Heating load as a design target revisited

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Summary

A Passivhaus can be designed to meet a specific heating demand (SHD) target of 15 kWh/(m^2.a) or a peak heating load of 10 W/m^2. The SHD target is more usual but the authors explore the benefits of designing for peak load. These include reduced costs, better summer comfort, reduced sensitivity to shading, orientation and location, and greater potential for standardised designs. Space allows only one example but we are drawing on many years of experience designing and monitoring many types of Passivhaus buildings including houses, flats, schools and offices. Our experience is mostly limited to the UK but we expect most of the principles outlined here to be more widely applicable.

Passivhaus is not passive-solar but old habits die hard

One of the inspirations for writing this was a regular comment by CEPH students, 'I finally have a client with an ideal site for a Passivhaus'. The passive solar fantasy is to face all habitable rooms towards a beautiful private south view with utility rooms to the north. This allows generous glazing (more than required for daylight) shaded in summer by overhangs. If Passivhaus is to be a scalable solution, this approach is too limiting. Also whilst heat from the sun is free, capturing it with extra window area is not cost-effective and increases summer overheating risk. Solar gains are part of the peak load calculation but we can see from figure 1 that they are less of a driver when designing to this metric. Solar shading can be difficult to model accurately and will change over the life of the building as trees grow or new buildings are constructed. Similarly the load calculation is less sensitive to unknowable internal heat gains (IHGs) which will change with occupancy, technologies and affluence.

In the UK climate, an optimised south-facing Passivhaus with overhang shading can achieve <15kWh/(m^2.a) and <10W/m^2 with good summer comfort. Hope View House (ID 5822, passivehouse-database.org) achieved 12kWh/(m^2.a) and 9W/m^2 in PHPP. However when we see a building where the PHPP indicates say 12kWh/(m^2.a) and 12W/m^2 our experience suggests this is likely to be a building that is uncomfortable in summer. Additional glazing is providing a modest amount of extra heat in winter but the extra glass is increasing the peak heat loss hence the load is over the 10 W/m^2 target. If we move our solar-optimised building to a west facing site we will see the annual heat demand go up and the summer overheating will become catastrophic (unless we add external shutters that we close by day). However if we design a building that works well in an east west orientation, it will almost certainly work well facing south.

East-west orientation forces us to design our glazing for optimum daylight (also views, ventilation, escape etc) rather than solar heat gain. We may struggle to achieve the 15kWh/(m^2.a) but can more easily achieve the heat load target due to less glazing. Heat load has been seen as a fallback to certify dwellings with unfavourable shading or orientation but we are finding it to be a better metric for economical and comfortable homes in the UK climate.

The graphs below comparing specific heating demand and load clearly illustrate how IHG and solar gains are much less dominant in the peak heat load balance. Previous conference papers by the same authors have explored the impact of IHG assumptions on the energy balance. Whilst these gains can never be predicted with any certainty, the values used have a significant impact on the energy balance which in turn drives design decisions relating to insulation thickness and required solar gain. For the heat load balance, for the many studied examples in the UK climate, the accuracy of assumptions on IHG and solar gains is less critical.

The graphs show the heating energy and power balance for a detached west facing Passivhaus on a plot in Bishop's Castle, Shropshire UK, with other houses to the north and south. Using the builder's standard 300mm I stud construction and glazing optimised for daylight and summer comfort resulted in a 2kWh/m^2 shortfall in the heating demand energy balance. The design was well optimised with limited options remaining to meet the 15 kWh/(m^2.a). All the options considered had extremely poor cost-benefit and made summer comfort worse. The house is very comfortable all year and has measured space heating costs of about £150/year by air source heat pump (170m^2 TFA). PHPP shows the building works better facing south but the occupants say they now prefer the east-west orientation.

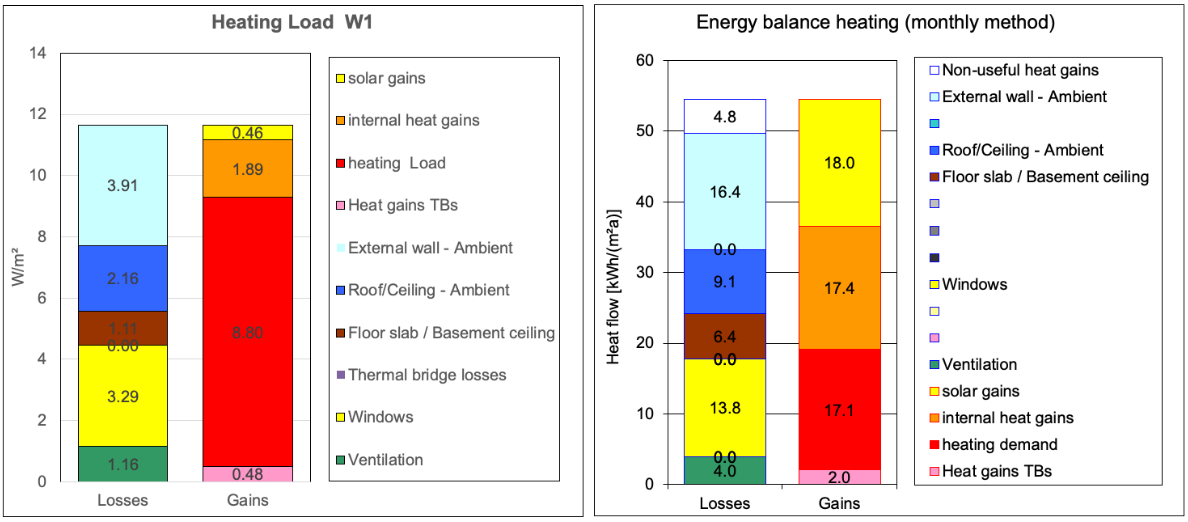

Figure 1: A west facing Passivhaus with optimised glazing and 0.1h^{-1} n50 airtightness.

Option	As built	SHD kWh/(m^2.a)	Heat Load W/m^2	>25°C (no window vent)	Notes
As built		17.1	8.8	5%	200m altitude
0.62 g glass	0.54	17.1	9.0	7.5	Glass area is 13% of TFA
400mm floor ins'	200	15.4	8.4	7.6	High cost and embodied carbon
400mm wall studs	300	15.0	8.1	6.1	High cost, redesign, larger footprint
400mm roof	300	15.4	8.3	5.7	Higher cost, raised ridge height
Face south	west	15.0	8.5	1.5	Works even better
Move to Dundee	Zone 7	18.9	8.8	0.2	Scotland, 200m altitude, facing W

Table 1: Options to meet 15 kWh/(m^2.a) & a test of the performance rotated 90° or moved to Scotland.

In terms of emissions, for a fossil fuel heated building, energy use is more relevant than peak load. As we move to 100% renewables, it is the capacity to meet peak loads and to match demand and supply that becomes the more important challenge. The energy is free, power when needed is expensive.