	-11.2
3rd Off 3 W 4p	3.8	31.2	827	911	-9.3
3rd Off 4 W 6p	4.8	39.4	1046	1152	-9.2
3rd Off 5 W 2p	2.4	13.3	521	582	-10.5
3rd Off 6 NW 8p	15.1	57.3	2512	3628	-30.8
3rd Off 7 N 6p	5.0	36.5	713	1198	-40.5
3rd Off 8 N 3p	2.5	19.3	355	604	-41.2

9.0 Appendix C

9.1 Table C1 - Required Free Open Areas Assessed Occupied Rooms

Natural Ventilation Requirements											
Ground Floor Zones			Assumptions					Requirements		Performance	
Room No	Orientation	Room Type	Occupants	Sens Gain W/m²	Light Gains W/m²	Equipment Gain W/m²	Diversity	Free Open area m²	FAO % of Floor area	DRT hours >25ºC %	DRT hours >28ºC %
0nd Cafe S	S	Café	17	12	7.5	2	0.7	0.00	0.0%	0.0%	0.0%
0nd Meet 1 SW 8p	SW	Meeting	8	24	7.5	17	0.8	1.48	5.0%	0.7%	0.0%
0nd Meet 2 W 8p	W	Meeting	8	24	7.5	17	0.8	1.17	5.0%	0.4%	0.0%
0nd Meet 3 int 4p	int	Meeting	4	28	7.5	20	0.8	0.00	0.0%	1.6%	0.0%
0nd Meet 4 int 4p	int	Meeting	4	28	7.5	20	0.8	0.00	0.0%	1.4%	0.0%
0nd Meet 5 int 11p	int	Meeting	11	21	7.5	15	0.8	1.59	5.0%	0.6%	0.0%
0nd Off 1 W 6p	W	Office	6	12	7.5	19	0.8	1.50	5.0%	0.5%	0.0%
0nd Off 2 N 9p	N	Office	9	12	7.5	19	0.8	2.04	4.4%	2.2%	0.0%
0nd Post int	int	Store	1	8	7.5	1	0.8	0.00	0.0%	0.0%	0.0%
0nd Reception S 3p	S	Reception	3	6	7.5	9	1.0	0.00	0.0%	0.0%	0.0%
1st Breakout int	int	Breakout	12	34	7.5	2	0.7	0.00	0.0%	0.2%	0.0%
1st Meet 1 int 8p	int	Meeting	8	24	7.5	17	0.8	1.01	5.0%	0.8%	0.0%
1st Off 1 SW 8p	SW	Office	8	10	7.5	16	0.8	2.10	4.0%	1.0%	0.0%
1st Off 10 E 2p	E	Office	2	9	7.5	14	0.8	0.66	5.0%	0.5%	0.0%
1st Off 11 E 2p	e	Office	2	9	7.5	14	0.8	0.67	5.0%	0.8%	0.0%
1st Off 12 SE 8p	SE	Office	8	10	7.5	16	0.8	2.10	3.9%	0.8%	0.0%
1st Off 13 S 6p	S	Office	6	12	7.5	19	0.8	1.07	2.6%	2.0%	0.0%
1st Off 14 S 4P	S	Office	4	9	7.5	15	0.8	1.05	3.8%	0.9%	0.0%
1st Off 15 S 4p	S	Office	4	9	7.5	15	0.8	1.05	4.1%	0.9%	0.0%
1st Off 16 S 3p	S	Office	3	9	7.5	15	0.8	1.05	5.0%	0.6%	0.0%
1st Off 17 int 4p	int	Office	4	9	7.5	15	0.8	1.48	4.3%	1.0%	0.0%
1st Off 2 W 2p	w	Office	2	9	7.5	14	0.8	0.68	5.0%	1.8%	0.1%
1st Off 3 W 4p	W	Office	4	9	7.5	15	0.8	1.05	3.4%	1.8%	0.1%

Natural Ventilation Requirements											
Ground Floor Zones			Assumptions					Requirements		Performance	
Room No	Orientation	Room Type	Occupants	Sens Gain W/m²	Light Gains W/m²	Equipment Gain W/m²	Diversity	Free Open area m²	FAO % of Floor area	DRT hours >25ºC %	DRT hours >28ºC %
1st Off 4 W 7p	W	Office	7	11	7.5	17	0.8	1.05	2.7%	2.8%	0.1%
1st Off 5 W 2p	w	Office	2	9	7.5	14	0.8	0.67	5.0%	1.5%	0.1%
1st Off 6 NW 8p	NW	Office	8	10	7.5	16	0.8	2.10	3.7%	0.9%	0.0%
1st Off 7 N 6p	N	Office	6	12	7.5	19	0.8	1.05	2.9%	1.0%	0.0%
1st Off 8 N 3p	N	Office	3	9	7.5	15	0.8	0.96	5.0%	0.2%	0.0%
1st Off 9 NE 8p	NE	Office	8	10	7.5	16	0.8	2.10	3.9%	0.0%	0.0%
1st Tea Stn	int	Tea Stn	2	13	7.5	3	0.7	0.00	0.0%	0.0%	0.0%
2nd Breakout int	int	Breakout	12	34	7.5	2	0.7	0.00	0.0%	0.5%	0.0%
2nd Off 1 SW 8p	SW	Office	8	10	7.5	16	0.8	2.62	5.0%	0.9%	0.0%
2nd Off 10 E 2p	E	Office	2	9	7.5	14	0.8	0.66	5.0%	1.0%	0.0%
2nd Off 11 E 2p	E	Office	2	9	7.5	14	0.8	0.67	5.0%	1.2%	0.0%
2nd Off 12 SW 8p	SW	Office	8	10	7.5	16	0.8	2.69	5.0%	0.7%	0.0%
2nd Off 13 S 6p	S	Office	6	12	7.5	19	0.8	1.43	3.4%	2.3%	0.1%
2nd Off 14 S 4p	S	Office	4	9	7.5	15	0.8	1.36	5.0%	0.9%	0.0%
2nd Off 15 S 4p	s	Office	4	9	7.5	15	0.8	1.27	5.0%	0.8%	0.0%
2nd Off 16 S 3p	S	Office	3	9	7.5	15	0.8	1.05	5.0%	1.0%	0.0%
2nd Off 17 int 4p	int	Office	4	9	7.5	15	0.8	1.49	4.4%	1.6%	0.0%
2nd Off 18 int 3p	int	Office	3	9	7.5	15	0.8	1.01	5.0%	1.4%	0.0%
2nd Off 2 W 2p	W	Office	2	9	7.5	14	0.8	0.68	5.0%	1.8%	0.1%
2nd Off 3 W 4p	W	Office	4	9	7.5	15	0.8	1.43	4.6%	1.5%	0.1%
2nd Off 4 W 6p	W	Office	6	12	7.5	19	0.8	1.43	3.6%	2.9%	0.2%
2nd Off 5 W 2p	W	Office	2	9	7.5	14	0.8	0.67	5.0%	1.7%	0.1%
2nd Off 6 NW 8p	NW	Office	8	10	7.5	16	0.8	2.86	5.0%	0.5%	0.0%
2nd Off 7 N 6p	N	Office	6	12	7.5	19	0.8	1.52	4.2%	1.0%	0.0%
2nd Off 8 N 3p	N	Office	3	9	7.5	15	0.8	0.96	5.0%	0.5%	0.0%
2nd Off 9 NE 8p	NE	Office	8	10	7.5	16	0.8	2.67	5.0%	0.2%	0.0%
3rd Breakout int	int	Breakout	12	34	7.5	2	0.7	0.00	0.0%	3.1%	0.0%

Natural Ventilation Requirements											
Ground Floor Zones			Assumptions					Requirements		Performance	
Room No	Orientation	Room Type	Occupants	Sens Gain W/m²	Light Gains W/m²	Equipment Gain W/m²	Diversity	Free Open area m²	FAO % of Floor area	DRT hours >25ºC %	DRT hours >28ºC %
3rd Off 1 SW 8p	SW	Office	8	10	7.5	16	0.8	2.45	4.7%	1.3%	0.0%
3rd Off 10 E 2p	E	Office	2	9	7.5	14	0.8	0.67	5.0%	1.3%	0.0%
3rd Off 11 SE 8p	SE	Office	8	10	7.5	16	0.8	2.45	4.6%	0.9%	0.0%
3rd Off 12 S 6p	S	Office	6	12	7.5	19	0.8	2.08	5.0%	2.3%	0.1%
3rd Off 13 S 4p	S	Office	4	9	7.5	15	0.8	1.22	4.5%	1.5%	0.0%
3rd Off 14 S 4p	s	Office	4	9	7.5	15	0.8	1.22	4.8%	1.4%	0.0%
3rd Off 15 S 3p	S	Office	3	9	7.5	15	0.8	1.05	5.0%	1.4%	0.0%
3rd Off 16 int 4p	int	Office	4	9	7.5	15	0.8	2.00	5.9%	3.8%	0.0%
3rd Off 17 int 3p	int	Office	3	9	7.5	15	0.8	1.70	8.4%	3.0%	0.0%
3rd Off 2 W 2p	W	Office	2	9	7.5	14	0.8	0.68	5.0%	2.3%	0.2%
3rd Off 3 W 4p	W	Office	4	9	7.5	15	0.8	1.22	3.9%	2.4%	0.2%
3rd Off 4 W 6p	W	Office	6	12	7.5	19	0.8	1.97	5.0%	2.8%	0.2%
3rd Off 5 W 2p	w	Office	2	9	7.5	14	0.8	0.67	5.0%	2.3%	0.2%
3rd Off 6 NW 8p	NW	Office	8	10	7.5	16	0.8	2.35	4.1%	1.1%	0.1%
3rd Off 7 N 6p	N	Office	6	12	7.5	19	0.8	1.12	3.1%	1.9%	0.1%
3rd Off 8 N 3p	N	Office	3	9	7.5	15	0.8	0.96	5.0%	0.7%	0.0%
3rd Off 9 NE 8p	NE	Office	8	10	7.5	16	0.8	2.35	4.4%	0.3%	0.0%

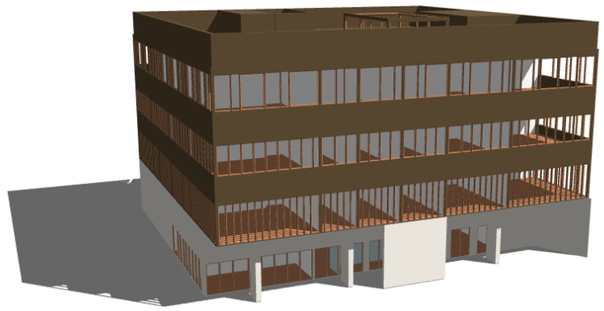
9.2 Required Free Open Areas Assessed Occupied Rooms

9.2.1 Table C2 - TM52 Category II Report

Zone Name	Occupied Summer Hours	Max. Exceedable Hours	Criterion 1: #Hours Exceeding Comfort Range	Criterion 2: Peak Daily Weighted Exceedance	Criterion 3: #Hours Exceeding Absolute Limit	Result
0nd Meet 1 SW 8p	918	27	1	1.0	0	Pass
0nd Meet 2 w 8p	918	27	0	0.0	0	Pass
0nd Off 1 W 6p	1377	41	0	0.0	0	Pass
0nd Meet 3 int 4p	918	27	0	0.0	0	Pass
0nd Meet 4 int 4p	918	27	0	0.0	0	Pass
0nd Off 2 N 9p	1377	41	0	0.0	0	Pass
0nd Kitchen SE	3672	110	0	0.0	0	Pass
0nd Cafe S	3672	110	0	0.0	0	Pass
0nd Reception S 3p	1377	41	0	0.0	0	Pass
0nd Meet 5 int 11p	918	27	0	0.0	0	Pass
0nd Atrium	0	0	0	0.0	0	Pass
1st Off 1 SW 8p	1377	41	1	1.0	0	Pass
1st Off 2 W 2p	1377	41	5	5.0	0	Pass
1st Off 3 W 4p	1377	41	5	5.0	0	Pass
1st Off 4 W 7p	1377	41	11	8.0	0	Pass
1st Off 5 W 2p	1377	41	4	5.0	0	Pass
1st Off 6 NW 8p	918	27	3	3.0	0	Pass
1st Off 7 N 6p	1377	41	0	0.0	0	Pass
1st Off 8 N 3p	1377	41	0	0.0	0	Pass
1st Off 9 NE 8p	1377	41	0	0.0	0	Pass
1st Off 10 E 2p	1377	41	0	0.0	0	Pass
1st Off 11 E 2p	1377	41	0	0.0	0	Pass
1st Off 12 SE 8p	1377	41	1	1.0	0	Pass
1st Off 13 S 6p	1377	41	6	6.0	0	Pass
1st Off 14 S 4P	1377	41	0	0.0	0	Pass
1st Off 15 S 4p	1377	41	0	0.0	0	Pass
1st Off 16 S 3p	1377	41	0	0.0	0	Pass
1st Off 17 int 4p	1377	41	0	0.0	0	Pass
1st Meet 1 int 8p	1377	41	0	0.0	0	Pass
1st Breakout int	612	18	0	0.0	0	Pass
2nd Off 1 SW 8p	1377	41	0	0.0	0	Pass
2nd Off 2 W 2p	1377	41	7	6.0	0	Pass
2nd Off 3 W 4p	1377	41	5	6.0	0	Pass
2nd Off 4 W 6p	1377	41	11	8.0	0	Pass
2nd Off 5 W 2p	1377	41	7	6.0	0	Pass
2nd Off 6 NW 8p	1377	41	2	2.0	0	Pass
2nd Off 7 N 6p	1377	41	0	0.0	0	Pass
2nd Off 8 N 3p	1377	41	0	0.0	0	Pass
2nd Off 9 NE 8p	1377	41	0	0.0	0	Pass
2nd Off 10 E 2p	1377	41	0	0.0	0	Pass
2nd Tea Stn int	3672	110	0	0.0	0	Pass
2nd Off 11 E 2p	1377	41	0	0.0	0	Pass
2nd Off 12 SW 8p	1377	41	0	0.0	0	Pass
2nd Off 13 S 6p	1377	41	7	8.0	0	Pass
2nd Off 14 S 4p	1377	41	1	1.0	0	Pass
2nd Off 15 S 4p	1377	41	0	0.0	0	Pass
2nd Off 16 S 3p	1377	41	0	0.0	0	Pass
2nd Off 18 int 3p	1377	41	0	0.0	0	Pass
2nd Breakout int	612	18	0	0.0	0	Pass
3rd Off 1 SW 8p	1377	41	1	1.0	0	Pass
3rd Off 2 W 2p	1377	41	9	8.0	0	Pass
3rd Off 3 W 4p	1377	41	10	8.0	0	Pass
3rd Off 4 W 6p	1377	41	11	5.0	1	Pass
3rd Off 5 W 2p	1377	41	9	8.0	0	Pass
3rd Off 6 NW 8p	1377	41	3	3.0	0	Pass
3rd Off 7 N 6p	1377	41	4	4.0	0	Pass
3rd Off 8 N 3p	1377	41	0	0.0	0	Pass
3rd Off 9 NE 8p	1377	41	0	0.0	0	Pass
3rd Kitchen E	3672	110	0	0.0	0	Pass
3rd Off 10 E 2p	1377	41	3	3.0	0	Pass
3rd Off 11 SE 8p	1377	41	1	1.0	0	Pass
3rd Off 12 S 6p	1377	41	7	9.0	0	Pass
3rd Off 13 S 4p	1377	41	5	5.0	0	Pass
3rd Off 14 S 4p	1377	41	2	2.0	0	Pass
3rd Off 15 S 3p	1377	41	2	2.0	0	Pass
3rd Off 16 int 4p	1377	41	6	6.0	0	Pass
3rd Off 17 int 3p	1377	41	4	4.0	0	Pass
3rd Breakout int	612	18	0	0.0	0	Pass

10.0 Appendix D

10.1 Table D1 - Proposed Building and HVAC Assumptions



Building Fabric -			
Element	U-Value W/m²K	General Fabric Details	
External Walls	0.15	Glazing Light Transmittance	70%
Roof	0.18	Glazing g-Value East, South and West, Levels 00,01 and 03	0.33
Ground Floor	0.15	Glazing g-Value North all Levels and Level 02, East, South and West	0.39
Exposed Floor	0.15		
		Air Permeability	m³/hr.m²@50Pa
Glazing (Centrepane)	1.40	New Building	3.0

Thermal Bridges			
Junction	Ψ Value W/m K	Junction	Ψ Value W/m K
Roof to Wall	0.180	Lintel above Window or Door	0.450
Wall – Ground Floor	0.240	Sill below Window	0.080
Wall – Wall (Corner)	0.140	Jamb at Window or Door	0.090
Wall – Floor (int not ground floor)	0.110		

Heating System - Heating- ASHP District Heating to all areas			
Fuel Type	Grid Electricity	ASHP Seasonal Efficiency	323%
Heating Water Pumps	Variable Speed	Distribution System Efficiency	92.5%

Hot Water System - HWS – ASHP District Heating to all areas			
Fuel Type	Grid Electricity	ASHP Seasonal Efficiency	323%
Heating Water Pumps	Variable Speed	Distribution System Efficiency	92.5%

Cooling -			
Fuel Type	NA	Seasonal Efficiency	NA
Chilled Water Pumps	NA	Distribution System Efficiency	NA

HVAC System - Natural Ventilation - all Perimeter areas		
Natural Ventilation	Supply Air Fan Specific Fan Power (W/l.s)	NA
	Extract Fan Specific Fan Power (W/l.s)	NA
	Heat Recovery Efficiency	NA
	CO2 Sensor	NA
Mechanical Ventilation - Kitchens and Changing areas		
Mechanical Ventilation (MV)	Supply Air Fan Specific Fan Power (W/l.s)	0.7
	Extract Fan Specific Fan Power (W/l.s)	0.4
	Heat Recovery Efficiency	NA
	CO2 Sensor	NA
Mechanical Ventilation with heat recovery - Changing areas		
Mechanical Ventilation (MVHR)	Supply Air Fan Specific Fan Power (W/l.s)	0.5
	Extract Fan Specific Fan Power (W/l.s)	1.0
	Heat Recovery Efficiency	70%
	CO2 Sensor	NA
Extract Only - toilets and stores		
Extract Ventilation (Ex)	Extract Fan Specific Fan Power (W/l. s)	0.3

Lighting - Proposed				
Space Type	Presence Detection Switching	Daylight Control	Lamp and ballast Efficacy (lumens/W)	Light Output ratio
Breakout	Auto On/Off	Manual	95	0.85
Café	Manual	Photocell / Dimming	95	0.85
Changing	Auto On/Off	Manual	95	0.85
Circulation	Auto On/Off	Photocell / Dimming	95	0.85
Comms	Auto On/Off	Manual	95	0.85
Kitchen	Auto On/Off	Photocell / Dimming	95	0.85
Meeting 4p	Auto On/Off	Photocell / Dimming	95	0.85
Office	Auto On/Off	Photocell / Dimming	95	0.85
Post 1P	Auto On/Off	Photocell / Dimming	95	0.85
Reception 1 S 3p	Manual	Manual	95	0.85
Store	Auto On/Off	Photocell / Dimming	95	0.85
Tea Stn	Auto On/Off	Photocell / Dimming	95	0.85
Toilet 1 N	Auto On/Off	Photocell / Dimming	95	0.85

Controls - Proposed	
Automatic monitoring and targeting with alarms for out of range values	Yes
Power factor correction to achieve a whole building power factor of at least	>95%

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