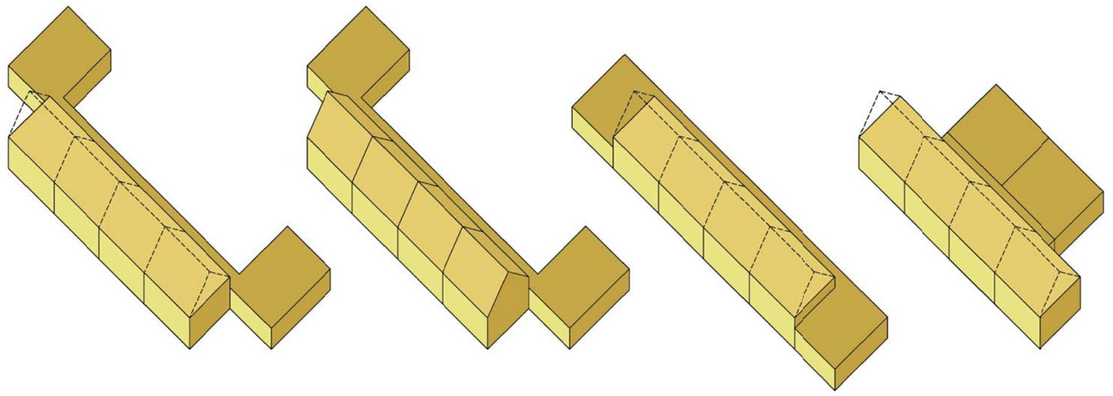
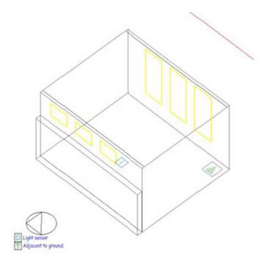
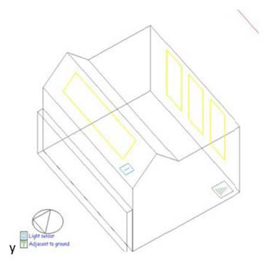
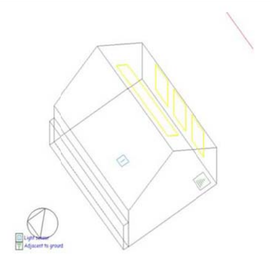
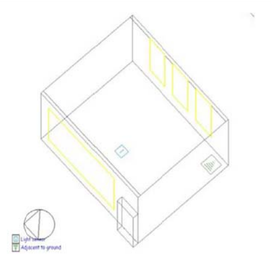
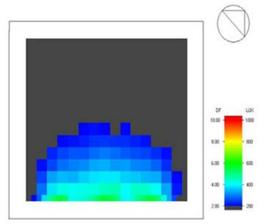
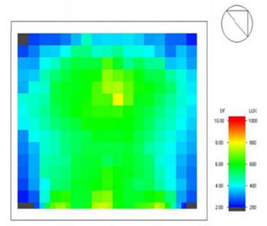
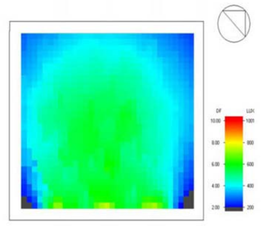
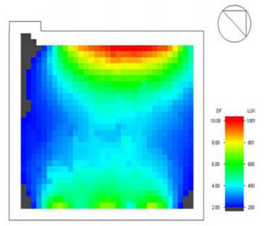
form

Specification	
Walls	0.12
Roof	0.10 / 0.11
Floors	0.085
Windows	0.75
Air Tightness	1 ach
Heat Recovery	83%



	BASE	OPTION 1 (thermal envelope encloses entire building volume)	OPTION 2 (toilet blocks moved to bookend the classroom block)	OPTION 3 (toilet blocks moved to the middle of the corridor)
External Surface Area	1,370 m^2	1,490 m^2	1,290 m^2	1,175 m^2
Ventilation Volume	1,076 m^3	1,310 m^3	1076 m^3	1,024 m^3
Treated Floor Area	314 m^2	314 m^2	314 m^2	291 m^2
Space Heating Demand	**30 kWhr/m^2a**	**34 kWhr/m^2a**	**28 kWhr/m^2a**	**24 kWhr/m^2a**
Primary Energy Demand	**126 kWhr/m^2a**	**138 kWhr/m^2a**	**121 kWhr/m^2a**	**116 kWhr/m^2a**

classroom daylight

ENERPHIT OPTIONS	1. Existing upgraded	2. Introduce north roof lights	3. Introduce south roof lights	4. Demolish corridor & glaze north wall
				
				
Daylight Factor (Avg.)	**1.82 %**	**4.79 %**	**4.46%**	**4.25%**

energy reduction steps

		Available Solar Gains kWh/m^2a	Internal Gains kWh/m^2a	Airtight-ness Ach	Over-heating %	Heating Load W/m^2	**Heating Demand kWh/m^2a**	**Energy Demand kWh/m^2a**
Base		37.2	24.5	10.6	0	161	**528**	**813**
1	Airtightness improved to 1 Ach	37.2	24.5	1	0	109	**434**	**702**
2	U-values Improved (Walls 0.14, Roof 0.10, Timber Floor 0.09)	37.2	24.5	1	0	47	**165**	**384**
3	Windows Improved (u-Value 0.75, g-factor 0.6)	30.0	24.5	1	0	39	**134**	**346**
4	Heat Revovery Installed (84% efficiency, 0.38 Wh/m3)	26.5	22.4	1	0	26	**80**	**283**
5	Replace Concrete Floor (U-value 0.09)	30	24.5	1	8.5	19	**39**	**236**
6	Adjusted Thermal Mass setting to Massive	30	24.5	1	6.5	19	**37**	**233**
7	Reduced U-Values Further (Walls 0.11, Roof 0.10, Floor 0.085)	30	24.5	1	9.4	18	**31**	**227**
8	Reduced framing percentage, omitted clerestory windows	31.2	24.5	1	19.8	17	**27**	**222**
9	Reduced Hot water demand	33.6	24.5	1	11.1	17	**27**	**160**
10	Reduce Lighting Load and use Lighting Control	33.6	24.5	1	11.1	17	**27**	**142**
11	Change boiler to Heat Pump and Space Heating to Electric	33.6	24.5	1	11.1	17	**27**	**125**
12	Input correct areas according to new insulation values	33.6	24.5	1	10.3	17	**29**	**130**
13	Improved u-values and windows (Walls 0.10, Windows (0.56)	27.5	20.4	1	31.6	17	**25**	**120**

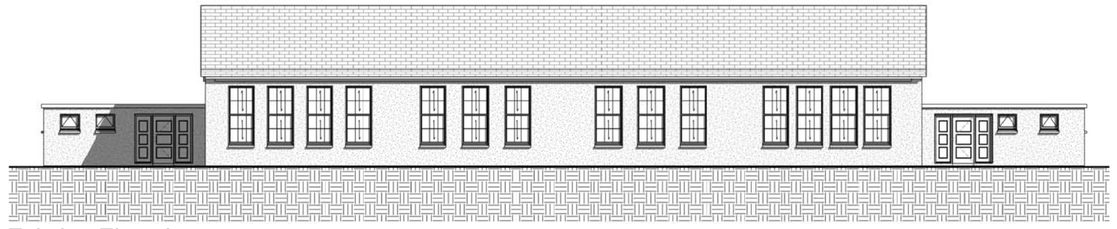
existing school

Specification:		U-Value	
Wall Type 1	(325mm)	1.735	(25mm render, 100mm block, 75mm cavity, 100mm block, 25mm wet plaster)
Wall Type 2	(440mm)	1.504	(25mm render, 100mm block, 75mm cavity, 215mm block, 25mm wet plaster)
Roof Type 1	(pitched)	0.633	(12.5mm plasterboard, 50mm fibreglass insulation between ceiling joists)
Roof Type 2	(flat)	1.279	(18mm asphalt, 98mm concrete, 22mm cork insulation, 3mm plaster)
Floor Type 1	(timber)	0.452	(22mm timber floor boards on suspended ventilated joists)
Floor Type 2	(concrete)	0.978	(18mm tile, 25mm concrete screed, 100mm concrete slab)
Windows		2.560	(1.8W/m²K frames, 2.7W/m²K glazing)

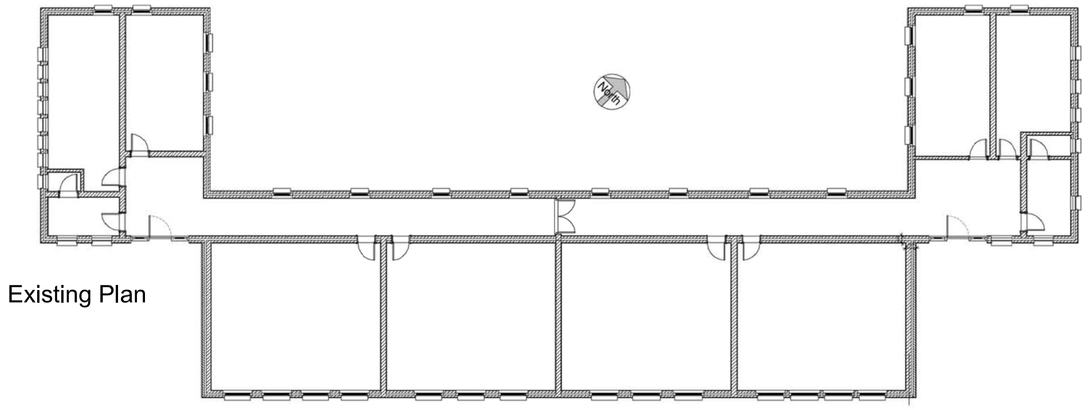
Air Tightness 10.6 Ach @n50

Ventilation Natural background trickle vents in windows

AnnualHeating Demand	**528kWh/m2a**
Heating Load	161 W/m2
Primary Energy	813kWh/m2a
Total Heating Energy	165,693 **kWh**
Total Primary Energy	**255,132 kWh**

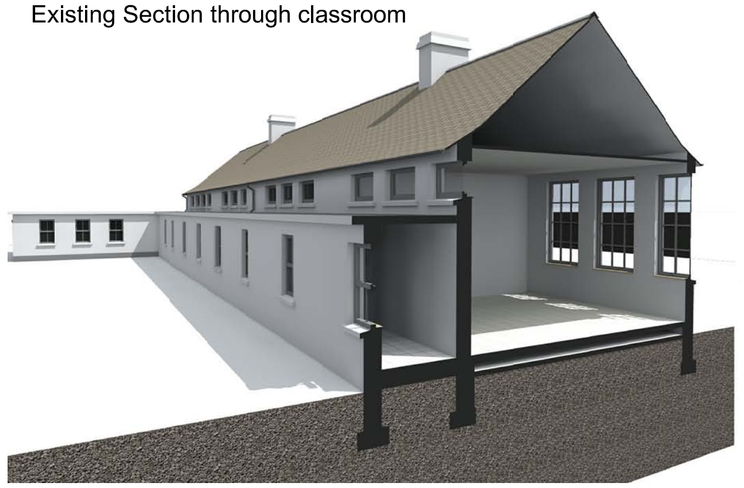


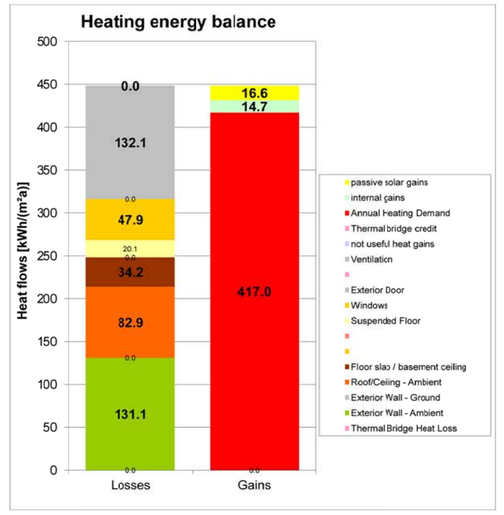
Existing Elevations

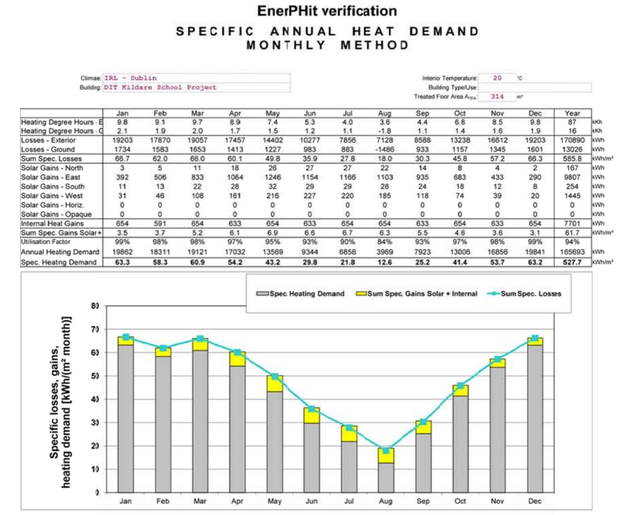


Existing Plan

Existing Section through classroom

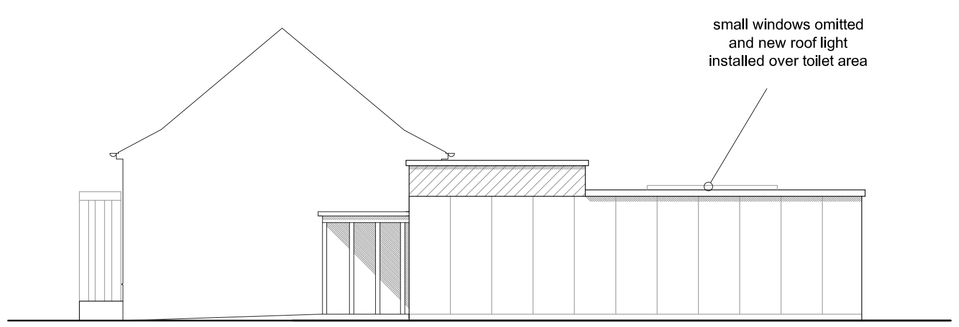




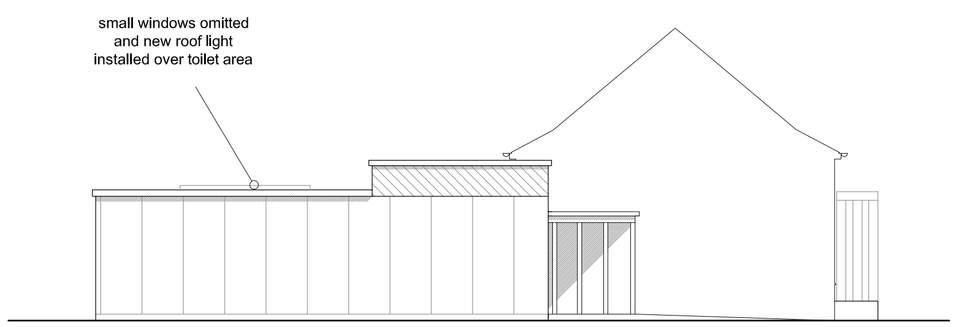


elevations

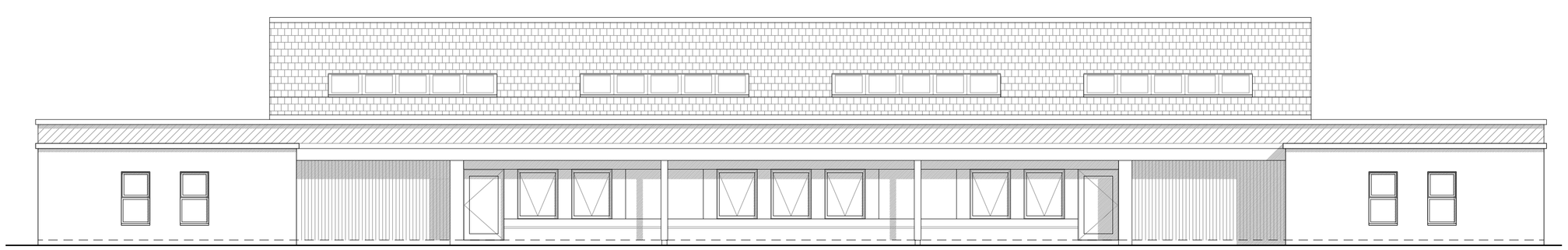
FRONT (SOUTHEAST) ELEVATION 1:100



SIDE (NORTHEAST) ELEVATION 1:100



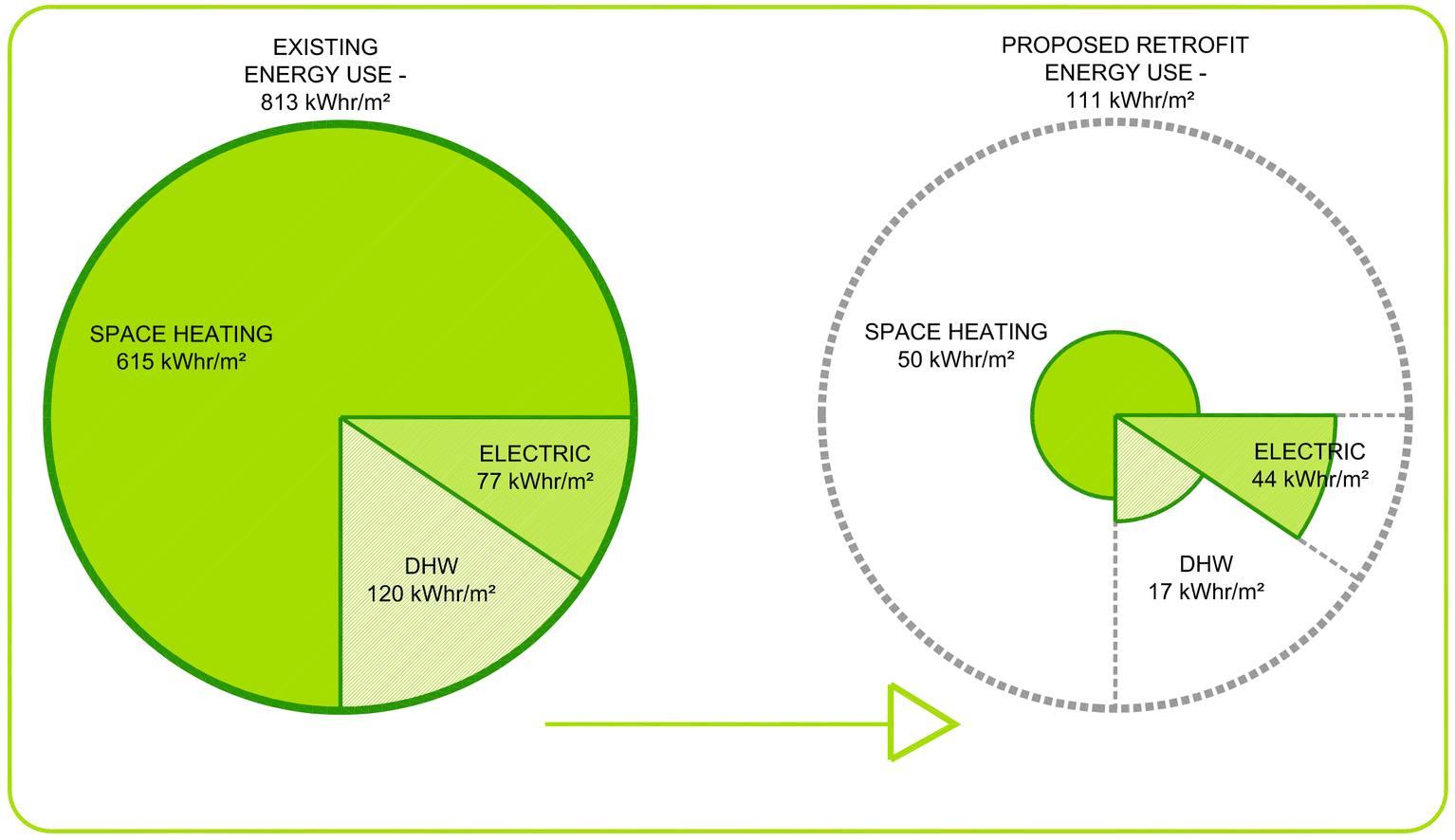
SIDE (SOUTHWEST) ELEVATION 1:100

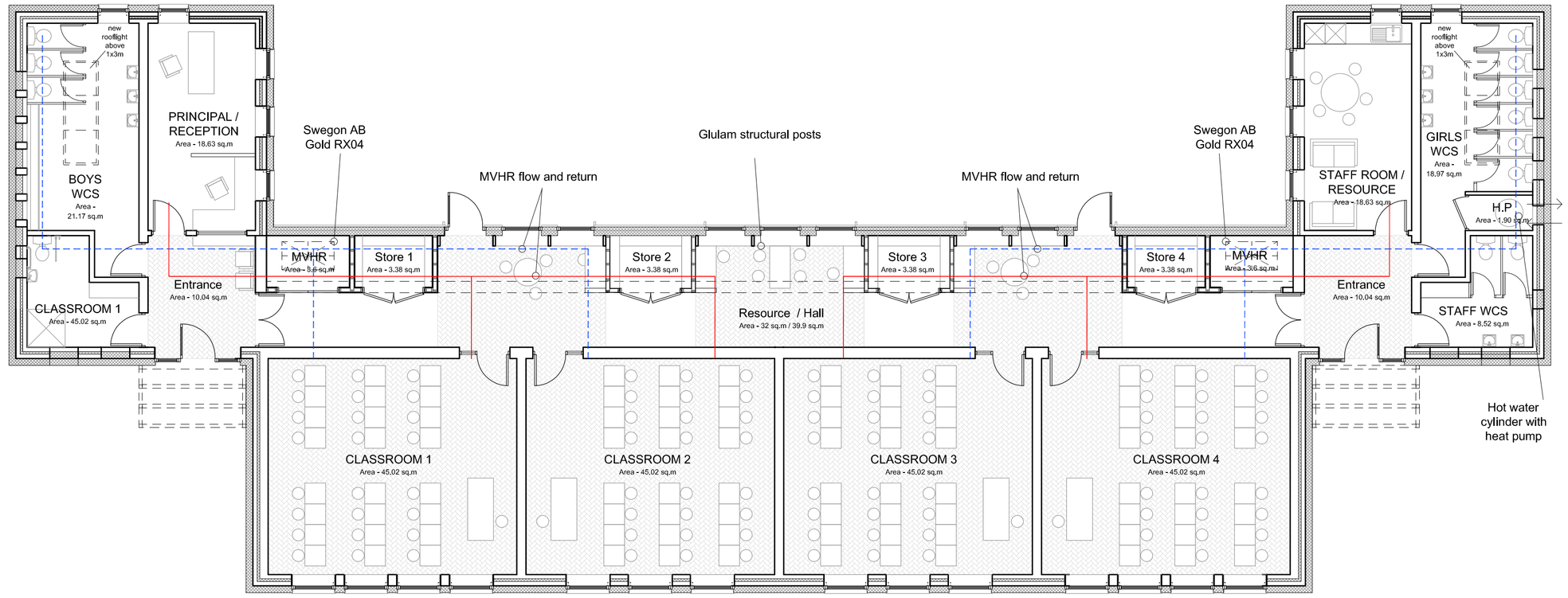


REAR (NORTHWEST) ELEVATION 1:100

ENERPHIT PRIMARY SCHOOL

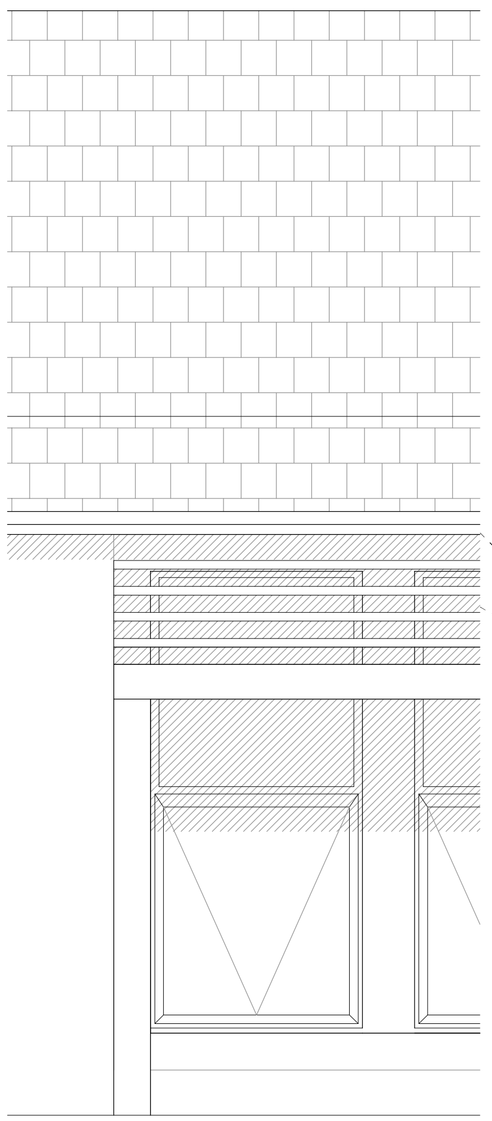
primary energy demand





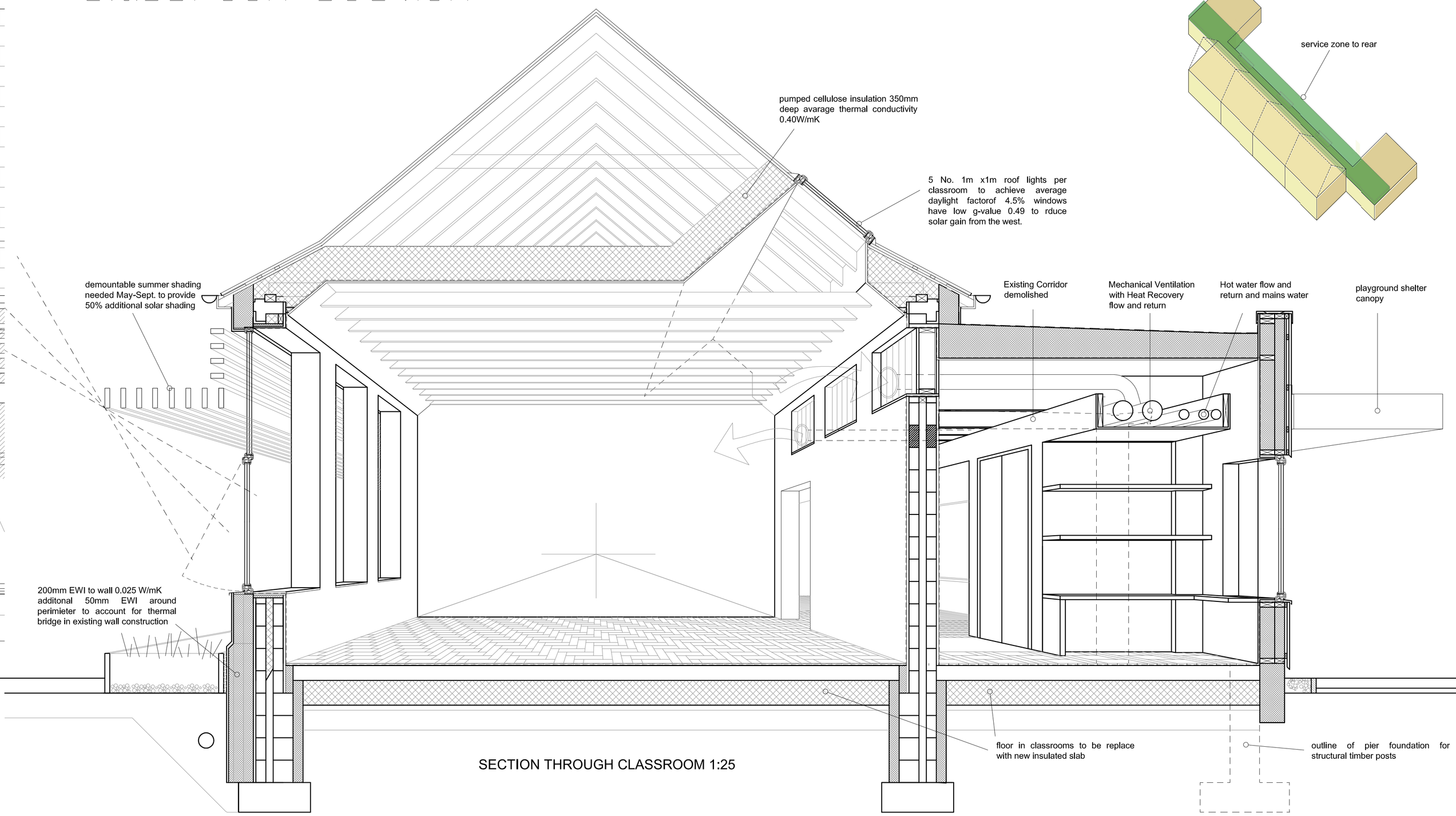
GROUND FLOOR PLAN 1:100

front



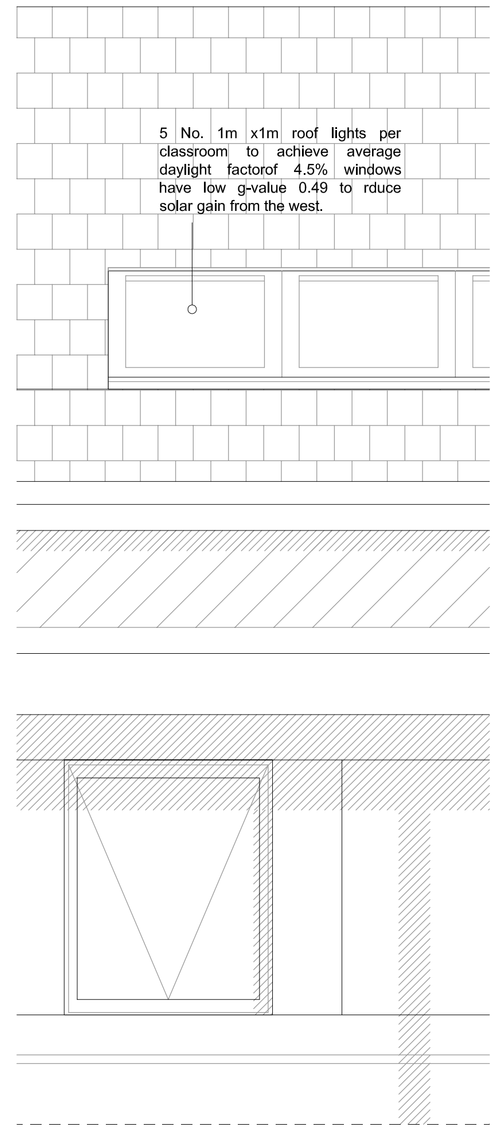
FRONT ELEVATION DETAIL 1:25

classroom section



SECTION THROUGH CLASSROOM 1:25

rear

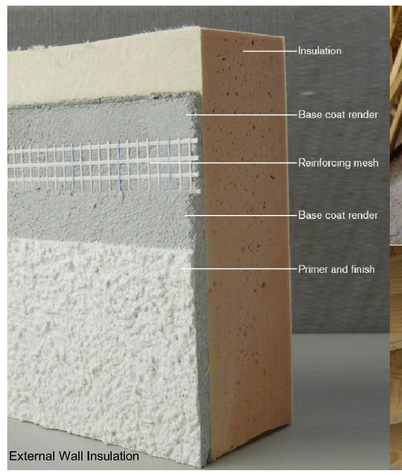


REAR ELEVATION DETAIL 1:25

spec.

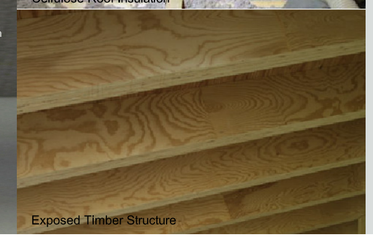
OCCUPANCY:	VENTILATION:	SPACE HEATING:	SUMMER SOLAR SHADING:
100 people	Volume: 1338 m³ Infiltration Rate: 1Ach @50Pa System: Mechancial Ventiatlion with Heat recovery Product: Swegon AB Gold RX04 Efficiency: 85% Length of Outdor Duct: 3m intake, 3m extract Delivered Ventilation Rate: 15 l/sperson	Primary : Heat Electric Coil in MVHR system Secondary: Back up Electric Room Heaters	Temporary Shading Louvres to south east facing classroom windows to provide 50% shading. Classrom Windows at low and high level and windows long corridor can to be opened (min. 100mclear width) to provide summer ventilation (addtional 0.64 Ach)
TREATED FLOOR AREA		**HOT WATER SUPPLY:**	**SPACE HEATING DEMAND:**
362.5 m²	**EQUIPMENT GAINS**	Demand: 4l/person/day - 400 litres System: Kingspan Aeromax Plus Efficiency : 396% Circulation Route -85m Circulation Pipes Insulation - 15mm (0.04W/mK) Hot Taps: 25m of pipe	**21 kWhr/m²/yr**
U-VALUES:	17 No. PCs (Hardrive & Mointor) 1 No. Photocopier 1 No. Printer 1 No. Telephone system 1 no. Cooker 1 no. Dishwasher 1 No. Fridge	**ARTIFICIAL LIGHTING:**	**PRIMARY ENERGY DEMAND:**
		Lighting Control -Automatic and not permanently on Luminaire Type - T5 fluorescent dimmable Luminaire Efficiency - 2W/100lux/m²	**111 kWhr/m²/yr**

External Wall 1 -	0.099 W/m²K
External Wall 2 -	0.098 W/m²K
External Wall 3 -	0.114 W/m²K
Pitched Roof -	0.108 W/m²K
Concrete Roof -	0.093 W/m²K
Timber Roof -	0.097 W/m²K
Concrete Floor -	0.080 W/m²K
Window Glazing -	0.057 W/m²K (g-0.61)
Window Frames -	0.074 W/m²K
Roof Window Glazing -	0.058 W/m²K (g-0.49)
Roof Window Frames -	0.074 W/m²K



External Wall Insulation


Cellulose Roof Insulation


Exposed Timber Structure

Air to Water Heat pump for hot water supply



Swegon AB Gold RX04 MVHR unit

text

It is proposed to upgrade an existing primary school constructed in the 1930s to Passiv Haus Enerphit standard. The existing building consists of four classrooms, an office, a staffroom, toilet facilites and circulation areas and had an annual primary energy demand of 813kWhr/m² when analysed using the Passiv Haus Planning Package or a total consumption of 255,130 kWhr. Space heating at 615kWhr/m² (75%) was the greatest energy use with the hot water demand second at 120kWhr/m² (15%) and the remaining 77kWhr/m² (10%) consumed by electrical fitting and equipment.

The annual heating demand for the building was 528kWhr/m² which was provided by a condensing gas boiler giving the primary energy demand of 615kWhr/m². A space heating demand of 25kWhr/m² or less is required to achieve Enerphit standard. This equates to 95% reduction in space heating.

The major heat loss elements were as follows: Ventilation (29.5%), Extenal Walls (29.4%), Roof (18.5%), Windows (10.6%), Concrete Floor (7.6%), Timber Floor (4.4%)

A series of retrofit measures were explored using the PHPP software to tackle each of the major heat loss elements in order of significance. It became clear that all elements would need to be addressed in equal measures to achieve the required reductions. Note the 95% reduction would mean that the total building losses would be almost equal to the total losses through the existing timber floor alone.

Due to the high ratio of external envelope to floor area and enclosed volume to floor area (4.06 : 1 and 3.40 : 1 respectively). A study was also carried which found that the form of the building had a major effect on the energy losses. An iterative process upgrade proposals revealed that a highly insulated thermal envelope would be necessary with an average u-value of 0.10W/m²K for opaque elements and 0.60W/m²K for windows and doors.

A daylight study was also carried out in parallel to the PHPP studies. Triple glazed windows would also have a lower light transmission than the existing double glazed windows and with the addition of external insulation the existing clerestory windows would be redundant. This resulted in a reduction in average daylight factor from 2.4% to 1.8% for a typical classroom. The Department of Education require a miniumum level of 4.5% for new build. A series of interventions were explored and it was found that introducing north facing roof lights to the classrooms had the best effect in terms of achieving the required daylight levels with mimimal increased heat loss.

An intervention is proposed as part of the retrofit measures to provide adiitional floor area. The existing corridor is narrow, dark and an inefficient use of space. The Passiv Haus Institue allows only 60% of these types of space to be counted as useful/ treated floor area. It is proposed to extended the width of the corridor and to introduce informal teaching / break out spaces equivalent to two 16sq.m resource rooms. Theses space are seperated by new stroage areas , one per classroom. Space for the MVHR units is also provided in this new area creating a new service spine along the building with ventilation duct and hot water pipe runs.

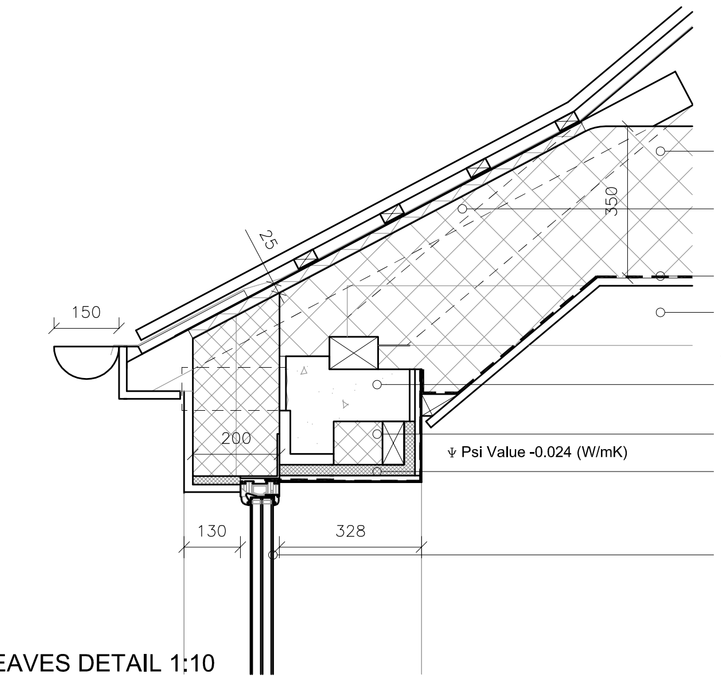
This new space will provide a place for display and cross over between classes and students. It will also provide a place to display information on the retrofit works including digital display and moniroring devices so teachers, students, and the public can learn from the building works. It is important that projects like this have a legacy and act as exemplars. Schools and education facilities represent an obvious route to informing the wider public about the possibilites of deep retrofit.

The proposed specification achieves a space heating demand of 25kWhr/m² and a primary energy demand of 120kWhr/m² (or a total of 37,676kWhr/yr). Including the proposed extension the building achieves a a space heating demand of 21kWhr/m² and a primary energy demand of 111kWhr/m² (or a total of 40,238 kWhr/yr).

The reduced space heating is to be provided by an electric coil in each of the two MVHR units with back up electric room radiators. Hot water demand was reduced by reducing the demand per person to 4l/pers./day inline with Department of Education guidelines. The resultant demand is then to be met by an air to water heat pump. Efficiencies could be further improved by using the exhaust MVHR air in conjunction with the heat pump.

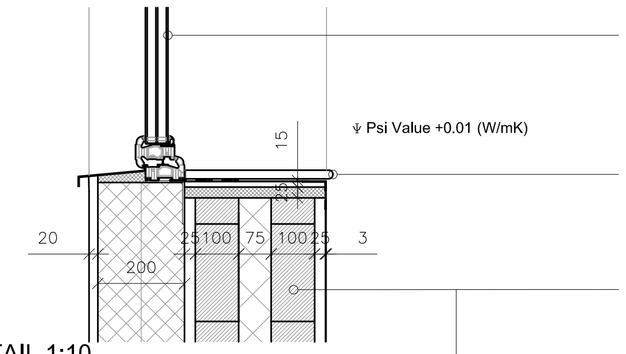
The improvements in the daylight availability and the introduction of high efficiency daylight responsive lights achieved a reduction in electric demand from 9568 kWhr to 6505kWhr including the extended area.

details

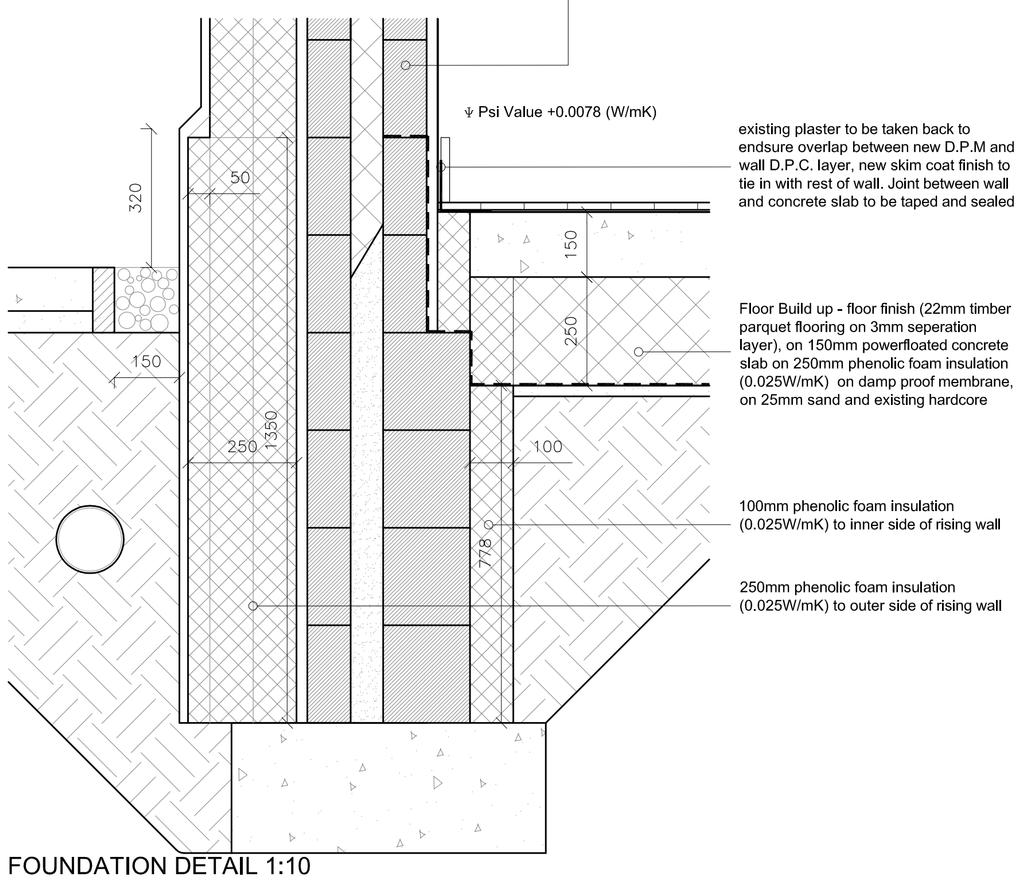


EAVES DETAIL 1:10

WINDOW FRAME DETAIL 1:10

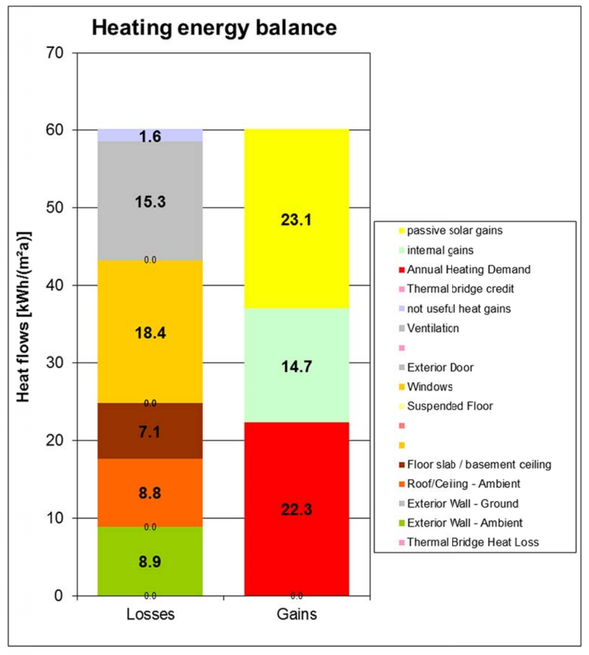


CILL DETAIL 1:10

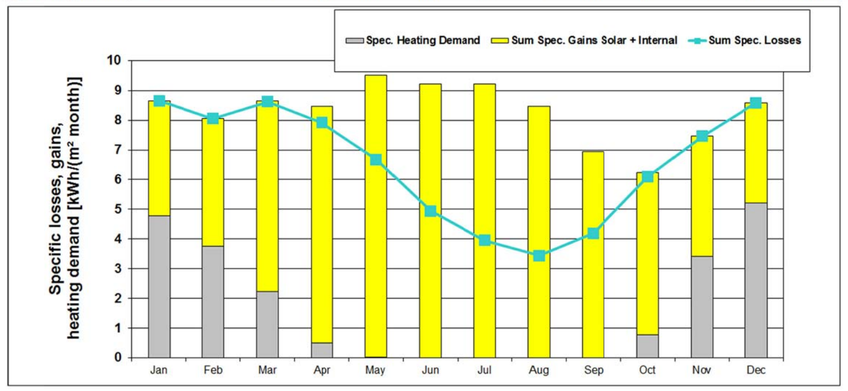


FOUNDATION DETAIL 1:10

phpp

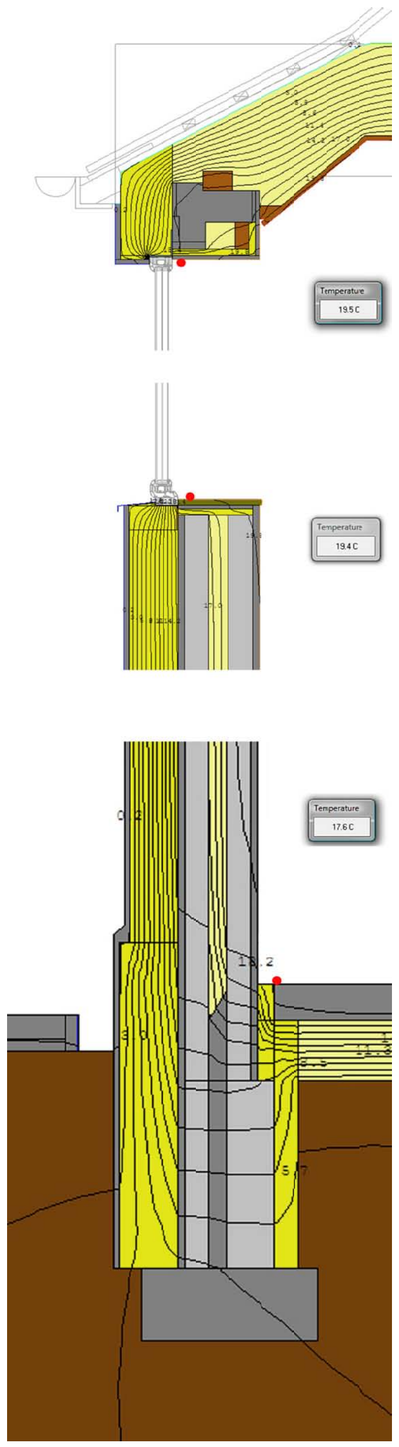


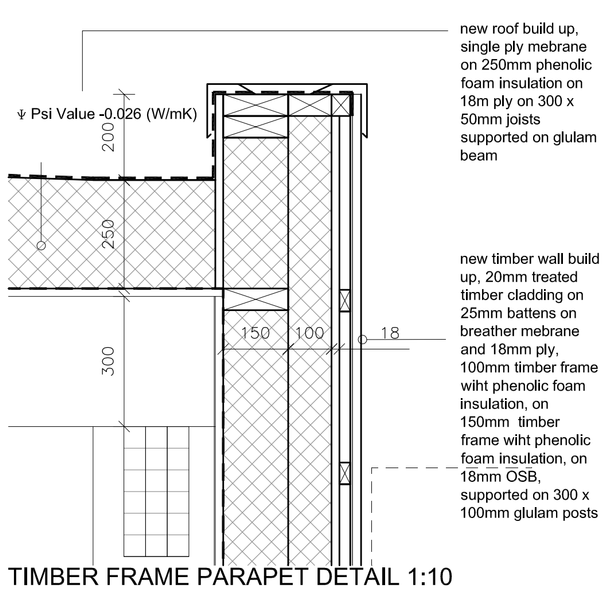
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Heating Degree Hours - E	9.8	9.1	9.7	8.9	7.4	5.3	4.0	3.6	4.4	6.8	8.5	9.8	87	kKh
Heating Degree Hours - C	5.5	5.1	5.6	5.2	5.1	4.5	4.4	3.2	4.1	4.4	4.6	5.1	57	kKh
Losses - Exterior	2751	2560	2731	2501	2064	1473	1126	1021	1230	1897	2380	2751	24486	kWh
Losses - Ground	386	360	397	370	358	321	308	227	288	312	325	363	4015	kWh
Sum Spec. Losses	8.7	8.1	8.6	7.9	6.7	4.9	4.0	3.4	4.2	6.1	7.5	8.6	78.6	kWh/m²
Solar Gains - North	2	5	10	16	23	25	25	20	12	7	3	2	152	kWh
Solar Gains - East	490	632	1040	1328	1556	1441	1456	1377	1168	853	541	362	12243	kWh
Solar Gains - South	10	12	20	25	28	25	25	25	21	16	11	7	223	kWh
Solar Gains - West	111	175	398	621	861	901	871	713	453	274	142	76	5597	kWh
Solar Gains - Horiz	32	52	109	166	221	218	214	184	128	78	40	22	1466	kWh
Solar Gains - Opaque	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh
Internal Heat Gains	755	682	755	731	755	731	755	755	731	755	731	755	8891	kWh
Sum Spec. Gains Solar +	3.9	4.3	6.4	8.0	9.5	9.2	9.2	8.5	6.9	5.5	4.0	3.4	78.8	kWh/m²
Utilisation Factor	100%	100%	100%	93%	70%	54%	43%	41%	60%	97%	100%	100%	73%	
Annual Heating Demand	1737	1362	805	182	5	0	0	0	0	280	1238	1890	7500	kWh
Spec. Heating Demand	**4.8**	**3.8**	**2.2**	**0.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.8**	**3.4**	**5.2**	**20.7**	kWh/m²



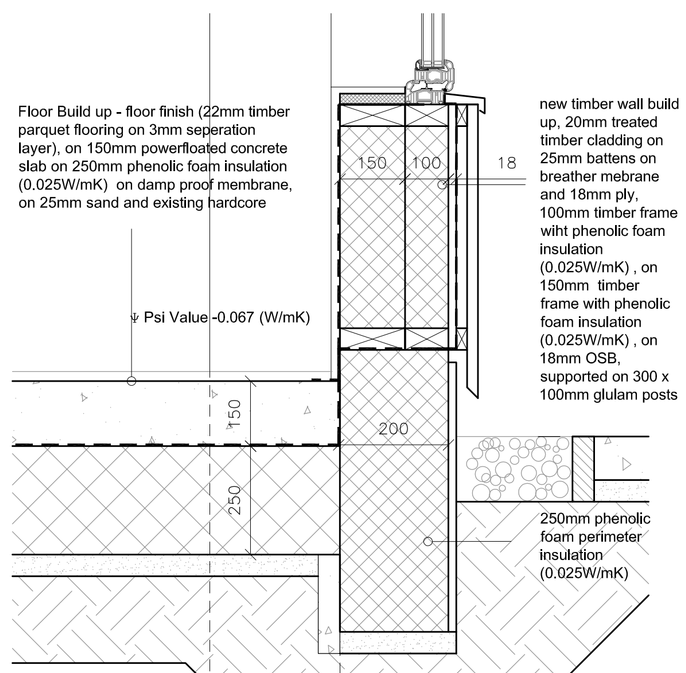
thermal bridge

No. L2D - (U X + UY) =	Psi Value Ψ (W/mK)
1. Ground Floor / Foundation 0.7247 - (0.5216+0.1959) =	+0.0073
2. Window Cill 0.1684 - (0.5750+0.000) =	+0.0108
3. Eaves / Window Head / Roof 0.2277 - (0.2512+0.0770) =	- 0.0240
4. Eaves / Wall/ Roof 0.3294 - (0.3670+0.1928) =	- 0.0380
5. Concrete Roof / Window Head 0.1828 - (0.1219+0.0620) =	- 0.0010
6. Timber Roof Eaves / Wall 0.2382 - (0.1251+0.1395) =	- 0.0260
7. Timber Wall / Foundation 0.5895 - (0.4916+0.1650) =	- 0.0670

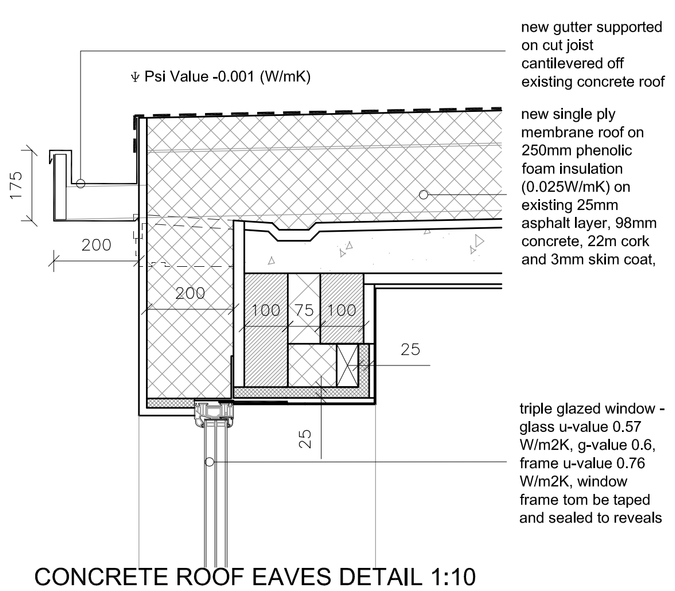




TIMBER FRAME PARAPET DETAIL 1:10



TIMBER FRAME WALL / FOUNDATION DETAIL 1:10



CONCRETE ROOF EAVES DETAIL 1:10