



Scaling Up Passivhaus:
The Centre for Medicine,
University of Leicester

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Overview of the Client Brief:

- Bring together the Schools of Medicine, Health Sciences and Psychology
- Sensitive to context – ecology and heritage
- Contribute towards reducing the University's carbon footprint
- 13,000sqm of teaching, research and support space
- 2,400 occupants
- BREEAM 'Excellent'
- EPC 'A' and DEC 'A'




Carbon Reduction Context: *Environmental Sustainability Strategy to 2015*

- 60% carbon emissions reduction by 2020
- Develop and refurbish the estate to minimise carbon
- Increased energy efficiency in operation
- Improved communication about carbon and energy savings.



Maurice Shock Building vs Centre For Medicine

MSB



<p>19,000 m²</p> <p>550 kWhr/m²/yr</p> <p>140 kgCO₂/m²/yr</p> <p><u>ENERGY COST</u></p> <p>£503,000.00 p.a</p>	<p style="color: red; font-weight: bold; font-size: 1.2em;">UPGRADE SERVICES</p> <p style="font-size: 2em; color: red;">↓</p> <p>400 kWhr/m²/yr</p> <p>112 kgCO₂/m²/yr</p> <p><u>ENERGY COST</u></p> <p>£378,000.00 p.a</p>	<p style="color: red; font-weight: bold; font-size: 1.2em;">ENHANCE FABRIC</p> <p style="font-size: 2em; color: red;">↓</p> <p>370 kWhr/m²/yr</p> <p>98 kgCO₂/m²/yr</p> <p><u>ENERGY COST</u></p> <p>£327,000.00 p.a</p>
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25%

Energy Saving

35%

Energy Saving

- Opened 1977
- Wet lab research facility
- Lecture/ Seminar facility

CFM



12,000 m²

80 kWhr/m²/yr

20 kgCO₂/m²/yr

ENERGY COST

£57,000.00 p.a

- Opened 2016
- Dry lab research facility
- Lecture/ Seminar facility

Why Passivhaus?

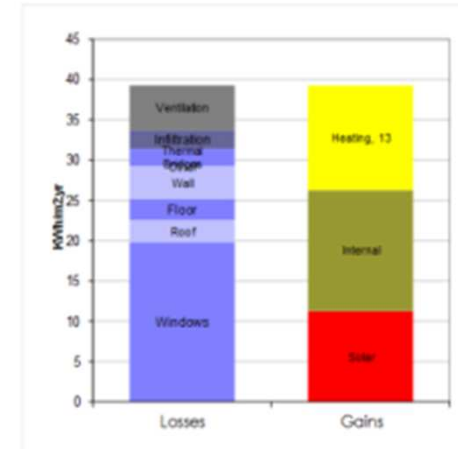
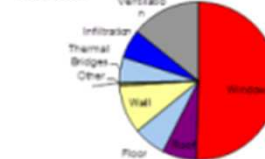
- Proven ability to deliver low energy buildings
- Low base energy demand
- Prioritises user comfort
- Walls 0.13W/m²/k
- Roof 0.13W/m²/k
- Floor 0.13W/m²/k
- Airtightness Target: 1m³/m²/hr @ 50Pa (0.33 ac/h)
- Treated Floor Area: 9,863m²
- Exposed thermal mass to regulate internal temperatures
- Ground Air Heat Exchange labyrinth
- District heating
- PV solar renewables

Treated floor area: 9,865 m²

Annual Heat balance kWh/m²

	Losses	Gains
Windows	19.8	
Roof	2.7	
Floor	2.6	
Wall	3.9	
Other	0.2	
Thermal Brid	2.1	
Infiltration	2.3	
Ventilation	5.6	
Solar		11.4
Internal		14.9
Heating		13.0
Total	29.2	29.2

Heat losses:



Turn off htg display? No

Window breakdown

	Losses kWh/m ²	Heat gains kWh/m ²	Balance kWh/m ²	area m ² (% of wall)
North	2.6	1.0	-1.6	715.5 (8.7%)
East	6.7	4.1	-2.6	1,658.5 (20.2%)
South	2.9	2.2	-0.8	721.2 (8.8%)
West	5.2	2.4	-2.8	1,558.5 (19.0%)
Horizontal	1.5	2.4	0.9	232.4 (2.8%)
Total	19.8	12.1	-7.8	4,651.7 (56.7%)

Heat loss form factor

(what is it?)

Heat loss form factor	Value
Wall	0.6
Roof	0.3
Floor	0.3
Other	0.6
Total	1.52



Average fabric U value required: 0.277 W/m²·K

Average fabric U value of design: 0.232 W/m²·K

Heat Losses

1 Windows	191,576 kWh/a
2 Exterior wall - Ambient	31,731 kWh/a
3 Roof/Ceiling - Ambient	26,396 kWh/a
4 Floor slab / Basement wall	25,222 kWh/a
5 Exterior TB (lengths)	16,388 kWh/a

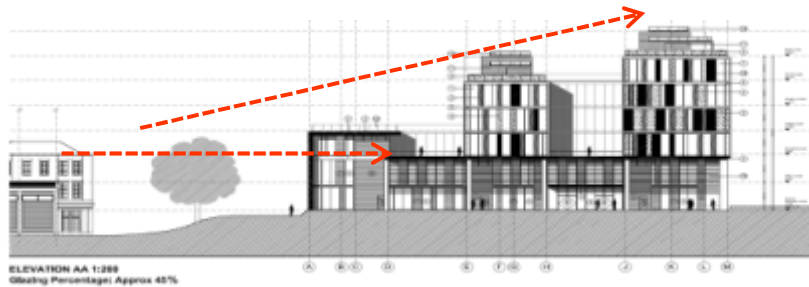
Planning Context

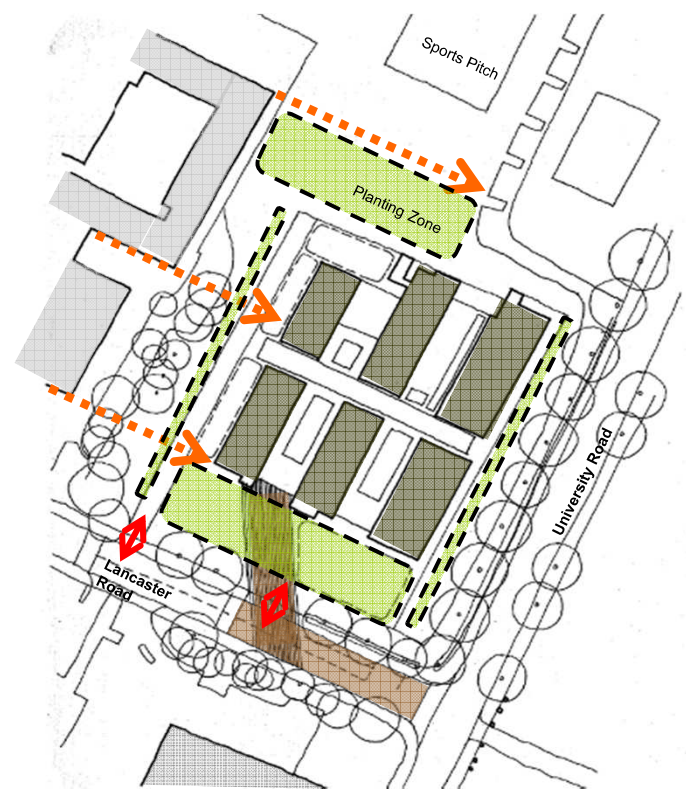
- Adjacent to locally listed building
- Conservation Area
- Listed Fire Station Cottages
- Protected trees on site boundary
- Protected views
- Risk of overshadowing
- Loss of open space & playing fields
- Ecological impact
- Concerns over car parking provision
- Bomb shelter & archaeology



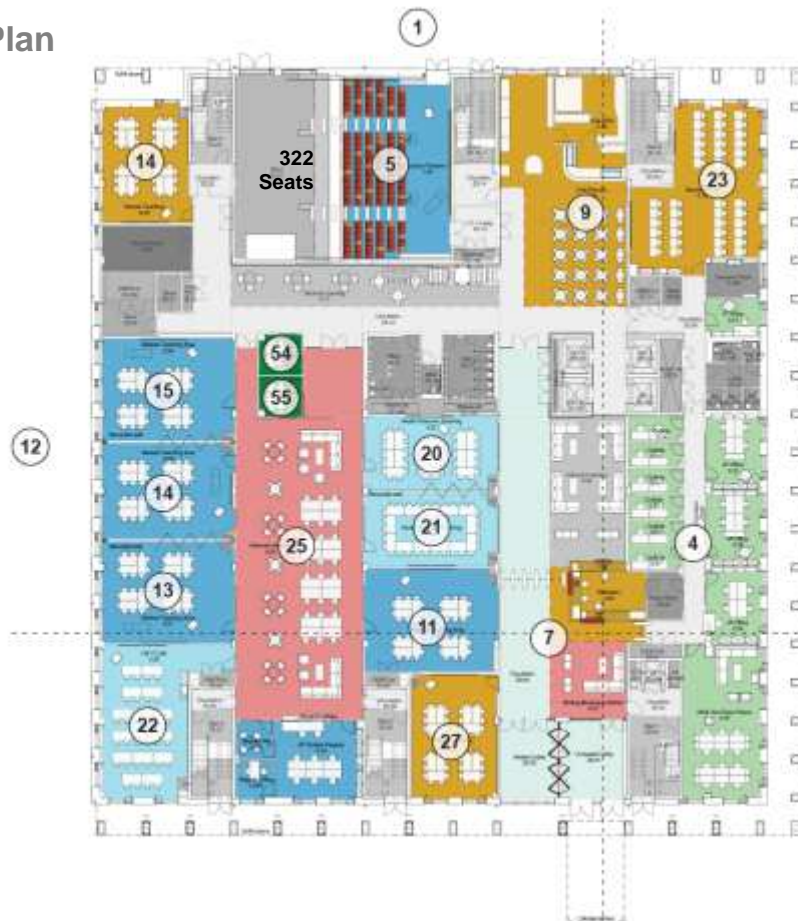
Design Approach

- Demolish bomb shelter - provide new football pitch
- Increase site biodiversity
- Respect Regent College
- Face the University and mark the start of the campus
- Provide an efficient plan form
- Maximise passive measures





Ground Floor Plan



1. Whole Building
2. Medical School (Blue Rooms)
3. Health Sciences (Light Blue Rooms)
4. Psychology (Light Green Rooms)
5. Main Lecture Theatre
7. Atrium including Foyer, Exhibition Space, Informal Learning and Reception
9. Cafe
11. "Leicester Medics Teaching & Seminar Room" (Medical Teaching Room)
12. Greenwall
13. Medical Teaching Room
14. Medical Teaching Room
15. Medical Teaching Room
20. Health Sciences Teaching Room
21. Health Sciences Teaching Room
22. HS IT Lab
23. Shared IT Lab
25. Informal Shared Space
27. Shared Teaching Room
28. Shared Teaching Room
54. David De Bono Room (Meeting Room)
55. John Swales Room (meeting Room)

First Floor Plan



1. Whole Building
2. Medical School (Blue Rooms)
4. Psychology (Light Green Rooms)
5. Main Lecture Theatre
7. Atrium including Foyer, Exhibition Space, Informal Learning and Reception
8. Lecture Theatre 2
12. Green Wall
16. Medical Teaching Room
17. Medical Teaching Room
18. Medical Teaching Room
19. Medical Teaching Room
24. ODP Practical Room
26. ODP Teaching Room
29. Shared Teaching Room
30. Shared Teaching Room
36. Medical Teaching Room
37. Medical Teaching Room
38. Medical Teaching Room
39. Medical Teaching Room
40. Medical Teaching Room
41. Medical Teaching Room
42. Medical Teaching Room
43. Medical Teaching Room
44. CP Teaching Space
45. Long Informal Learning Space
52. "Collaboration Zone" (Meeting Space)
53. Forensic Lab
56. Meeting Space
57. Meeting Space
60. Meeting Space (Psychology)
63. Psychology Lab

Building Cross Section



- 2. Medical School (Blue Rooms)
- 3. Health Sciences (Light Blue Rooms)
- 4. Psychology (Light Green Rooms)
- 7. Atrium including Foyer, Exhibition Space, Informal Learning and Reception
- 11. "Leicester Medics Teaching Seminar Room" (Medical Teaching Room)
- 13. Medical Teaching Room
- 18. Medical Teaching Room
- 25. ODP Teaching Room
- 36. Medical Teaching Room
- 41. Medical Teaching Room
- 45. Long Informal Learning Space
- 47. Faraday Psychology Lab
- 63. Psychology Lab
- 67. Psychology Lab
- 68. Psychology Lab

Departmental Totals	
Department	Area
Carpeted Meeting	0.0 m ²
Circulation	2284.1 m ²
Health Sciences	1424.2 m ²
Health Learning	451.0 m ²
IT Services	22.0 m ²
Medical School	3044.2 m ²
Psychology	1742.2 m ²
Sanitary	283.1 m ²
Storage	1624.3 m ²
Student Accommodation	750.0 m ²
Services	493.3 m ²
Grand Total	11800.5 m²

Second Floor Plan

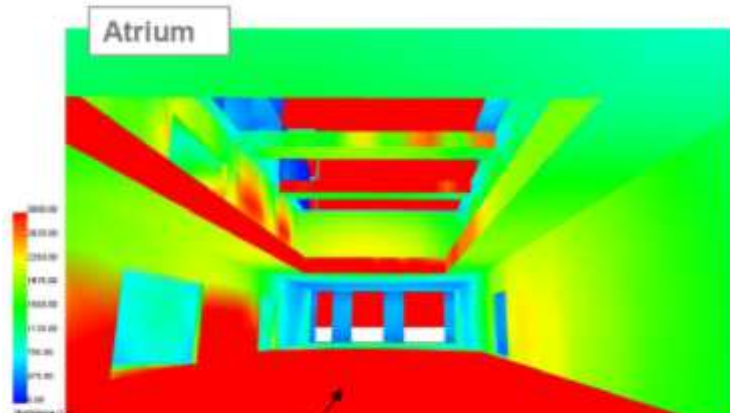


1. Whole Building
2. Medical School (Blue Rooms)
4. Psychology (Light Green Rooms)
12. Green Wall
31. Psychology Teaching Lab
32. Psychology Teaching Lab
33. Psychology Teaching Lab
34. Psychology Teaching Lab
58. Meeting Space (Medical School)
59. Meeting Space (Medical School)

Departmental Totals	
Department	Area
Desk - Meeting	0.0 m ²
Circulation	228.1 m ²
Health Screening	1424.2 m ²
Health Learning	451.0 m ²
IT Services	22.0 m ²
Medical School	3944.2 m ²
Psychology	1742.2 m ²
Sanitary	283.1 m ²
Storage	1624.3 m ²
Student Accommodation	750.0 m ²
Unlabelled	493.3 m ²
Unlabelled	11800.1 m²

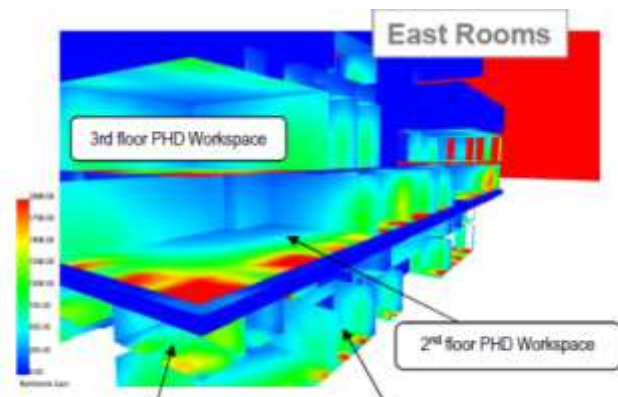
Maximised Daylight

Calculation Summary (% daylight)		
Room	Average	Minimum
Central Atria	11.37	3.0

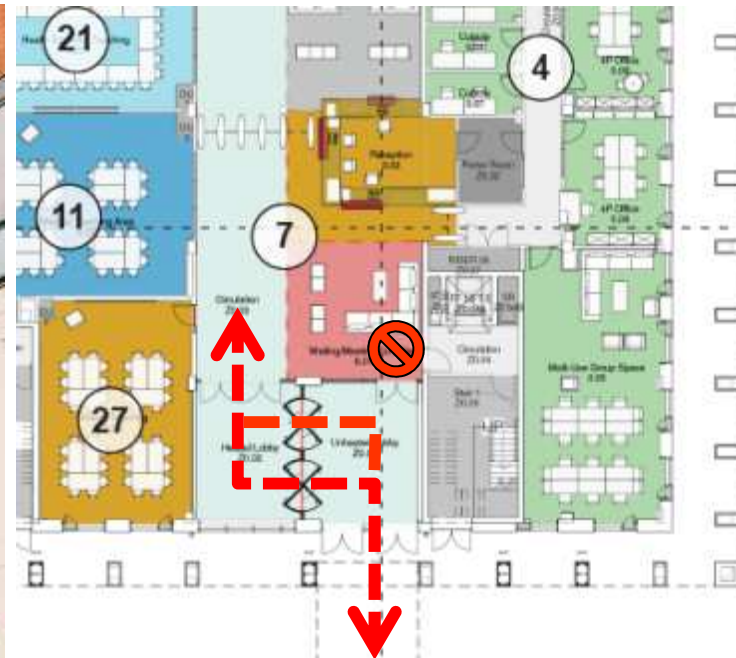


Atria receives in excess of 3000 lux during the daytime requiring no artificial lighting

- Daylight Availability**
- 10,000 Lux for 70 % working year
 - 300 to 500 Lux
 - 1,486 hours of sunshine (34% of daylight)
 - 4% DF = 400 Lux from 10,000 Lux external



Double Lobby Arrangement



First Defence Against Heat Loss

Unheated lobby / Revolving Doors / Heated lobby



Atria





AssociatedArchitects

Atria





Specialist Spaces





Teaching Spaces

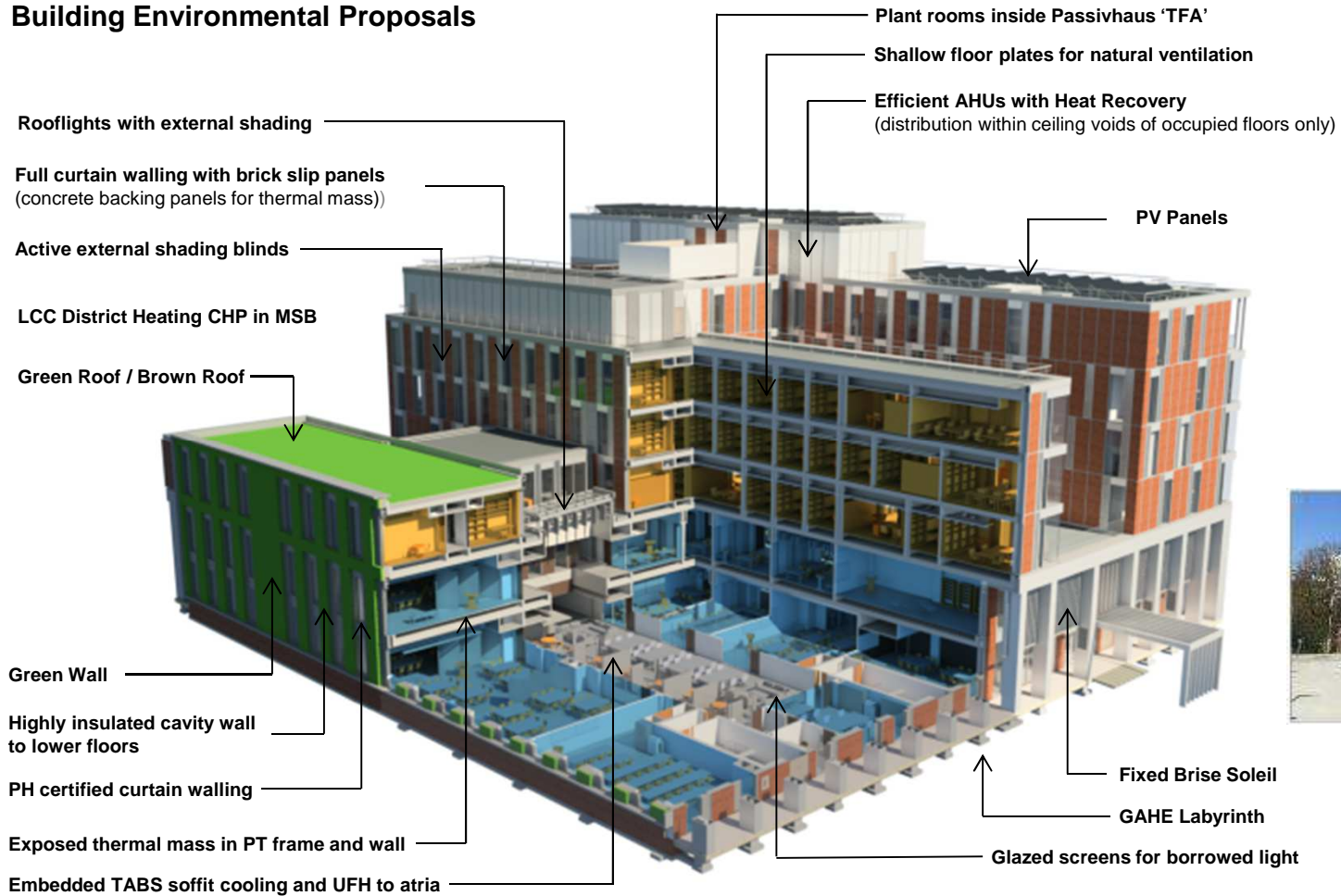




Teaching Spaces

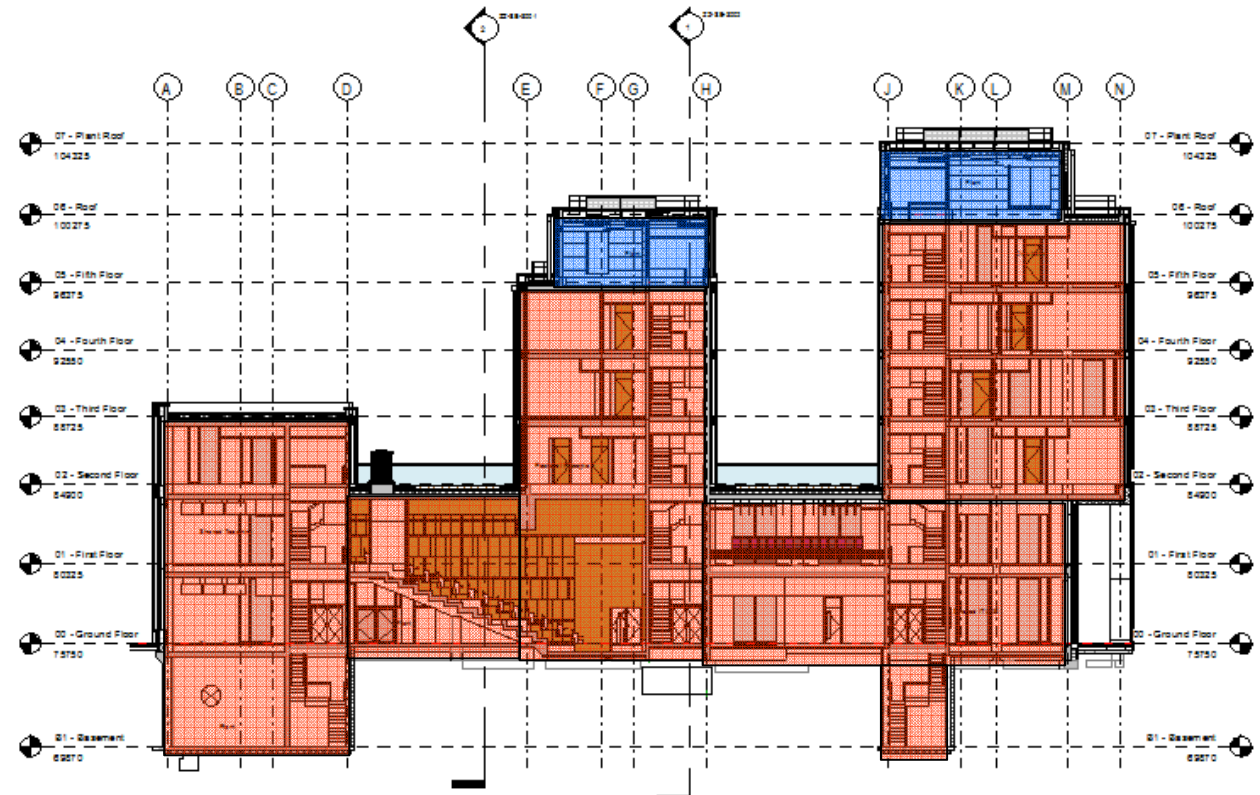
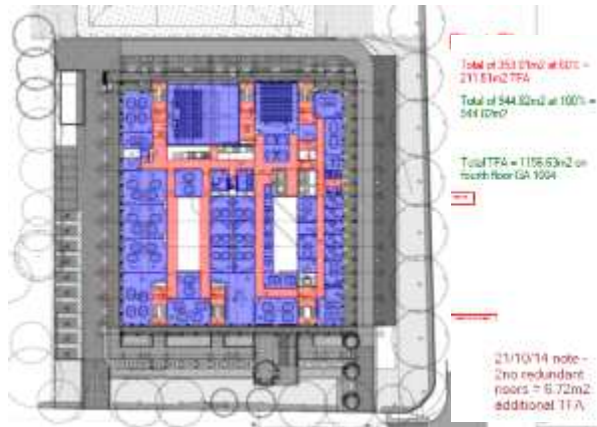


Building Environmental Proposals



Thermal Envelope

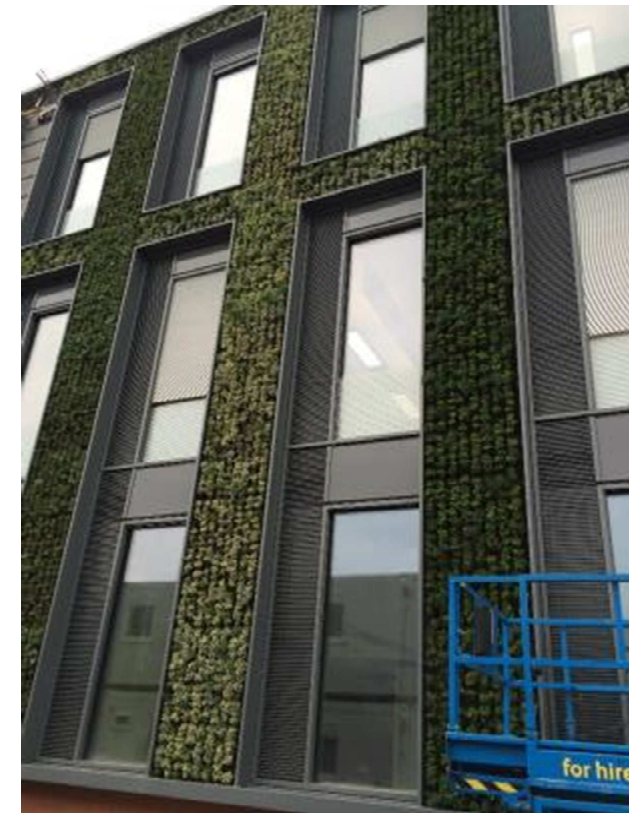
Form factor/Compactness = 1.5



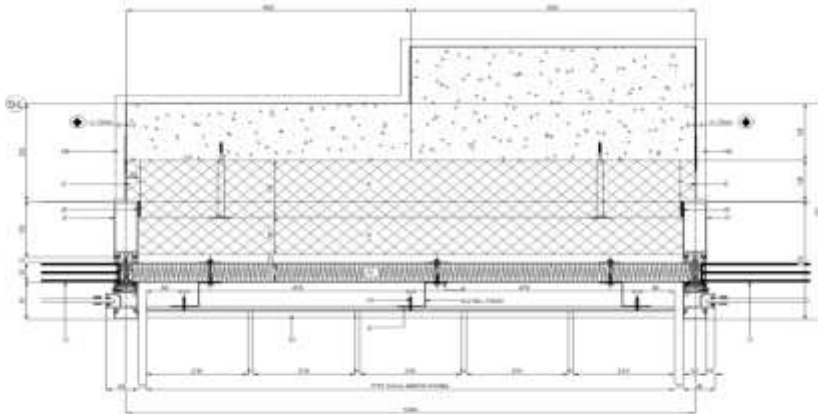
Masonry Cavity Construction



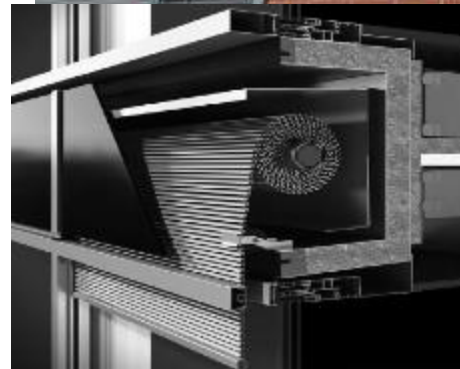
- 300mm cavity with full fill insulation
- Low conductivity brick ties
- Wet plaster as internal airtightness line
- Windows formed from curtain walling
- Windposts required due to size of openings



Curtain Walling with Brick Slips



- Single subcontractor responsibility
- Faster construction programme
- Tighter tolerances
- PH certified products
- Incorporates vent panels and external shading blinds



Building component	U value (W.m ² K)
Masonry	0.11
Glazing	0.57
Roller blind boxes	0.4
Opening panels	0.4
Brick cladding	0.1
CW frame	0.85
Roof	0.13
Ground	0.13

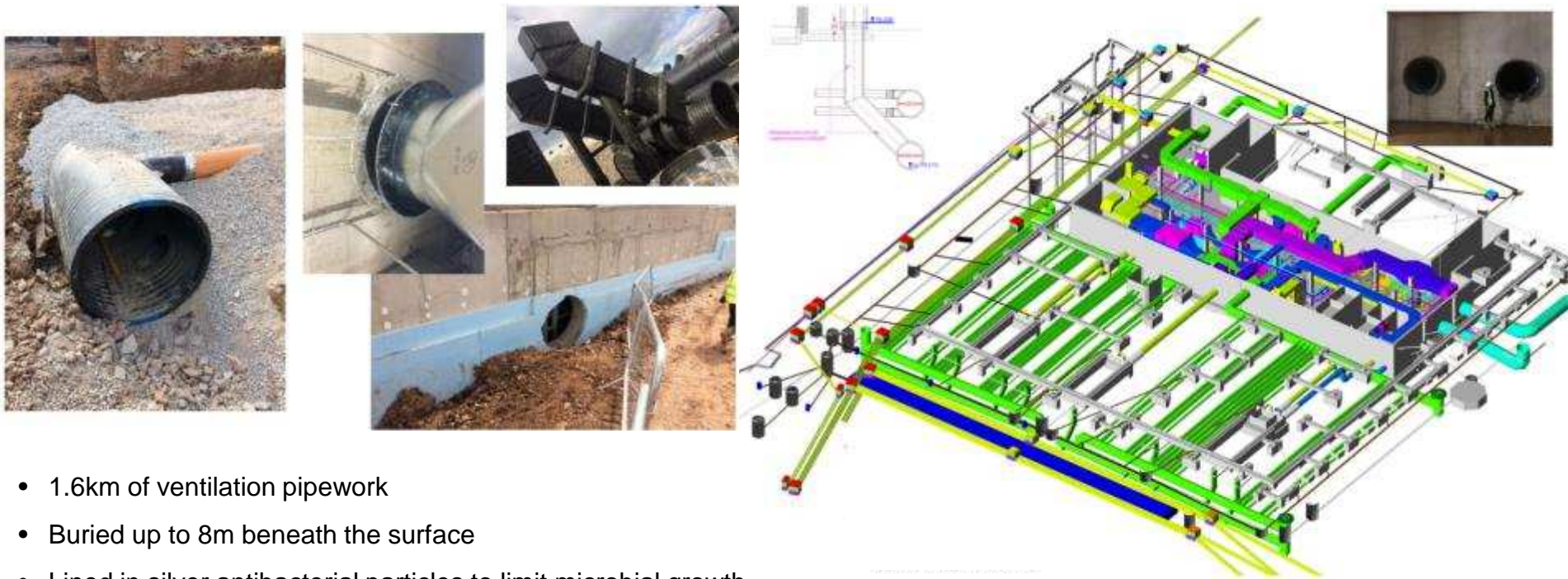


Installed Façade vs Factory Tested Mock-Up



Inspection of the façade mock-up prior to air & water testing at Wind-techs Telford Facility. Colours and workmanship benchmark.

Ground Air Heat Exchanger (GAHE)

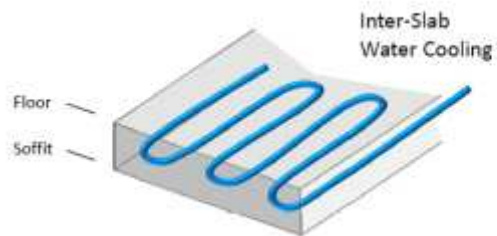
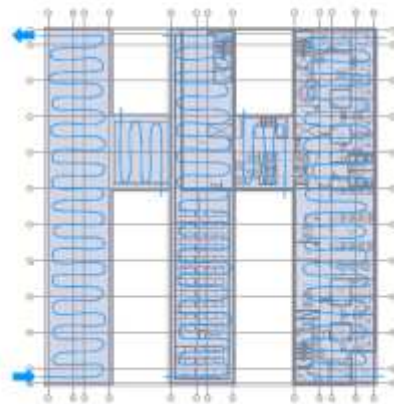


- 1.6km of ventilation pipework
- Buried up to 8m beneath the surface
- Lined in silver antibacterial particles to limit microbial growth

Thermally Activated Building Structure (TABS)



Thermal Mass and Night Purging (Air)



Airtightness – Partial Testing

Construction Stage

Sectional air permeability test in a large/complex building





Airtightness result:

Under pressurisation: 1.10 m³/m².hr

Under depressurisation: 0.98 m³/m².hr

~10 times better than building regs



Thermal Bridging

- Schedule of thermal bridges maintained by WDES
- WDES did thermal modelling
- Pile caps insulated on all sides, piles not insulated
- Thermal pads included on all steelwork connection
- GRC cladding changed to insulated render

Thermal bridge description	Base 2A estimate		WD proposal	
	W(mK)	% losses	W(mK)	% losses
Balustrade/monafe fixings	0.000		0.000	
Parapet wall	0.100	1.0%	0.100	1.0%
Plant room upstands for walls	0.200	0.7%	0.200	
Plantroom to internal space	0.000		0.000	
Rooflight upstands - will be insulated			0.200	
Wall-roof with ballustrade	0.200	0.7%	0.100	0.0%
W 13 Inverted wall-roof junction	0.200	1.0%	0.044	0.3%
Rooflight-wall junction	0.200	0.6%	0.200	0.7%
Thresholds	0.200		0.200	
Wall-window junction	0.070		0.070	
Shade support fixings				
Structure (columns & floors) into walls	0.000		0.000	
W 14 Colonnade soffits to wall beneath	0.000	0.1%	0.070	0.2%
Cladding support to colonnade soffit & wall - e	0.100	0.7%	0.100	
Colonnade (RSC) soffits to support column	4.000	1.4%	4.000	1.2%
Colonnade steel soffits to support column	4.000	1.6%	0.000	0.3%
Windparks			0.000	
Column with sags to windows - ceiling soffits	1.500	0.6%	1.500	0.6%
Column with sags from to ceiling to floor	1.500	1.4%	1.500	1.4%
Column with sags from to ceiling	1.000	0.6%	0.770	0.2%
Colonnade ground beam	0.100	0.7%	0.000	
		10.0%		7.7%





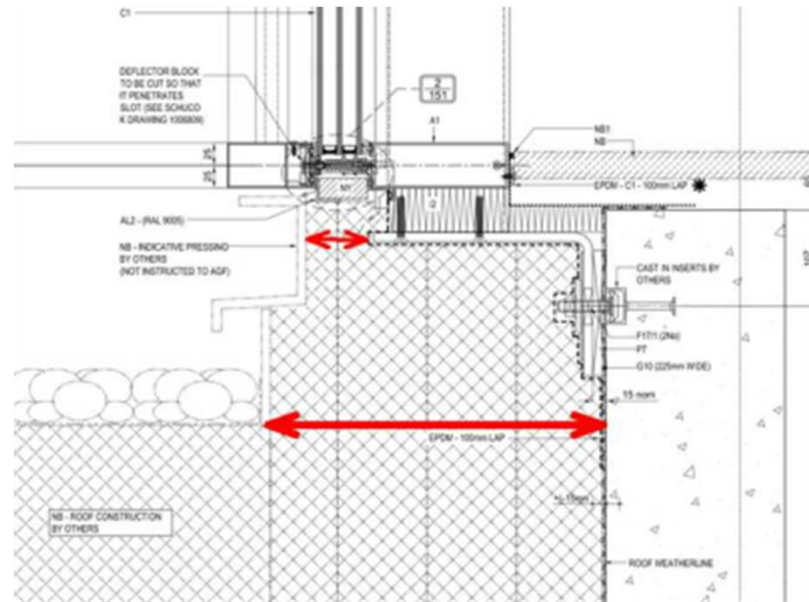
Contractor's Challenges



Design and Procurement Stage:

- Main contract procurement route – Single stage D&B ?
- Sub-contractor procurement – design responsibility and timing?

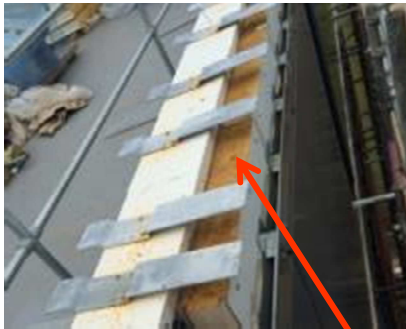
Contractor's Challenges



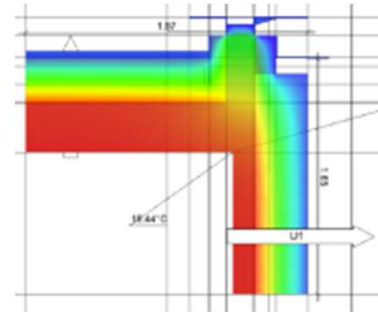
Design and Procurement Stage:

- Simplicity of design and detailing needed
- Material choices for air-tightness and thermal bridging

Contractor's Challenges



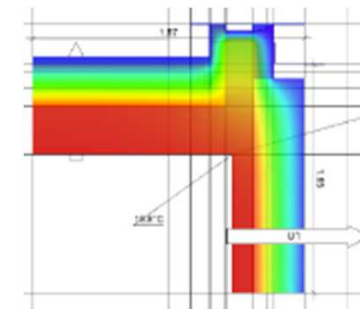
Final design:
Standard roof Insulation
 $\lambda D = 0.038 \text{ W/(m}\cdot\text{K)}$



$\Psi = 0.210$
W/m.K



During construction continuity
of insulation was checked and
rectified



$\Psi = 0.105$
W/m.K



Contractor's Challenges



Construction Stage:

- Achieving Passivhaus standard on build quality control measures
- Procurement limitations and PHPP design penalties on large-scale AHUs

Contractor's Challenges



Design and Procurement Stage:

- Integration of insulation to the slab/foundations for multi-storey structures

Contractor's Challenges



Construction Stage:

- Programme challenges with ground ducts and piled foundations



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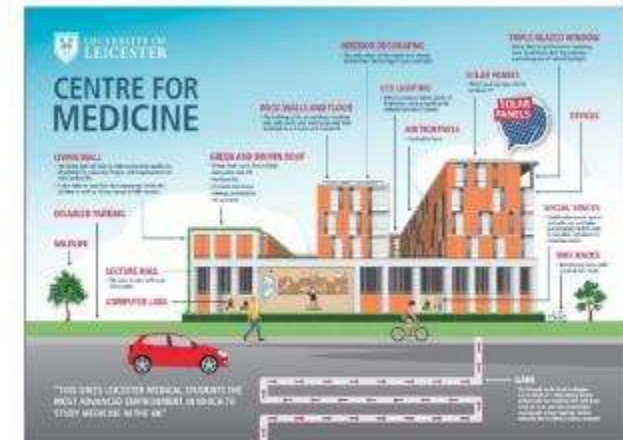
Passivhaus certification achieved 3rd Feb 2016...

- Designed in 2010 - difficulties sourcing PH products to meet aesthetic (more available now)
- Lack of Passivhaus knowledge & experience amongst contractors during tender period back in 2013
- PHPP proved a useful design tool - testing 'what if' scenarios
- Individual components have less impact on larger schemes - able to trade off performance in some areas
- But.... don't get complacent! Constant monitoring of progress is required - 'death by 1000 cuts!'
- Effective communication of key design requirements is more difficult to achieve on larger sites
- Good intentions to do early phased air tests was difficult - but air testing of sample rig was vital.
- PH certification not achieved until after practical completion but was a requirement of the contract - conflict
- Increased capital costs for Passivhaus relative to more stringent 'Part L' have fallen
- Achieving DEC 'A' is a significant challenge - three year soft landings period

Soft Landings

Soft Landings - Translating Passivhaus/Low Carbon Build to Low Carbon Operation

- Soft Landings and Passivhaus (needs to go hand-in-hand).
- Involvement in Soft Landings (final stages of construction, handover and post occupancy support for 3 years).
- Importance of operations and actual use of the building from a energy and carbon reduction strategy is paramount.
- Building user training during handover is key.
- First time where users, University FM teams and contractor working together post construction.



Soft Landings issues – Post Occupancy

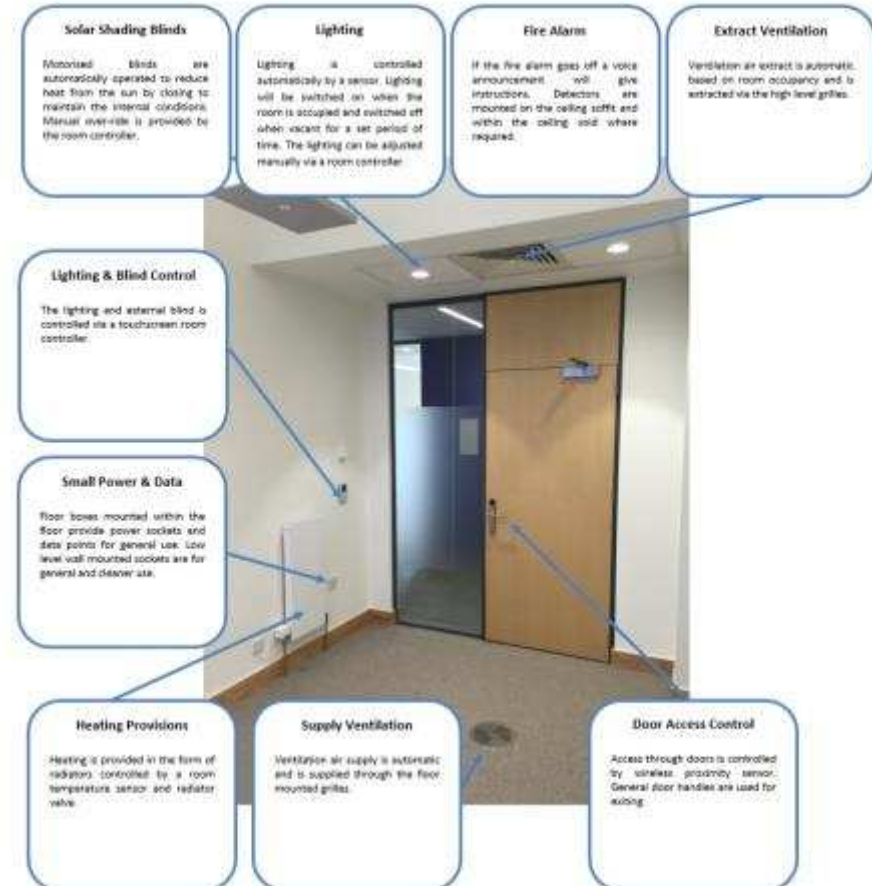
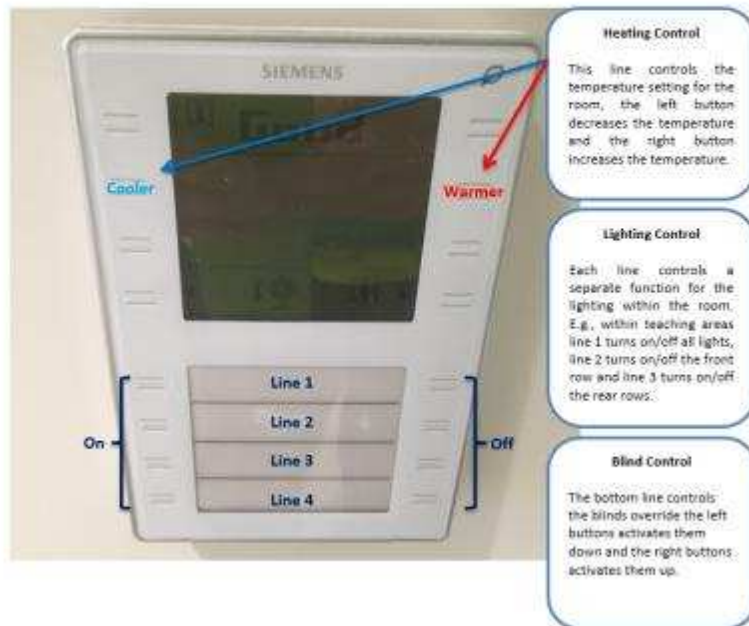


Soft Landings – Building User’s Guide

2.0 General Rooms

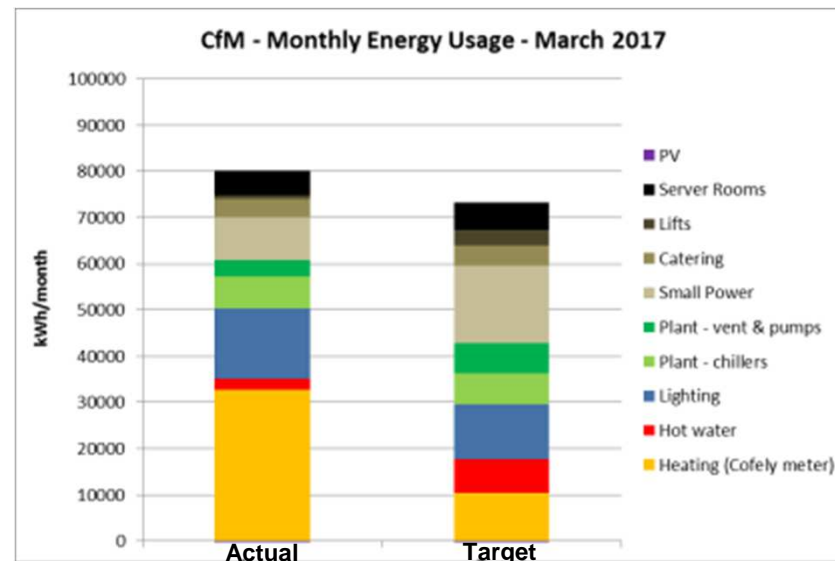
2.1 Room Controller

The room controller can be used to control lighting, heating and the solar shading blinds where fitted and the display shows the conditions within the room. The parameters for each can be changed by pressing the relevant buttons as shown.



Monitoring Building Performance

- The building has over 90 sub-meters.
- The meters record electricity, heat/cooling and water consumption data on 30 mins interval.
- Each type of energy use has been benchmarked and is proactively monitored by Estates Energy Team.



Future Monitoring & Management Issues

- Provide monthly feedback to building users.
- Using automated metering alarms to pick up anomalies on data and consumption.
- Key ongoing challenges:
 - On-going building user engagement
 - Maintaining competency of how to use the building
- Issue the first Display Energy Certificate (DEC) during May 2017.