DEPARTMENT OF EDUCATION GRD SCHOOL TO ENERPHIT STANDARD BY PASSIVE HOUSE

Introduction:
The Department of Education's Planning and Building Unit is developing a low-energy building using Generic Repeat Design (GRD) principles. This program intends to deliver many primary schools using the single prototype building. This should minimize risk to project finaces and outcomes by the use of proven technologies.The intention is the building can be orientated to suite numerous sites while applying the standard repeating design system. The building is intended to be a low-energy building and the energy level is to be aimed at half of the applied standard in the field.

Existing Condition
The school building is a two story building with a traditional heavy construction, consisting of a composite roof panel on steel portal frames supported on block cavity walls with traditional strip foundations and concrete first and second floors.
There are classrooms to the south of the building on both floors and a gymnasium and support rooms such as offices and teachers accommodation to the north with a corridor running east west between them.
The south facing elevation contains large double glazed windows in a thermally broken aluminium frame. All other windows and doors in the building are large double glazed windows in a thermally broken aluminium frames.

The roof panel is a 75mm thick kingspan kingzip panel with an aluminium skin either side of xps insulation, further insulation is provided inside this in the void left by the steel 'z' purlins spanning between the main structure and supporting the roofing panel, this insulation is a mineral wool slab. The mineral wool slab is proposed to be held in position by friction with the purlins while also using a wire netting between the purlins, in other locations a liner sheet is proposed while in the gymnasium a layer of 12.5mm plasterboard is provided. No design value has been proposed for the roof constructions.

The external walls are constructed from high density forticrete blocks 215mm un-rendered internally and 100mm Common Block rendered externally with a 110mm cavity with 70mm xps insulation in the cavity. This wall construction is proposed to have an elemental U-value of 0.22 W/m2k

The ground floor slab is constructed of 150mm concrete slab on 60mm of xps floor insulation the floor is proposed to have an elemental U-value of 0.21 W/m2k. the floor perimeter is provided with a 30mm thick vertical insulation band. The gymnasium floor also has a timber floor supported on durabella battens. All floors are on a radon barrier which is folded in to the cavity and where there are steel columns sealed to them with radon tape.

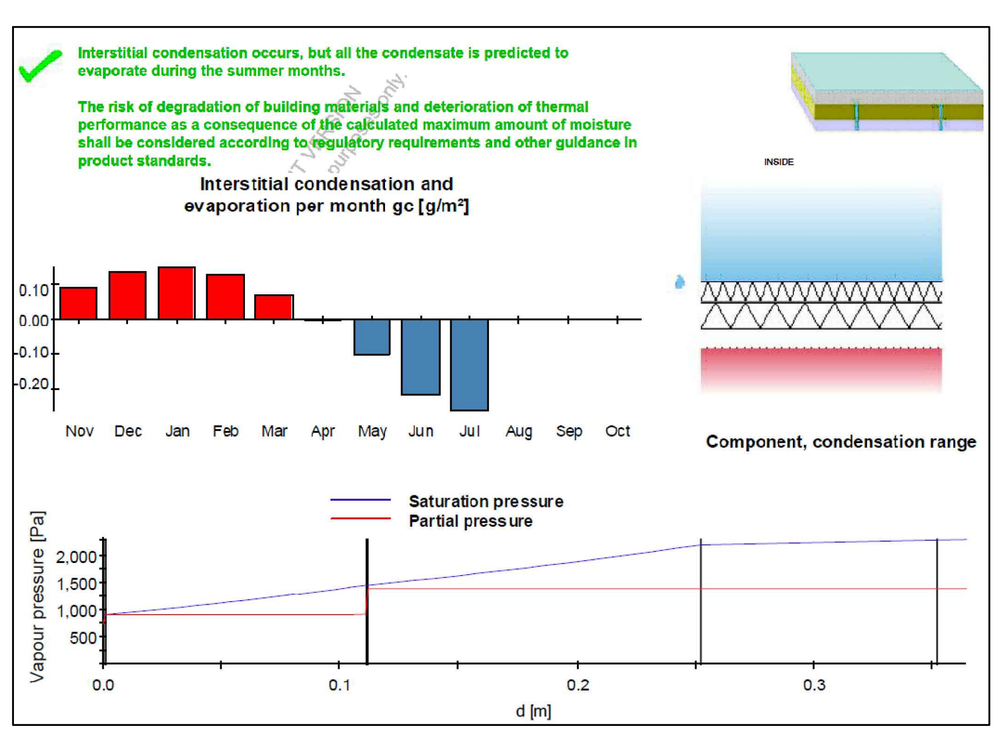
The Double glazed windows in thermally broken frames are sitting on a precast concrete sills which sit on the inner leaf of block work with an xps insulation backing. the windows are fixed at the jambs traditionally and sealed with airtight tape to the inner leaf of block work and covered with a timber reveal on heads, sills and jambs. There is no design proposal for the elemental U-value of the windows, doors etc.

There are other minor elements of construction of the building including an insulated sandwich panel on the side walls of the dormers to the plant room and north light to the gymnasium. This construction is 60mm composite kingspan panel externally surface fixed to a timber frame construction internally with 175x50mm studs with OSB board externally, 12.5mm plasterboard internally and filled with 175mm mineral wool. There is a vapour barrier between the plasterboard and the stud which is proposed to act as an airthghtness layer and this is sealed to the metal construction of the connecting metal of the inner side of the metal roof. There is no proposed elemental U-value for this construction.

The building is proposed to have an airtight enclosure on the inside of the construction.

Roof:
75mm thick kingspan kingzip panel
140mm Minerial Wool insulation between 'z' purlins held in position by friction
12.5mm plasterboard is provided.
U-value = 0.16 W/(m²K)
fRsi value =The critical month is December with fRsi,max = 0.675

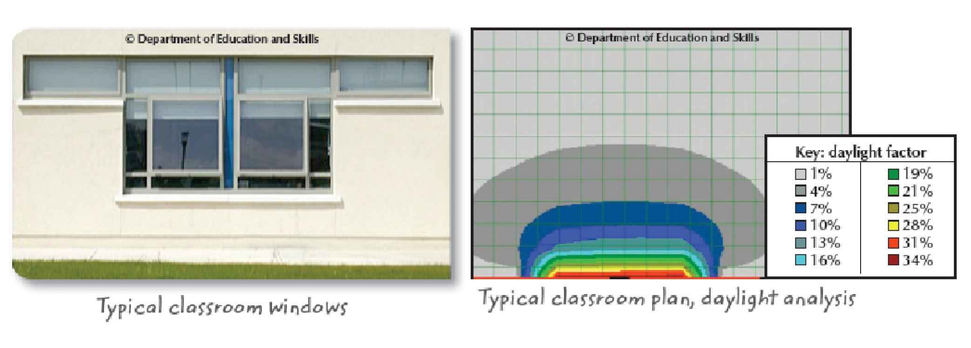
Warning! This U-value result is invalid as the ratio between the upper and lower resistances exceeds 1.5.
This calculation method is not suitable where insulation is bridged by metal framing.
Consider modifying the basic or separating material in the inhomogeneous layer or replacing it as a light gauge steel frame layer.


Interstitial condensation occurs, but all the condensate is predicted to evaporate during the summer months.
The risk of degradation of building materials and deterioration of thermal performance as a consequence of the calculated maximum amount of moisture shall be considered according to regulatory requirements and other guidance in product standards.
Interstitial condensation and evaporation per month gc [g/m²]
Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
INSIDE
Component, condensation range
Saturation pressure
Partial pressure
Vapour pressure [Pa]
d [m]

DAYLIGHT FACTOR BASED ON THE DEPARTMENT OF EDUCATION GUIDELINES

The existing classrooms are designed to comply with the DoE guidelines requiring a Daylight Factor between 4.5% and 5.5%. The tests below is from the DoE Document outlining the project

Ireland's generic repeat design schools programme

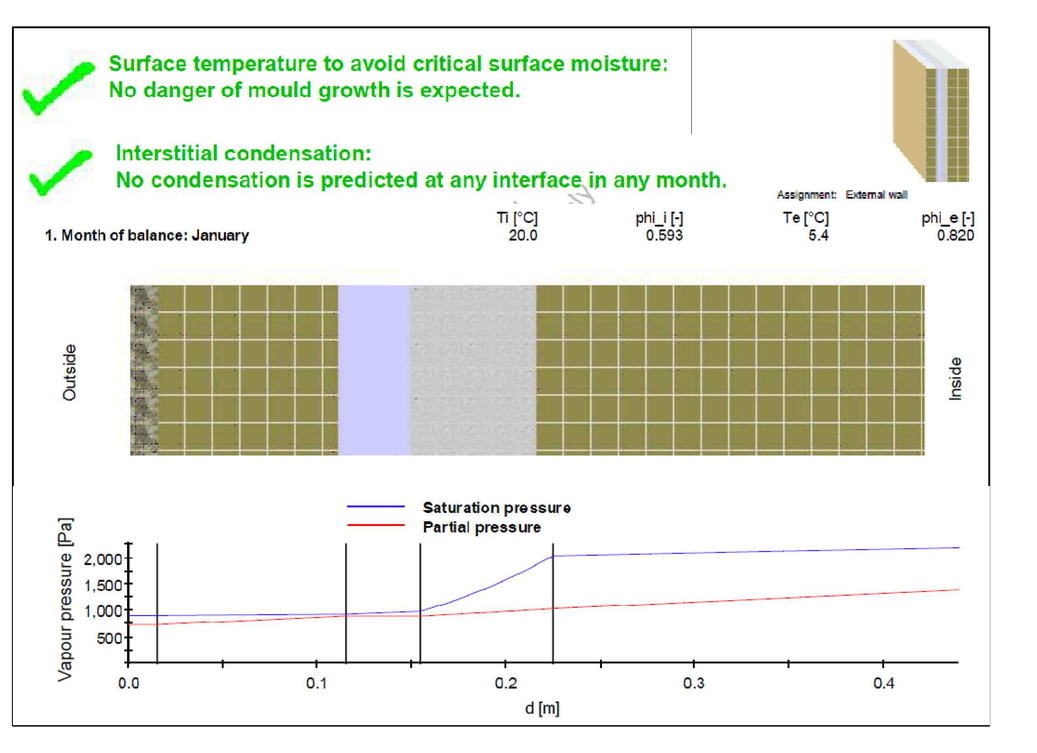


Typical classroom windows — Typical classroom plan, daylight analysis

School hall
An average daylight factor of 5.4% was achieved within this space. Balanced distribution is ensured by a north-facing window screen together with a high-level roof lantern at the rear of the space. These duplicate as openable windows to give very good cross-ventilation for this high-occupancy room.

Walls:
100mm Common Block rendered externally
110mm cavity with
70mm xps insulation
215mm un-rendered high density forticrete blocks

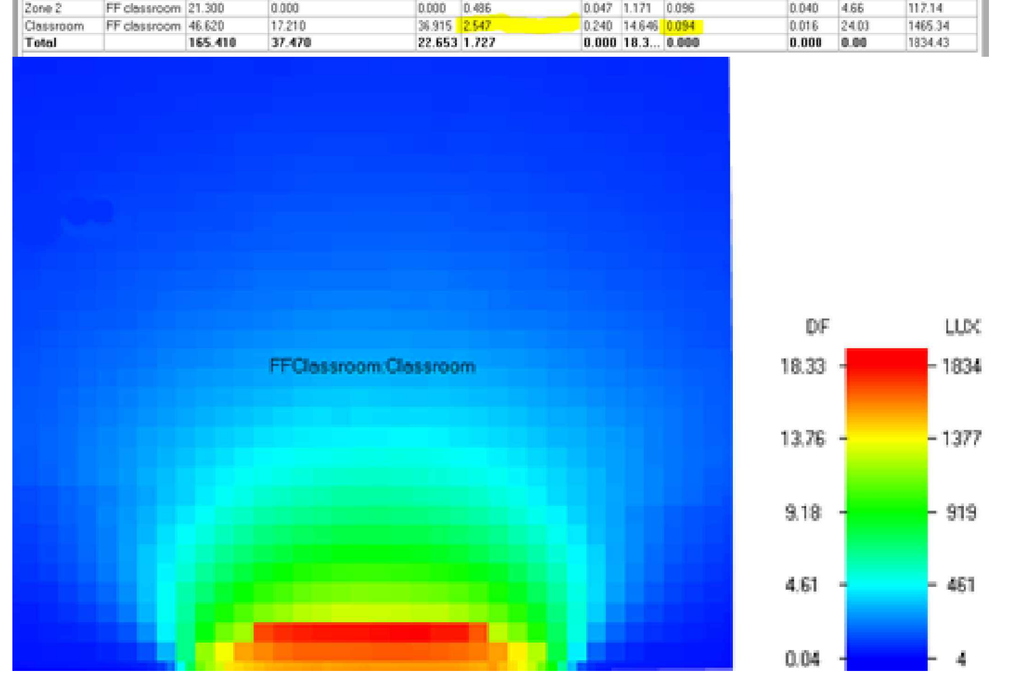
U-value = 0.34 W/(m²K)
fRsi value = The critical month is December with fRsi,max = 0.675


Surface temperature to avoid critical surface moisture: No danger of mould growth is expected.
Interstitial condensation: No condensation is predicted at any interface in any month.
1. Month of balance: January
Ti [°C] 20.0
phi_i [-] 0.593
Te [°C] 5.4
phi_e [-] 0.820
Outside
Inside
Saturation pressure
Partial pressure
Vapour pressure [Pa]
d [m]

DAYLIGHT FACTOR BASED A REVIEW USING DESIGNBUILDER.

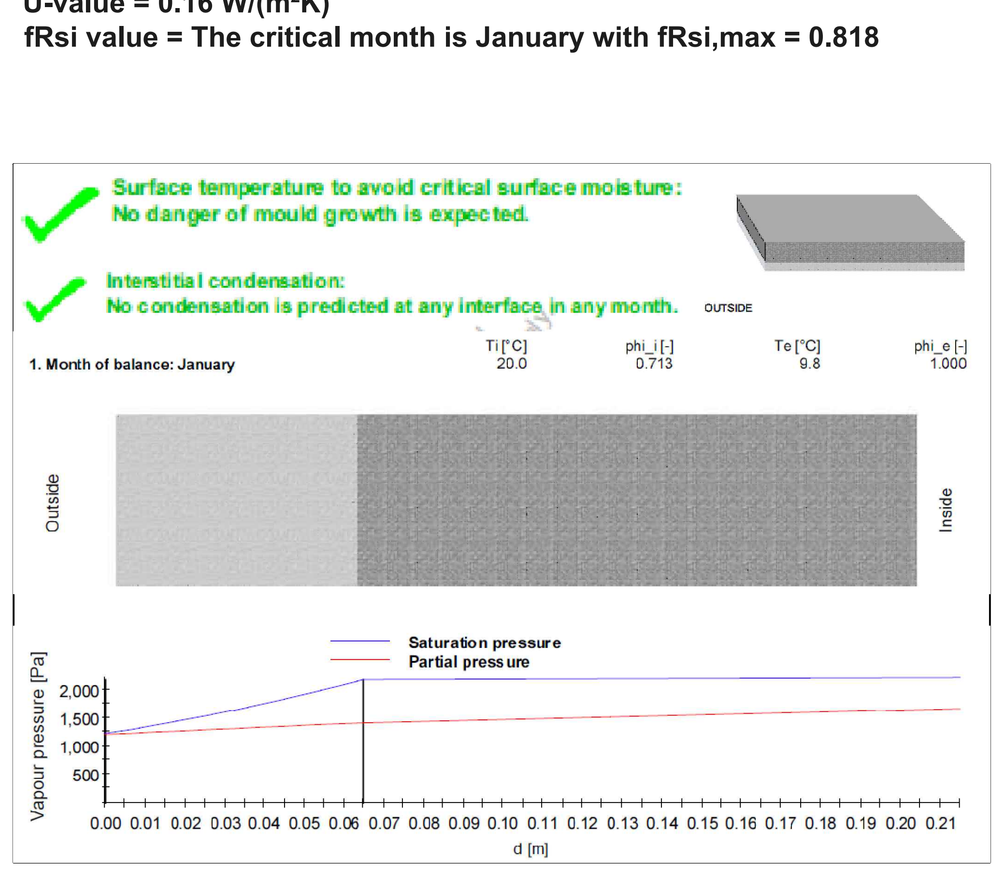
Using DesignBuilder The existing classrooms Daylight Factor is 3.022%.

Zone	Block	Floor Area (m2)	Floor Area above Threshold (m2)	Floor Ar...	Average Daylight Factor	Minim...	Maxim...	Uniformity ratio (Min / Avg)	Uniformit...	Min Illumina...	Max Illumina...
Zone 1	GF classroom	6.720	0.000	0.000	0.507	0.087	0.802	0.172	0.109	8.74	80.30
Zone 2	GF classroom	21.990	0.000	0.000	0.479	0.038	1.570	0.078	0.024	3.75	157.04
Classroom	GF classroom	46.620	20.260	43.458	3.022	0.253	18.337	0.084	0.014	25.36	1834.43
Zone 1	Trees	15.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
Zone 1	FF classroom	6.720	0.000	0.000	0.252	0.072	0.432	0.284	0.166	7.16	43.22
Zone 2	FF classroom	21.300	0.000	0.000	0.486	0.047	1.171	0.096	0.040	4.66	117.14
Classroom	FF classroom	46.620	17.210	36.915	2.547	0.240	14.646	0.094	0.016	24.03	1465.34
Total		165.410	37.470	22.653	1.727	0.000	18.3...	0.000	0.000	0.00	1834.43



Ground Floor:
150mm concrete slab on
60mm of xps floor insulation
30mm thick vertical insulation band.
The gymnasium floor also has a
22mm timber floor supported on durabella battens
All floors are on a radon barrier which is folded in to the cavity and where there are steel columns sealed to them with radon tape.

U-value = 0.16 W/(m²K)
fRsi value = The critical month is January with fRsi,max = 0.818


Surface temperature to avoid critical surface moisture: No danger of mould growth is expected.
Interstitial condensation: No condensation is predicted at any interface in any month.
OUTSIDE
1. Month of balance: January
Ti [°C] 20.0
phi_i [-] 0.713
Te [°C] 9.8
phi_e [-] 1.000
Outside
Inside
Saturation pressure
Partial pressure
Vapour pressure [Pa]
d [m]

SYSTEMS:
the building is heated with a condensing oil boiler through a wet system of radiators in all rooms.

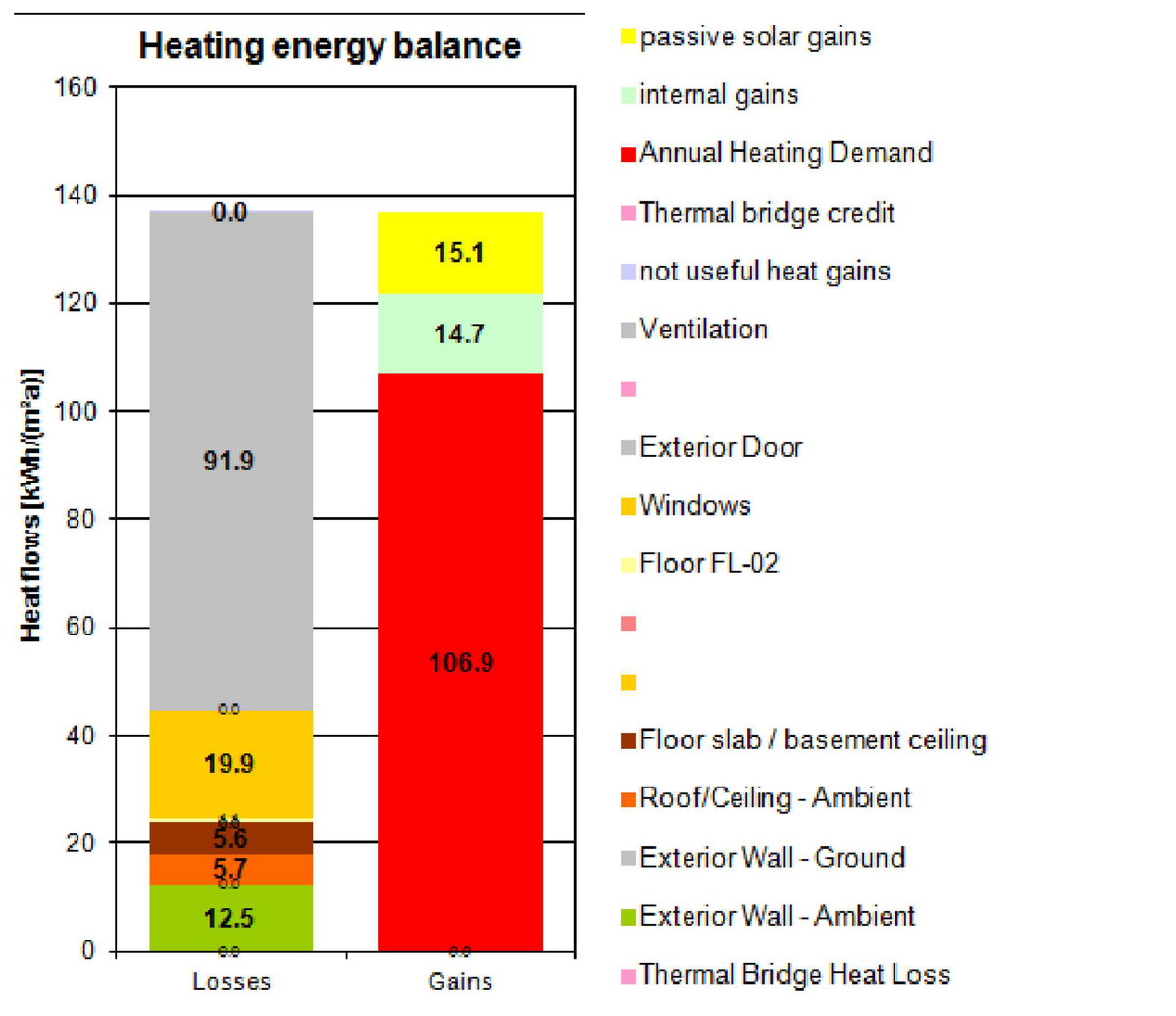
Passive house test:
The building has been assessed using the Passive house standard assessment software PHPP.
The building was assessed to have an annual heating demand of 127kW/(m2a)
while the primary energy demand is 251kW/(m2a)
The airtightness test result 4.6 1/h

Specific building demands with reference to the treated floor area — use: Monthly method

				Requirements	Fulfilled?*
	Treated floor area	1281.9	m²		
Space heating	Annual heating demand	127	kWh/(m²a)	25 kWh/(m²a)	no
	Heating load	57	W/m²	-	-
Space cooling	Overall specific space cooling demand		kWh/(m²a)	-	-
	Cooling load		W/m²	-	-
	Frequency of overheating (> 25 °C)	0.3	%	-	-
Primary Energy	Space heating and cooling, dehumidification, household electricity.	251	kWh/(m²a)	255 kWh/(m²a)	yes
	DHW, space heating and auxiliary electricity	194	kWh/(m²a)	-	-
	Specific primary energy reduction through solar electricity		kWh/(m²a)	-	-
Airtightness	Pressurization test result n_{50}	4.6	1/h	1 1/h	no

* empty field: data missing; '-': no requirement

Passive house test:
The heat loss from the building is outlined below
Ventilation 91.9kW/(m2a)
Windows 19.9kW/(m2a)
Exterior wall 12.5kW/(m2a)
Being the main contributers to the heat losses of the building, There is one issue not assessed in the inital assesement, Thermal Bredge heat loss which would contribute about 1 quater of the fabric heat loss.


Heating energy balance
Heat flows [kWh/(m²a)]
0.0
91.9
19.9
5.6
5.7
12.5
15.1
14.7
106.9
Losses
Gains
passive solar gains
internal gains
Annual Heating Demand
Thermal bridge credit
not useful heat gains
Ventilation
Exterior Door
Windows
Floor FL-02
Floor slab / basement ceiling
Roof/Ceiling - Ambient
Exterior Wall - Ground
Exterior Wall - Ambient
Thermal Bridge Heat Loss

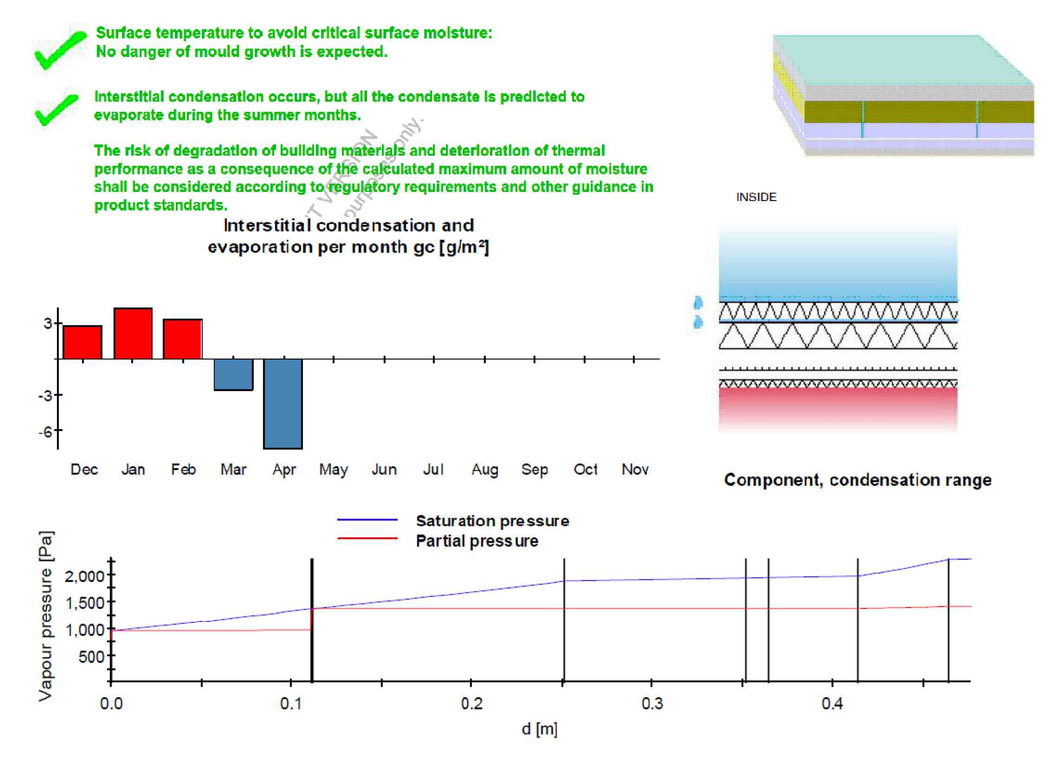
Passive house Goals
The Goal of the project is to provide an Enerphit standard in to the building, which is
Annual heating demand of 25kW/(m2a)
Primary energy demand of 120kW/(m2a)
Airtightness of 1.0 1/h
Achieving this standard without impacting on the DoE standards in place already

Passive House Procedure:
To achieve the Enerphit standard proposed by Passive House and calculated using the PHPP software a number of alterations to the building are required. As we have seen by the study of the existing building we know where the building under performers. These areas are heat loss through infiltration ventilation, Heat loss through External Walls and Windows. Further heat loss is experienced through the Floor and roof construction.

I propose to improve the construction fabric off all these elements thus reducing the heat loss to the whole building. This requires you to look at the building as a whole. Though the original design considered airtightness the fact is the building performs very badly in this aspect. So improving the airtightness goes hand and hand with the general insulation upgrade.

Taking the roof as the example of this, though the roof does not perform badly in a U-value approach we also know that the U-value is unreliable due to the construction also the underside of the aluminium panel is considered as the airtight layer this layer is penetrated to support the aluminium composite panel over head as well as the diffeculty of applying the airtight tape to the junctions with Purlins, Joists etc to be dealt with. If I apply an airtight membrane to the underside of the existing finished ceiling tape it to the existing structural concrete or newly rendered walls and cover with a 50mm insulated plasterboard sheeting taped and jointed the airtightness is improved to a standard required and the concern with the U-value calculation is corrected. Also the interstitial condensation issue is reduced but not removed without the use of a vapour barrier.

U-value = 0.13 W/(m²K)
fRsi value = The critical month is December with fRsi,max = 0.675


Surface temperature to avoid critical surface moisture: No danger of mould growth is expected.
Interstitial condensation occurs, but all the condensate is predicted to evaporate during the summer months.
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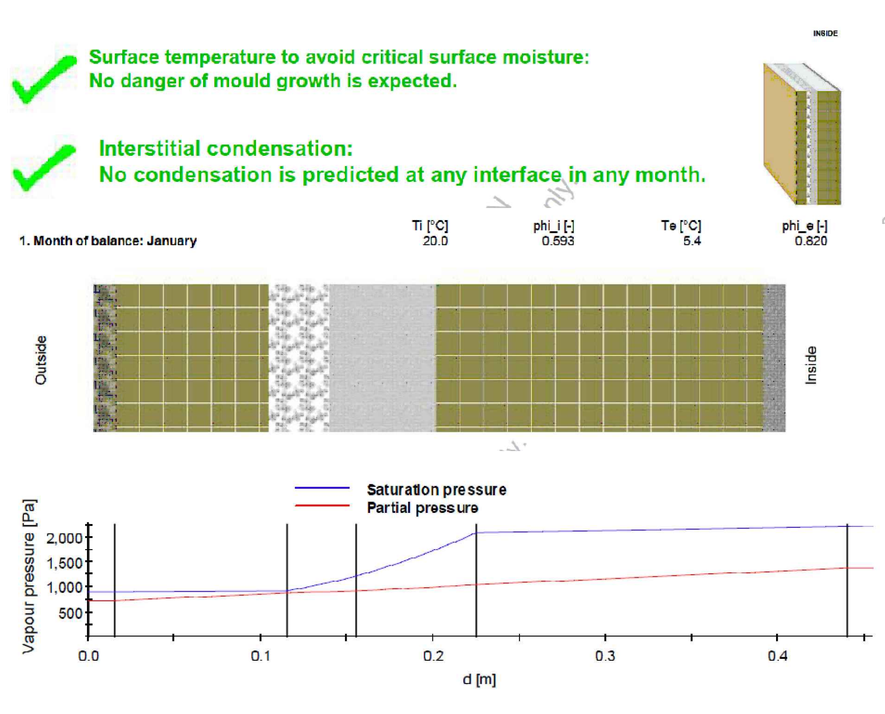
Interstitial condensation and evaporation per month gc [g/m²]
Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov
INSIDE
Component, condensation range
Saturation pressure
Partial pressure
Vapour pressure [Pa]
d [m]

Taking this approach to the External walls of the building not only is the insulation aspect of the building to be dealt with but so too the airtightness of this construction. When picking an approach to this aspect I did not want to apply an external insulation to the building as this building will be surrounded by sharp objects and a dubious maintenance schedule so filling the cavity with a beaded insulation product and rendering the internal blockwork for airtightness is my solution. additional benefits include no obvious reductions to the internal area of the building.

All the junction of the walls with the other elements and penetrations have to be taped to maintain the airtight layer inside the building. These include all the windows and doors and main junctions with roofs and floors

U-value = 0.25 W/(m²K)
fRsi value = The critical month is December with fRsi,max = 0.675


Surface temperature to avoid critical surface moisture: No danger of mould growth is expected.
Interstitial condensation: No condensation is predicted at any interface in any month.
1. Month of balance: January
Ti [°C] 20.0
phi_i [-] 0.593
Te [°C] 5.4
phi_e [-] 0.820
Outside
Inside
Saturation pressure
Partial pressure
Vapour pressure [Pa]
d [m]

No modification are proposed for the floors to the building as the expense will out weigh the benefit that could be achieved, however this does highlight the importance of considering the issues when designing especially in the heavy and permanent elements of construction.

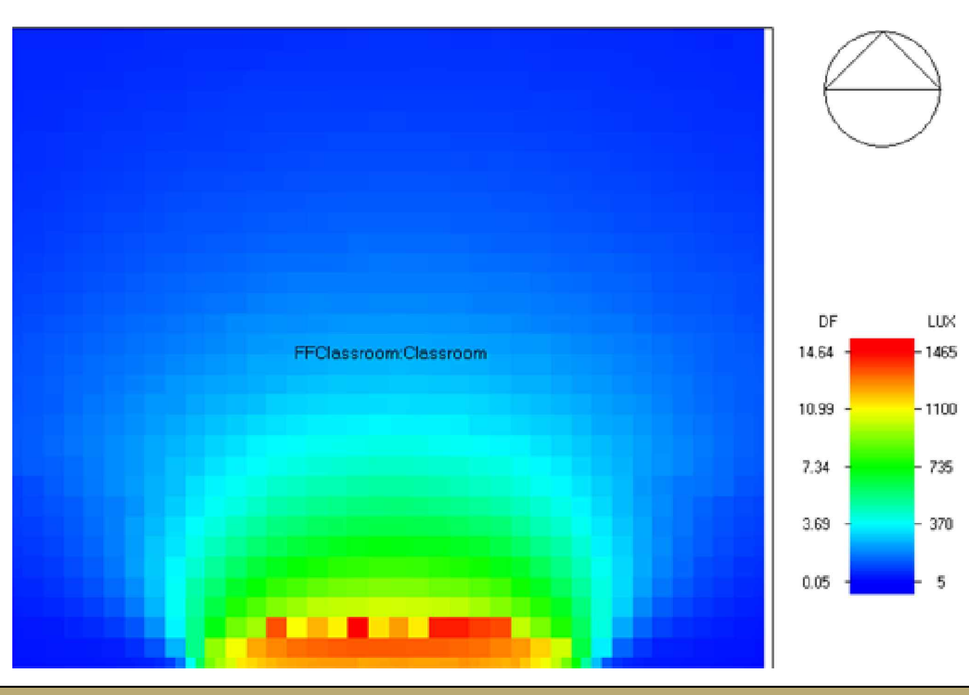
Details along the perimeter will have to be inspected and renewed if required in relation to the airtightness of the building. All skirting will have to be replaced or at least removed and repositioned.

The other element of the fabric that requires improvement is the windows and doors and even thought the existing windows are of a high standard they are still a large contribute to the heat loss of the fabric and the building will not meet the standard required without their upgrade.

I propose the building be upgraded to a triple glazed window and door system from Munster joinery. The triple glazed unit proposed has the following characteristics: A g-Value of 0.51 and a U-value of 0.50 W/m2K. There is however an issue with upgrading the windows to this standard in relation to the reduced light transmittance of the triple glazed windows. Another daylight factor test was under taken to determine the loss and the solution to the loss.

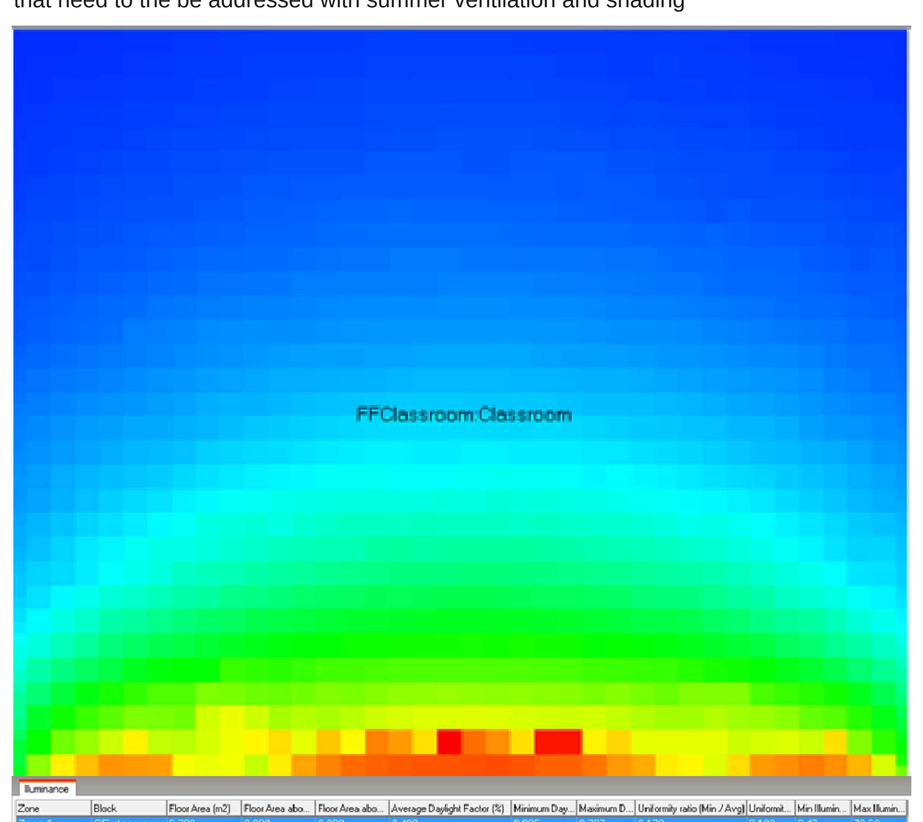
The test undertaken shows a reduction in the daylight factor to a low of 2.416 and a uniformity of 0.044%

Zone	Block	Floor Area...	Floor Area...	Floor Area...	Average ...	Minimum ...	Maximum ...	Uniformity ...	Uniformity ...	Min Illumin...	Max Illumi...
Zone 1	GF clas...	6.720	0.000	0.000	0.436	0.041	0.733	0.094	0.056	4.12	73.38
Zone 2	GF clas...	21.990	0.000	0.000	0.374	0.008	1.457	0.022	0.006	0.83	145.70
Classro...	GF clas...	46.620	18.940	40.626	2.998	0.132	17.942	0.046	0.007	13.23	1795.08
Zone 1	Trees	15.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
Zone 1	FF clas...	6.720	0.000	0.000	0.191	0.033	0.394	0.173	0.084	3.31	39.42
Zone 2	FF clas...	21.300	0.000	0.000	0.371	0.009	0.942	0.025	0.010	0.94	94.35
Classro...	FF clas...	46.620	15.010	32.196	2.416	0.101	14.541	0.044	0.007	10.13	1455.48
Total		165.410	33.950	20.525	1.584	0.000	17.942	0.000	0.000	0.00	1795.08



A proposed modification to the window arrangement with triple glazing is tested.
This assesement shows an increase in the daylight factor to 4.344 and a uniformity of 0.119%

Though these results are very good there is an overheating effect associated with PHPP that need to the be addressed with summer ventilation and shading



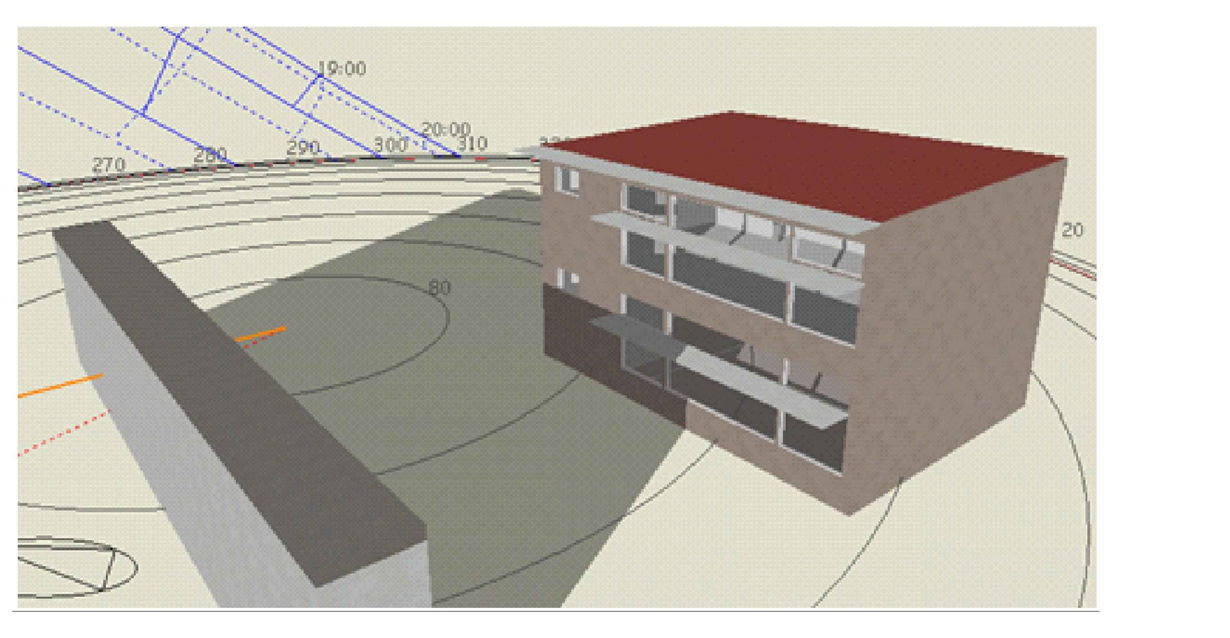
Zone	Block	Floor Area (m2)	Floor Area abo...	Floor Area abo...	Average Daylight Factor (%)	Minimum Day...	Maximum D...	Uniformity ratio (Min / Avg)	Uniformit...	Min Illumin...	Max Illumin...
Zone 1	GF classroom	6.720	0.000	0.000	0.498	0.085	0.787	0.170	0.108	8.47	78.69
Zone 2	GF classroom	21.990	1.670	7.594	0.742	0.053	4.024	0.071	0.013	5.31	402.71
Classroom	GF classroom	46.620	27.000	57.915	4.344	0.518	18.129	0.119	0.029	51.85	1813.82

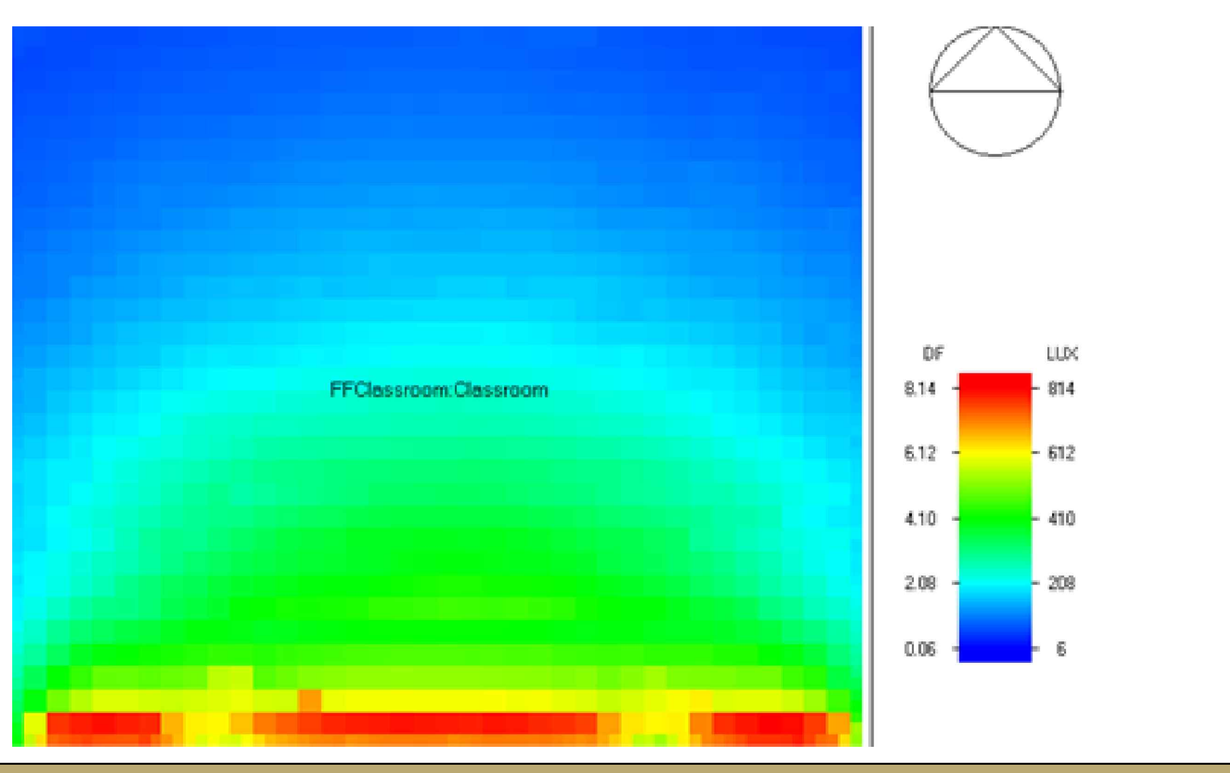
The ultimate compromise is to provide larger triple glazed windows with perminent shading. this proposal is again tested.

Daylight factors are 2.870 and a uniformity of 0.158%

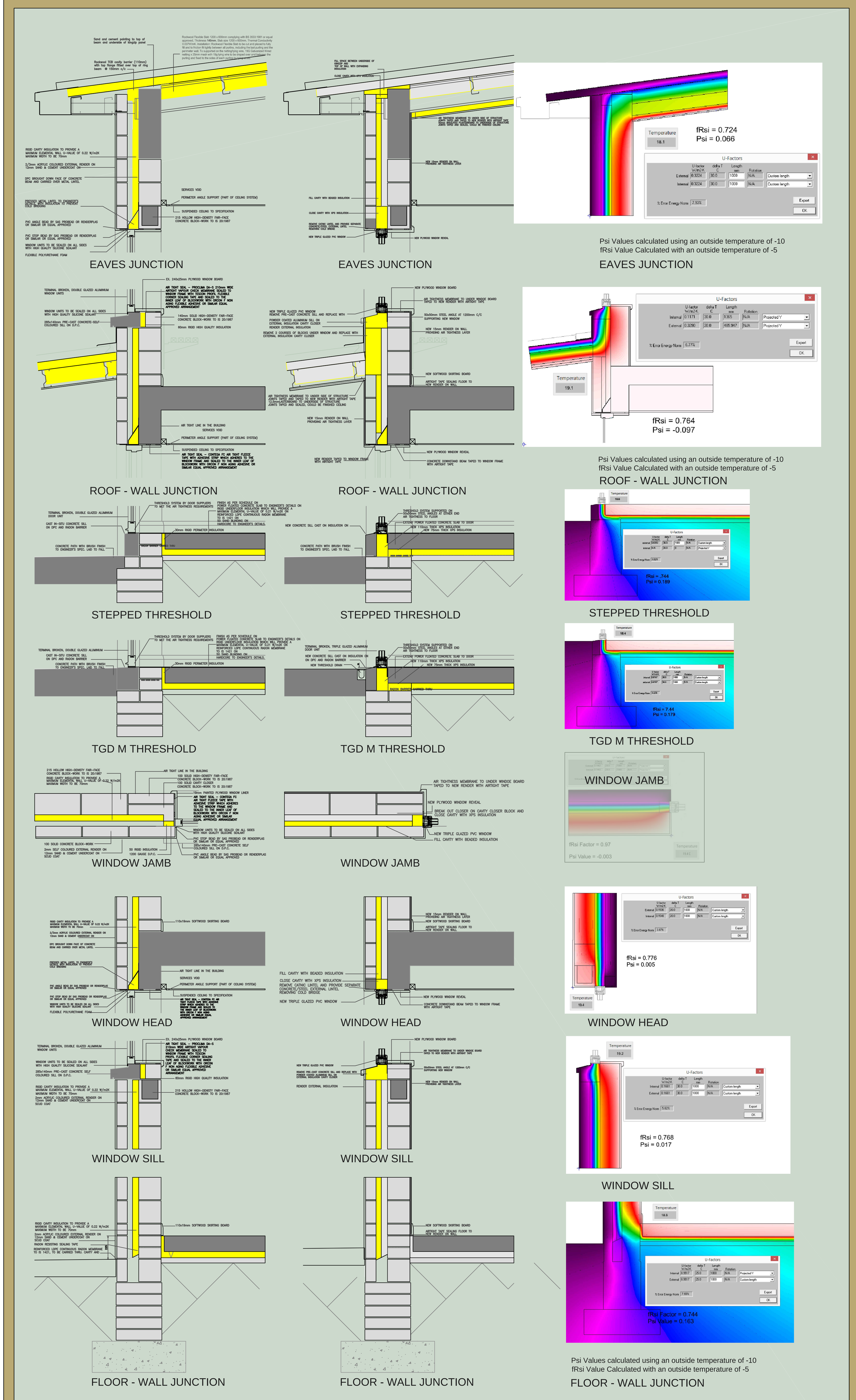
Though the Daylight factor is Reduced the uniformity stays high with the big windows. The dept of light penetration in the room is increased with the larger windows as can be seen from the chartsaccross.

Zone	Block	Floor Area...	Floor Area...	Floor Area...	Average ...	Minimum ...	Maximum ...	Uniformity ...	Uniformity ...	Min Illumin...	Max Illumi...
Zone 1	GF clas...	6.720	0.000	0.000	0.508	0.084	0.840	0.166	0.100	8.44	84.00
Zone 2	GF clas...	23.490	0.440	1.873	0.605	0.048	2.421	0.080	0.020	4.83	242.30
Classro...	GF clas...	46.620	23.570	50.558	2.870	0.454	9.727	0.158	0.047	45.45	973.07

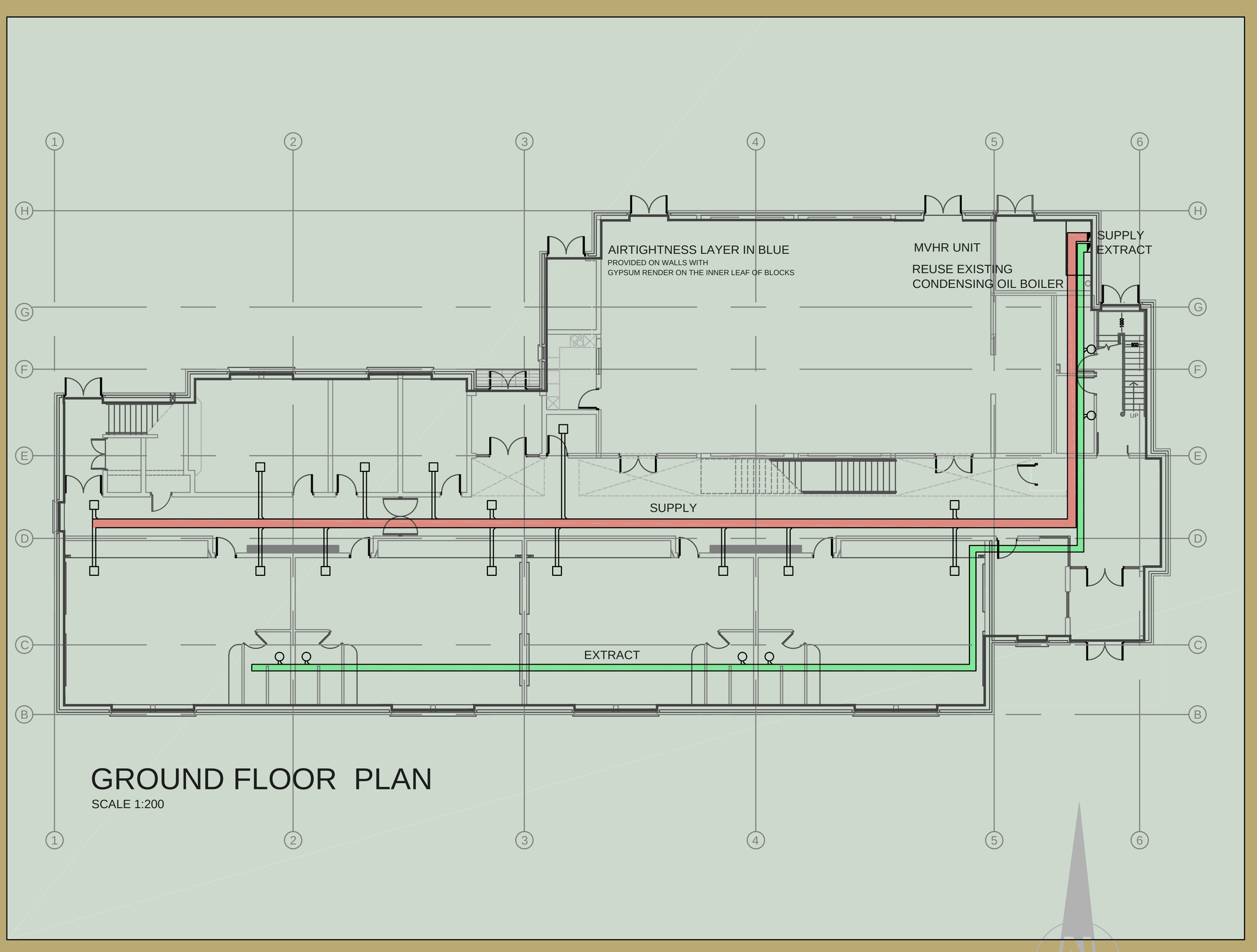


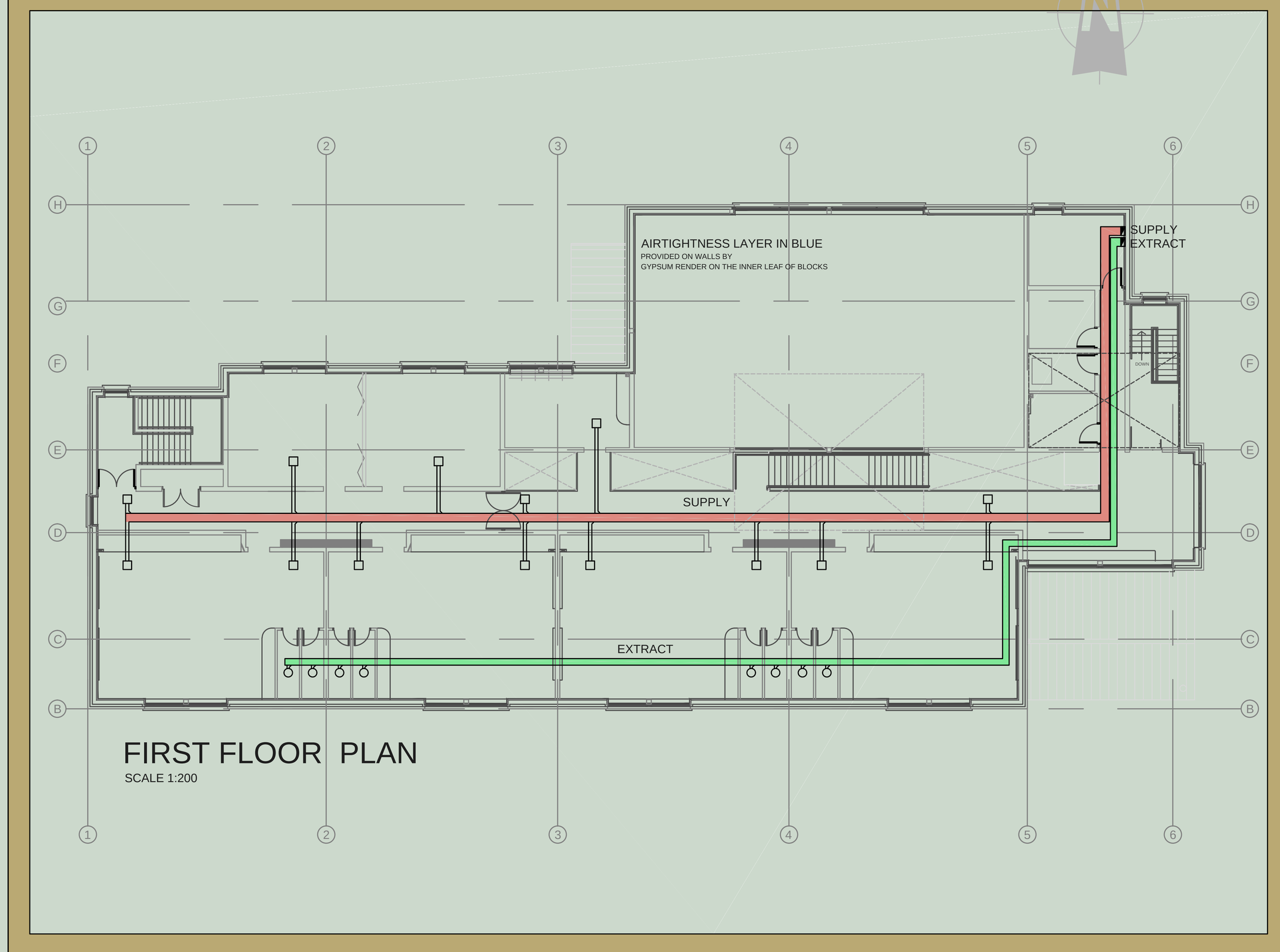



NEW WINDOWS ALLOWING FOR COMPLIANCE WITH DEPARTMENT OF EDUCATION GUIDELINES
SOLAR REFLECTORS FITTED INTERNALLY TO REFLECT LIGHT TO BACK OF CLASSROOMS
TRIPPLE GLAZED THROUGHOUT WITH U-VALUE 0.8w/m2K REQUIRED FOR REDUCED HEAT LOSS
FIXED SOLAR SHADING PROVIDED TO CONTROL INTERNAL OVER HEATING CONDITIONS


EAVES JUNCTION
EAVES JUNCTION
fRsi = 0.724
Psi = 0.066
Psi Values calculated using an outside temperature of -10
fRsi Value Calculated with an outside temperature of -5
EAVES JUNCTION
ROOF - WALL JUNCTION
ROOF - WALL JUNCTION
fRsi = 0.764
Psi = -0.097
Psi Values calculated using an outside temperature of -10
fRsi Value Calculated with an outside temperature of -5
ROOF - WALL JUNCTION
STEPPED THRESHOLD
STEPPED THRESHOLD
STEPPED THRESHOLD
TGD M THRESHOLD
TGD M THRESHOLD
TGD M THRESHOLD
WINDOW JAMB
WINDOW JAMB
WINDOW JAMB
WINDOW HEAD
WINDOW HEAD
WINDOW HEAD
WINDOW SILL
WINDOW SILL
fRsi = 0.768
Psi = 0.017
WINDOW SILL
FLOOR - WALL JUNCTION
FLOOR - WALL JUNCTION
Psi Values calculated using an outside temperature of -10
fRsi Value Calculated with an outside temperature of -5
FLOOR - WALL JUNCTION

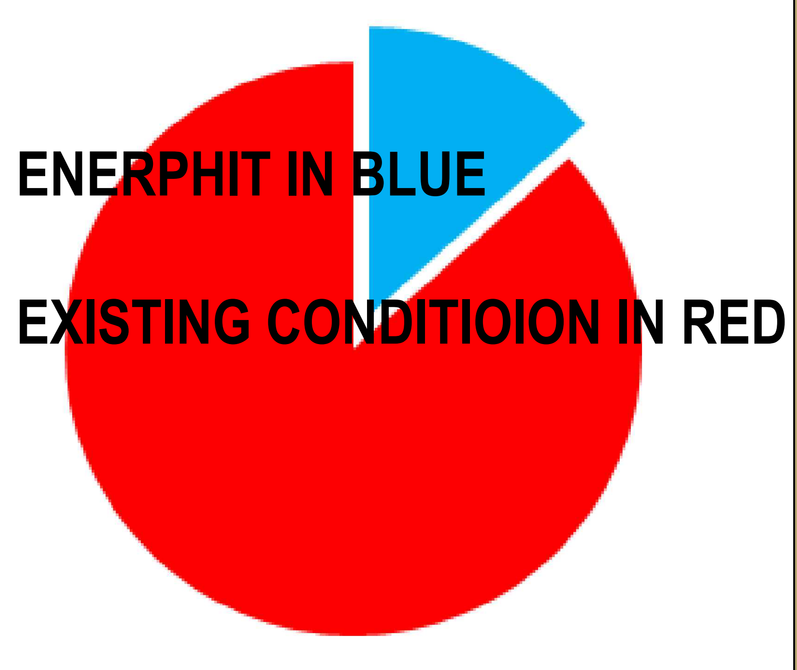
EXISTING CONDITION — PROPOSED CONDITION — THERMAL BRIDGE





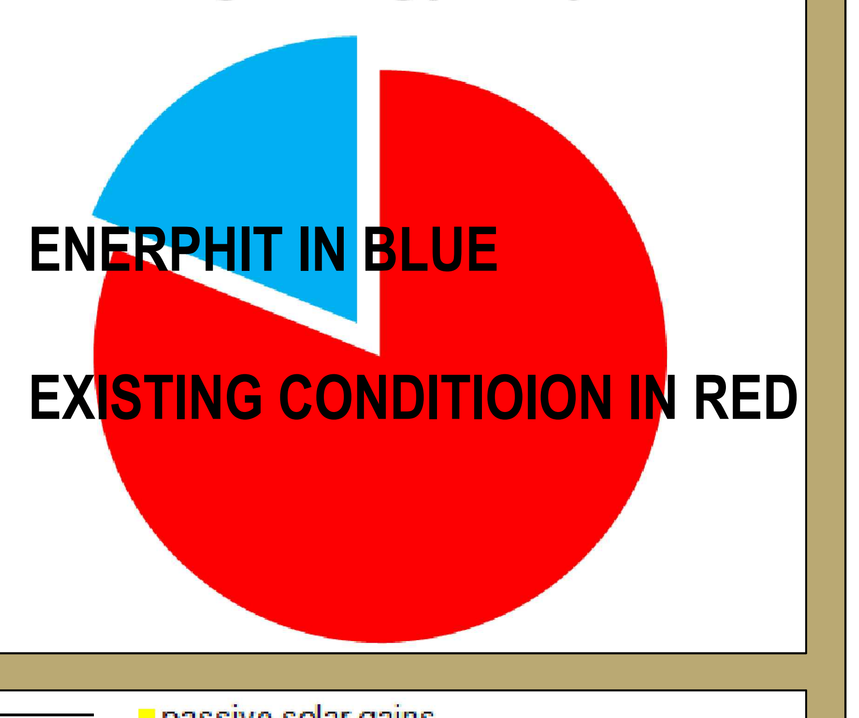

Selection of ventilation data input - Results
Selection of ventilation unit with heat recovery
Central unit within the thermal envelope.
Central unit outside of the thermal envelope.
Ventilation unit selection
0.84
0.42
1500 - 3200
yes
no
comfosystems zehnder

Ventilation Heat Loss



HEAT LOSS IS REDUCED THROUGH THE IMPROVEMENT OF AIRTIGHTNESS IN THE BUILDING. A CONTROLLED ENVIRONMENT IS PROVIDED IN WHICH TEMPERATURE IS MANAGED THROUGH HEAT RECOVERY VENTILATION

Heating Energy Required



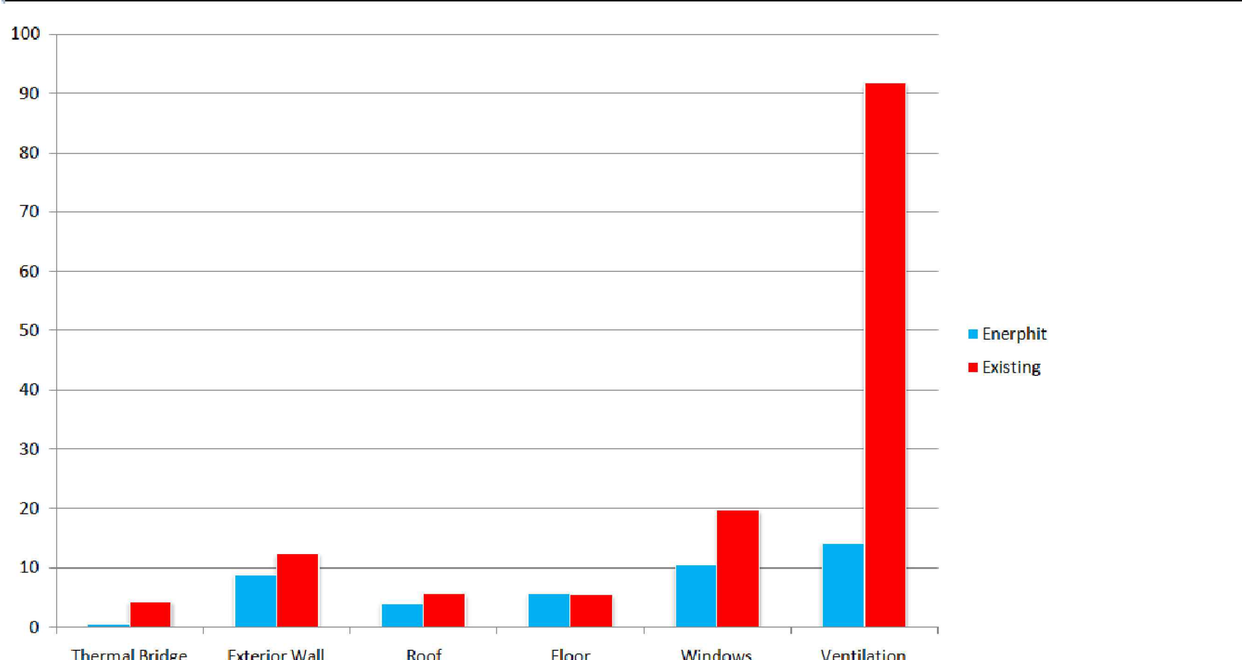
Passive House Results

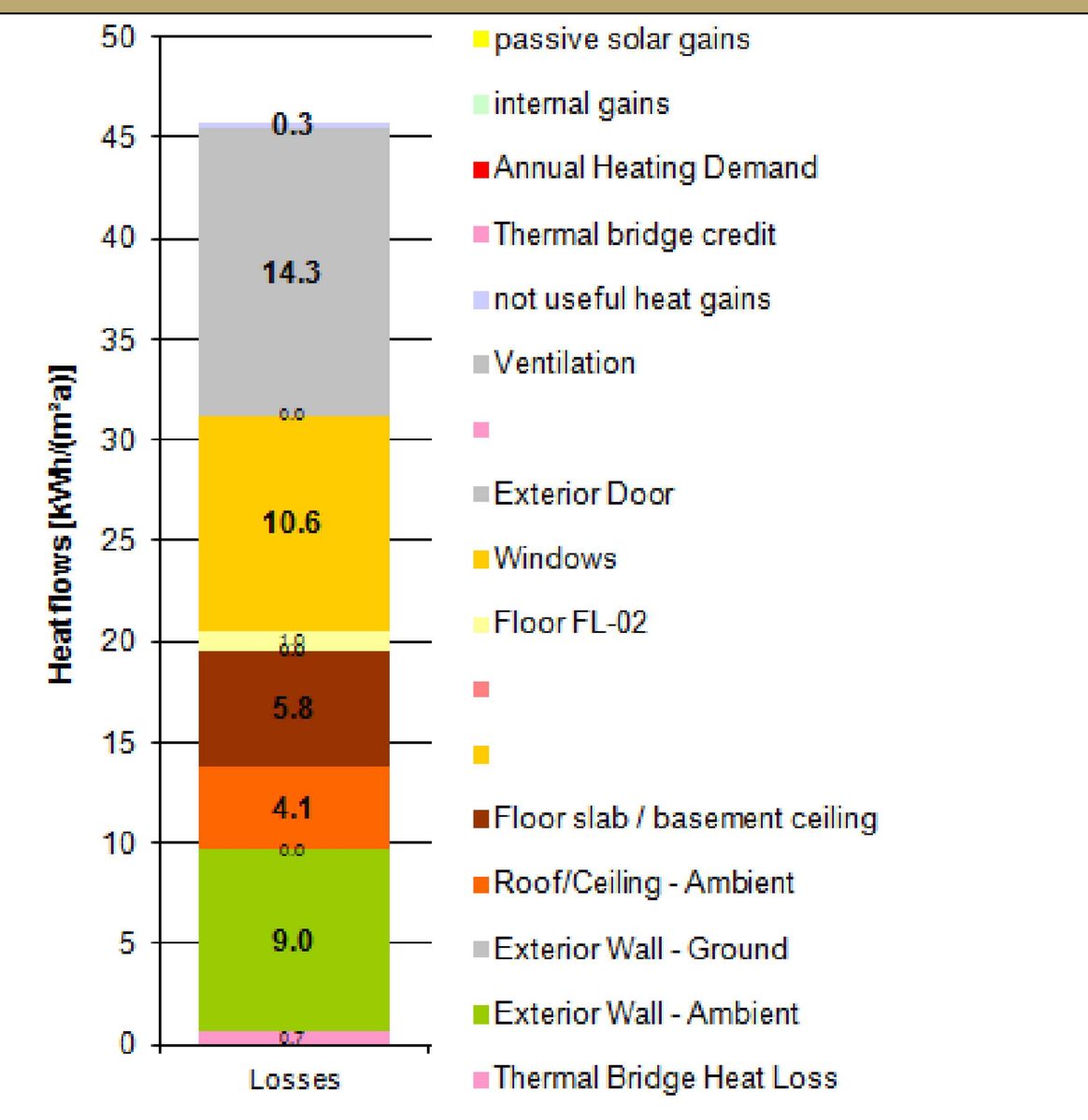
With the now vastly reduced heating load it is now possible to continue using the existing condensing oil boiler for heating space and water.

The Improved fabric and some small alterations to lighting, ie LED and more onerous lighting control systems applied improves the energy demand to a level that achieves the enerphit standard as set out by Passive House.

Boiler Type	(Project)	Condensing boiler oil		
Primary Energy Factor	(Data worksheet)	1.1	kWh/kWh	
CO_2-Emissions Factor (CO_2-Equivalent)		310	g/kWh	
Useful Heat Provided	Q_{Use}	57146	kWh/a	
Max. Heating Power Required for Heating the Building	P_{SH} (Heating Load worksheet)	20.31	kW	
Length of the Heating Period	t_{HP}	5237	h	
Length of DHW Heating Period	t_{DHW}	8760	h	

Boiler			PE Value	CO_2-Emission Factor (CO_2-Equivalent)
Covered Fraction of Space Heating Demand	(Project)	100%	kWh/kWh	g/kWh
Covered Fraction of DHW Demand	(Project)	100%	1.1	310
Boiler Type	(Boiler worksheet)	Condensing boiler oil		
Performance Ratio of Heat Generator	(Boiler worksheet)	100%		
Annual Energy Demand (without DHW Wash&Dish)	(Boiler worksheet)	44.5	49.0	13.8
Non-Electric Demand, DHW Wash&Dish	(Electricity worksheet)	0.0	0.0	0.0
Total Heating Oil/Gas/Wood		44.5	49.0	13.8




Heat flows [kWh/(m²a)]
0.3
14.3
10.6
5.8
4.1
9.0
Losses
passive solar gains
internal gains
Annual Heating Demand
Thermal bridge credit
not useful heat gains
Ventilation
Exterior Door
Windows
Floor FL-02
Floor slab / basement ceiling
Roof/Ceiling - Ambient
Exterior Wall - Ground
Exterior Wall - Ambient
Thermal Bridge Heat Loss

Passive House Results

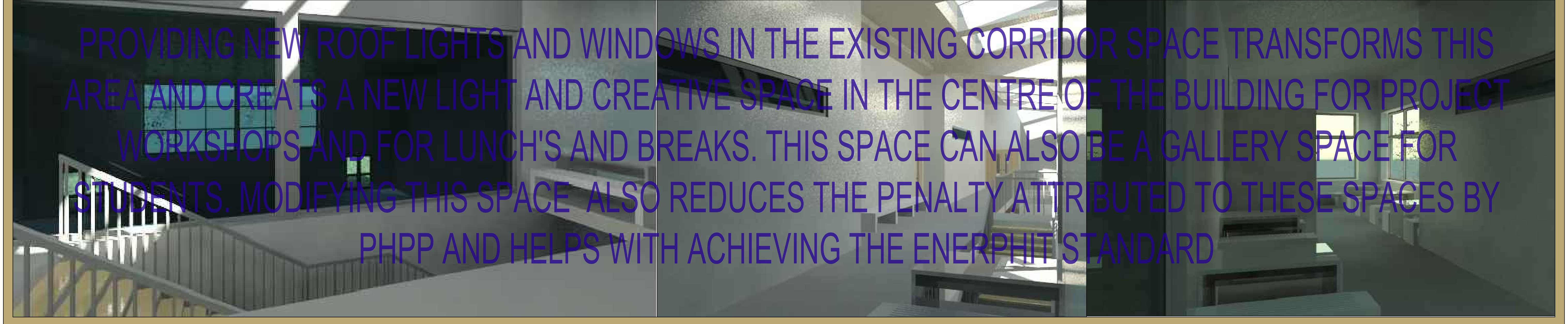
The new heat loss figures through the retrofitted building fabric is outlined to the left

Ventilation heat loss is reduced from 91.9kW/(m2a) to **14.3kW/(m2a)**
Windows heat loss is reduced from19.9kW/(m2a) to **10.6kW/(m2a)**
Exterior wall heat loss is reduced from 12.5kW/(m2a) to **9kW/(m2a)**

Thermal Bridge heat loss has been calculated and measures taken to reduce its impact and the total heat loss through LTB's is **0.7kW/(m2a)**

There is a slight reduction in the heat loss through the roof but the effect of the retrofit work to the roofs and ceilings can be seen in the drastic reduction in the heat loss from ventilation. there is a slight increase in heat loss through the floor.

HEAT LOSS WITH FABRIC RETROFIT COMPLETE


PROVIDING NEW ROOF LIGHTS AND WINDOWS IN THE EXISTING CORRIDOR SPACE TRANSFORMS THIS AREA AND CREATES A NEW LIGHT AND CREATIVE SPACE IN THE CENTRE OF THE BUILDING FOR PROJECT WORKSHOPS AND FOR LUNCH'S AND BREAKS. THIS SPACE CAN ALSO BE A GALLERY SPACE FOR STUDENTS. MODIFYING THIS SPACE ALSO REDUCES THE PENALTY ATTRIBUTED TO THESE SPACES BY PHPP AND HELPS WITH ACHIEVING THE ENERPHIT STANDARD

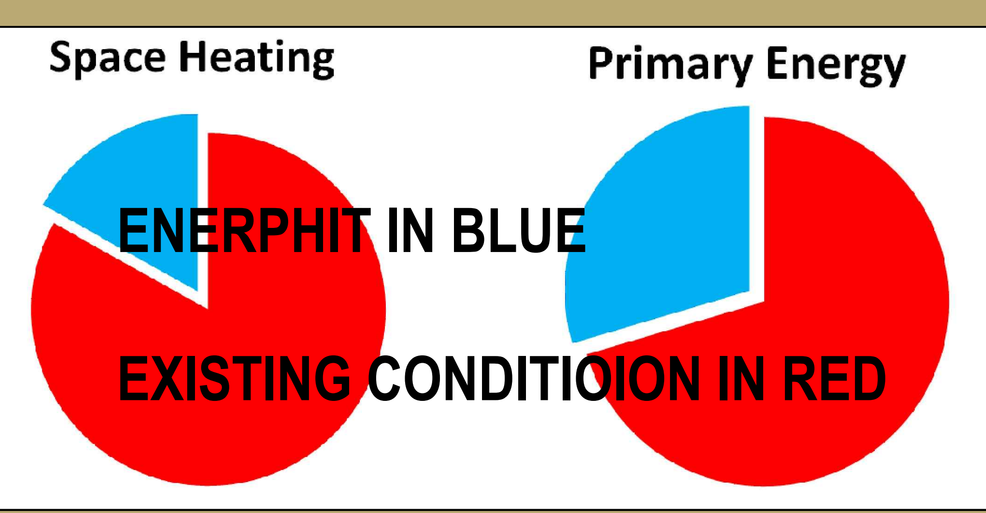
Specific building demands with reference to the treated floor area — use: Monthly method

				Requirements	Fulfilled?*
	Treated floor area	1383.2	m²		
Space heating	Annual heating demand	25	kWh/(m²a)	25 kWh/(m²a)	yes
	Heating load	15	W/m²	-	-
Space cooling	Overall specific space cooling demand		kWh/(m²a)	-	-
	Cooling load		W/m²	-	-
	Frequency of overheating (> 25 °C)	0.3	%	-	-
Primary Energy	Space heating and cooling, dehumidification, household electricity.	102	kWh/(m²a)	132 kWh/(m²a)	yes
	DHW, space heating and auxiliary electricity	60	kWh/(m²a)	-	-
	Specific primary energy reduction through solar electricity	2	kWh/(m²a)	-	-
Airtightness	Pressurization test result n_{50}	1.0	1/h	1 1/h	yes

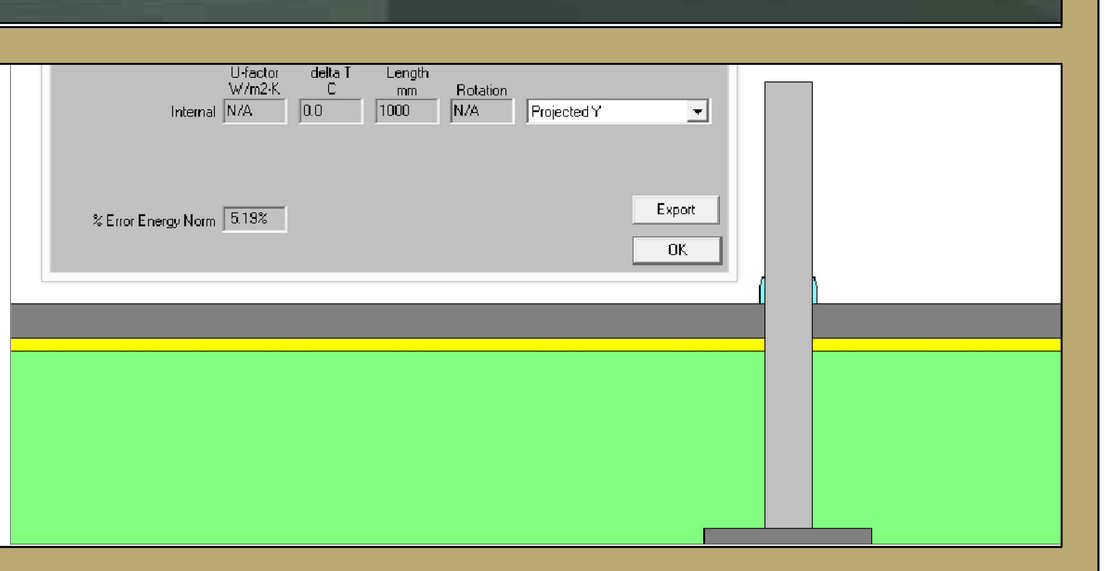
* empty field: data missing; '-': no requirement

RETROFIT SCHOOL COMPLIES WITH PASSIVE HAUS STANDARD FOR RETROFIT SPACE HEATING 25kWh/m2

RETROFIT SCHOOL COMPLIES WITH PASSIVE HAUS STANDARD FOR RETROFIT PRIMARY ENERGY 132kWh/m2



EnerPHit



TOM DOWNES - PG Dip DEAR - ENERPHIT

DIT — seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND