

The Passive House Formulary

CONTENT:

Passive House basics	02
The U-value, R-value	03
U-value – increased thickness	04
Thermal bridges	05
Windows	06
Windows – Energy balance	07
Airtightness & Blower Door testing	08
Ventilation	09
Insulation thicknesses	10
The Magic Formula	11
Thermal Energy (heat) Demand & Load	12
Heat vs Energy	13
Energy diagram	14
Heating, Cooling and Dehumidification; DHW	15
Systems, Heat pumps	16
Economics	17
Economics - Profitability calculations	18
Economics - a-value table	19
PHPP – PER factor, worksheets	20
PHPP – U-values worksheet	21
PHPP – ground worksheet	22
Mathematics and Definitions	23
Symbols and Definitions	24
Psychrometric chart	25
λ-value	26
The PH Building standard	27
Retrofit guidelines	28
Tables and tools	29

The Passive House Basics

The Passive House Standard:

- I. **Heating demand:** $q_H \leq 15 \text{ kWh}/(\text{m}^2\text{a})$
(or) **Heating load:** $p_H \leq 10 \text{ W}/\text{m}^2$
- II. **Cooling demand:** $q_C \leq 15 \text{ kWh}/(\text{m}^2\text{a})$
(or) **Cooling load:** $p_C \leq 10 \text{ W}/\text{m}^2$
(or) **No cooling system:** 10 % of time over 25°C
- III. **Primary Energy Demand: (Electricity)**
PE $\leq 120 \text{ kWh}/(\text{m}^2\text{a})$
(or) **Primary Energy Renewable Demand:**
PER $\leq 60 \text{ kWh}/(\text{m}^2\text{a})$
- IV. **Airtightness** $n_{50}: \leq 0.6 \text{ h}^{-1}$ (@ 50Pa)

Passive House requirements

- ✓ Comfort Zone 20 -25°C
- ✓ $\Delta T \leq 4.2 \text{ K}$ between air temp. and surface temp.
- ✓ $\Delta T \leq 2 \text{ K}$ between 0.1m and 1.1m off ground and 0.5m away from the window.
- ✓ Relative Humidity (RH) 30% -60%
- ✓ absolute humidity (AH) $\leq 12 \text{ g}/\text{kg}$ @ 25°C
- ✓ Min. temperature 12.6°C at any point
- ✓ min supply air: 30m³ per person and hour
- ✓ Heat Recovery Ventilation (HRV)
 $\eta \geq 75 \%$ heat recovery efficiency

Passive House classes:

Passive House classes	Classic	Plus	Premium	Units
Primary Energy Demand (PER)	≤ 60	≤ 45	≤ 30	$\frac{\text{kWh}_{\text{PER}}}{\text{m}^2_{\text{TFA}}\text{a}}$
Renewable Energy Generation	n/a	≥ 60	≥ 120	$\frac{\text{kWh}_{\text{PER}}}{\text{m}^2_{\text{ground}}\text{a}}$

Why Passive House:

Health

- We spent 90% indoors (artificial environment)
- Indoor environment should not give any cause for health risks (air pollution, mould)
- The indoor climate must be comfortable

Sustainability

- We need to drastically reduce CO₂ emissions to slow down climate change
- CO₂ emission: 28% building use, 11% construction
- 50% of household energy used for space conditioning

Economics

- The home is the biggest investment of a lifetime
- Low-risk investment/long term return on investment
- Additional investment: a coffee a day

The 5 Passive House components (or principles) (for cool temperate climate - as in exam)

3. Thermal bridge free

$$\sum(l \times \Psi) + \sum(n \times X) \leq 0.0 \frac{\text{W}}{\text{K}}$$

(Linear) Thermal bridge free: $\Psi \leq 0.01 \text{ W}/\text{mK}$

(Point) Thermal bridge free: $X \leq 0.01 \text{ W}/\text{K}$

2. Passive House windows

$$U_{w_{inst}} \leq 0.85 \frac{\text{W}}{\text{m}^2\text{K}}; U_w \leq 0.80 \frac{\text{W}}{\text{m}^2\text{K}}$$

$$U_g = 0.5 - 0.7 \frac{\text{W}}{\text{m}^2\text{K}};$$

$$U_f = 0.65 - 0.80 \frac{\text{W}}{\text{m}^2\text{K}}$$

$$g\text{-value} = 0.5 - 0.55 \text{ (SHGC)}$$

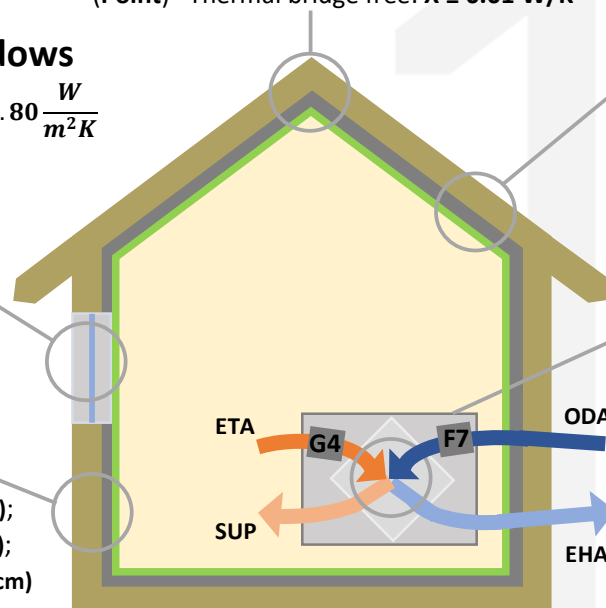
1. Thermal insulation

U-value [W/m²K]:

Roof $\leq 0.15 \text{ W}/\text{m}^2\text{K}$ (30-40cm);

Wall $\leq 0.15 \text{ W}/\text{m}^2\text{K}$ (24-30cm);

Ground $\leq 0.25 \text{ W}/\text{m}^2\text{K}$ (15-25cm)



4. Airtightness

$$n_{50} \leq 0.6 \text{ h}^{-1} \text{ (@ 50Pa)}$$

5. Heat recovery Ventilation

$\eta \geq 75 \%$ heat recovery efficiency

Electricity demand max.

$$p_{el} \leq 0.45 \text{ Wh}/\text{m}^3$$

Filter:

Outdoor air intake: F7;

Extract air: G4

Max. imbalance between intake & exhaust = 10%