The Optimal Solution

Dublin School of Architecture
Postgraduate Diploma in Building Performance DT9772

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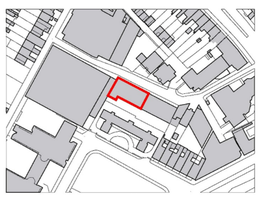
1) Abstract



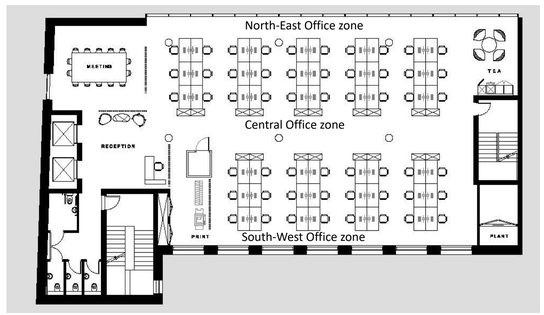
Kildress House is a recently completed, air-conditioned office building in Dublin city centre.

Using Design Builder software, a number of dynamic simulation studies were completed on the building to show that a passive cooling solution can be feasible alternative to air-conditioning.

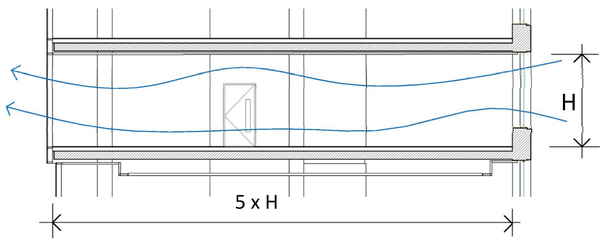
This can result in lower energy consumption while still achieving thermal comfort levels and maintaining suitable levels of daylighting within the open plan office areas.

This study focuses on simple alterations to the façade such as shading, natural ventilation and high performance glazing to achieve a passive cooling solution.

An optimal solution was then established that met the required parameters and had the lowest energy use.

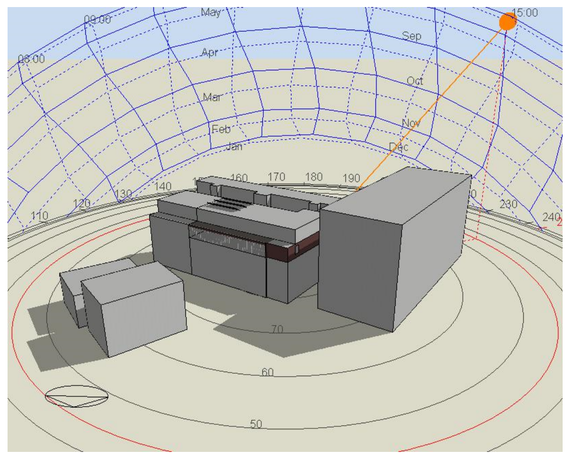


The building has an open plan office layout with full height glazing to the front and large windows at the rear.



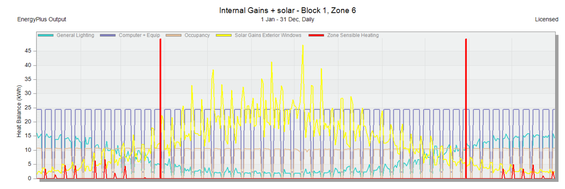
A building depth of 15.5m means that it is still possible to achieve a natural ventilation solution.

2) Preliminary study

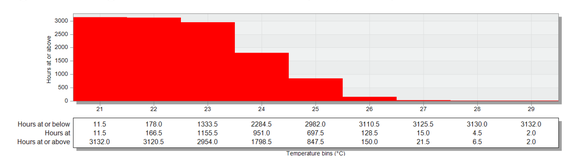


One floor of the building and surrounding context was modelled in Design Builder without air-conditioning to investigate overheating and possible causes.

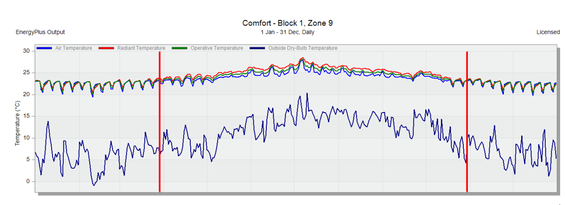
DesignBuilder SOFTWARE



Annual internal gains in the north-east office zone show solar gain during the summer months (in yellow)



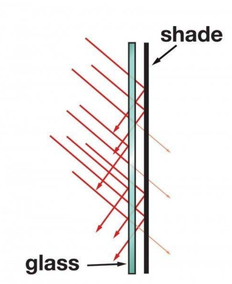
Thermal comfort levels in the central office zone show that 27% of occupied hours are over 25°



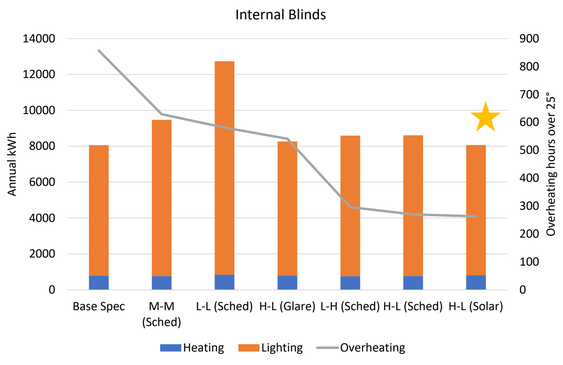
Annual temperature in the central office zone peaks at 29°

3) Detailed Study

• Internal blinds



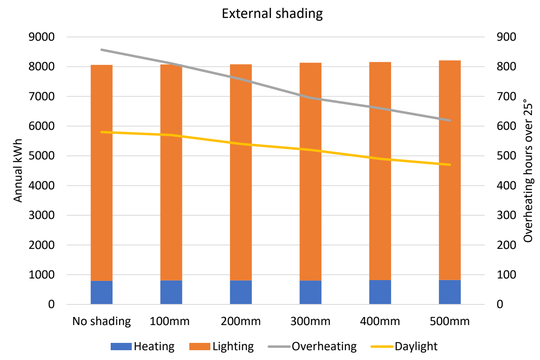
- Internal blinds reduce glare and provide privacy
- Have an impact on energy for lighting and thermal comfort.
- High reflectance, low transmittance blinds are the most effective at reducing overheating
- Blinds are most effective if operated based on solar radiation.



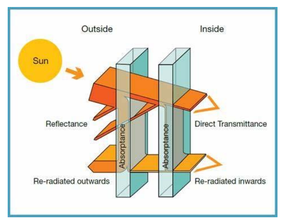
M-M: medium reflectance, medium transmittance. L-L: Low reflectance, Low transmittance,
H-L: High reflectance, low transmittance, L-H: Low reflectance, high transmittance

• External Shading

- Shading reduces internal daylight levels
- Improves thermal comfort conditions
- Increases energy use for both heating and lighting
- Horizontal shading was measured on the south-west elevation and vertical shading on the north east.

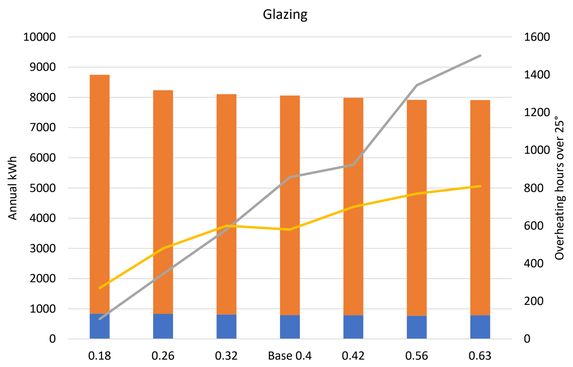


• Solar Performance Glass



As solar and light transmission in the glazing increases:

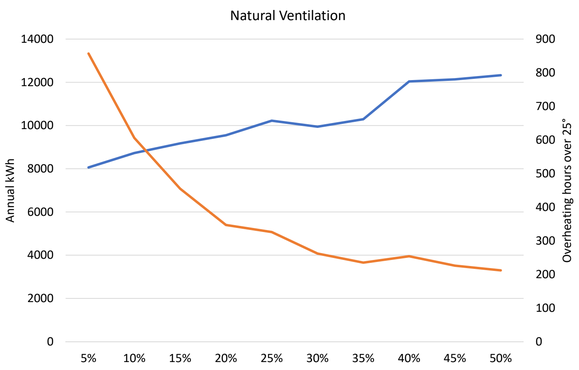
- Energy required for heating and lighting reduces
- The daylight factor improves
- There is an increase in the number of overheating hours



• Natural Ventilation

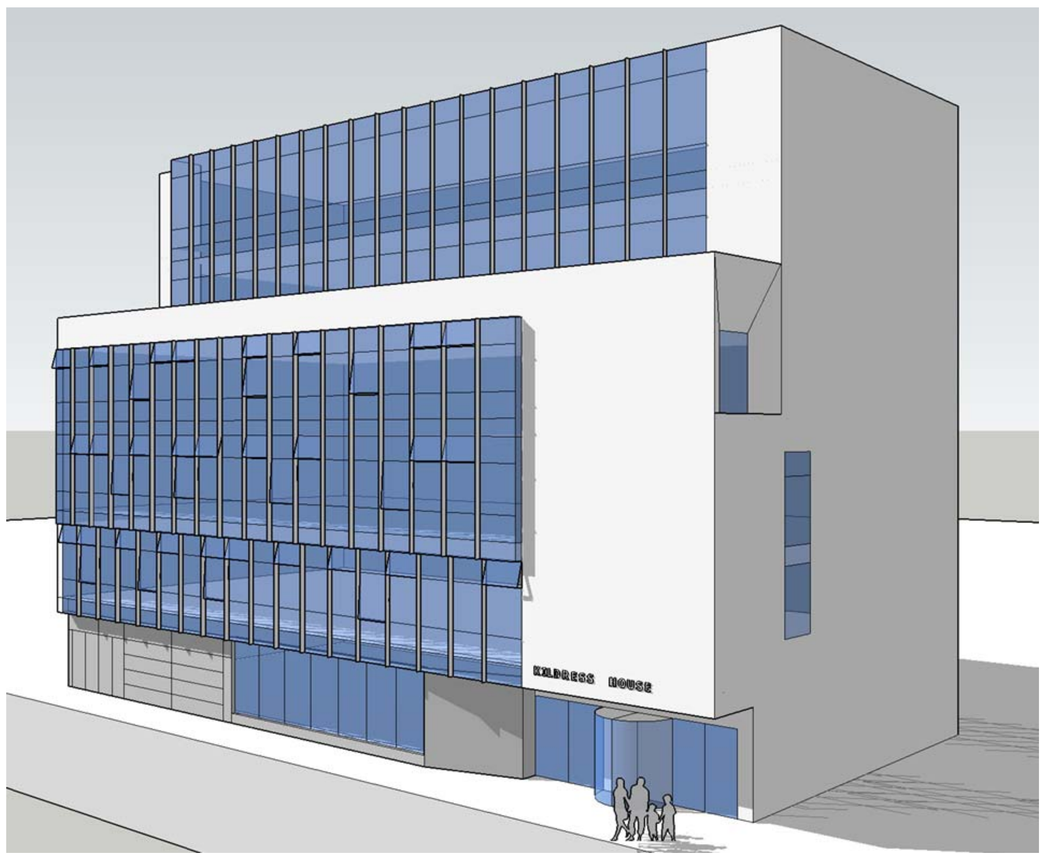
By increasing the open area of the windows and therefore the amount of natural ventilation:

- Results in a large reduction in overheating hours due to passive cooling.
- The energy required or heating increases due to a certain amount of overcooling that is often a result of the external weather conditions.
- There is no impact on the daylighting or the energy for lighting



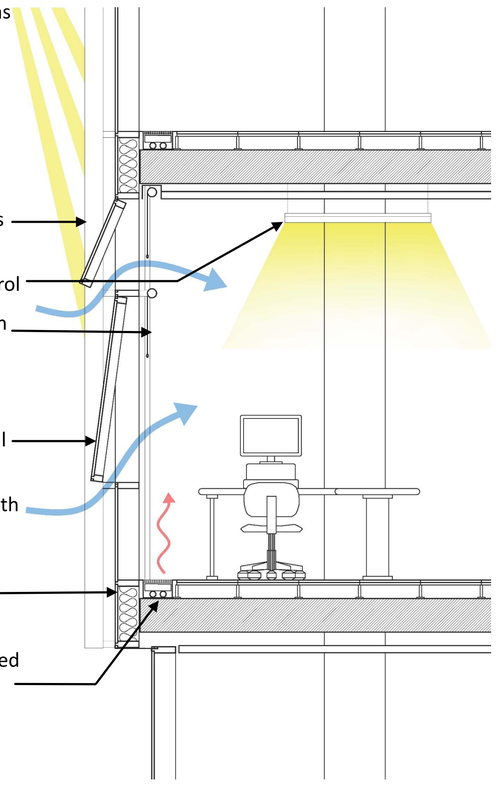
4) The Optimal Solution

	Shading	Nat Vent	Glass	Thermal Comfort	Daylight Factor	Energy
1	100mm	10%	0.26/0.51	28.5	3.2	8737
2	100mm	10%	0.32/0.61	51	3.9	8647
3	100mm	10%	0.42/0.70	155	4.5	8568
4	100mm	20%	0.26/0.51	13	3.2	9489
5	100mm	20%	0.32/0.61	18	3.9	9421
6	100mm	20%	0.42/0.70	45	4.5	9421
7	100mm	30%	0.26/0.51	6.5	3.2	9766
8	100mm	30%	0.32/0.61	12	3.9	9678
9	100mm	30%	0.42/0.70	28.5	4.5	9871
10	300mm	10%	0.26/0.51	27.5	2.8	8822
11	300mm	10%	0.32/0.61	43.5	3.5	8711
12	300mm	10%	0.42/0.70	124	4.1	8609
13	300mm	20%	0.26/0.51	10.5	2.8	9519
14	300mm	20%	0.32/0.61	18	3.5	9445
15	300mm	20%	0.56/0.76	182.5	4.5	9502
16	300mm	30%	0.26/0.51	7.5	2.8	9810
17	300mm	30%	0.32/0.61	9	3.5	9471
18	300mm	30%	0.56/0.76	103	4.5	9818
19	500mm	10%	0.32/0.61	42	3.1	8780
20	500mm	10%	0.56/0.77	113	4.0	8679
21	500mm	10%	0.63/0.80	555	4.3	8679
22	500mm	20%	0.32/0.61	17	3.1	9510
23	500mm	20%	0.56/0.77	154	4.0	9504
24	500mm	20%	0.63/0.80	295	4.3	9546
25	500mm	30%	0.32/0.61	10	3.1	9819
26	500mm	30%	0.56/0.77	100	4.0	9879
27	500mm	30%	0.63/0.80	187	4.3	9929

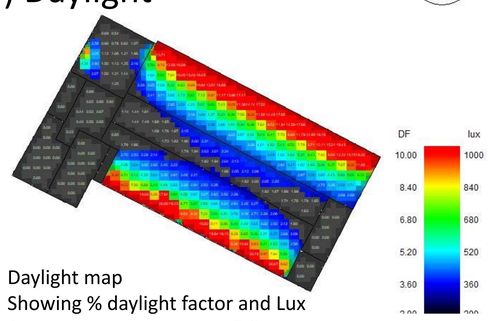


The Optimal Solution as determined by the sensitivity analysis for this particular building and specification is as follows:

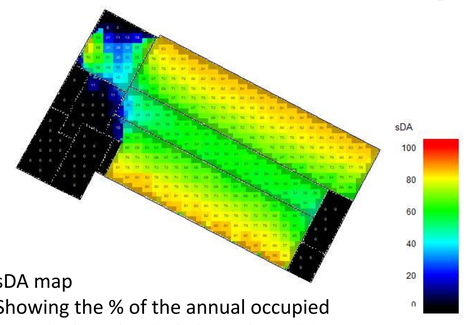
- 100mm vertical fins to N-E facade
- LED lighting & control
- Internal blinds. High reflectance, low transmittance
- 10% open area to windows for natural ventilation.
- Automat control with manual override.
- Solar performance glass
- Air to water heat pump. Floor recessed radiators



5) Daylight

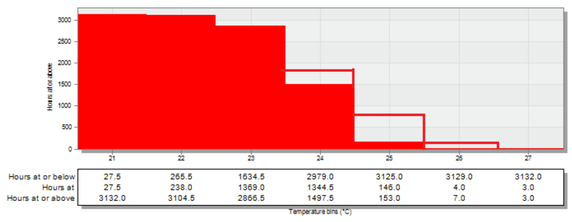


Daylight map
Showing % daylight factor and Lux
Average daylight factor is 5.8
in the office area. A good level of daylight is required to reduce the energy for lighting

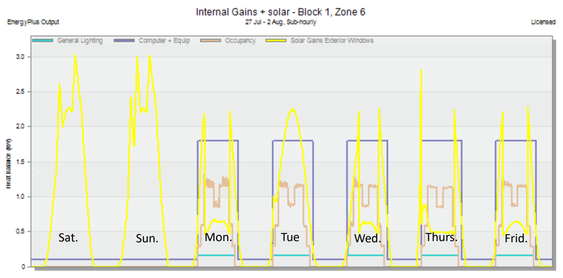


sDA map
Showing the % of the annual occupied period when the daylight is above 300 Lux

6) Thermal comfort



Annual overheating hours in the central office area showing the reduction after modifications to the façade. Occupied hours where the temperature was above 25° reduced from 847 to 153 which is below 5%

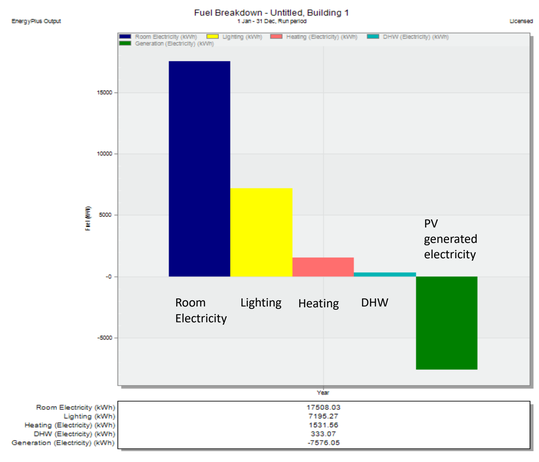


Internal gains during the summer design week. The yellow line shows the reduction in solar gain when the blinds are activated during occupied hours

7) Energy

Renewable energy

Roof mounted PV panels	
Area of PV panels per floor	60m²
Annual electricity generation	7,576 kWh
Electrical demand per floor	26,567 kWh
% of electrical demand met by PV	29%



Fuel breakdown for a typical floor

8) Compliance

SBEM Building Regulations Compliance

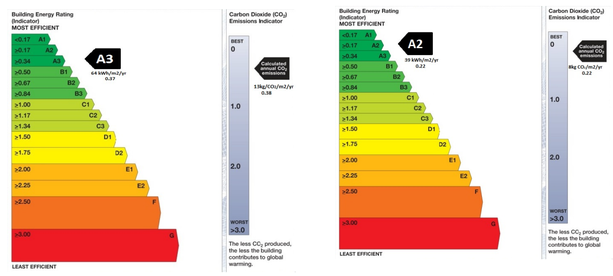
Compliance	Results	Units
Primary Energy (Actual)	64.24	kWh/m2.yr
Energy Performance Coefficient (EPC)	0.92	-
Maximum Permitted EPC (MPEPC)	1	-
Primary Energy Pass?	YES	
CO2 Emissions (Actual)	12.63	kg.CO2/m2.yr
Carbon Performance Coefficient (CPC)	0.94	-
Maximum Permitted EPC (MPCPC)	1.15	-
CO2 Pass?	YES	
Renewable Energy Ratio	0.22	-
Minimum RER	0.2	-
Renewable Energy Pass?	YES	

Air-conditioned building
64.24 kWh/m²/yr

Compliance	Results	Units
Primary Energy (Actual)	38.59	kWh/m2.yr
Energy Performance Coefficient (EPC)	0.72	-
Maximum Permitted EPC (MPEPC)	1	-
Primary Energy Pass?	YES	
CO2 Emissions (Actual)	7.59	kg.CO2/m2.yr
Carbon Performance Coefficient (CPC)	0.74	-
Maximum Permitted EPC (MPCPC)	1.15	-
CO2 Pass?	YES	
Renewable Energy Ratio	0.36	-
Minimum RER	0.1	-
Renewable Energy Pass?	YES	

Optimal passive cooling solution
38.59 kWh/m²/yr

Energy Performance Certificate



Air-conditioned building: A3

Optimal solution: A2