Stage 1 improved report.

Proposed Bird Life international Centre Bowers Marsh stage 1

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Introduction

Bird Life International is a charity organisation working on a sustainable building design suitable for any country (erected in virtually any country) and also to provide a comfortable building to watch birds year-round and provide educational facilities for school-children. The building consists of a viewing station on two sides (South-West and South-East), office room, meeting room/education room, store room, café and plant room. The viewing station is located next to glazed windows and the meeting room has a rooflight, providing sun light during the day. Half of the building is transparent (glazed windows and rooflight) reducing electricity demand for lighting, but may lead to massive heat gains during the summer. This will cause rising temperatures in the building which will impact the visitors. The designer must consider the factors above and the impact to the environment that might affect the birds' habitat. Moreover, for a sustainable building, climate change is a major concern; the amount of a greenhouse gases must be limited following the energy regulation.

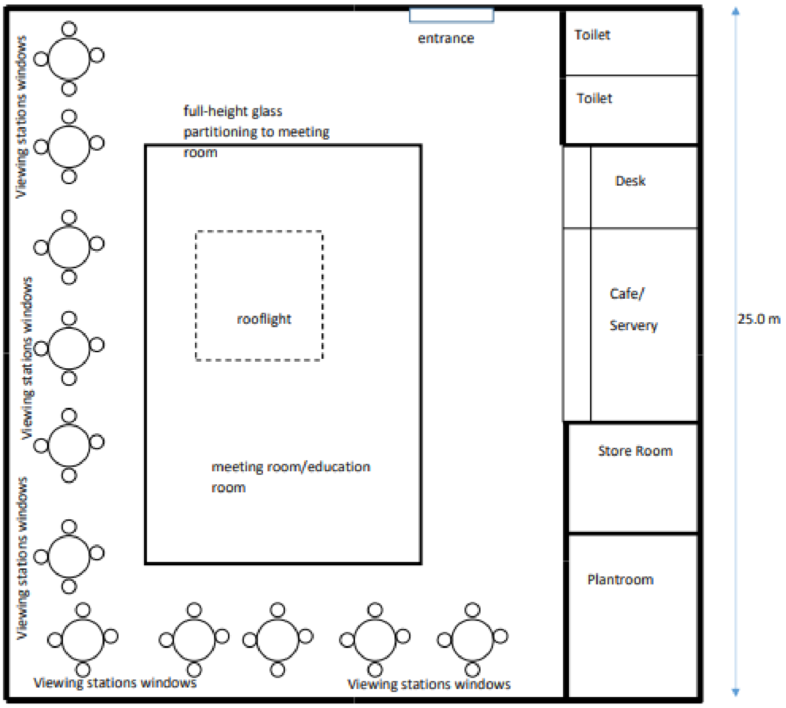

Figure 1 Building general plan[1]

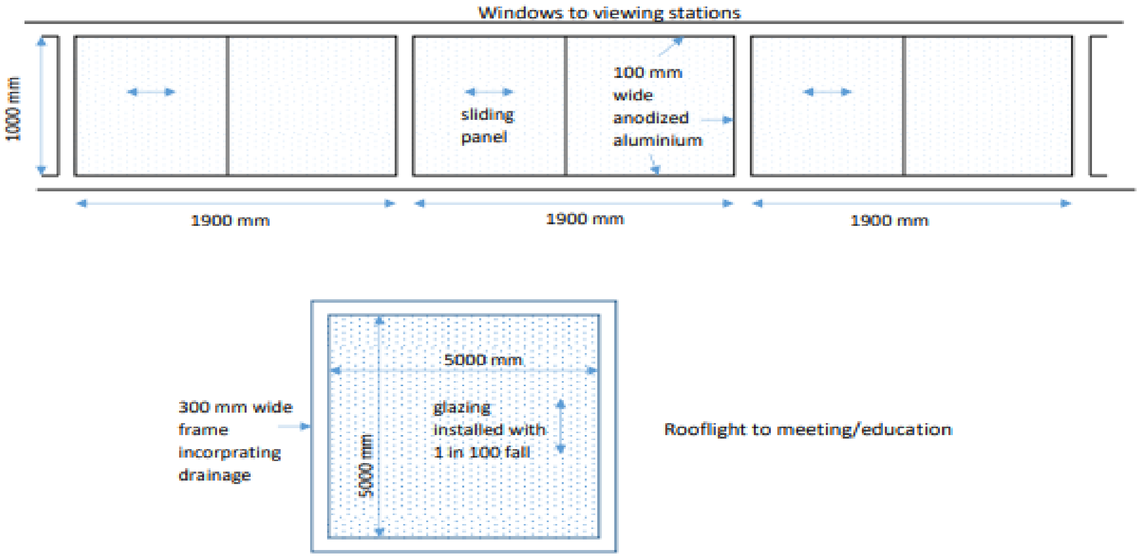

Figure 2 Glazing details [1]

1) Rationale of building regulation choice

The building regulations provided by Approved Document L2A: Conservation of fuel and power in new buildings other than dwellings have been chosen against which to assess and inform the building's design. In choosing which building regulations are most appropriate to use for the project, the following was considered:

- The building is a new, purpose-built structure and is not a residential building
- The building must have a minimal impact on its environment (both in its construction and operation)
- The building should have very good energy efficiency while catering to its users
- The L2A regulations sets out recommendations on choice of construction materials and services as regards their energy efficiency
- The regulations also serve to help inform design decisions about creating a reasonable internal environment for the building's users

2.) Set of time-based energy demand profile for the building

2.1) Building U-values (W/m^{2}K)

Assume that thermal transmittance (U-values) in the building is comply with Part L regulation. The values are in the following table.

	Comply with Part L	Stage 1	Improved
Floor	0.25	0.23	0.08
Walls	0.35	0.17	0.08
Entrance door	3.5	3.5	1.5
Plant room door	1.6	1.6	0.5
SW windows	2.2	2	1.3
SE windows	2.2	2	1.3

Rooflight	2.2	2	1.3
Flat roof	0.25	0.18	0.08
Sloping roof	0.25	0.18	0.08

Table 1 Building U-values

2.2) Make reasonable assumptions about the environmental conditions, occupancy and internal heat gains. Summarise data use in calculations

2.2.1) The operation hour of the building based on the sunrise and sunset time.

	Time	total hour
Jan	8.00-16.00	8
Feb	8.00-16.00	8
Mar	8.00-16.00	8
Apr	8.00-16.00	8
May	8.00-19.00	11
Jun	8.00-19.00	11
Jul	8.00-19.00	11
Aug	8.00-19.00	11
Sep	8.00-19.00	11
Oct	8.00-16.00	8
Nov	8.00-16.00	8
Dec	8.00-16.00	8

Table 1 Operating hours

2.2.2) Occupancy

Assume that the building has 40 visitor 4 staff for bird watching area and 1 staff for the café, in total 45 people. The ventilation rate is 10l/s.

I assumed that the heat generated from each person come from their activity. The building is used for bird watching so the main activity is sitting and watching birds (resting, seated). Each person generates 70 W.

2.2.3) Lighting

The building has windows for south-west and south-east and the roof-light which is allowed light to get through the building. Those light can be associate for lighting demand. Artificial lighting is installed to provide an illuminance of 300 Lux with an overall efficacy of 50 Lum/W. I assumed that 300 Lux is enough light for the use of the building, the visitors will be able to experience the feeling of hiding from the birds. I use the recommended daylight factor 2% will provide full load equivalent at 20%. [Course book: Figure 2.3 (page 38)]

Equation 1

Installed lighting load = (design illuminance (Lm/m^2)/ overall efficacy (Lm)) x area(m^2)

Only office area and Café require lighting during occupancies period.

	W(m)	L(m)	A(m^2)	install lighting load(W)	20% full load (W)
office	6	5.5	33	198	39.6
Café	6	2.5	15	90	18
total				288	57.6

Table 2 Install lighting load and average lighting load

From equation 1, the average lighting load at 20% full load equivalent is 57.6 W

2.2.4) Appliances in the building

The office room contains with 2 desktop computers and 2 flat screen monitors. The café will have small refrigerator for preserving drinks and food ingredients for sandwich, and 1 coffee machine.

Room	Appliances	energy consumption(W)	Unit	total(W)
1.) office	Desktop computer	75	1	75
	flat screen monitor	55	1	55
2.) meeting room	Laptop	24	1	24
3.) café	coffee machine	1500	1	1500
	Small fridge for drink and food	250	1	250
		Total		1904

Table 3 the energy consumption for each appliance in the building

2.2.5) Summarise data used in calculations.

occupant numbers	40 visitors and 45 staff
ventilation rate	10 l/s per person
heat gains	from internal (lighting and electric appliances) and solar gains
heat losses	Through fabrics and ventilation or infiltration
heating requirements	Calculate from HLC x design temperature difference
cooling requirements	based on heat gain
noise level	depends on the machinery used
electrical demand	lighting and appliances
toilet provision	Use CIBSE guide
water requirements	Use CIBSE guide
Daylighting	based on the lecture
electric lighting requirement	Office and café

Table 4 Summarise data used in calculations.

2.3) Calculate heat loss coefficient.

Design temperature for outdoor and indoor is -3C and 18C respectively.

Elements	W(m)	L(m)	A(m^2)	U ($W/m^2°K$)	AU(W/°K)	delta T (18-(-3))	Q(W)	Note*	
Floor	25	25	625	0.08	50	21			
Walls (exclude doors and windows)	2.5	100	188.96	0.08	15.1168	21			
Entrance door	2	2	4	1.5	6	21			
Plantroom door	2	2	4	0.5	2	21			
SW windows	1.2	24.1	28.92	1.3	37.596	21			
SE windows	1.2	20.1	24.12	1.3	31.356	21			
Rooflight	5.6	5.6	31.36	1.3	40.768	21			
Flat roof	18.08	18.0	326.88	0.08	26.16	21			

		8							
Sloping roof	4	86.14	344.56	0.08	27.56	21			
AU total					236.55				
Thermal bridging					41.74	21		15% of total	
Total			1577.806		278.3	21	5844.239	5.845	kW
Infiltration			V	ach or N	NV/3(W/K)	delta T	Q(W)		
			1502.5	0.6	300.5	21	6310.5	*exclude plantroom and storeroom(60m^3)	
Total steady state heating							12154.74	12.15	kW
Pre heating factor								1.5	
Heating system capacity								18.225	kW
Ventilation rate				450					l/s
Heating of ventilation air					540	21	11340	11.34	kW
Total of air and fabric heating requirements							17184.24	17.185	kW

Table 5 Heat loss coefficient calculation.

HLC = heating of ventilation + AU = 540+236.55 = 777 W/°K

2.4) Calculate peak heating load

Peak heating load is heating capacity, from table 5, heating capacity is 18.3 kW

2.5) Energy calculation

Table below shows monthly heating energy demand and monthly heating less gain based on HLC and degree days. The correction factor for lightweight building with 8 hours operating, 7 days per week is 0.55. Assume that the seasonal heating efficiency is 65%

Month	Day, length (h)	Mean solar gain(W day)	Internal gain(W)	Base temp	DD (°C)	24h heating demand (kWh)	8h heating demand (kWh)	Monthly Solar gain(kWh)	Monthly heating less gain(kWh)	Cooling requirement
Jan	8.5	779	3571.6	12.4	211	6053.43	3329.39	205	3124.39	
Feb	10.5	1268	3571.6	11.7	174	4991.93	2745.56	373	2372.56	
Mar	12	1890	3571.6	10.9	138	3959.11	2177.52	703	1474.52	
Apr	14	2593	3571.6	10.0	91	2610.72	1435.90	1089	346.90	
May	16	3000	3571.6	9.5	34	975.44	536.49	1488		951.52
Jun	16.5	3082	3571.6	9.4	7	200.83	110.46	1526		1415.55
Jul	16	3041	3571.6	9.4	1	28.69	15.78	1509		1493.23
Aug	14	3081	3571.6	9.4	1	28.69	15.78	1337		1321.23
Sep	12	2577	3571.6	10.1	9	258.21	142.012	928		786.0
Oct	10.5	1640	3571.6	11.3	45	1291.02	710.06	534	176.059	

Nov	8.5	1019	3571.6	12.1	201	5766.54	3171.6	260	2911.60	
Dec	8	670	3571.6	12.5	215	6168.19	3392.51	166	3226.51	
Total					1127	32332.77	17783.1		6314.16	

Table 6 Energy calculations

From table 6, annual heating energy is 6314.16 kWh. For the floor area equals to 625 m^2, the annual heating energy is 10.11kWh/m^2.

2.6) Monthly heating less gain profile

From table 6, monthly heating less gain profile is shown in figure 3 below.

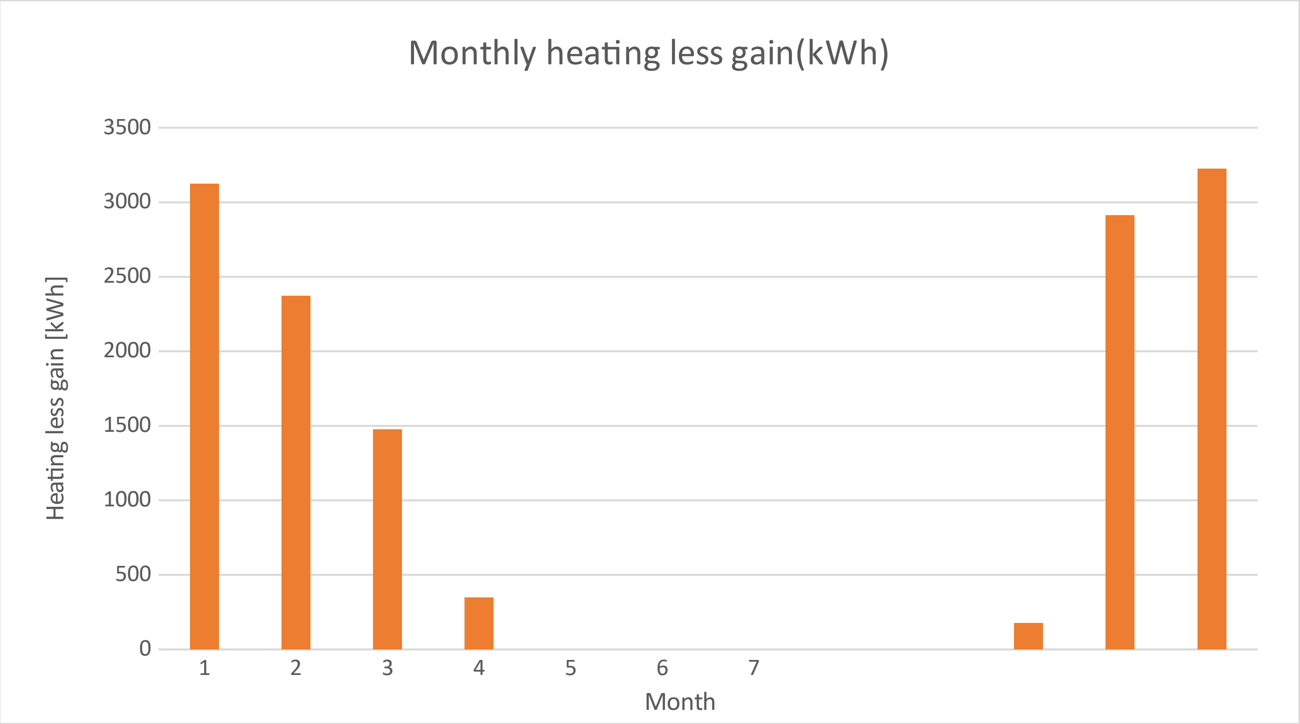

Figure 3 Monthly heating less gain profile

2.7) Solar heat gain profile in summer

In order to calculate solar heat gain in the building we must know how much irradiation gets through the building in each hour. Using table 2.13(g) Design 97.5 percentile of beam and diffuse irradiance on vertical and horizontal surfaces: London area (London Weather Centre) (1996–2005) from CIBSE Guide A [2]. The building has glazing windows in South-West and South-East and glazing rooflight, so we only use the data in South-West and South-East for the amount of light that get through the windows. For the rooflight, we use the horizontal global irradiance to calculate solar heat gain.

Solar heat gain can be estimated from following equation;

$Q = AGI$

Where Q = solar heat gain [watt]

A = glazing area in South-East , South-West or hozizontal roof [m^2]

I = solar intensity [w/m^2] from table 2.13(g) in CIBSE Guid A [2]

Figure 4 shows the solar heat gain profile in summer, the calculation for solar heat gain profile can be found in the attached excel spread sheet.

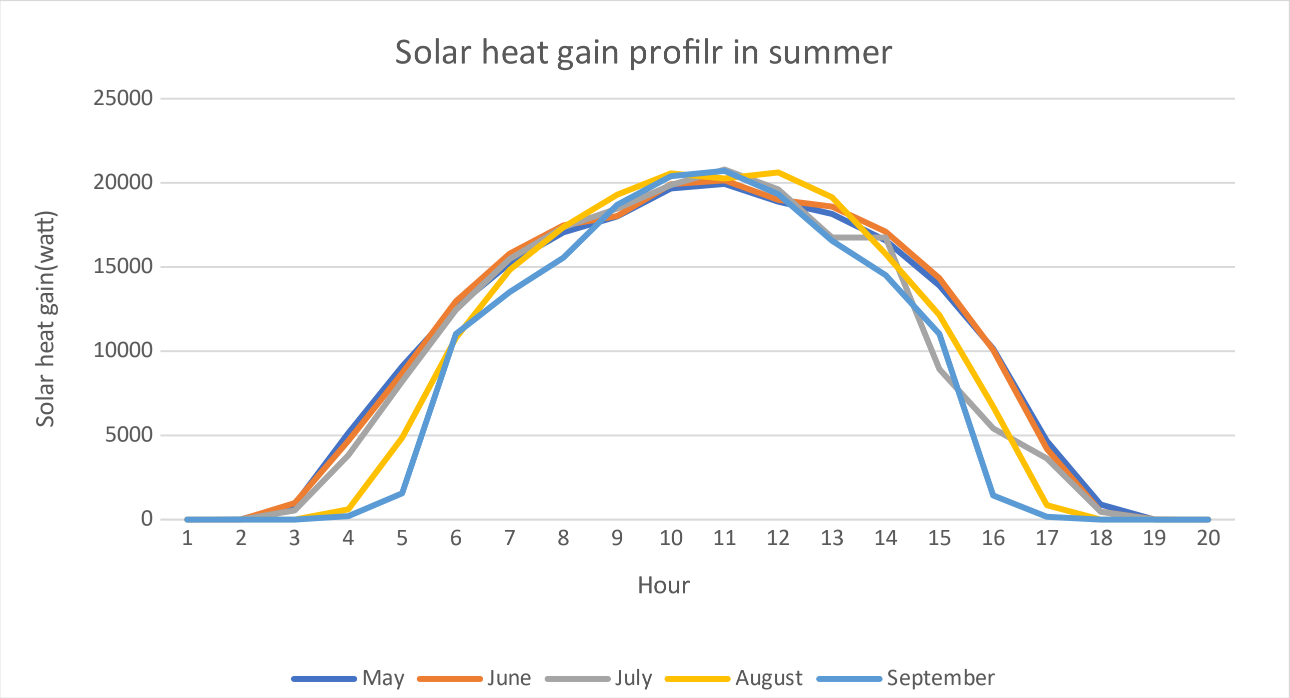

Figure 4 Solar heat gain profile in summer

2.8) Estimate maximum internal temperature

Internal temperature can be estimated from equation below.

Internal temperature = solar heat gain/ HLC

Using the data from 2.7) and HLC equals to 777 W/k, internal temperature resulted in table below.

May	June	July	August	September
0	0	0	0	0
0.012124	0	0	0	0
1.157838	1.263089	0.708417	0	0
6.612124	6.025328	4.919073	0.778764	0.266873
11.70239	11.1929	10.55822	6.256911	2.005405
16.22293	16.68911	16.03212	13.87807	14.18417
19.59722	20.3234	19.92208	19.07707	17.39328
21.96139	22.49035	22.3471	22.35042	20.01645
23.17413	23.20224	23.77042	24.83483	24.06541
25.31537	25.64363	25.57205	26.46394	26.24942
25.65892	25.92965	26.76185	26.08317	26.65452
24.30031	24.44247	25.24378	26.53583	24.87436
23.36247	23.92517	21.56448	24.64116	21.321
21.33552	22.01274	21.5627	20.30942	18.68409
17.89282	18.45097	11.50154	15.62849	14.18548
13.0634	12.96139	6.969266	8.645869	1.845174
6.007336	5.399614	4.668108	1.103861	0.208649

1.15166	0.604093	0.604093	0	0
0	0.012124	0	0	0
0	0	0	0	0

Table 7 Internal temperature

From table 7, the maximum internal temperature is roughly 26.7 degree Celsius and is also shown in figure 5.

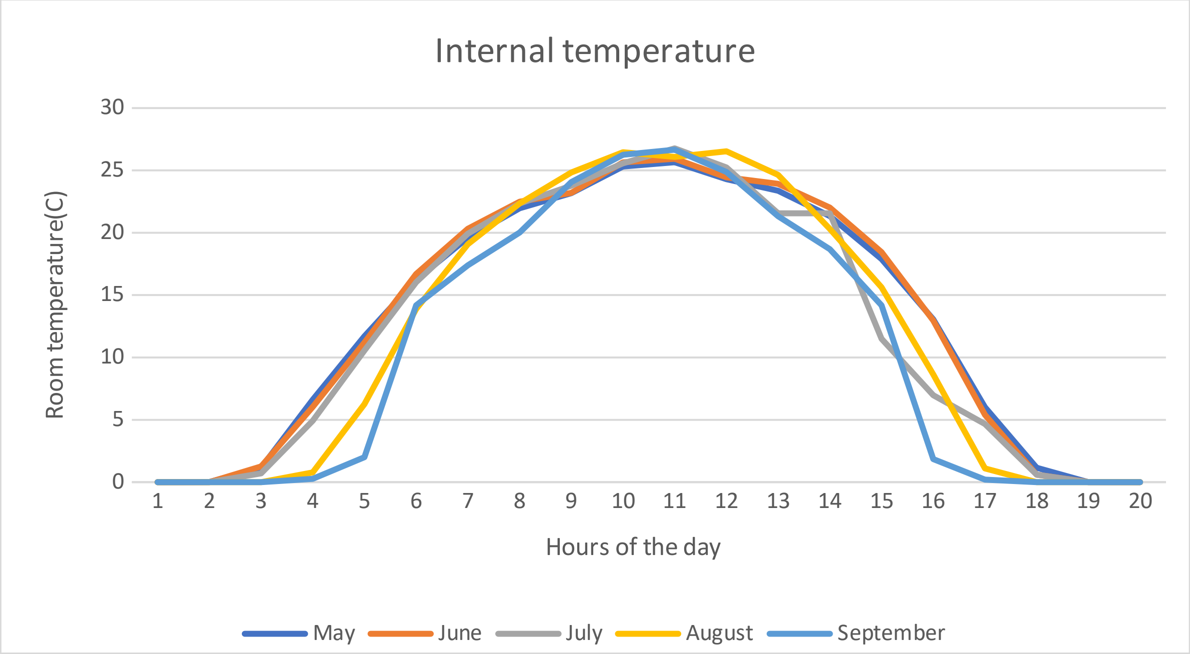

Figure 5 Internal temperature

2.8) Cooling requirement

Some form/s of cooling must be used to reduce the temperature to maintain the internal temperature below 25 degree Celsius. In this case, the maximum internal temperature is only 26.7 degree Celsius, we can use natural cooling to cool the temperature down such as opening the windows.

2.9) Total internal heat gains profile in summer

Total internal heat gains consist of heat gain from solar, lighting, appliances and visitors. Figure 6 shows internal heat gains profile in summer.

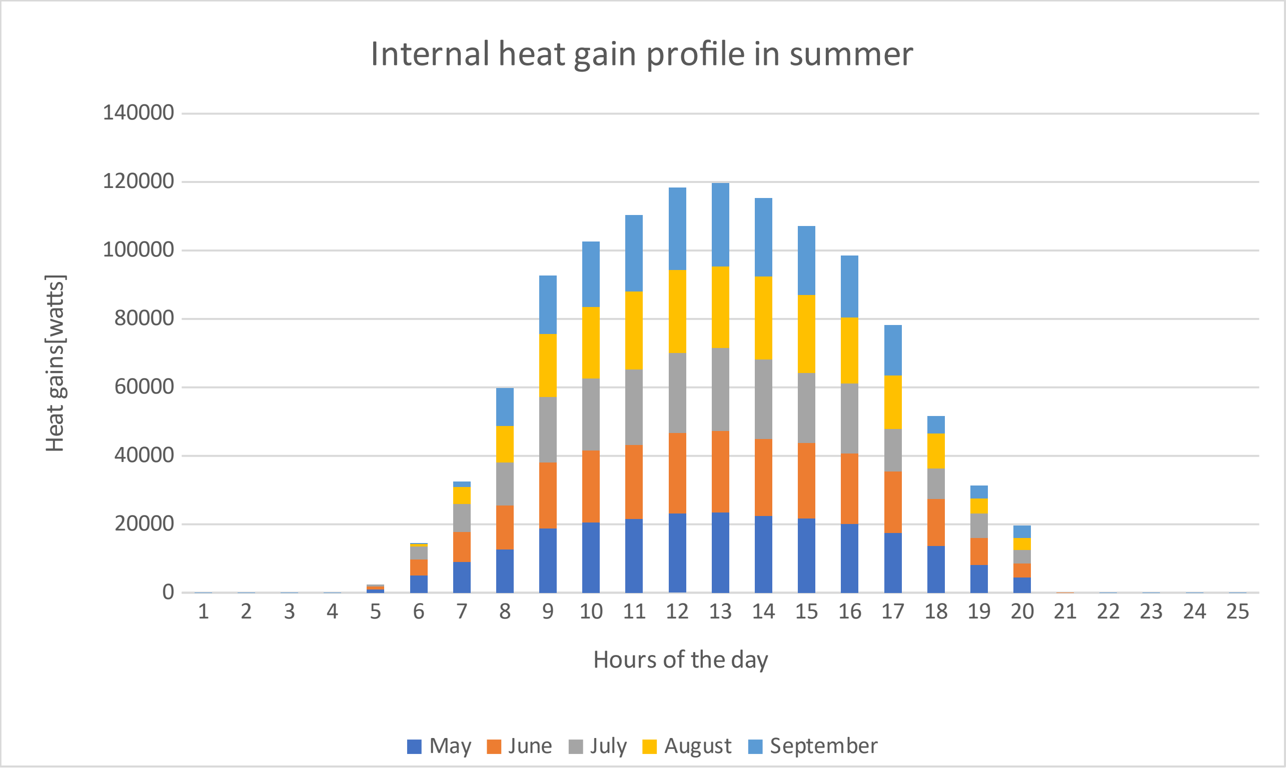

Figure 6 Internal heat gain profile in summer

3) Recommendations

3.1) Use of Phase Change Materials to buffer temperature changes

Phase Change Materials (PCMs) are a class of materials used to store thermal energy in their latent heat of phase change (usually from solid to liquid). PCMs can be tailored for a certain temperature range. As they absorb heat from their surroundings, they can melt, storing large amounts of energy in their latent heat of fusion. This heat is later released when the PCM's temperature drops below a certain point. Panels of PCM can be built into wall cavities or roof spaces where they effectively buffer the building's climate, absorbing excess heat (usually during the day) and releasing it when the environment cools. In order to reduce the building's reliance on active (energy intensive) cooling, a recommendation might be to include a PCM 'envelope' in the building's wall cavities and roof space. The amount of energy saved is difficult to estimate, since it would depend entirely on the specific PCM employed, how much is used and exactly how/where it is integrated into the building's structure [5].

3.2) Use of thermochromic or electrochromic glass to provide automatic/dynamic shading

Thermochromic glass darkens (reversibly) as its temperature increases. This offers a mechanism to passively reduce solar heat gains during the most sunny and hot days of the year. An alternative to this is electrochromic glass, where a small current is applied to tint the glass. However, electrochromic glass is generally more expensive, requires a small amount of electricity to run and is generally better suited to privacy applications, or where light levels need to be carefully controlled. Here, we are mainly concerned with saving on the costs of actively cooling the building during the hottest days of the year in an efficient and passive way. A recommendation would be to use thermochromic coated glass in the building's roof light, which would provide automatic shade in the middle of the sunniest, hottest days of the year, when the solar heat gains of the building are problematic [6].

3.3) Use of passive ventilation system to provide additional cooling

An Automatic Opening Vent (AOV), which is essentially a motorised vent, could be installed in the building, to allow adjustable ventilation, helping to balance temperature and ventilation during both hot and cold days of the year. These are usually installed in the roof, often serving also as smoke vents in the case of a fire. Including several, small, adjustable floor level vents will help greatly to increase passive ventilation during summer days. When these are open, cooler air will be drawn in at floor level, rising as it heats up and escaping through the roof vent, creating an upward breeze to cool the building's interior [7].

4) Conclusion

The building can provide a comfortable envionment from which to bird watch year-round and is eco-friendly to the birds' habit. The energy consumption of the building is low with a low carbon footprint, which meets the proposed standards of a sustainable building from Bird Life International. The U value of the building complies with Building Regulation L2A. The heat gains in the building are low and equate to a maximum temperature of 26.7°C which acceptable for its use.

5) References

[1] Assignment brief

[2] The chartered Institution of Building Services Engineers, CIBSE Guild A

[3] Building Regulations L2A

[4] Lecture notes provided

[5] **Phase Change Materials for Energy Efficiency in Buildings and Their Use in Mortars** (Mariaenrica Frigione, Mariateresa Lettieri and Antonella Sarcinella) https://www.mdpi.com/1996-1944/12/8/1260/pdf

[6] Thermochromic smart window technologies for building application: A review, Applied Energy, Volume 255, 2019, 113522, ISSN 0306-2619 (Marina Aburas, Veronica Soebarto, Terence Williamson, Runqi Liang, Heike Ebendorff-Heidepriem, Yupeng Wu) https://doi.org/10.1016/j.apenergy.2019.113522

[7] Residential Passive Ventilation System: Evaluation and Design (Jame W. Axley) https://www.aivc.org/sites/default/files/members_area/medias/pdf/Technotes/TN54%20RESIDENTIAL%20PASSIVE%20VENTILATION.pdf