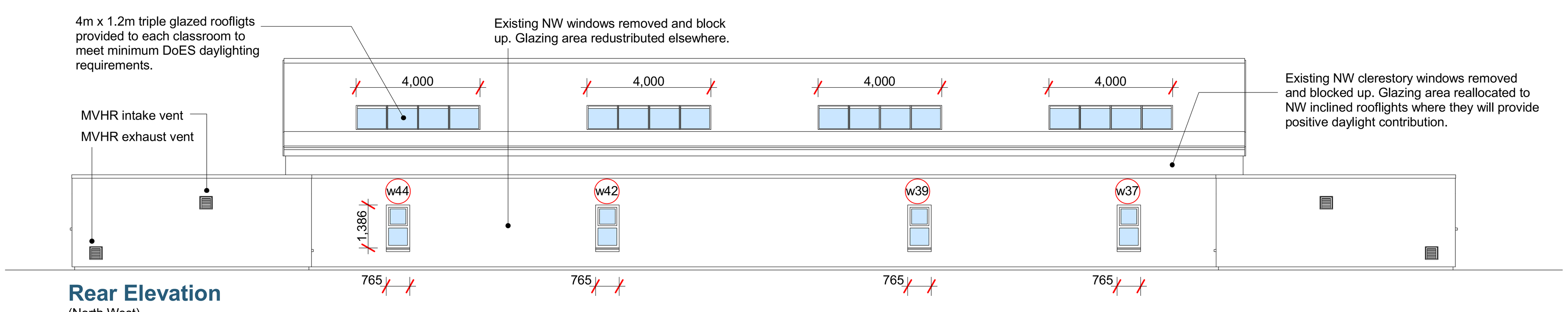
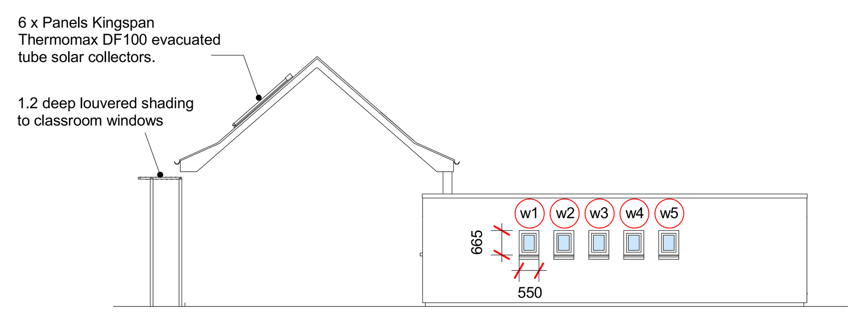
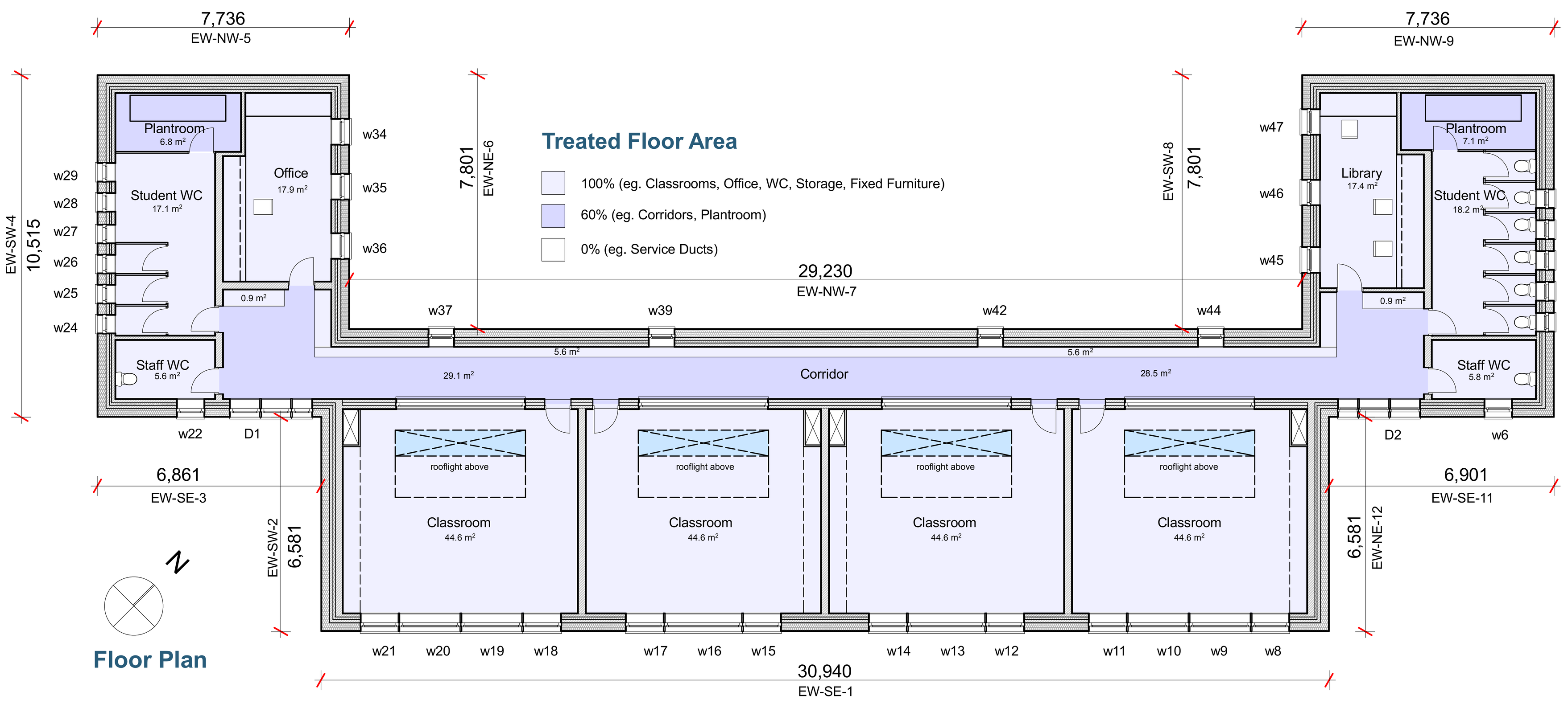


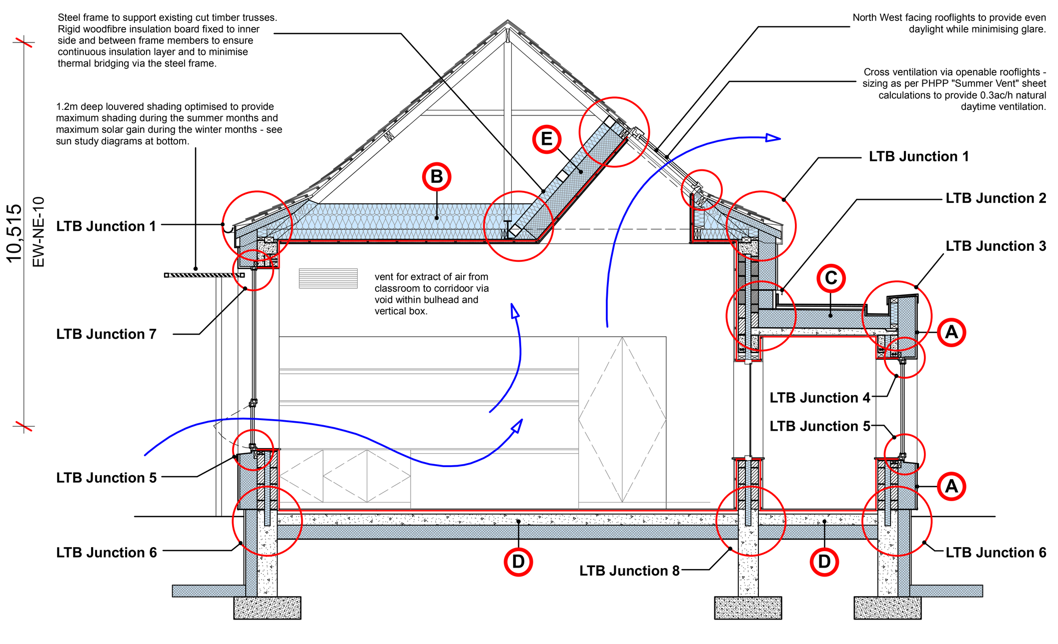
Rear Elevation
(North West)



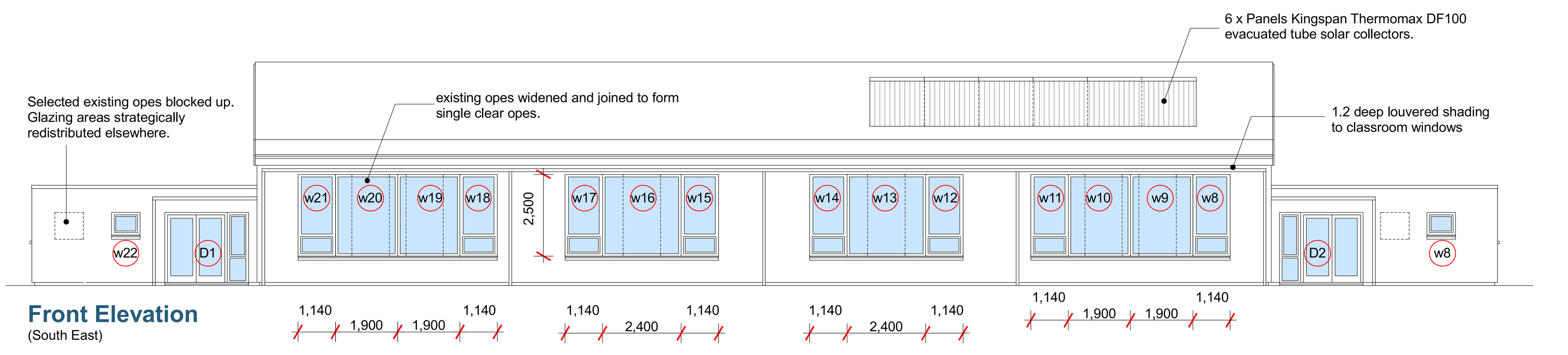
Side Elevation
(North East)



Floor Plan

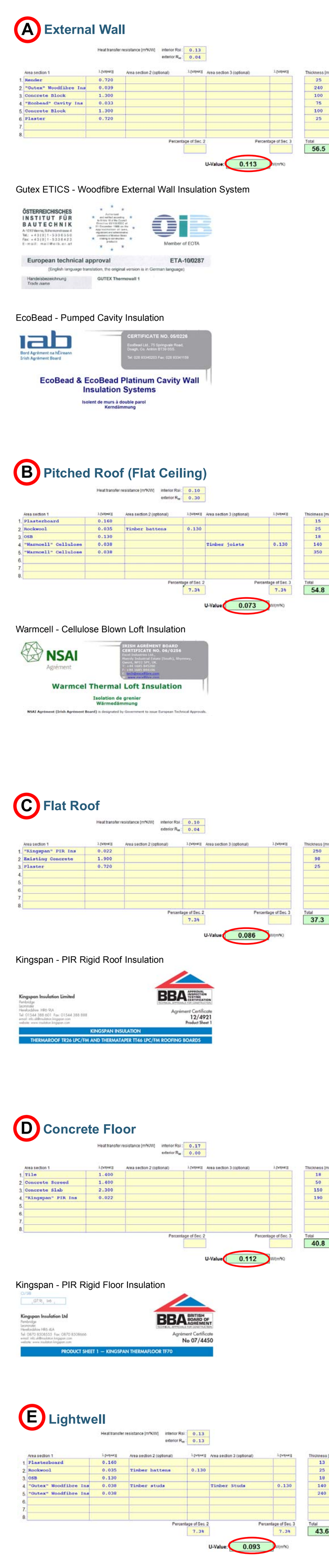


Section 1:50

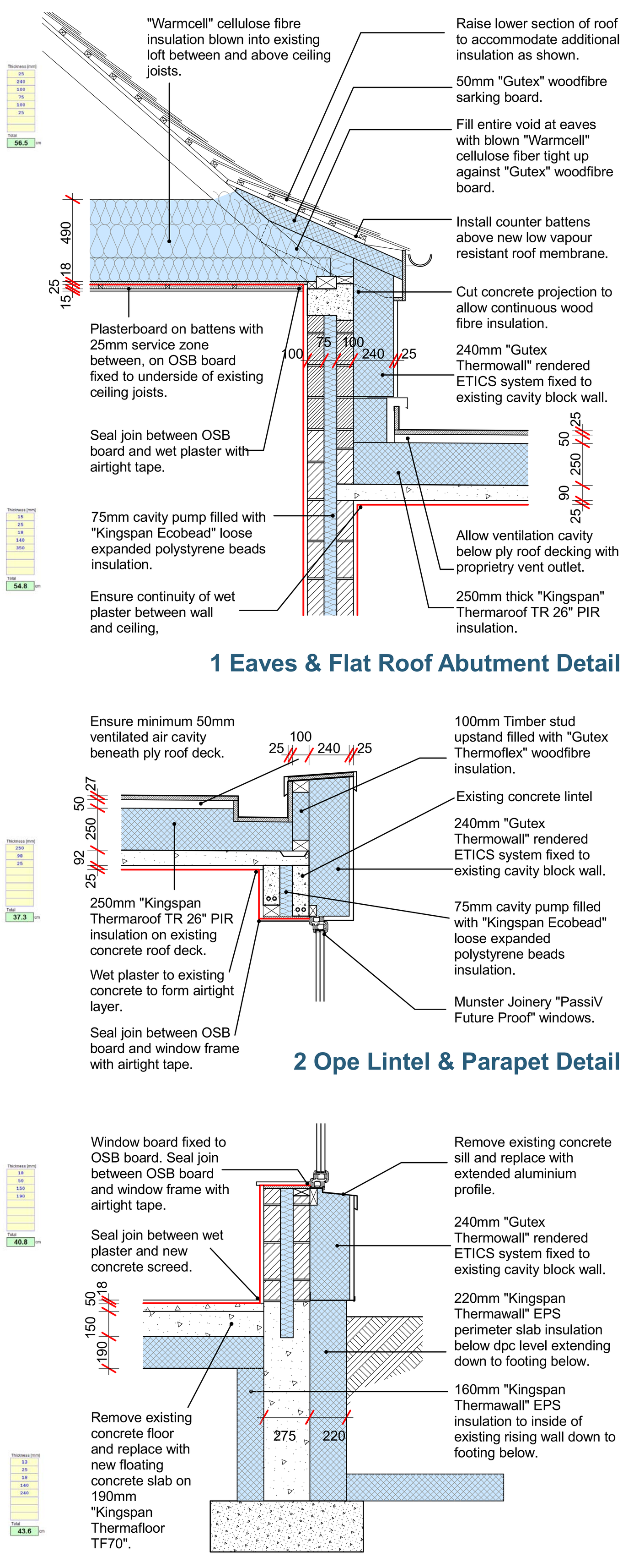


Front Elevation
(South East)

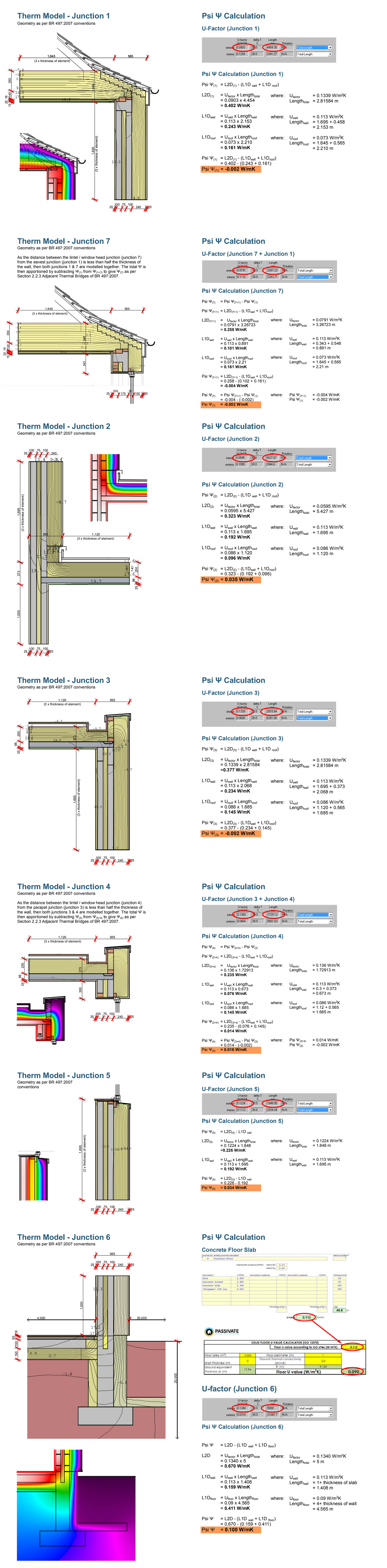
U-values



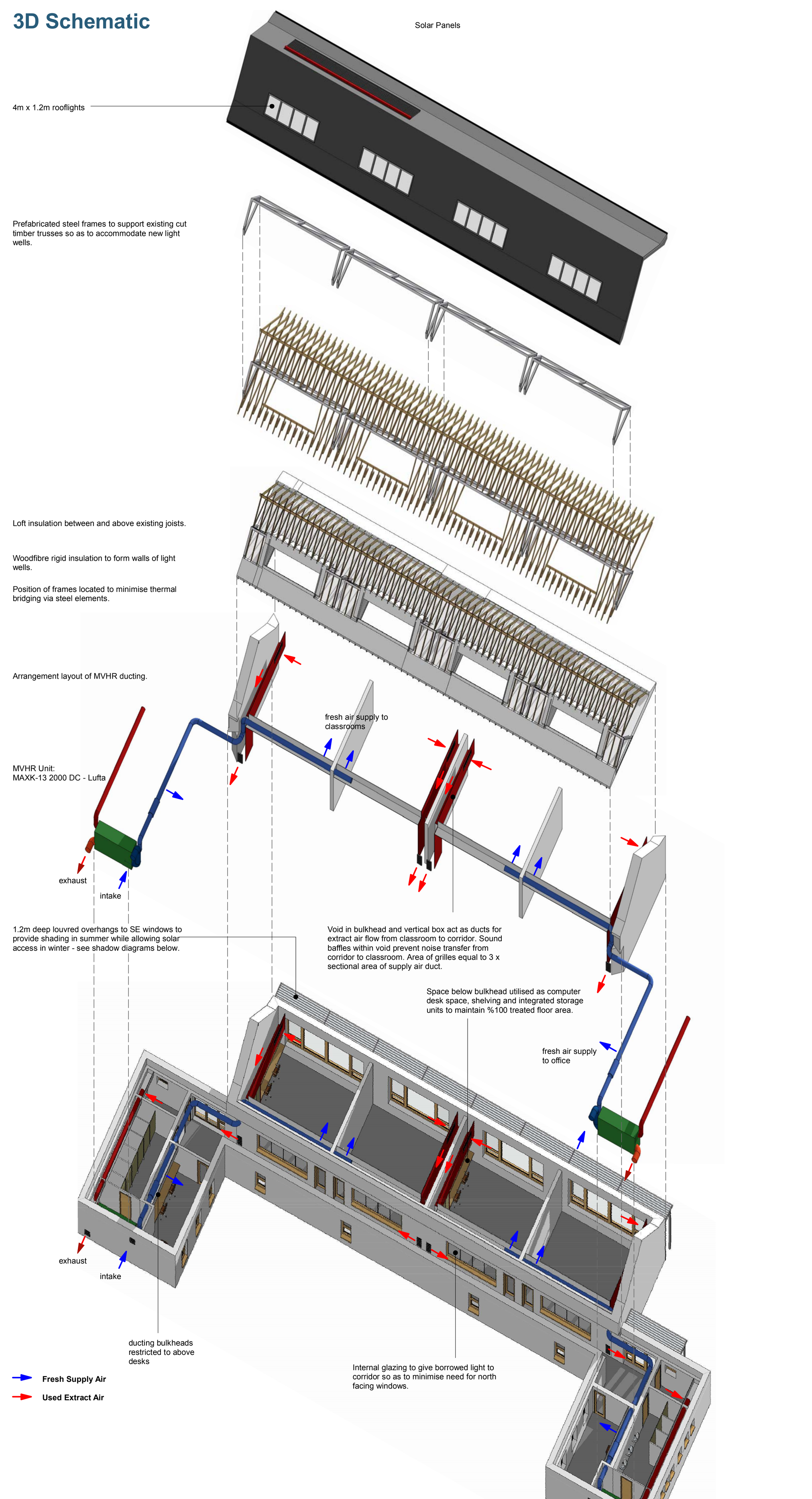
Construction Details & Specifications



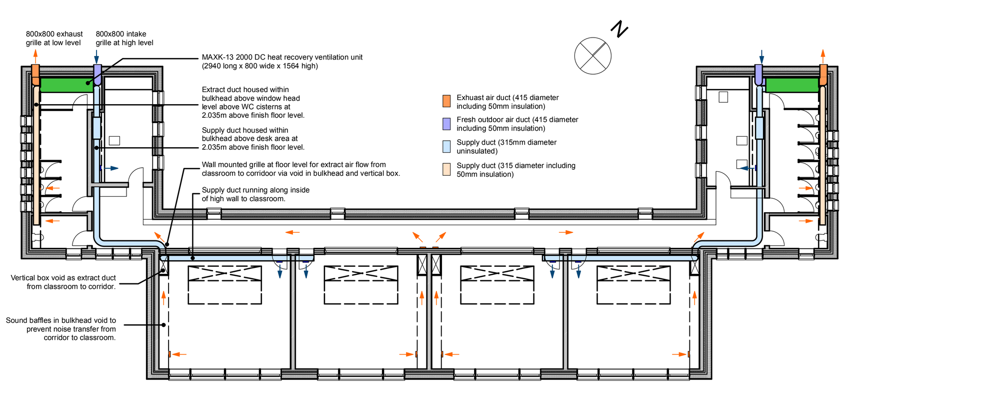
Linear Thermal Bridge Calculations



3D Schematic



Mechanical Ventilation & Heat Recovery



Design Process

A Basecase

Detailed analysis of existing conditions using PHPP to establish a basecase model. Incremental improvements introduced into PHPP with each step recorded separately to monitor the impact of each intervention.
A total of 17 steps (A to Q) were recorded with their impacts on annual heat demand, primary energy and frequency of overheating summarised in the adjacent design tracker graph.

B External Insulation

The first step was to upgrade the thermal fabric with improved U-values. External insulation was chosen as the prime insulation strategy. It was decided that materials with higher sustainabilty credentials would be used to begin the optimisation process to see how far one could get in attempting to achieve EnerPHit standard without resorting to highly synthetic materials. It was anticipated that such materials would quickly reach their thresholds and that those with increasingly lower U-values would need to be introduced in order to reach the Enerphit standard. "Gutex" woodfibre insulation with a thermal conductivity of 0.039 W/mK was therefore chosen as the external wall insulation while "Warmcell" Cellulose blown insulation with a thermal conductivity of 0.038 W/mK was chosen for the pitched roof loft. While these remained in place throughout the optimisation process, it proved necessary to use "Kingspan" PIR insulation with a conductivity of 0.022 W/mK for both the floor and flat roof insulation. "Ecobead" pumped insulation was used for the existing wall cavities.

The "Area" sheet was updated to account for the increased wall thicknesses and therefore external surface areas. Likewise, the Vn50 and enclosed volume (Ve) were also revised to accound for the increased window reveals.

C Airtightness

Airtightness was improved to an n_{50} of 1.0ac/h @ 50pa - the minimum required for achieving Enerphit standard.

D Glazing

All glazing replaced with triple glazing with a g-value of 0.63 and a U-value of 0.69 W/m^{2}K.

E Window Frames

Munster Joinery "PassiV Future Proof" with SP Tri seal.
Uf = 0.76 W/m^{2}K, 102mm thick frames.
The number of divisions were also reduced.

F Thermal Mass

The thermal mass of the existing concrete structure and the new floor concrete slab are retained and taken into account.

G Openings

A selection of existing windows (mainly north west facing) were removed to reduce unnecessary glazing heat loss. The clerestory windows in particular were proven through simulation to provide zero contribution to daylighting. They were therefore removed and blocked up so that glazing areas could be redistributed elsewhere to better advantage.

The following existing windows were removed:

South East Windows - w7,23
North West Windows - w32, 33, 38,40,43,48,49, 50-63.

An additional 2 windows were then added - 1 each for the two middle classrooms to match the existing so that they now had 4 rather than three opes so as to improve daylight and increase solar gain during the winter.

H Rooflights

4m x 1.2m rooflights inclined at 41 degrees were provided for each of the four classrooms mounted on the North West facing roof slope with the intention of achieving the minimum required Daylight Factors. The minimum DoES requirements for classrooms are an average DF range of 4.5 - 5.5 and a minimum threshold DF of 2.0%.

To achieve such daylight factors, the rooflights would need to be much larger, resulting in significant heat loss in winter and overheating in summer - even with very low U and g-values. It was attempted through PHPP to arrive at an optimum size which would provide reasonably good daylight but which would still be manageable in terms of glazing heat loss and solar gain.

Other PHPP implications of the rooflights included:

Increased "Enclosed Volume" (Ve) from 1280.4m^3 to 1325.76m^3 as a result of the newly created light wells.

U-values were established for the lightwell reveals using rigid woodfibre insulation on stud as exposed and semi-exposed areas. These areas were then input into the "Areas" sheet of PHPP.

I Volume

The volume was again revised to account for a slightly lowered ceiling (to accommodate a service zone below the airtightness layer) as well as numerous bulkheads and boxed-in ducting etc.

J Mech Ventilation & Heat Recovery

2 x MVHR units were introduced - "MAXK-13 2000DC Lufta" with a heat recovery efficiency of 83.6%. Adjustments were made to the floor plan to make way for two new plant rooms within the WC blocks. All ducting was kept within the thermal envelope. At this point, the annual heating demand target of 25 kWh/(m2a) had been reached but Primary Energy was still too high.

K Linear Thermal Bridging

Linear thermal bridge analysis using THERM was used to calculate Psi values and surface condensation risk along key juction details. Psi values were obtained for junctions at the eaves, flat-roof abutment, parapet, ope sill, ope head and base of wall as well as a number of combined juctions where they occured closer than the thickness of the surface elements. These Psi values were then input into the "Areas" sheet. The presence of positive Psi values in the slab perimeter junction resulted in an increase in the annual heating demand above the 25 kWh/(m^{2}a) threshold.

L Treated Floor Areas

Revisions were made to reflect previous planning changes such as plantrooms, reduced lobby area as well as the introduction of fixed furniture in circulation areas such as bench seating in the corridor and storage in the entrance lobby.

M Solar Hot Water

10m^2 aperture, vaccuum tube collectors on the south east facing roof pitch. The introduction of domestic solar hot water has effectively halved the Primary Energy.

N Lighting Controls

Energy efficient lights with automatic, dimming controls and motion detectors are introduced to provide daylight responsive lighting to reduce lighting energy demand.

O Additional Openings for Solar Gain

With the annual heating demand having increased again due to the linear thermal bridging, it is decided to join the south east facing openings to the classrooms in an attempt to increase the solar gain during the winter months thus reducing heat demand. This proves successful however exacerbates overheating.

Windows 9,10,13,16,19 and 20 are widened to create two new window types :

4 x T6 (2.5m high x 1.9m wide)
2 x T7 (2.5m high x 2.4m wide)

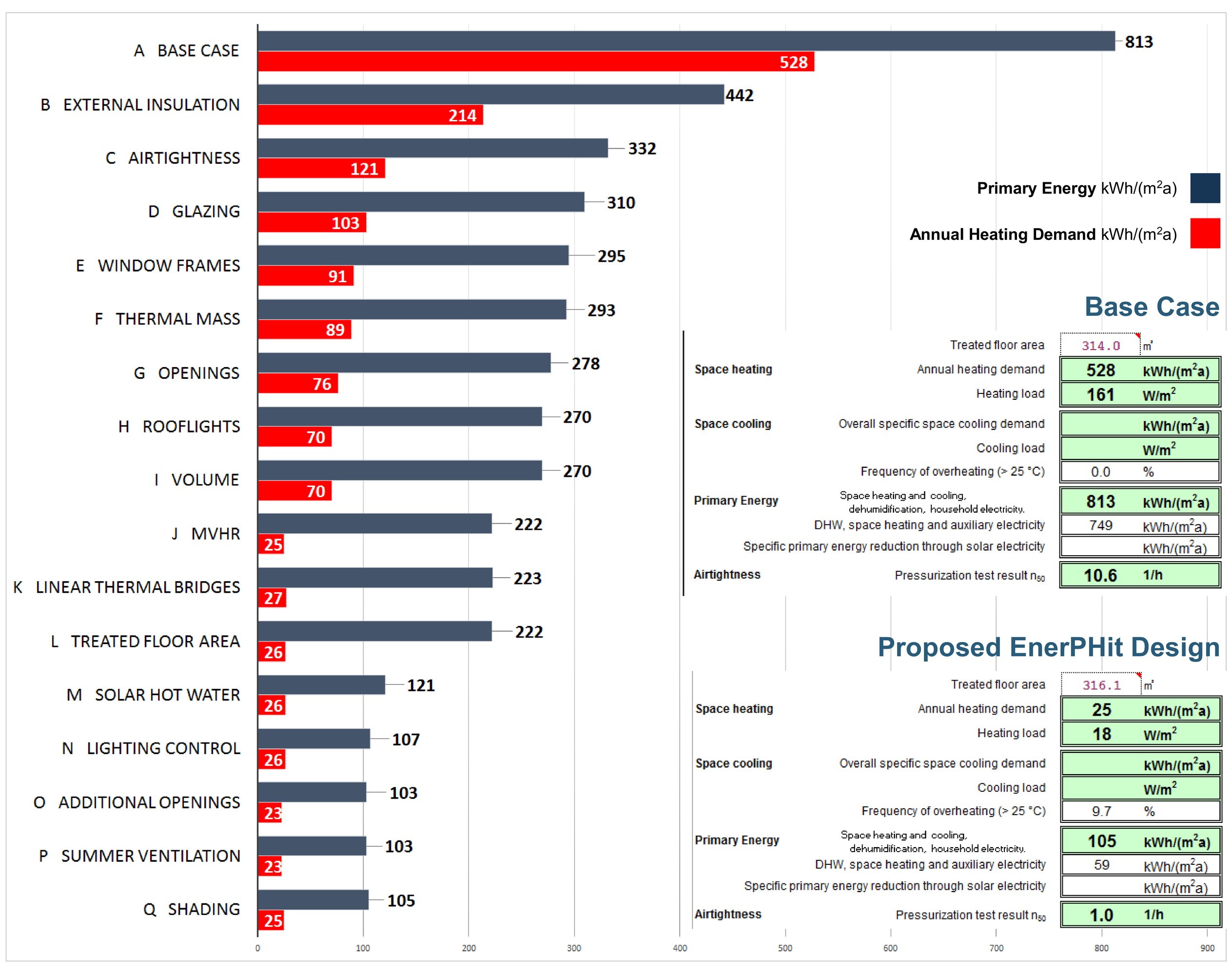
P Summer Daytime Natural Ventilation

Daytime natural ventilation in summer time is introduced with an air change rate of 0.3 ac/h - the minimum required for ventilation in any case. It is decided **not** to have night time purge ventilation during the summer as security may be an issue. It is intended that the design meet the 10% frequency of overheating without resorting to night purge ventilation.

Q Shading

Through the use of sun studies via a BIM model of the school simulating both winter and summer sun, it was established that the south east windows were the biggest source of solar gain. This was confirmed in the monthly solar and internal gains charts in PHPP. 1.2m deep horizontal louvered shading was found to provide maximum shade in the summer and maximum solar access during the winter. Once this was input into PHPP, the frequency of overheating fell below the 10% threshold without the need for any night purge ventilation.

Design Tracker



Base Case

	Treated floor area	314.0	m²
Space heating	Annual heating demand	528	kWh/(m^{2}a)
	Heating load	161	W/m^2
Space cooling	Overall specific space cooling demand		kWh/(m^{2}a)
	Cooling load		W/m^2
	Frequency of overheating (> 25 °C)	0.0	%
Primary Energy	Space heating and cooling, dehumidification, household electricity.	813	kWh/(m^{2}a)
	DHW, space heating and auxiliary electricity	749	kWh/(m^{2}a)
	Specific primary energy reduction through solar electricity		kWh/(m^{2}a)
Airtightness	Pressurization test result n_{50}	10.6	1/h

Proposed EnerPHit Design

	Treated floor area	316.1	m²
Space heating	Annual heating demand	25	kWh/(m^{2}a)
	Heating load	18	W/m^2
Space cooling	Overall specific space cooling demand		kWh/(m^{2}a)
	Cooling load		W/m^2
	Frequency of overheating (> 25 °C)	9.7	%
Primary Energy	Space heating and cooling, dehumidification, household electricity.	105	kWh/(m^{2}a)
	DHW, space heating and auxiliary electricity	59	kWh/(m^{2}a)
	Specific primary energy reduction through solar electricity		kWh/(m^{2}a)
Airtightness	Pressurization test result n_{50}	1.0	1/h

Solar & Internal Gains

A Basecase

The base case PHPP model shows there is very little solar gain relative to the heat demand. While this means that there is zero risk of over heating during the summer, there is significant heat deficit in winter thus requiring a very high heat demand during the colder months.

Key Points of Solar Gain Increase:

F Openings

By removing unnecessary north facing windows and reallocating them to better orientaions, solar access is increased through greater south facing windows while at the same time, glazing heat loss through north facing windows is reduced thus increasing overall heat gain.

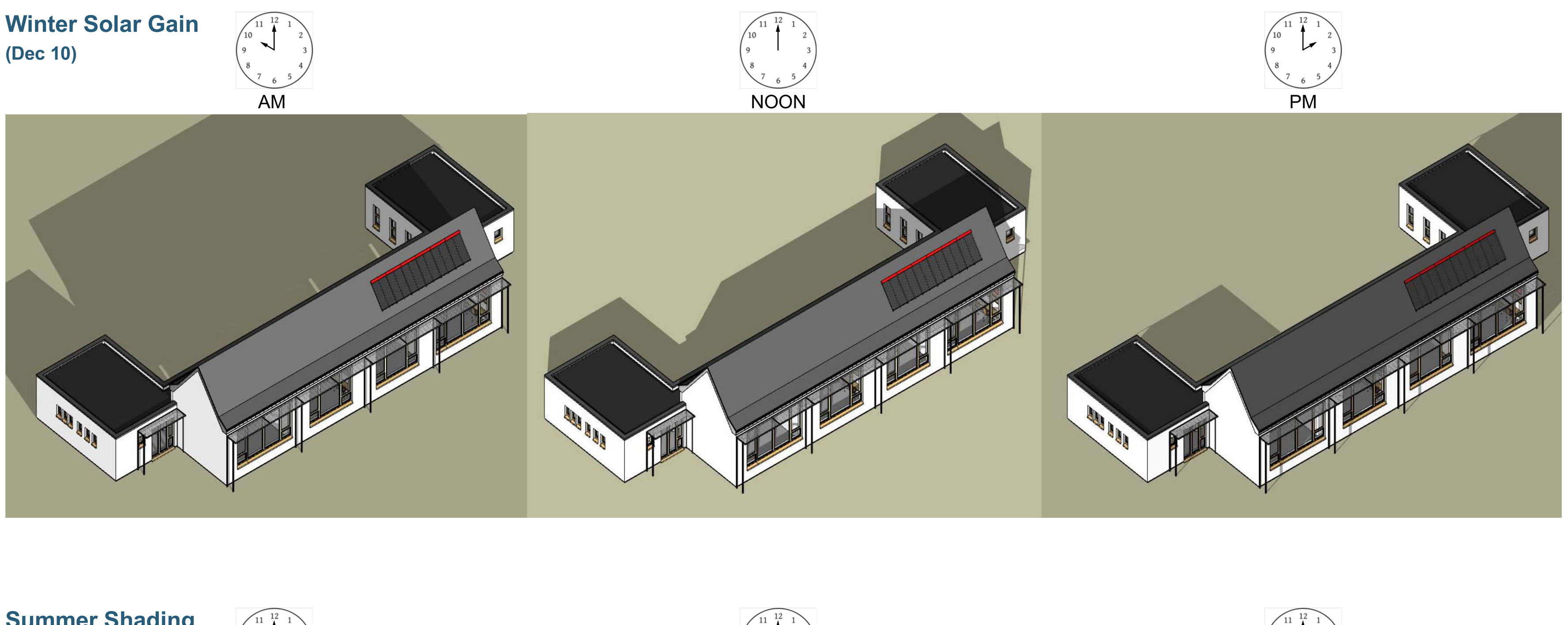
H Rooflights

Rooflights were introduced due to the poor level of daylight in the classrooms which fall well short of the DoES minimum daylight factor requirements. It was felt that the rooflights were a necessity to increase daylight while recognising that they would contribute to overheating issues and that other measures were needed to minimise the risk.

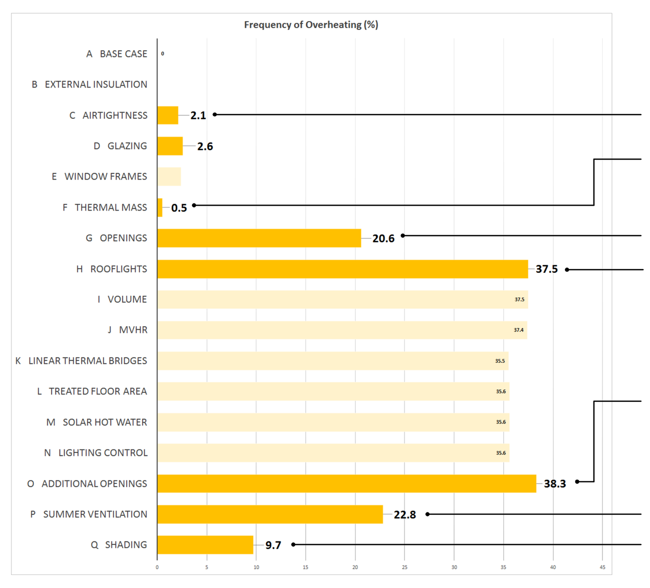
O Additional Openings

An increase in the annual heat demand at the latter stages of the PHPP design process (mainly due to linear thermal bridging) called for additional solar gain during the winter months to help reduce the heat demand. It was decided to join the windows in the classroom to create a larger glazing area. This helped to bring the annual heat demand back down to 25 kWh/m2a but worsened the overheating issues. Shading strategies were therefore necessary to tackle to the problem.

Winter Solar Gain
(Dec 10)



Overheating



Specific stages in the design process were identified as having a specific impact on overheating.

The early stages of the process showed that air tightness significantly increased the frequency of overheating. The increasingly improved fabric not only minimises heat loss during the winter but also traps heat in the summer.

While still too early to make any significant impact, the role of thermal mass in regulating internal temperature can already be seen here.

A significant jump in the frequency of overheating occurs when most of the existing north facing windows were removed and blocked up with some of the opening areas redistributed at other orientations. By now, south east and south west facing windows make up the majority of the total glazing area.

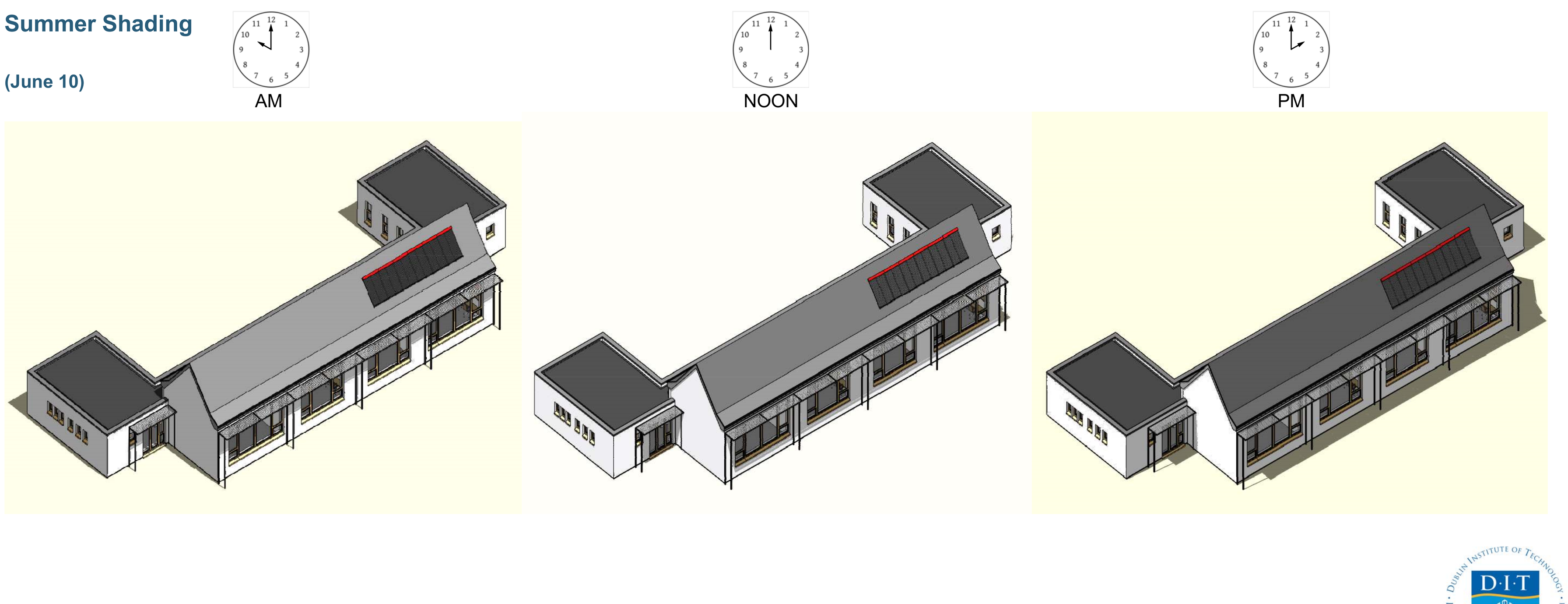
Further worsening of overheating occurs when the NW facing rooflights are introduced for the purpose of improving daylight in the classrooms - almost doubling the previous frequency. As the rooflights are inclined towards the sky, shading strategies would be difficult. Other windows would need to be targeted for shading potential. Having identified the SE facing classroom windows as the other major source of heat gain, they become the focus in the final stages of the design process.

However, before shading strategies could be introduced, the annual heating demand had increased above the 25 kWh/m2a threshold due to LTB heat losses. Any additional shading at this stage would only increase the heat demand due to reduced solar gain. After testing several window variations in PHPP, it was found that by joining the classroom windows together, adding glazing area between the existing windows, there was sufficient solar gain to bring the annual heat demand back down below the threshold without increasing the frequency of overheating too much. It is now that the focus can shift towards optimising shading and other strategies for reducing overheat.

To ensure that overheating was not being distorted and exagerated by inadequate ventilation, the minimum air change rate of 0.3ac/h was input for summer daytime natural ventilation. This is a requirement regardless of any overheat issues.

A strategy of horizontal louvered overhang shading to the classroom windows as illustrated in the sun study diagrams adjacent was finally adopted. This reduced the frequency of overheating below the 10% threshold.

Summer Shading
(June 10)



EnerPHit - School Project

mo zainal 10/01/2014

DT774b Energy Retrofit Technology