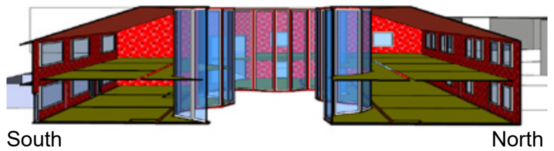
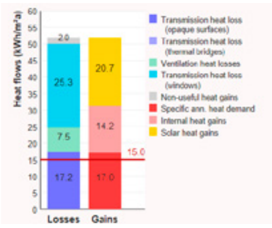
Design iterations

1. Shaping the design:

Initially, the design was an expansive building with a spacious open courtyard surrounded by glazed corridors that brought light and worked as buffer spaces. However, due to the high glazing ratio, the transmission heat loss through windows and the annual heat demand were too high and the project would be too expensive.

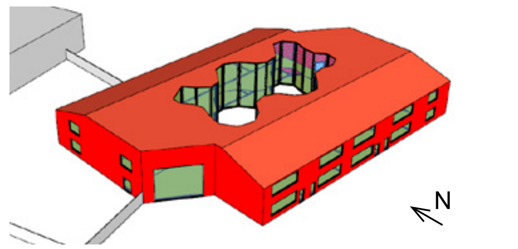


Heat balance



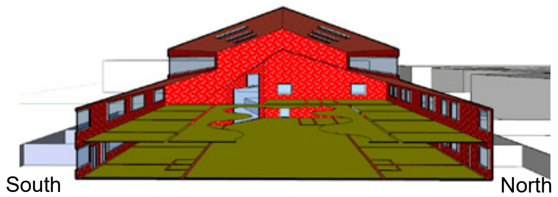
Project overview

Climate	Sutton Bonnington
Building type	School
Annual heat demand (Q_h)	17.0 kWh/m²a
Treated Floor Area (TFA)	2110 m² (Drawn TFA surfaces)
Thermal envelope area	4369 m²
Heat Loss Form Factor	2.07
Projected building footprint	-.-- m²
Number of windows	80
Number of thermal surfaces	52
Number of thermal bridges	None defined
Thermal envelope checks	

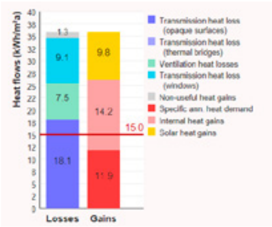


2. Improving the building form:

In order to improve the efficiency and reduce the glazing ratio and the cost of using so many high-quality windows, the central courtyard was closed and became an atrium with roof windows. Consequently, the transmission heat loss through windows was reduced in 64% and the heat demand was decreased to 11.8kWh/m²a.

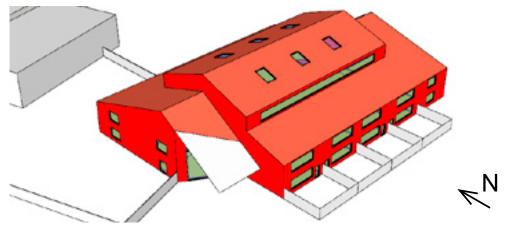


Heat balance



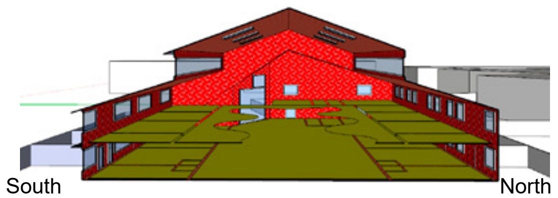
Project overview

Climate	Sutton Bonnington
Building type	School
Annual heat demand (Q_h)	11.9 kWh/m²a
Treated Floor Area (TFA)	2447 m² (Drawn TFA surfaces)
Thermal envelope area	4625 m²
Heat Loss Form Factor	1.89
Projected building footprint	-.-- m²
Number of windows	51
Number of thermal surfaces	19
Number of thermal bridges	None defined
Thermal envelope checks	



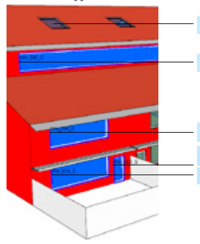
3. Designing the shading devices:

With the intent to avoid overheating during summer, fixed shading devices were installed in the south and west facades. The overhangs were carefully designed to deliver shading during summer months while allowing the solar radiation to reach the windows during winter months.

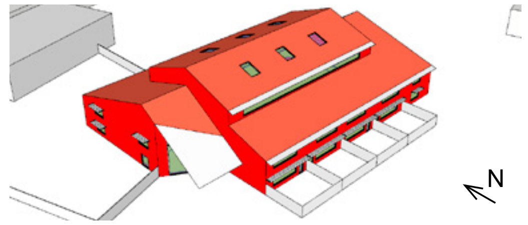


Heat balance

Shading factor



	factor (winter)	factor (summer)
Win_051_H	1.00	1.00
Win_045_S	0.69	0.55
Win_034_S	0.62	0.45
Win_005_S	0.72	0.60
Win_018_S	0.65	0.48



Final design

4. Improving the building envelope:

The external envelope properties were improved in order to reduce the transmission heat loss through opaque surfaces, which reduced from 18.1 to 13.1 kWh/m²a. However, improving the thermal insulation of the walls also means that the building does not lose the internal heat during the cooling season and probably has an overheating problem, thus, it is crucial to have the appropriate air flow for cooling through stack effect and also making use of night-time cooling.

Default construction properties

Assembly name	Total thickness	U-value (W/m²K)
PH external wall	0.46	0.15
PH roof	0.46	0.15
PH floor	0.41	0.25
PH basement wall	0.41	0.25
wall_neighbour	0.41	0.25
Wall to zone X	0.46	0.15
external_door	0.05	0.5

→

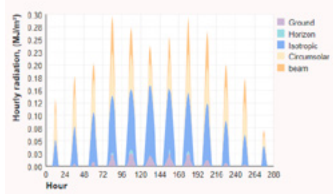
Final construction properties

Assembly name	Total thickness	U-value (W/m²K)
CLT external wall	0.34	0.12
CLT roof	0.52	0.12
CLT floor	0.68	0.15
PH basement wall	0.41	0.25
wall_neighbour	0.41	0.25
Wall to zone X	0.46	0.15
external_door	0.05	0.5

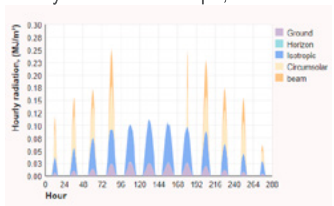
Shading device analysis

Ground floor south window

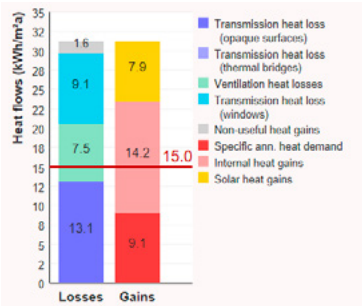
Hourly radiation on slope, unshaded



Hourly radiation on slope, shaded



Heat balance



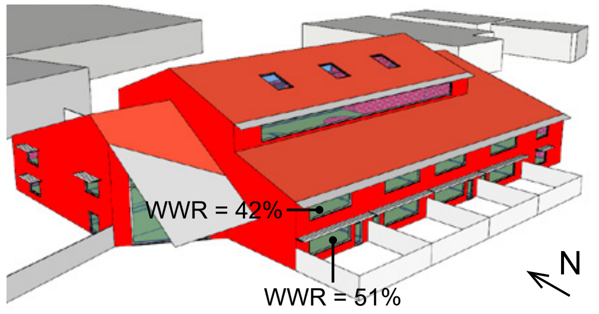
Project overview

Climate	Sutton Bonnington
Building type	School
Annual heat demand (Q_h)	9.1 kWh/m²a
Treated Floor Area (TFA)	2447 m² (Drawn TFA surfaces)
Thermal envelope area	4625 m²
Heat Loss Form Factor	1.89
Projected building footprint	-.-- m²
Number of windows	51
Number of thermal surfaces	19
Number of thermal bridges	None defined

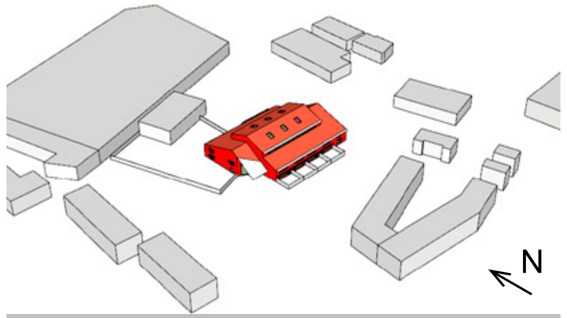
Thermal envelope checks

The thermal envelope appears to be complete!

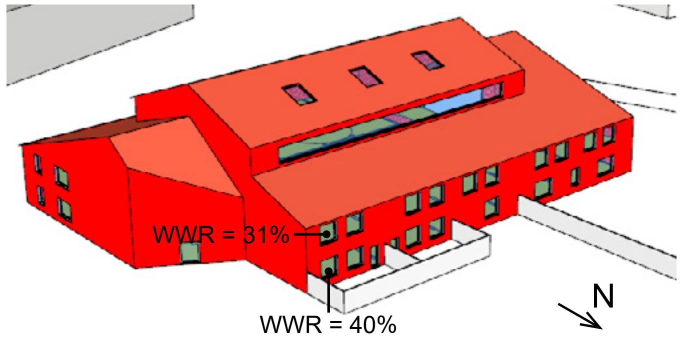
Final design



South façade

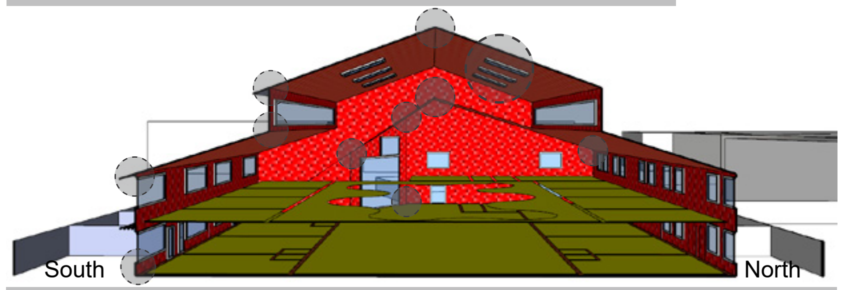


Site context

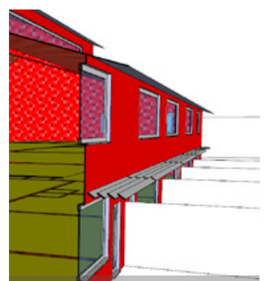


North façade

In order to have a balanced opening configuration that presented adequate daylight levels and did not compromise the thermal performance, a different arrangement was though for each facade individually. Therefore, each one has a specific window-wall-ratio (WWR) and windows disposition. Accordingly, classrooms facing south have larger openings with overhangs to protected them during summer months and north facing classrooms have less openings to control transmission heat loss. Also, to improve daylight levels, there is more glazed area on the ground floor classrooms than on the first-floor ones.



Section - Potential Thermal Bridges



Shading device

Heat balance sheet

Overview | Results | **Heat balance** | Climate | Vent.+IHG | Areas | U-value editor | Assemblies | Components | Shading

▾ Transmission heat loss (opaque surfaces)

Area group	Total area (m²)	Area weighted U-value (W/m²K)	Av. temp. factor	Ann. htg. degree hours (kKh/a)	Transmission heat losses (kWh/a)	Q_t (kWh/m²a)
7 - External Door	0.00			69.00		
8 - External Wall - Ambient	1110.40	0.12	1.00	69.00	9194.09	3.76
9 - External Wall - Ground	0.00			69.00		
10 - Roof/Ceiling - Ambient	1611.98	0.12	1.00	69.00	13347.15	5.45
11 - Floor slab / Basement ceiling	1548.86	0.15	0.60	69.00	9618.42	3.93
12 -	0.00			69.00		
13 -	0.00			69.00		
14 - Temperature zone X	0.00			69.00		
18 - Partition Wall to Neighbour	0.00			69.00		
	4271.23				**32159.67**	**13.14**

▾ Transmission heat loss (windows)

Area group	Total area (m²)	Area weighted U-value (W/m²K)	Av. temp. factor	Ann. htg. degree hours (kKh/a)	Transmission heat losses (kWh/a)	Q_t (kWh/m²a)
2 - North Windows	109.81	0.93	1.00	69.00	7011.37	2.86
3 - East Windows	13.50	0.95	1.00	69.00	882.00	0.36
4 - South Windows	177.22	0.90	1.00	69.00	10968.35	4.48
5 - West Windows	17.20	0.93	1.00	69.00	1106.78	0.45
6 - Horizontal Windows	36.00	0.91	1.00	69.00	2272.50	0.93
	353.72				**22241.00**	**9.09**

▸ Transmission heat loss (thermal bridges)

▾ Ventilation heat losses

	Energy effective air change rate (1/h)	Ventilation volume (m³)	Heat capacity of air	Ann. htg. degree hours (kKh/a)	Ventilation heat losses (kWh/a)	Q_v (kWh/m²a)
Ventilation system	0.0752	6608.07	0.33	69.00	11320.71	4.63
Infiltration	0.0462	6608.07	0.33	69.00	6951.52	2.84
	0.1214				**18272.23**	**7.47**

▾ Solar heat gains

Area group	Win. area (m²)	Glazing area (m²)	g-value	Reduction factor	Radiation, G_s (kWh/a)	Solar heat gains (kWh/a)	Q_s (kWh/m²a)
2 - North Windows	109.81	83.40	0.50	0.57	97.31	3059.37	1.25
3 - East Windows	13.50	9.70	0.50	0.56	194.00	729.02	0.30
4 - South Windows	177.22	144.26	0.50	0.37	346.55	11313.25	4.62
5 - West Windows	17.20	12.82	0.50	0.43	208.00	765.55	0.31
6 - Horizontal Windows	36.00	28.07	0.50	0.63	303.36	3421.32	1.40
	353.72	**278.25**				**19288.50**	**7.88**

▾ Internal heat gains

Treated Floor Area (m²)	Internal heat gain rate (W/m²)	Heating period (days/a)	Heating period (kh/a)	Internal heat gains (kWh/a)	Q_i (kWh/m²a)
2447.43	2.80	212.00	5.09	34867.12	**14.25**

PASSIVHAUS Student Competition

in partnership with

TARMAC A CRH COMPANY

CAROLINA BLEY

TRENT BASIN PRIMARY SCHOOL

NOTTINGHAM UNIVERSITY

Design & development:

Passivhaus standards can be achieved in any design, by appropriately managing the building envelope properties, shading devices, openings percentage and ventilation. Therefore, the design process began by trying to achieve a satisfying and efficient form factor. Than, the chosen design was analysed with Design PH to achieve a balanced heat losses and gains ratio. In this way, openings were appropriately positioned, shading devices were carefully designed and the external envelope properties were adjusted to better fit the building needs.

Finally, the project was revised to carefully manage overheating problems during the summer months and thus strategies such as stack effect ventilation and night cooling were adopted.

designPH