PHPP Estimation and Overheating Analysis

Project Reference:	A0151
Prepared for:	Kirkland Fraser Moor
Prepared by:	Ali Tariq
Date:	05-07-2023

Contents

1. Introduction

The calculations were carried out using Passivhaus Planning Package (PHPP - the Passivhaus calculation and assessment software), according to Passivhaus criteria. The Passivhaus methodology determines the measurements used to define the areas and volumes of the property, with heat loss areas measured to external faces of insulation layers in all directions. Assuming full-fill masonry cavity construction measurements were taken to the outer face of external masonry. Use of external heat loss areas allows an element of built-in provision for the additional heat flows of thermal bridging at building junctions. Measurements were derived from DWG drawings provided by Kirkland Fraser Moor (KFM).

The energy balance of the building is determined from the energy efficiency of its construction (affected primarily by U values, airtightness, glazing) combined with region-specific climate data, along with solar and internal heat gains. Where specific details are not yet known default values are used. All assumptions are listed below.

The resulting energy demand figures are given per square metre of Treated Floor Area (TFA - the useable internal floor area), per year (kWh/m2 /a). To achieve Passivhaus standard the annual space-heating demand according to PHPP must be 15 kWh/m2 or lower, or the peak heating load (the maximum output required from the heating system on the most challenging winter day) must be 10 W/m2 or lower. At the same time, risk of overheating must be avoided to achieve PHPP standards (discussed in more detail later in this report).

Heating demand or peak load and overheating risk are the primary criteria for Passivhaus compliance, and those most attention needs to be given to at design stage. There are additional requirements to ensure an excellent level of thermal comfort and indoor air-quality. These ensure that overheating is avoided in summer without a need for air-conditioning, and that minimum surface temperatures of any external element are high enough in winter to avoid cold air dropping from surfaces, causing internal draughts. This is especially relevant for windows and doors. The ventilation requirement ensures a continuous supply of fresh air while removing CO_2 and moisture from the living spaces along with any other contaminants.

2. Assumptions

The base case is assessed using the following assumptions:

- U values and thicknesses of walls and roofs derived from plans supplied by KFM. Thickness measured from internal surface to outer edge of insulation, or of any material in direct contact with the insulation. Floor thickness is based on reasonable assumptions for floor build up. These thicknesses determine the external areas. Once construction build-ups are finalised the PHPP calculations should be adjusted for the resulting final areas.
    - Basement Floor: 465mm, 0.086 W/m^2K
    - Basement Wall: 412mm, 0.24 W/m^2K
    - Cavity Wall: 515mm, 0.17 W/m^2K
    - Ground Floor: 465mm, 0.085 W/m^2K
    - Roof: 150mm, 0.108 W/m^2K

- Basement floor construction
    - 200mm celotex XR4000
    - 150mm concrete
    - 50mm celotex GA4000
    - 65mm screed

- Basement wall construction
    - 67mm expanded polystyrene
    - 250mm concrete
    - 67mm expanded Polystyrene
    - 15mm airspace/plaster dabs
    - 13mm plasterboard

- Cavity wall construction
    - 100mm brick, outer leaf
    - 50mm standard cavity
    - 120mm expanded polystyrene
    - 150mm concrete
    - 67mm expanded polystyrene
    - 15mm airspace/ plaster dabs
    - 13mm plasterboards

- Ground floor construction
    - 200mm celotex XR4000
    - 150mm concrete
    - 50mm Celotex GA4000
    - 65mm Screed

- Roof Construction
    - 200mm Celotex XR4000

- Airtightness test result assumed to be 0.6 air changes per hour (ach) at test pressure of 50 Pascals (50 Pa). This is the maximum allowed for Passivhaus certification. Achieving lower values will directly improve building performance.

- Mechanical Ventilation with Heat Recovery (MVHR) units assumed to be within the thermal envelope. A total system heat recovery efficiency of 80% is assumed. PHPP calculates the efficiency including heat losses from intake and exhaust ducts. The air inside these ducts is at (or close to) external air temperatures; to achieve the required efficiency these ducts must be kept as short as possible (MVHR units should be located on an external wall) and be well insulated. Initial calculations suggest the efficiency of the Zehnder ComfoAir Q600 unit provisionally specified would be close to this efficiency, with insulated intake and exhaust ducts no more than 5m long. The efficiency could potentially be improved by using two smaller units.

- Windows and doors entered as shown on the provided drawings. PHPP requires glass and frame U value information to be entered separately, calculating the installed U value for each window depending on the ratio of frame to glazing. The U values entered in these cases are provided by the architect. The detail discussion on the effect of these values are further in the report.

- Shading from surrounding buildings is not considered as it is a detached house apart from with other buildings to have any affect. Shading from vegetation is also not considered as the drawings do not illustrate anything about this.

- Treated Floor Area (TFA - broadly: useable internal floor area excluding internal walls) and air test volumes are calculated according to plans provided by Aura. These are subject to changes in internal layout and clarification of internal floor thickness, stairway sizing etc. Changes may affect the overall PHPP results, which are expressed as energy used per square meter of TFA.

- Domestic hot water (DHW) and heating pipe work is estimated as a total of 500m of 22mm pipe within the thermal envelope of the main building. Reducing the length and diameter of these (e.g., use of short pipe runs and microbore pipe for low flow taps wash basins) can help reduce heat loss from the system, both significantly helping avoid summer overheating and reducing DHW/Heating energy use. Storage vessel have been assumed, at 400 liters, with heat loss rate of 3W/K.

3. Results and Discussion

Following the assumptions and other inputs available in the drawings PHPP software has given the result of peak heating load as **7W/m²** which is under the allowable value of 10W/m². Although due to the structure of the house and climate changes the house will go above 25 degrees around 34% in the year, whereas according to PHPP standards this should only be 10% in the year.

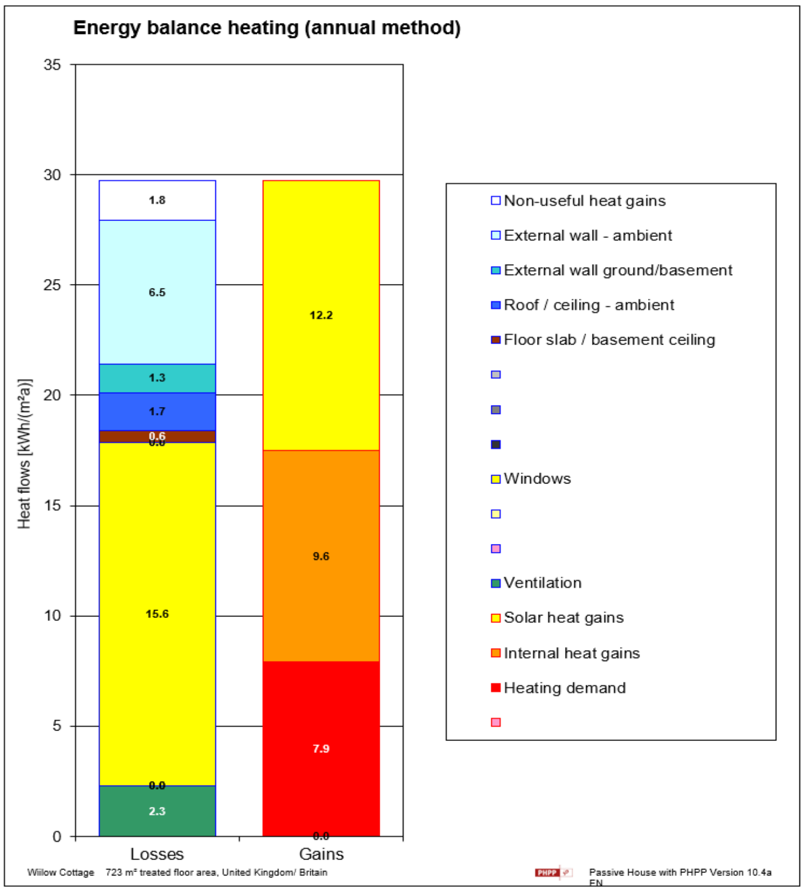

Figure 1: Willow Cottage energy balance heating

Figure 1 shows the heat balance of the current design, with sources of heat loss on the left and heat gain on the right. The large yellow bar on the left indicates significant heat loss from the windows and doors which is greater and constitutes almost 50% of total heat loss from the building. Also, the heat gain from the windows and doors is also significant but it does not balance itself with the heat loss through them.

3.1 Glazing

- Generally, frames are less thermally efficient than a good, sealed glazing unit - the amount of frame should be minimized.
    - A single opening window will perform better than two windows in the same structural opening.
    - Fixed windows have less frame than opening windows.
    - Opening windows or doors should be provided where needed to allow for additional summer ventilation and for access, with fixed windows used elsewhere. Often this relates to fixed larger windows and opening smaller ones.
    - Square windows have greater glazing to frame ratio than rectangular windows of the same area.
- It is generally more secure to leave windows open for ventilation (especially tilt and turn windows open in tilt mode) than doors. This can mean it is not possible to purge-ventilate at night if there are not sufficient opening windows due to most glazing being in the form of doors.
- For triple glazed units, a 1.2 m x 1.2 m window is generally the largest single unit that can be opened easily by hand.
- North, east and west-facing windows result in net heat losses. Efficient triple glazed units facing south will result in net heat gains. This can be useful in winter but must be balanced against avoidance of summer overheating.
- In addition to contributing to summer overheating, large windows can reduce winter comfort. Even the highest specification windows are significantly less insulating than walls. This can encourage draughts to develop, and results in a lower radiative temperature compared to walls, floors and ceilings leading occupants to feel cold.

As clearly seen in the energy balance heating figure 1 windows and doors are an important part of the building for heat gains and loss. The glazing material provided by the supplier has **U value of 0.6 W/m^{2}K.** The frames have different U values depending on their size and place where they will be installed. The installed U values of the windows are provided in the table below:

Description	Uf frame (mean)	Ug glazing	Uw installed
	W/(m2K)	W/(m2K)	W/(m2K)
D06	2.4	0.6	0.95
D11 & D12	3	0.6	1.44
W04	3.1	0.6	1.56
W10 & W11	2.7	0.6	1.75
D03 & D05	2.4	0.6	1.14
D13 & D14	3	0.6	1.45
W01	2.3	0.6	1.15
W09	2.7	0.6	1.41
W08	2.4	0.6	1.17
D15 & D16	3	0.6	1.45
W07	2.4	0.6	1.34
W08	2.4	0.6	1.17
W02	2.2	0.6	1.77
W03	2.7	0.6	1.45
D07	2.7	0.6	1.19
D10	2.4	0.6	1.08
D07	2.7	0.6	1.24
D09	3	0.6	1.23
D04	2.4	0.6	1.19
W05 & W06	2.7	0.6	1.41
Roof window 1	2.3	0.6	1.06
Roof window 2	2.3	0.6	1.47
Roof window 3	2.3	0.6	1.37

Table 1: Window U values

The average installed U value of the glazing is around **1.32W/m^{2}K** with some of them receiving comfort warning according to PHPP standards.

3.2 Recommendation

The focus of this report is not to get the PHPP certification but to achieve the standards set by the software. As there is room to reduce some U values of the construction elements in order to get closer to the allowed peak load of 10W/m^2 so for this purpose the roof insulation can be decreased to **150mm instead of 200mm.**

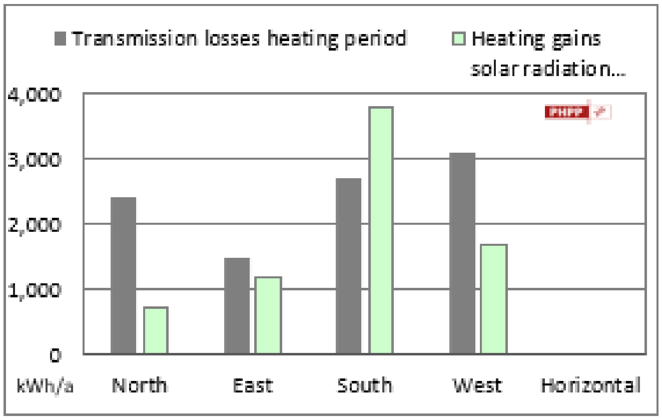

Figure 2: Willow Cottage winter heat loss and gain through windows

The graph represents the heat loss and gain through windows in winter. These values are obtained when glazing U value is set at 0.6W/m^{2}K. This shows that a total of 9,670KWh/a is heat loss and 7,387KWh/a is the heat gain through them. If the **U value of glazing is increased to 1.2W/m^{2}K**, then the heat loss will be 15,429KWh/a and heat gain through the windows will be 10,659KWh/a. This will result in more transmission lost during the winter season thus increasing the energy demand from **7W/m^2 to 9W/m^2** which is the target value that this report is focusing on. Also, the cost of glazing will be reduced as well as the higher the U value of glaze is the more it will cost. These results are achieved with having a good ventilation system that will contribute to the heat gains and transfer of energy from washroom and kitchen areas to the living areas of the house. The air tightness of the building also plays an important role in achieving this heat demand value and is considered as 0.6 air changes per hour at test pressure of 50Pa.

3.3 Overheating

The PHPP software not only helps in optimizing the building for less energy consumption but also provides information if the building under given circumstances will get any overheating in summer or not. With the change of global temperatures, the overheating of a house is becoming a concern in the UK as well. For the overheating calculation purpose first, a temperature increase of 15 degrees is added in the climate data for summers as the temperatures during summers go above 30 degrees in England. This will result in the following temperature data throughout the year.

Month	Temperature °C
January	4.6
February	5.2
March	6.7
April	8.7
May	17.8
June	30.2
July	31.9
August	32.6
September	28.6
October	13.8
November	7.2
December	4.7

Table 2: Annual temperature data in England

The data in Table 2 will help to calculate the amount of heat gain through walls and windows during the summers. Windows are the main source of heat loss and gain in this project as they have a large surface area exposed to the outer environment.

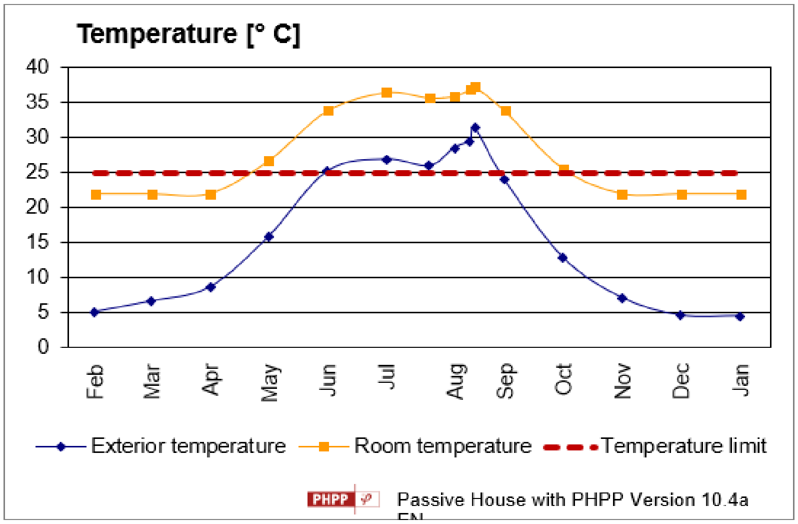

Figure 3: Willow Cottage during outside temperatures

Figure 3 graph represents the outside temperature and how the building will behave during that temperature. The orange line represents the inside temperature, and it can be clearly noticed from the graph that the temperature will even go above 35 degrees inside because the house is really well insulated so it acts as a trap and does not allow the building to cool down. Shading is important for a house that has a large surface area of windows. Therefore, if 50% of temporary shading is assumed in this scenario than the following results will be obtained as shown in Figure 4.

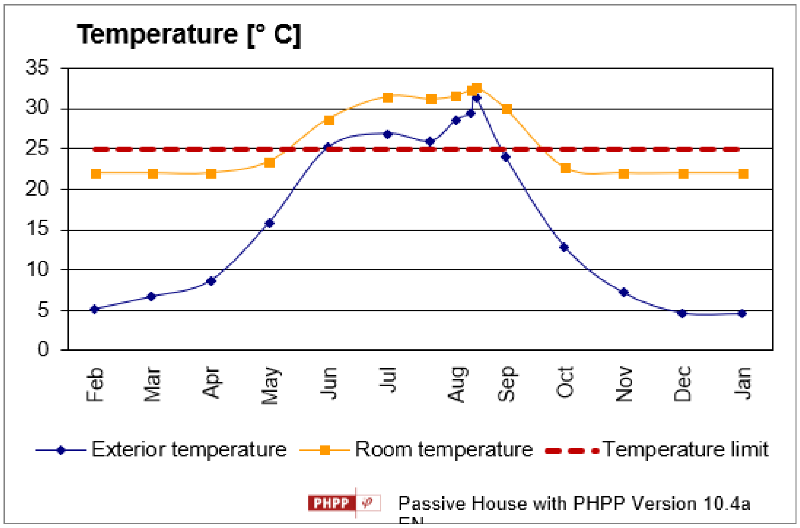

Figure 4: Willow Cottage during outside temperatures with 50% shading

As it can be seen from Figure 4 graph shading has quite a large effect on the internal temperature of the building. Temporary shading means that the windows are covered with some blinds or similar kind of design that will cut off direct sunlight into the rooms hence reducing the internal temperature.

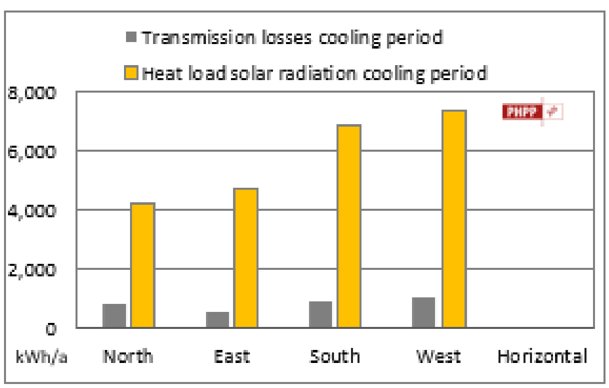

Figure 5: Willow Cottage summer heat loss and gain through windows

Figure 5 graph represents the amount of heat loss and gain through windows during the summertime. Another important factor is the U value of the glazing used in doors. If the current glazing with U value of 0.6W/m^{2}K is used than it will result in 3,298kwh/a of transmission loss and 23,102KWh/a of heat load gain during the summer without any temporary glazing. When we increase the U value of the glazing to 1.2W/m^{2}K than we can reduce heat gain to 19,792KWh/a without any temporary shading. As from these figures we can clearly see that the house will need cooling in the summer to bring the temperature below 25 degrees which is considered as the limit for summers and is the optimal summer temperature.

3.4 Cooling

Mechanical cooling does offer a way of reducing the overheating risk but at the expense of increased energy use, running costs, and capital costs of equipment. The increased energy use and equipment also increase associated carbon emissions. Cooling can be provided in various ways to the building, these can be recommended by the Mechanical and Electrical (M&E) design team which way they prefer. Purge cross ventilation from opening windows can be effective at providing additional cooling, especially at night when external temperatures are more likely to be lower than internal. Opening windows on the ground floor and on upper floor can make use of the stack effect, whereby warm air rising through the upper windows can draw in cooler air through the lower ones. With the roof windows on the first floor of the proposed architectural design there is good potential for this. However, as previously mentioned it is wise not to rely heavily on this for cooling. External conditions or security concerns can reduce the ability to leave windows open. It is also important that the building does not reach excessive indoor temperatures while closed when empty. It will be difficult to cool the building sufficiently on return.

In order to provide cooling PHPP software suggest a cooling load total of 9.4KW required. We have calculated per room cooling required on the bases of drawings provided. These calculations are not finalised and provide just an estimation on how much cooling is required; any change in the drawings might result in change of the required cooling as well.

- Master Bedroom: 750W
- Bedroom 2: 550W
- Bedroom 3: 550W
- Bedroom 4: 540W
- Lounge: 730W
- Family Room: 1170W
- Leisure Room: 870W

These estimations are based on U values of walls as described before in the report and U value of glazing provided by the supplier.

4. Conclusion

The current design is significantly working well according to PHPP standards during the winters requiring almost $7W/M^2$ of heat demand. This heat demand is increased to $9W/m^2$ by changing the U value of the glazing from $0.6W/m^2K$ to $1.2W/m^2K$ and reducing the insulation of the roof from 200mm to 150mm. This will result in cost reductions also.

Overheating risk under the current design is almost 34%, meaning that almost 34% of the year the house will be above 25degrees which will have impact on living in the building. Therefore, cooling is required during the summer. An estimation of cooling per room is provided in the report within Cooling section.

These results are subject to the assumptions stated, and the plans and information provided. Changes in design or specification will affect the results.