

Retrofit and Building Physics Wookey

Who am I?

- Wookey, Software Engineer
2 Houses, 3 projects
- 1933 Semi: IWI, CH, electrics, DG, loft
- 1963 Detached.
- Plus extension.
- Basics, Why, Examples, Discussion

1st house



Bricking up flue



2nd house



Terminology

- EWI
- IWI
- EPS/XPS/PUR/PIR
- SAP, rdSAP, EPC
- PHPP
- AECB
- Soffit, verge, purlin, rafter, joist
- U, R, K – value

Heat movement

- U-value – area. ($\text{W/m}^2\text{K}$) – per construction
- K-value ($1/\text{US R-value}$) ‘heat-conductivity’ (W/mK) – per material
- Psi-value – linear. (W/mK)
- Chi- value – point (W/K)
- U and K are simple, (Psi & chi need finite-element sums)

U-values

- U-value – area. Smaller is better
- $\text{W/m}^2\text{K}$
- 5 is terrible, 0.1 is good
- Whole construction (83% brick, 17% mortar)
- Single-glazed window: 5
- Double-Glazed: 2.6-1.4 (Triple 1.1-0.65)
- Brick wall: 2

K-value

- W/mK 'heat conductivity'
- Insulants < 0.05
- Glass 0.96, Brick 0.8, Wood 0.15
- Al 237, Steel 50, Stainless 14
- Straw 0.08, Woodfibre 0.038, Hempcrete: 0.06
- Foamglass: 0.041, Cellulose: 0.035-0.04
- Rockwool: 0.032-0.044, Fibreglass: 0.035
- EPS: 0.033, XPS:0.033, PUR:0.024
- Aerogel: 0.014
- $U = 1 / (1 / K * \text{thickness} + 1 / K * \text{thickness} + \dots)$

Building Physics

- Airtightness
- Insulation
- Vapour movement
- Solar Gain - PHPP
- Airtight != vapourtight (e.g. plasterboard)

Airtightness

- Just as important as insulation
- Continuous layer – 2 buckets
- Regs: $\text{m}^3/\text{h}.\text{m}^2$ @50 pascals
- Passivehouse: ACH @50 pascals
- Similar numbers – big is worse
- UK regs: $10\text{m}^3/\text{h}.\text{m}^2$
- Reasonable: 3 (MVHR)
- Good: <1 (0.6 ACH for passivehouse)
- Thermal bypass

Vapour

- No issue in draughty houses
- Improve walls+windows → soggy loft
- Warm walls → condensing windows
- 14C critical temp - dewpoint
- Vapour movement in walls is bad

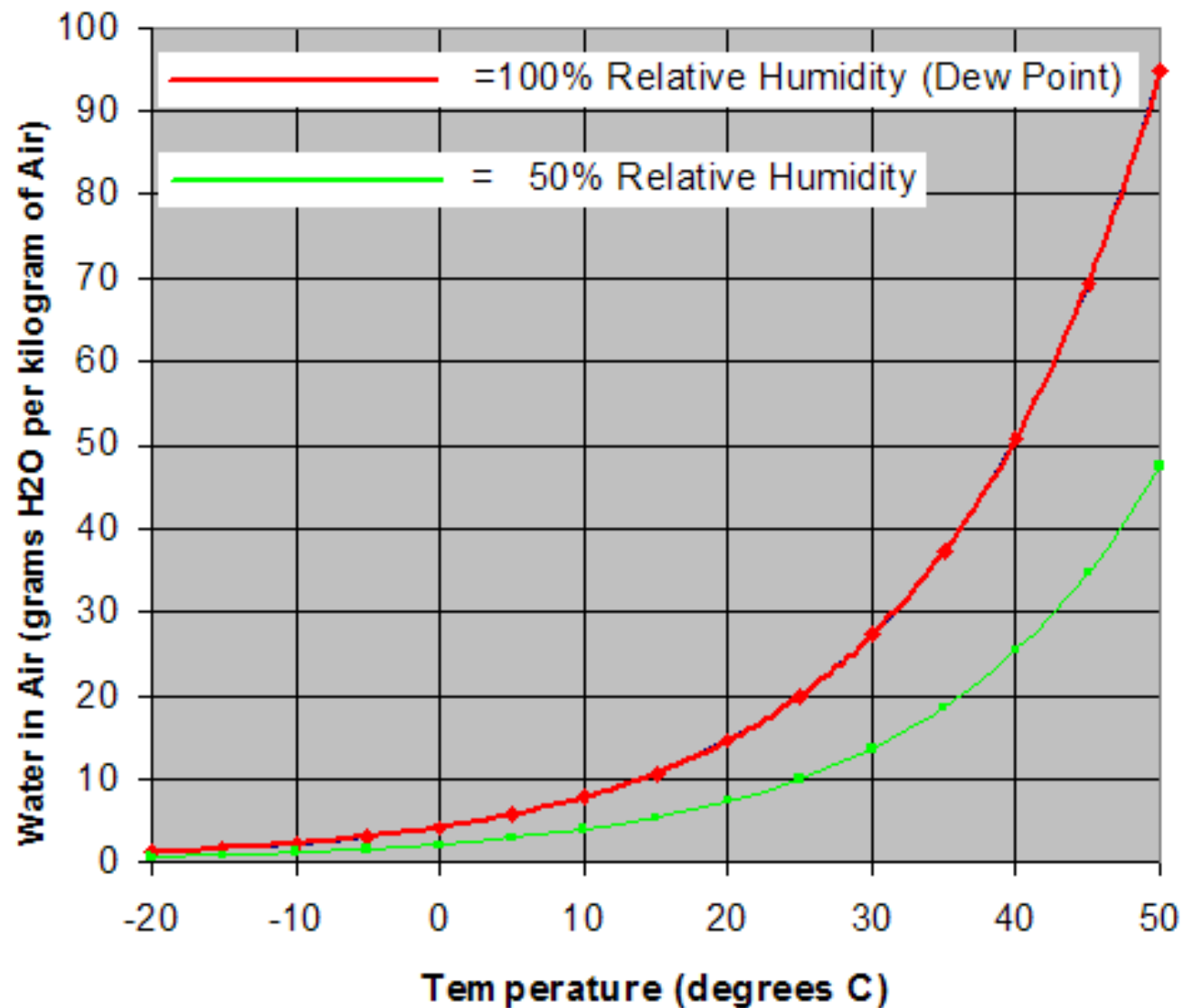
Humidity

- Indoor RH 30-60%
- Cold air has less water – air dryer in winter
- 100% RH → condensation
- Cool down 50% RH air @20C. Condenses at 8C (cold window, or half-way through wall...)

Dewpoint

Amount of Water in Air at 100% Relative Humidity Across a Range of Temperatures

Calculated with tool at <http://www.lennetech.com/calculators/relative-humidity.htm>



Other concepts

- Thermal Mass
- Decrement delay
- Comfort relates to radiant surfaces

Why Refurb

- Comfort. Visit a passivehouse!
- Energy: 5-10% extra. 10% of heating load – much cheaper over lifetime
- Environmental.
- Average gas house is 3 tonnes/yr.
- Huge job needs doing, responsibility for those with resources.
- Smaller heat pumps much cheaper.

Costs

- Refurb costs money
- Payback is silly – cars, kitchens
- 70 years for double glazing
- PH retrofit can be £100,000
- My retrofit so far £5000 (or -£15,000) - £500/yr
- £12,000 when done?

Passive retrofit



Thermal Camera



1963 detached house



Space heating

- PH is **15** kWh/m² per annum
- Enerphit (refurb) is **25** kWh/m².a
- My house as built is **377** kWh/m² per annum
- As bought (D/G+cavity wall ins): **120** kWh/m².a
- AECB carbonlite is **~40** kWh/m².a
- UK average 14,000 kWh/a
- 40kWh/m²a = 4000 kWh/a (@20C)
- PH ~2000 kWh/a (1kW heater on cold days).

Costs for refurb

- Solar thermal £800
- Woodburner £500, chimney £300
- IWI £1500
- Door £800
- Loft £300
- MVHR £1000
- Airtightness £350
- Workshop £500+£1000 custom door
- UFH £700
- PV £10500 (-£20,000 by 2030, 4% is usage saving)
- (Extension £40,000)
- £165/yr for electricity and gas
- Windows: £3000?
- EWI: £4000?.

Bay window



Move/New boiler





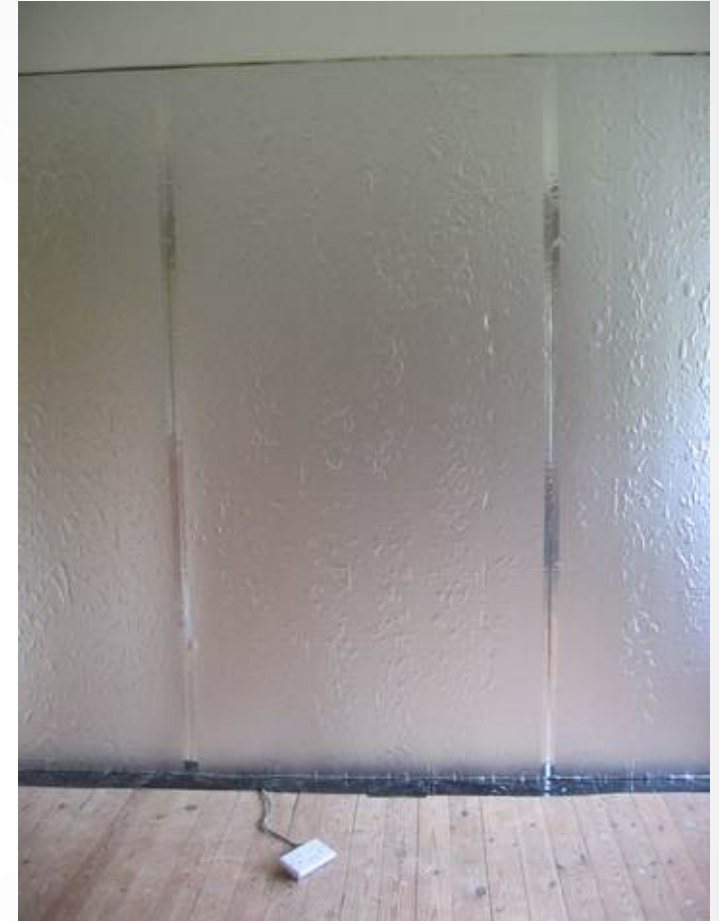
IWI – Ceiling void



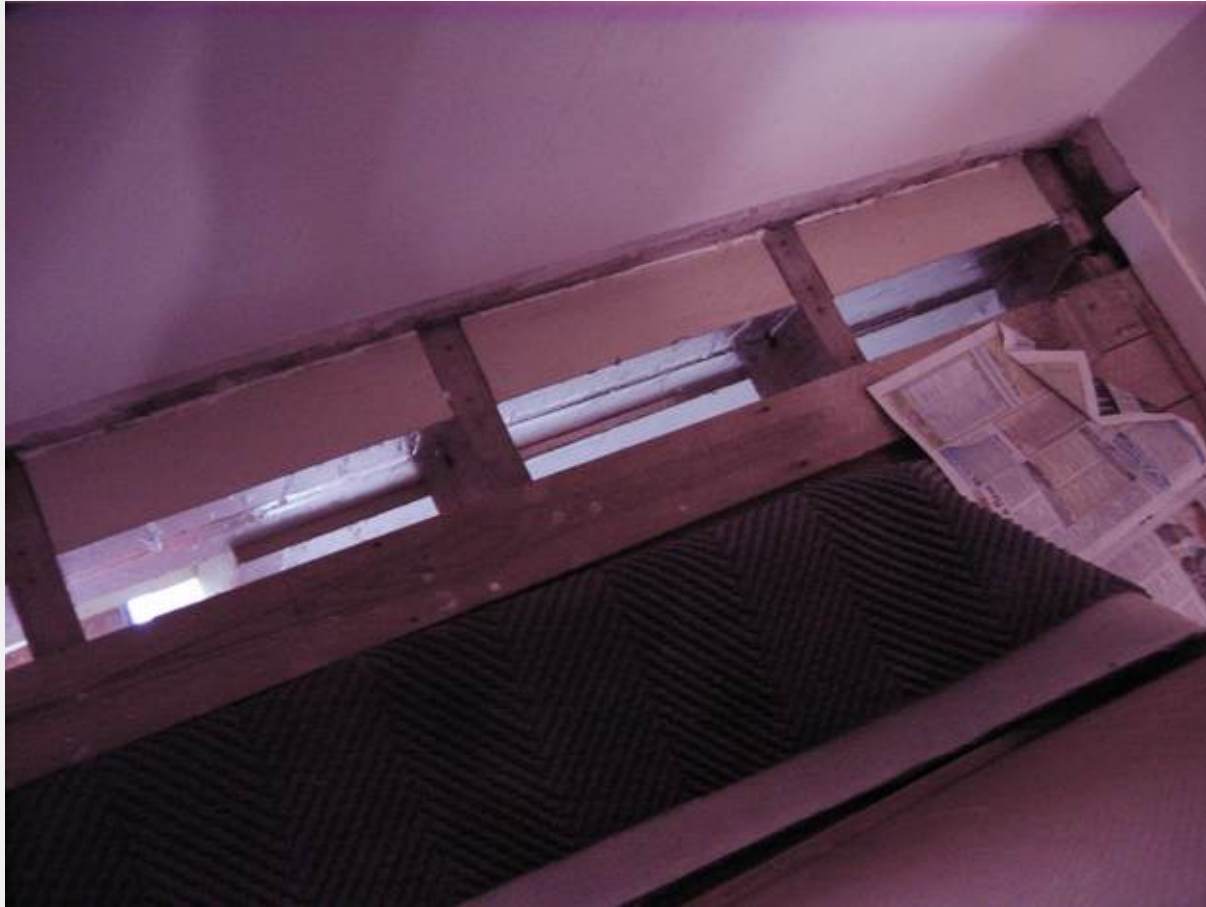
IWI – end joist



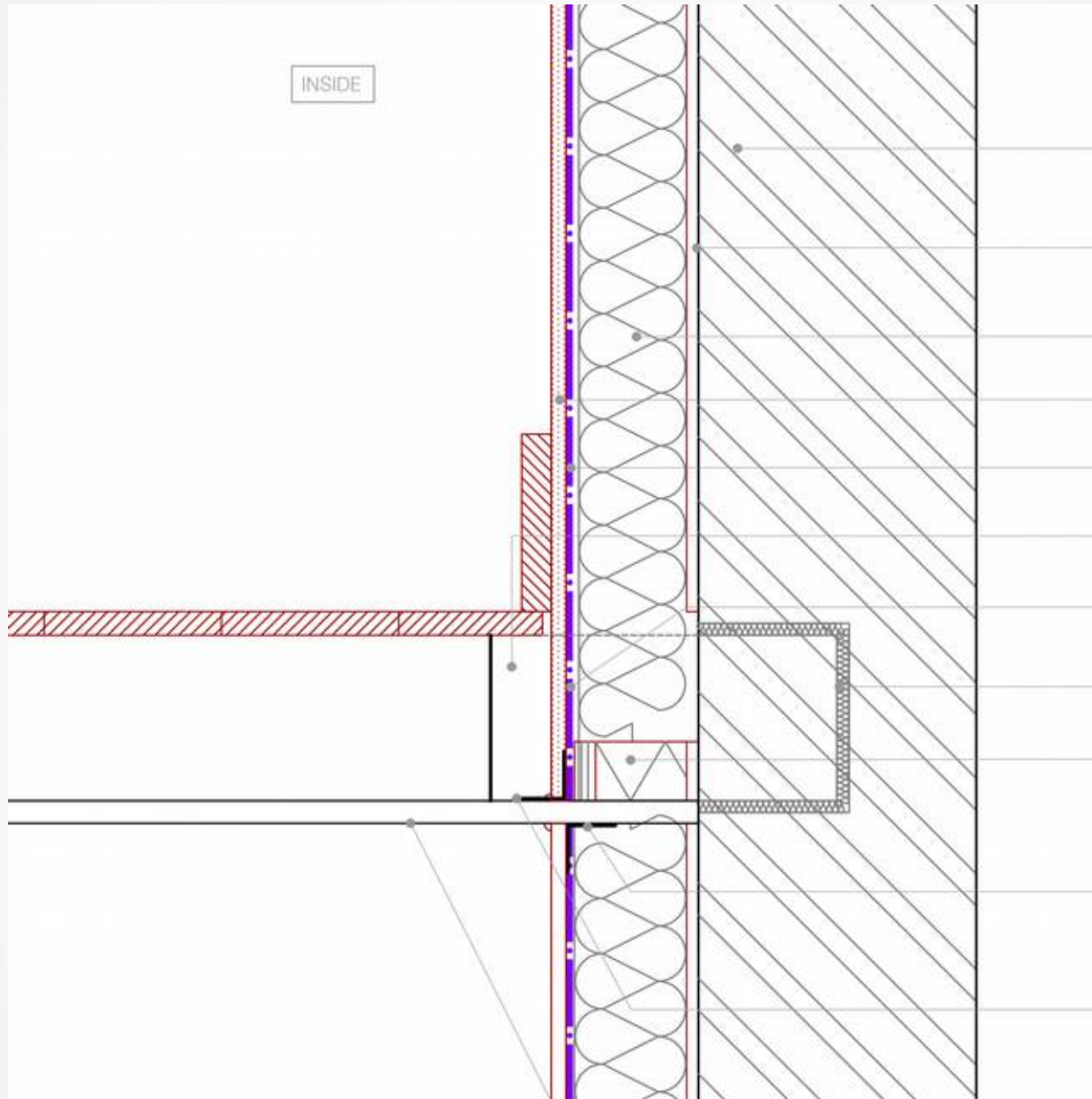
IWI-gable wall



IWI-joists



IWI layout



IWI – radiator mount





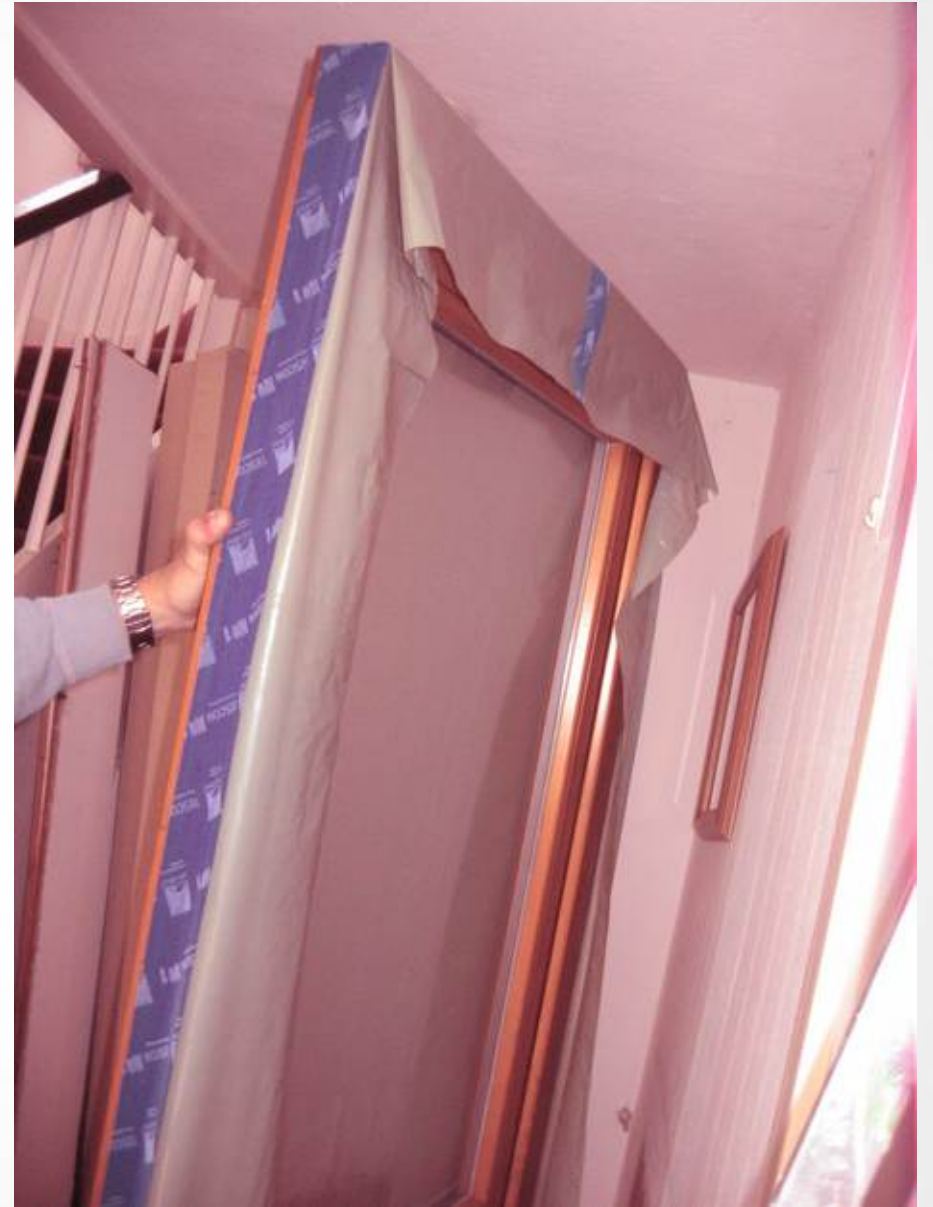
Lofthatch



Window reveals









Solar Thermal



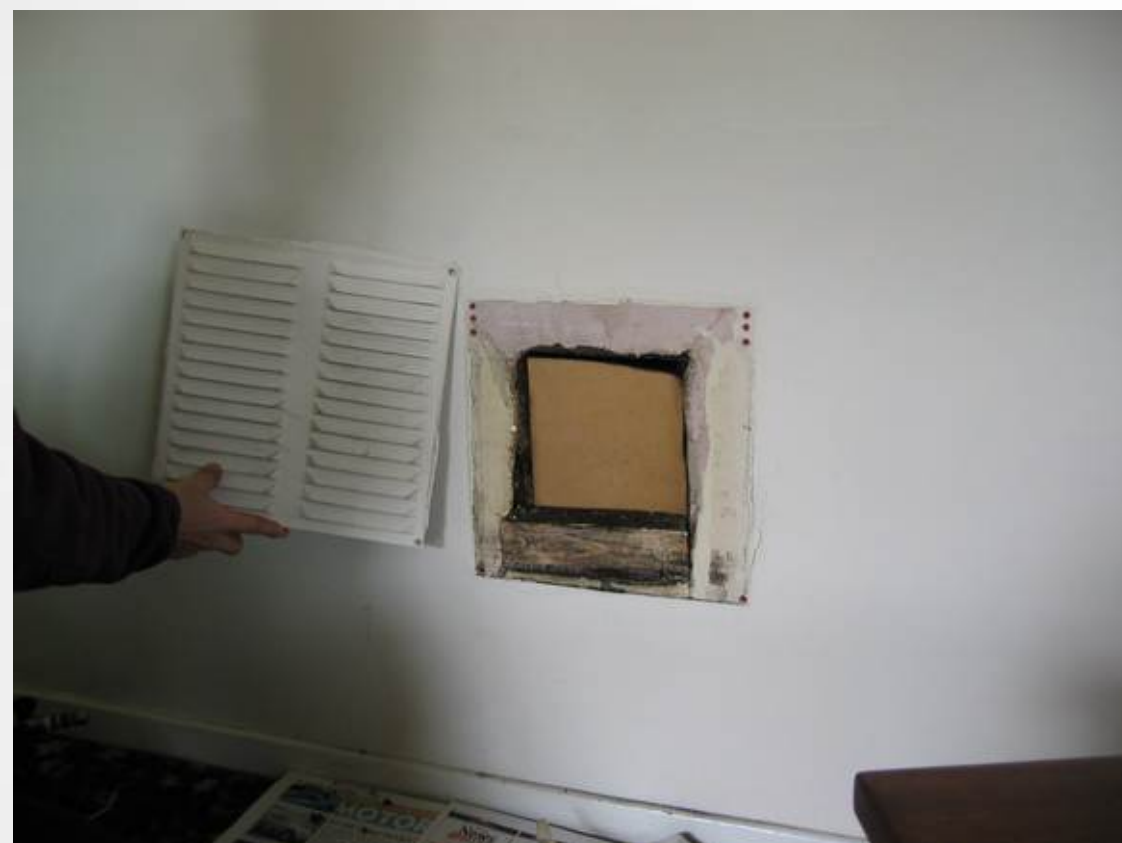
Solar Thermal



Solar PV



Woodburner



One less door



0.15 U wall



Thermal bridging



‘Interesting’



EWI



Modelling

- PHPP
- Therm
- (Energy2D)
- (e-SPR)
- U-value calculator

Suppliers

- Green Hat Construction (Builder)
- Green Building Store (Kit, advice, modelling)
- Navitron/Eco-nomical (Renewable kit)
- A.C. Architects (Architect)
- Margaret Reynolds (Architect)
- Mole Architects (Architect)

Handy sites

- <http://www.greenbuildingforum.co.uk/newforum>
- <https://readinguk.org/draughtbusters>
- <https://retrofit.support>
- <http://openecohomes.org/>
- <https://passivehouseplus.ie/>
- <http://www.greenspec.co.uk/building-design/insulation-materials-thermal-properties/>
- Many more