Retrofitting Towards our Dream Home

Stuart Dyer (Home-owner)
Margaret Reynolds (Architect)

Thu 10 Oct 2024, 7:30pm - 8:30pm

OPEN eco HOMES

Cambridge Carbon Footprint

CAMBRIDGE RETROFIT HUB

G V Harrison — THE ROOF WINDOW EXPERTS

Mole

KEYSTONE ARCHITECTURE & DESIGN

THE CAMBRIDGE Building Society

INCLUME

McCarthy Architectural Design

www.mccarthyarchitecturaldesign.co.uk

MR RIBA

IL

Ac

WRIGHT CHOICE

CFCI

CAMBRIDGE CITY COUNCIL

South Cambridgeshire District Council

Agenda

7:30 pm	Introduction
7:35 pm	Stuart - Background, Aims, Costs, Timeline, Lessons
7:50 pm	Q&A
8:00 pm	Margaret – Digging into the Details
8:15 pm	Q&A
8:30 pm	Thanks and feedback

Background & Aims

Engineer by background, had participated in Transition Energy & AECB meetups for many years, interest in Eco, Retrofit & Energy.
Bought 4 bed 1930s property in 2016.

Original Home as purchased:

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3) Retrofit for comfort

Retrofit for Comfort

1) Insulate
2) Improve Airtightness
3) Ventilate
4) Decarbonise - electrification to get off gas
5) Minimise wasted heat
6) Control temperature – minimise overheating

Retrofit for Comfort

1) Insulate
    1) Loft insulation
    2) External Wall Insulation
    3) Floor Insulation
    4) Insulate all hot & cold pipe runs – except heating pipes
2) Improve Airtightness
3) Ventilate
    1) Mechanical Ventilation with Heat Recovery (MVHR)
4) Decarbonise - electrification to get off gas
    1) Heating – Air Source Heat Pump (backup log burner)
    2) Induction Hob
    3) Solar PV (no battery)
5) Minimise wasted heat
    1) Waste Water Heat Recovery System
6) Control temperature
    1) Passive – design overhangs over windows, optimal glazing
    2) Active – external blinds on Fakro roof lights

Decarbonise – Electrification to Remove Gas

1) Heating – Air Source Heat Pump – should cut CO_2 by 77-85% vs gas boiler
2) Induction Hob
3) Solar PV (no battery)

Decarbonise - ASHP – Install Cost

Cost of Samsung HTQ 8kW ASHP (excluding radiators):

Description	Quantity	Sell	VAT	Total (Ex VAT)
Goods - Heating ancillaries.	1.00	£1,100.00	0.00%	£1,100.00
Goods - Electrical ancillaries.	1.00	£320.00	0.00%	£320.00
Goods - Samsung 8kw HTQ heat Pump & 300l hot water cylinder Kit.	1.00	£6,709.20	0.00%	£6,509.20
Goods - Additional to estimate| pre insulated pipework from heat pump to main building	1.00	£240.00	0.00%	£240.00
Services - Heating installation	1.00	£4,700.00	0.00%	£4,700.00
Services - Electrical installation	1.00	£1,500.00	0.00%	£1,500.00

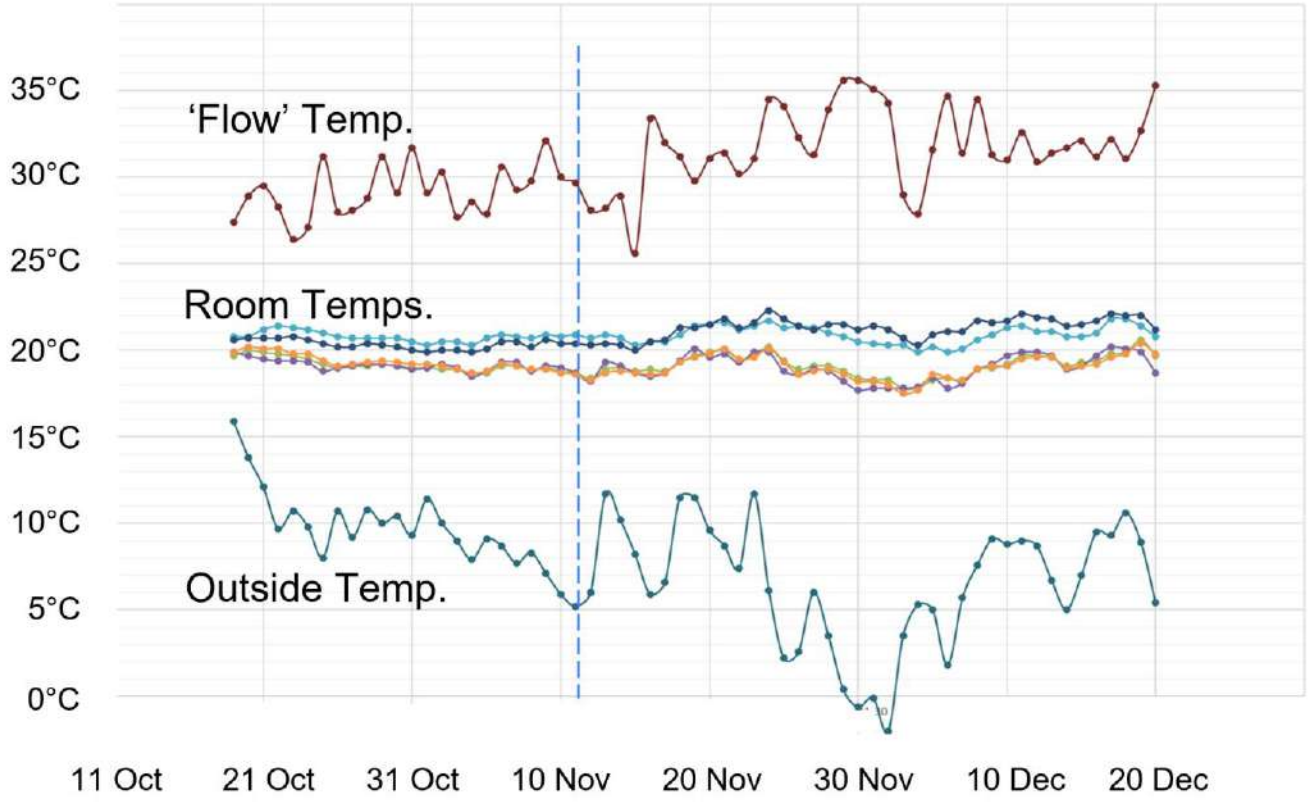
Total Excluding VAT:	£14,369.20
BUS VOUCHER:	£5,000.00
VAT Amount:	£0.00
Total Including VAT:	£9,369.20

Decarbonise - ASHP – Comfort

Constant, steady heat

=

Constant, steady temperature



Decarbonise - ASHP – Running Cost

- ASHP COP = 4.4 (i.e. 1 unit of electricity = 4.4 kWh of heat)
- Gas price = 6.99 p/kWh
- Electricity = 19.9 p/kWh (avg)
- So cost of ASHP heating = 19.9 / 4.4 = 4.5 p/kWh or 36% cheaper
  - Assumes gas 100% efficient – it’s more like 85%
  - Gas removed – no standing charge at 31p/day = £113 p.a.

Decarbonise – Solar PV

1) 21 x 405W panels = 8.505kW
2) 5kW inverter

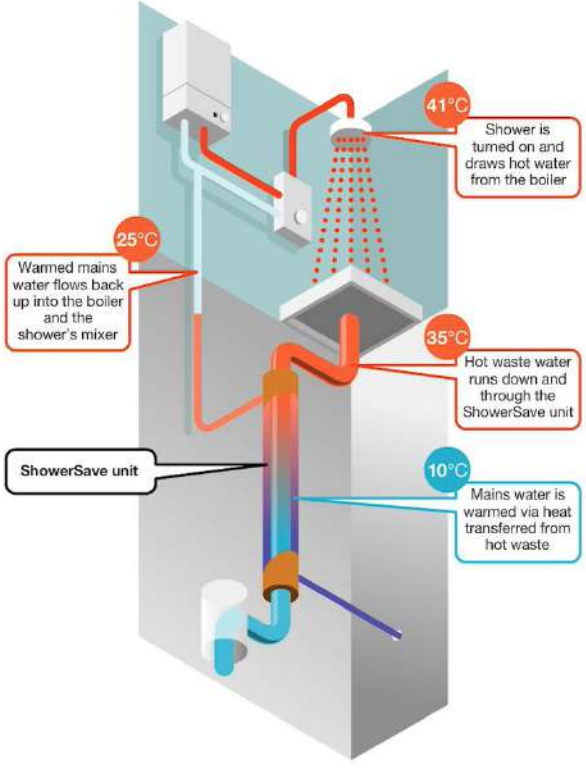
Induction Hob

1) Novy Panorama – significant IAQ improvement
2) Hard to work out whether to vent internally or externally

Minimise Wasted Heat

The more efficient a home, the higher the percentage of energy used to heat water – hence WWHRS fitted.

Grand name for something very simple – a pipe inside a pipe!



Costs

Big ticket items:

	Builder
£44k	Triple Glazing
£34k	Kitchen
	Architect
	Moving Twice & Renting for 12 months
£16k	MVHR
£14.5k	Solar PV
£ 9k	ASHP
£ 4k	Structural Engineer

Timescales

Very Long – but we were not in a hurry!

July 2016 – Bought house & moved in
Jun 2017 – Met 3 architects
Aug 2017 – Appointed architect, PHPP modelling, kitchen & bathroom quotes etc
Aug 2021 – Tender out to builders
April 2022 – Minor Works contract signed with Green Hat Construction
June 2022 – Foundation works start
July 2022 – Move to rented property
May 2023 – Move back into house
Sept 2023 – Finished work (23 weeks late)
Oct(?) 2024 – Snagging still to be done!

What Went Well, What Could Have Been Better

1) Very happy with end result
2) Largest issue - roof over sunroom went badly – should have got 3 quotes!
3) Annoying small things:
    1) Toilets not where they should be
    2) MVHR vent in master bedroom
    3) Missing light switches
    4) Boxing for MVHR ducts
4) MVHR good
5) ASHP great
6) Low running cost, low energy use, very comfortable, good indoor air quality

Main takeaway –
<u>You need to constantly monitor what's going on and ensure it's what you want!</u>

Questions (+ photos!)

Please put your questions into the chat

The End Result - outside

The End Result - inside

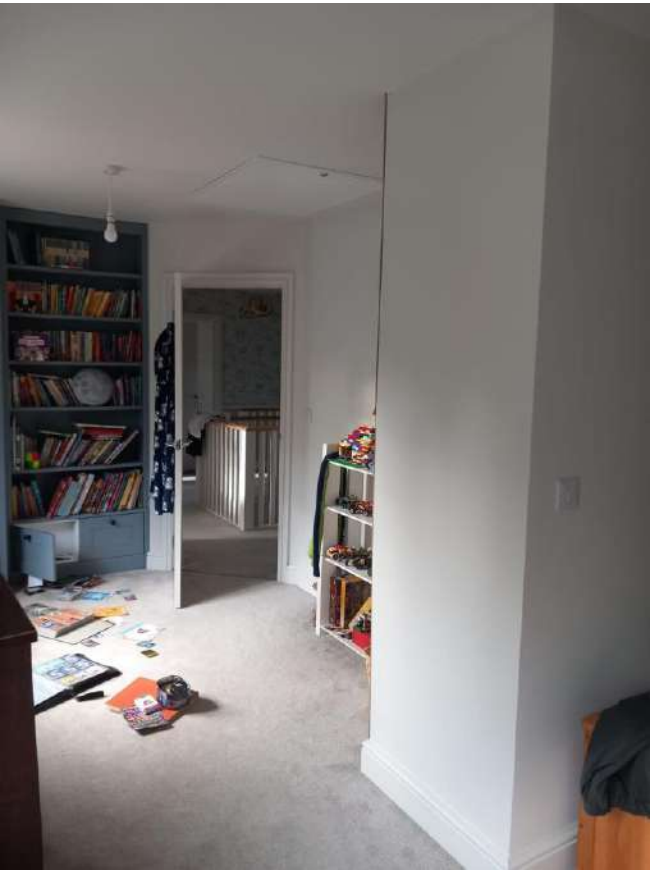
Hall

Sunroom

The End Result - inside

Lounge

The End Result - inside



One of the boys' identical bedrooms

The End Result - inside

Spare room

Master bedroom

The End Result - inside

Kitchen

Questions

Please put your questions into the chat

Contacts, Resources, Links

More details in the Cambridge Carbon Footprint case study

Builder	Green Hat Company
Architect	Margaret Reynolds
Triple Glazing	Green Building Store / 21 Degrees
Kitchen	Nicholas Hythe Kitchens
MVHR	Green Building Store / 21 Degrees (Zehnder)
WWHRS	Showersave
Solar PV	Cambridge Solar
ASHP	Infinite Heating and Energy
ASHP controls	Homely Energy
ASHP Heat Loss Calculation software	Heat Punk
Modelling software	Passive House Planning Package

Association for Environment Conscious Building

Transition Cambridge

National Self Build and Renovation Centre

Hills Road Retrofit

For Open Eco Homes

10 October 2024

Margaret Reynolds,
Architect & Retrofit Coordinator (retired)
M Reynolds RIBA

mrriba2018@gmail.com
http://uk.linkedin.com/in/margaretreynoldsriba

Hills Road Retrofit – 2017 to 2024

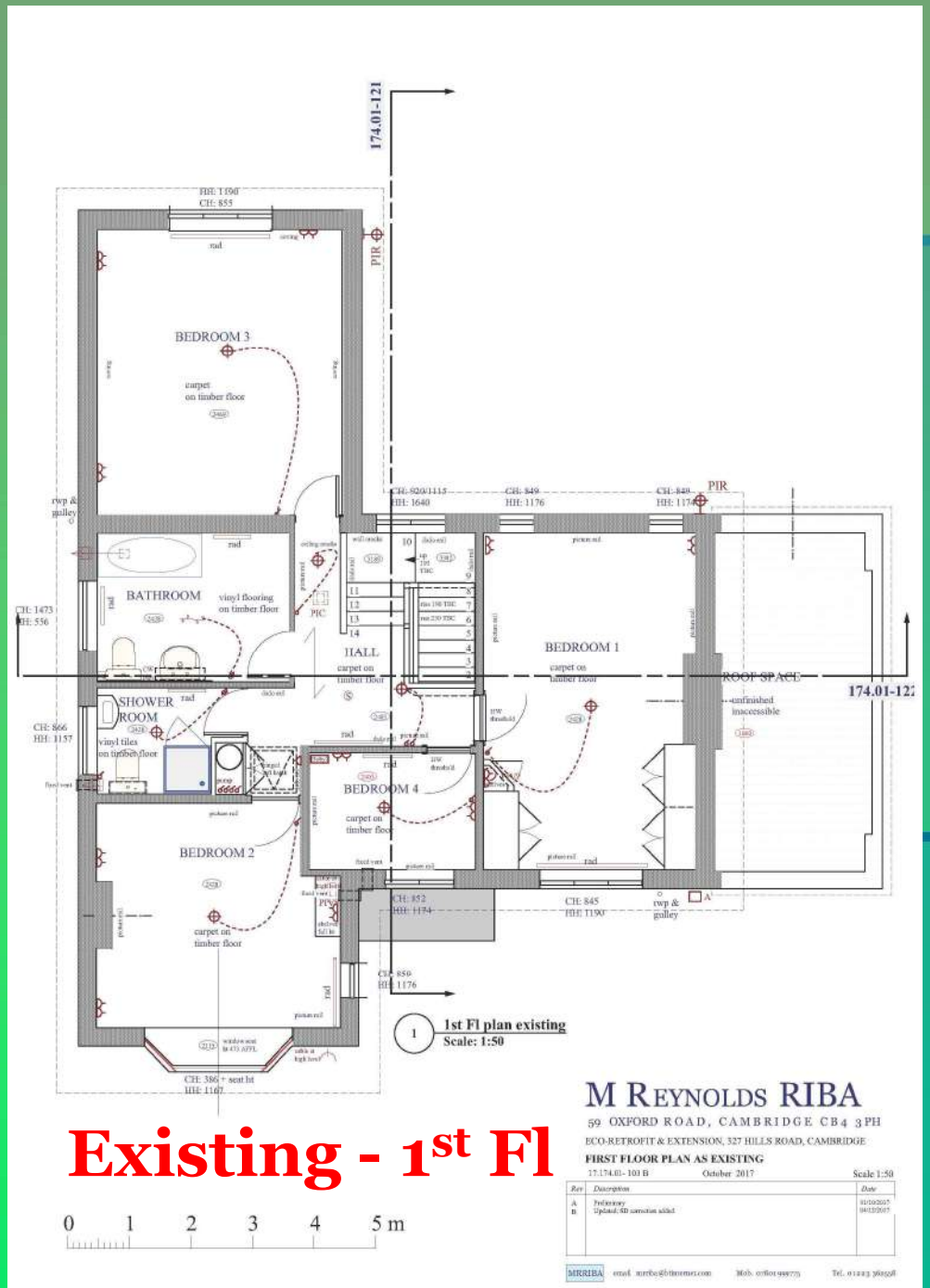
BEFORE – FRONT - 2017

BEFORE – REAR - 2017

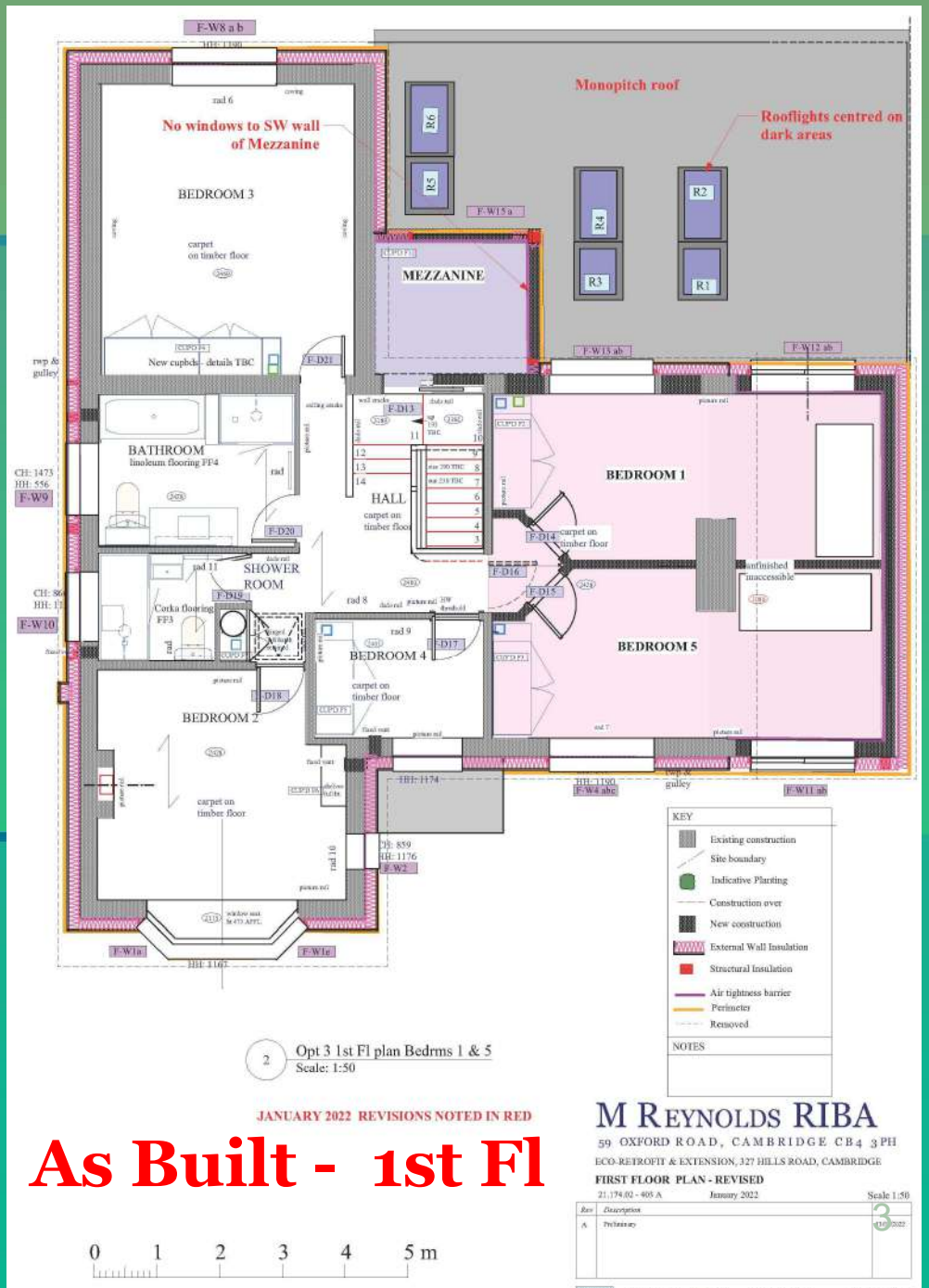
AFTER – FRONT - 2023

AFTER – REAR - 2023

Hills Rd Retrofit – Plans upstairs

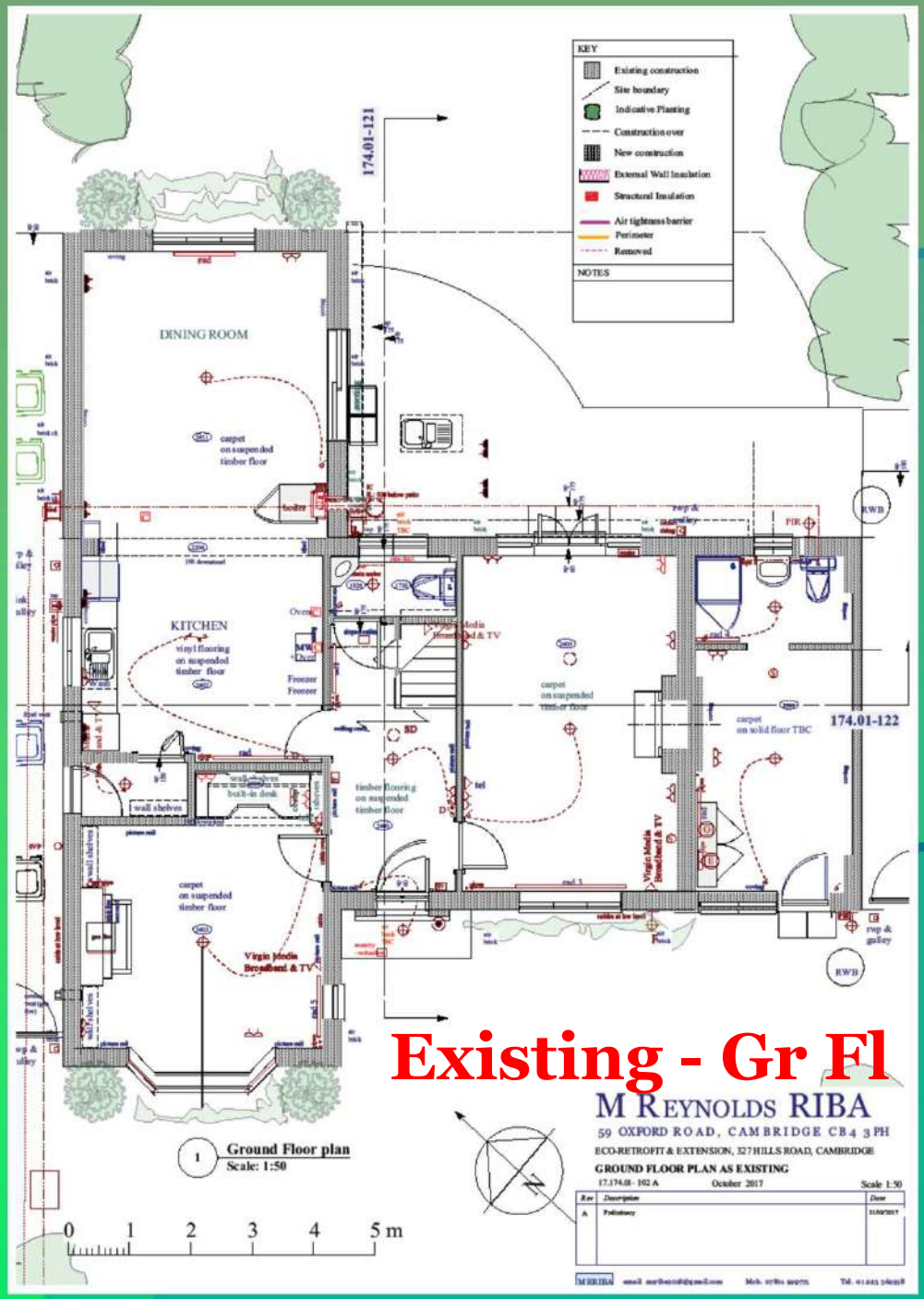


Existing - 1st Fl

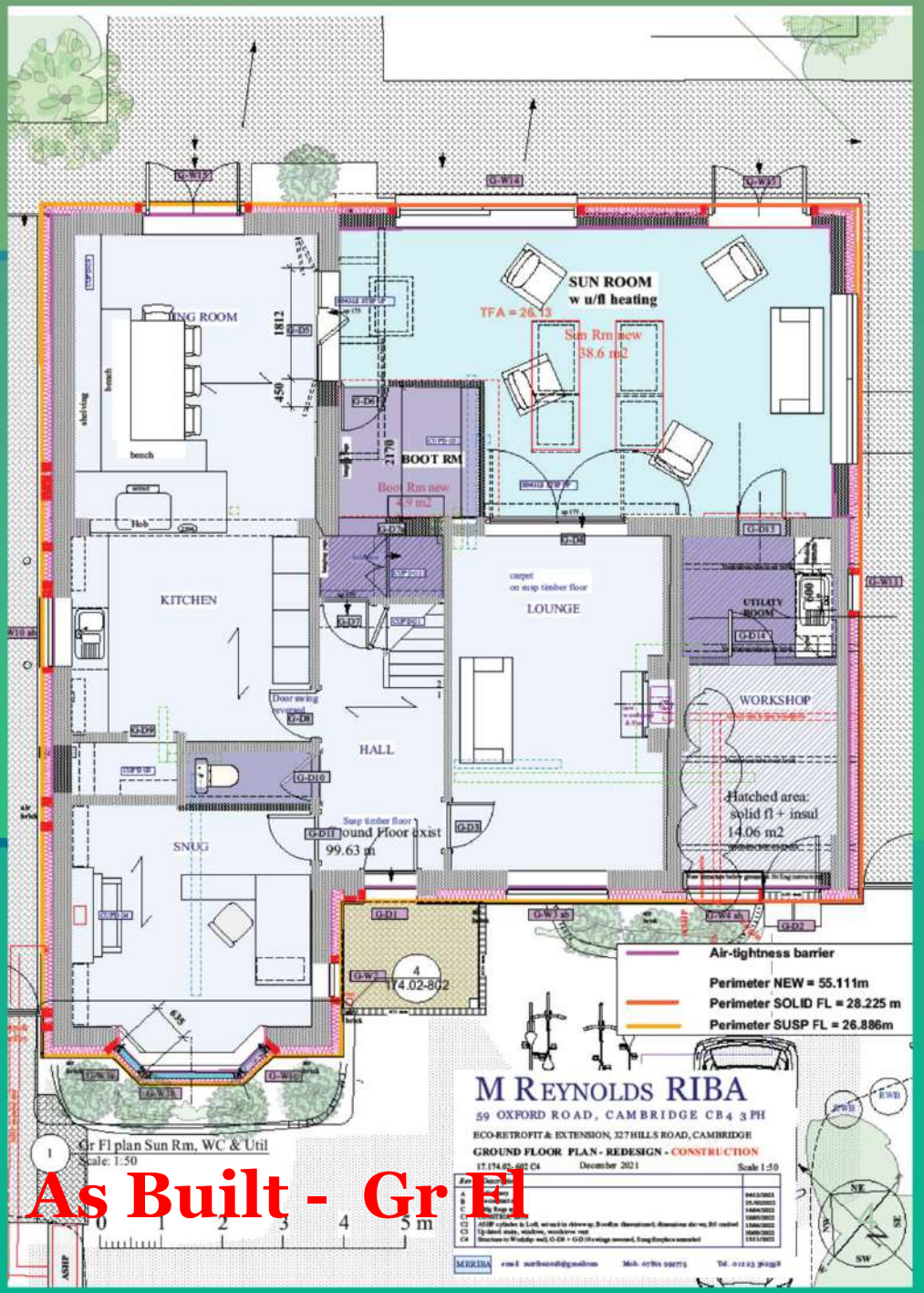


As Built - 1st Fl

Hills Rd Retrofit – Plans downstairs

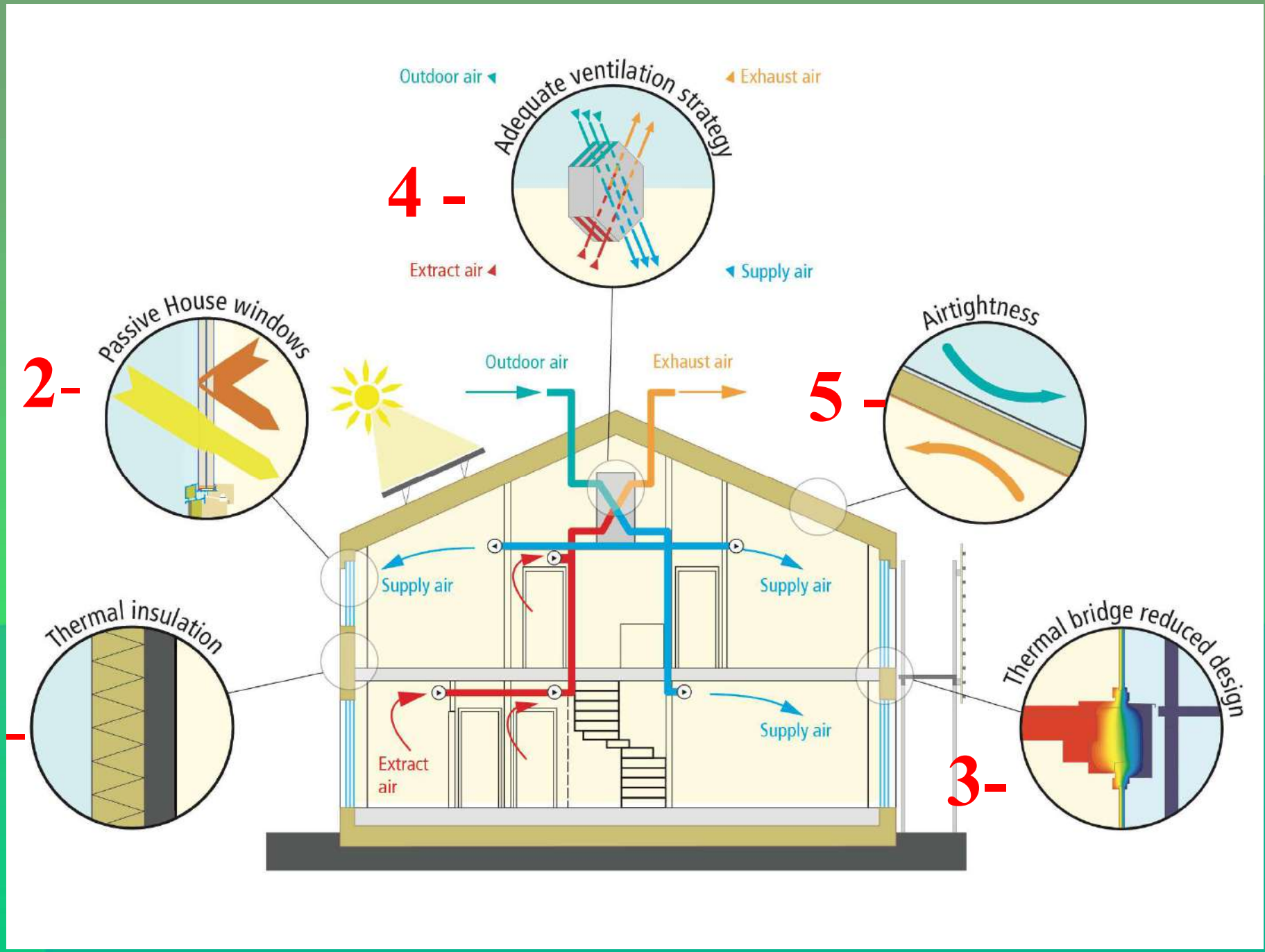


Existing - Gr Fl



As Built - Gr Fl

Hills Rd Retrofit – Passiv Haus



Hills Rd Retrofit – Passiv Haus

WHY?

- Low-energy buildings in UK since 2008
- PHPP modelling for EnerPHit retrofit
- Testing: EWI, below DPC, floors, Loft, windows, lower carbon materials
- PHPP model required for EnerPHit and AECB Standard.

PHPP: Areas + Therm Br – Constrn

Area Input

Area no.	Building assembly description	To group no.	Assigned to group	Quantity	x	a [m]	x	b [m]	+	User determined [m²]	-	User subtraction [m²]	-	Subtraction window areas [m²]	) =	Area [m²]
	Projected building footprint	0	Projected building footprint		x		x		+		-		)		=	0.0
	Treated floor area	1	Treated floor area		x		x		+		-		)		=	0.0
	Exterior door	7	Exterior door	3	x	0.90	x	2.10	+		-		) -		=	4.7
1					x		x		+		-		) -	0.0	=	
2	TFA_ground floor +Opt5	1	Treated floor area	1	x		x		+	84.01	-	-58.72	) -	0.0	=	133.7
3	TFA_first floor	1	Treated floor area	1	x		x		+	74.68	-	-10.00	) -	0.0	=	64.5
4	TFA_loft	1	Treated floor area	1	x		x		+	13.89	-		) -	0.0	=	13.8
5	Masonry wall NE-1	5	External wall - Ambient	1	x	13.82	x	4.04	+		-		) -	2.4	=	53.5
6	To DPC wall NE-1	6	External wall - Ground	1	x	13.82	x	0.52	+		-		) -	0.0	=	7.1
7	Masonry wall SE-3	5	External wall - Ambient	1	x	4.59	x	4.04	+	18.04	-		) -	3.0	=	36.3
8	To DPC wall SE-3	6	External wall - Ground	1	x	4.59	x	0.52	+		-		) -	0.0	=	2.4
9	Masonry wall SE-2 (reduc)	5	External wall - Ambient	1	x	5.00	x	1.15	+		-		) -	1.7	=	1.8
10	To DPC wall SE-2	6	External wall - Ground	0	x	5.59	x	0.52	+		-		) -	0.0	=	0.0
11	Masonry wall SE-1 a(over)	5	External wall - Ambient	3	x	3.00	x	1.20	+		-		) -	1.8	=	-1.9
12	To DPC wall SE-1	6	External wall - Ground	1	x	2.70	x	0.52	+		-		) -	0.0	=	1.4
13	Masonry wall SW-3(reduc)	5	External wall - Ambient	1	x		x		+	7.00	-		) -	0.0	=	7.0
14	To DPC wall SW-3	6	External wall - Ground	0	x	5.77	x	0.52	+		-		) -	0.0	=	0.0

- **EACH floor, wall, roof area is assigned a U-Value:**
- **THIS CAN BE CHANGED TO FINE-TUNE the design**
- **(Every surface type must be numbered , eg SE-3)**

Sort: BY ID

Selection building assembly / Building system	U-Value [W/(m²K)]	Deviation from North	Angle of inclination from the horizontal	Orientation	Reduction factor shading	Exterior absorptivity	Exterior emissivity
Exterior door	0.80						
Stud-Clay tile pitched roof 300 mm + new insul	0.159						
Stud-insulated masonry wall	0.148	47	90	East	0.70	0.80	0.90
Stud-Wall to DPC	0.172	47	90	East	0.70	0.80	0.90
Stud-insulated cavity masonry wall	0.441	137	90	South	0.70	0.80	0.90
Stud-Wall to DPC	0.172	137	90	South	0.70	0.80	0.90
Stud-insulated masonry wall	0.148	137	90	South	0.70	0.80	0.90
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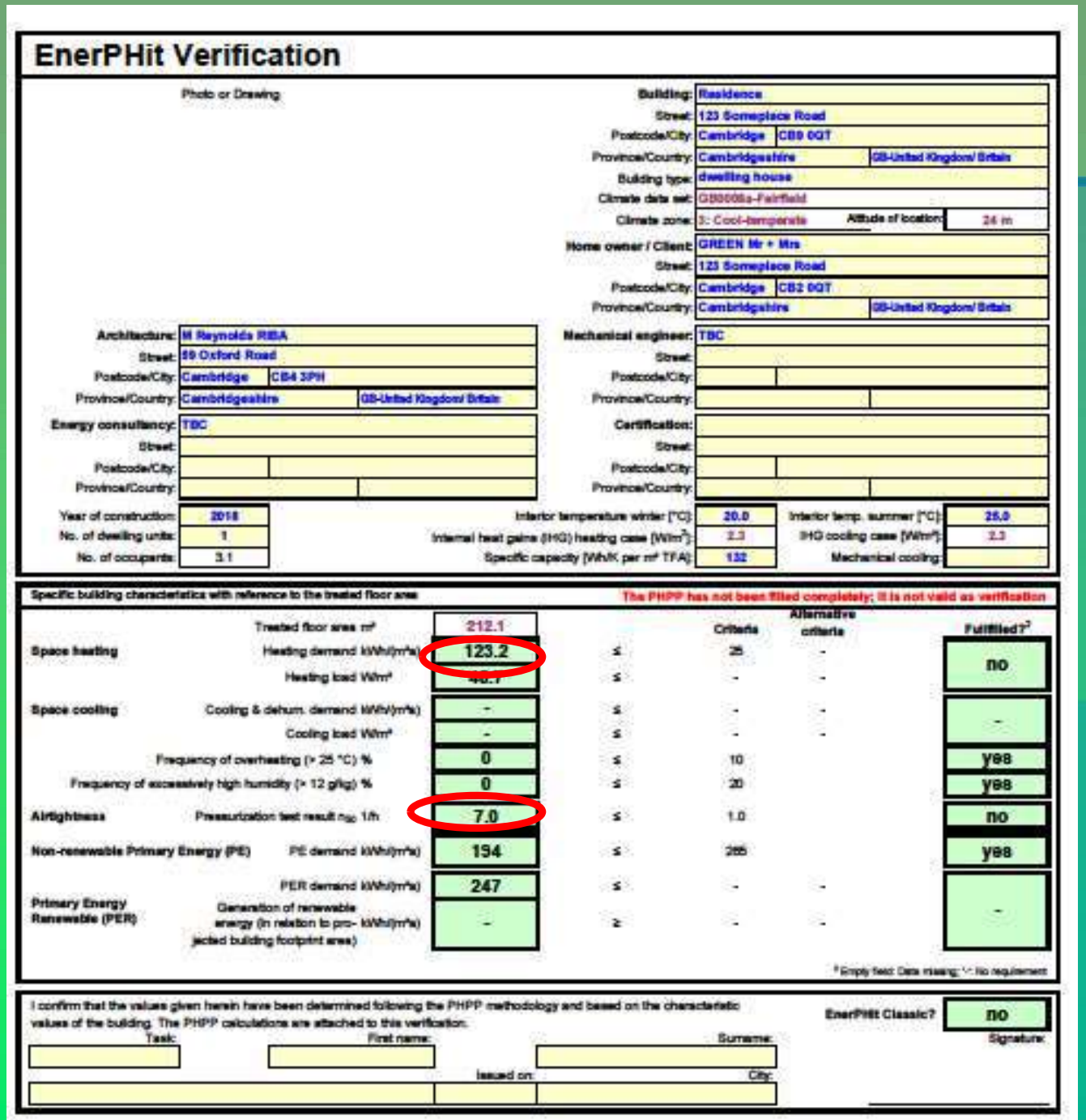
Stud-insulated cavity masonry wall	0.441	227	90	West	0.70	0.80	0.90

Hills Rd Retrofit – Passiv Haus



EnerPHit Verification

Photo or Drawing

Building:	Residence
Street:	123 Someplace Road
Postcode/City:	Cambridge CB9 0QT
Province/Country:	Cambridgeshire GB-United Kingdom/ Britain
Building type:	dwelling house
Climate data set:	GB0008a-Fairfield
Climate zone:	3: Cool-temperate — Altitude of location: 24 m
Home owner / Client:	GREEN Mr + Mrs
Street:	123 Someplace Road
Postcode/City:	Cambridge CB2 0QT
Province/Country:	Cambridgeshire GB-United Kingdom/ Britain
Architecture:	M Reynolds RIBA
Street:	89 Oxford Road
Postcode/City:	Cambridge CB4 3PH
Province/Country:	Cambridgeshire GB-United Kingdom/ Britain
Mechanical engineer:	TBC
Energy consultancy:	TBC
Certification:	

Year of construction:	2018	Interior temperature winter [°C]:	20.0
No. of dwelling units:	1	Internal heat gains (IHG) heating case [W/m²]:	2.3
No. of occupants:	3.1	Specific capacity [Wh/K per m² TFA]:	132
		Interior temp. summer [°C]:	25.0
		IHG cooling case [W/m²]:	2.3
		Mechanical cooling:	

Specific building characteristics with reference to the treated floor area — The PHPP has not been filled completely; it is not valid as verification

				Criteria	Alternative criteria	Fulfilled?[2]
	Treated floor area m²	212.1				
Space heating	Heating demand kWh/(m²a)	123.2	≤	25	-	no
	Heating load W/m²	46.7	≤	-	-	
Space cooling	Cooling & dehum. demand kWh/(m²a)	-	≤	-	-	-
	Cooling load W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C) %	0	≤	10		yes
	Frequency of excessively high humidity (> 12 g/kg) %	0	≤	20		yes
Airtightness	Pressurization test result n_{50} 1/h	7.0	≤	1.0		no
Non-renewable Primary Energy (PE)	PE demand kWh/(m²a)	194	≤	265		yes
Primary Energy Renewable (PER)	PER demand kWh/(m²a)	247	≤	-	-	-
	Generation of renewable energy (in relation to pro- jected building footprint area) kWh/(m²a)	-	≥	-	-	

[2] Empty field: Data missing; "-": No requirement

I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

EnerPHit Classic? no

Title: First name: Surname: Signature:

Issued on: City:

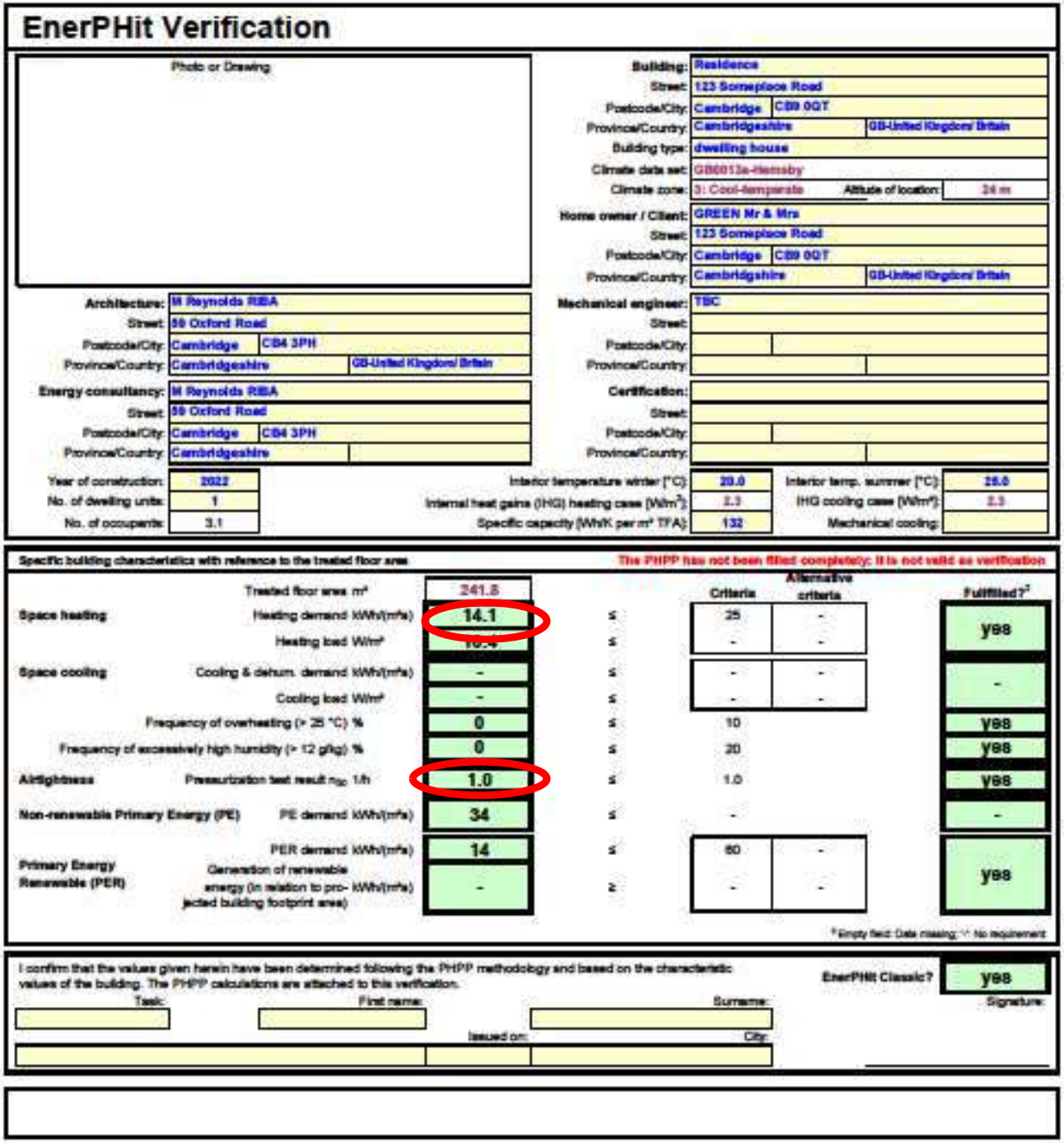
Building Type:

dwelling house

Existing Base File:

- **Heating demand:**
  123 kWh/m2/yr
- **Air tightness**
  7 m3/m2h
  (5 ACH)

PHPP: “Verification” – Construction



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Street:	59 Oxford Road
Postcode/City:	Cambridge CB4 3PH
Province/Country:	Cambridgeshire GB-United Kingdom/ Britain
Energy consultancy:	M Reynolds RIBA
Street:	59 Oxford Road
Postcode/City:	Cambridge CB4 3PH
Province/Country:	Cambridgeshire
Mechanical engineer:	TBC
Street:	
Postcode/City:	
Province/Country:	
Certification:	
Street:	
Postcode/City:	
Province/Country:	

Year of construction:	2022	Interior temperature winter [°C]:	20.0
No. of dwelling units:	1	Internal heat gains (IHG) heating case [W/m²]:	2.3
No. of occupants:	3.1	Specific capacity [Wh/K per m² TFA]:	132
		Interior temp. summer [°C]:	26.0
		IHG cooling case [W/m²]:	2.3
		Mechanical cooling:	

Specific building characteristics with reference to the treated floor area — The PHPP has not been filled completely; it is not valid as verification

					Criteria	Alternative criteria	Fulfilled?*
	Treated floor area	m²	241.8				
Space heating	Heating demand	kWh/(m²a)	14.1	≤	25	-	yes
	Heating load	W/m²	10.4	≤	-	-	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	-	≤	-	-	-
	Cooling load	W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C)	%	0	≤	10		yes
	Frequency of excessively high humidity (> 12 g/kg)	%	0	≤	20		yes
Airtightness	Pressurization test result	n_{50} 1/h	1.0	≤	1.0		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	34	≤	-		-
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	14	≤	60	-	yes
	Generation of renewable energy (in relation to projected building footprint area)	kWh/(m²a)	-	≥	-	-	

*Empty field: Data missing; "-": No requirement

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EnerPHit Classic? yes

Title: First name: Surname: Signature:

Issued on: City:

Construction File:

- Heating + DHW demand:

  14.1 kWh/m2

- Air tightness

  (1 m3/m2h)

  1 ACH

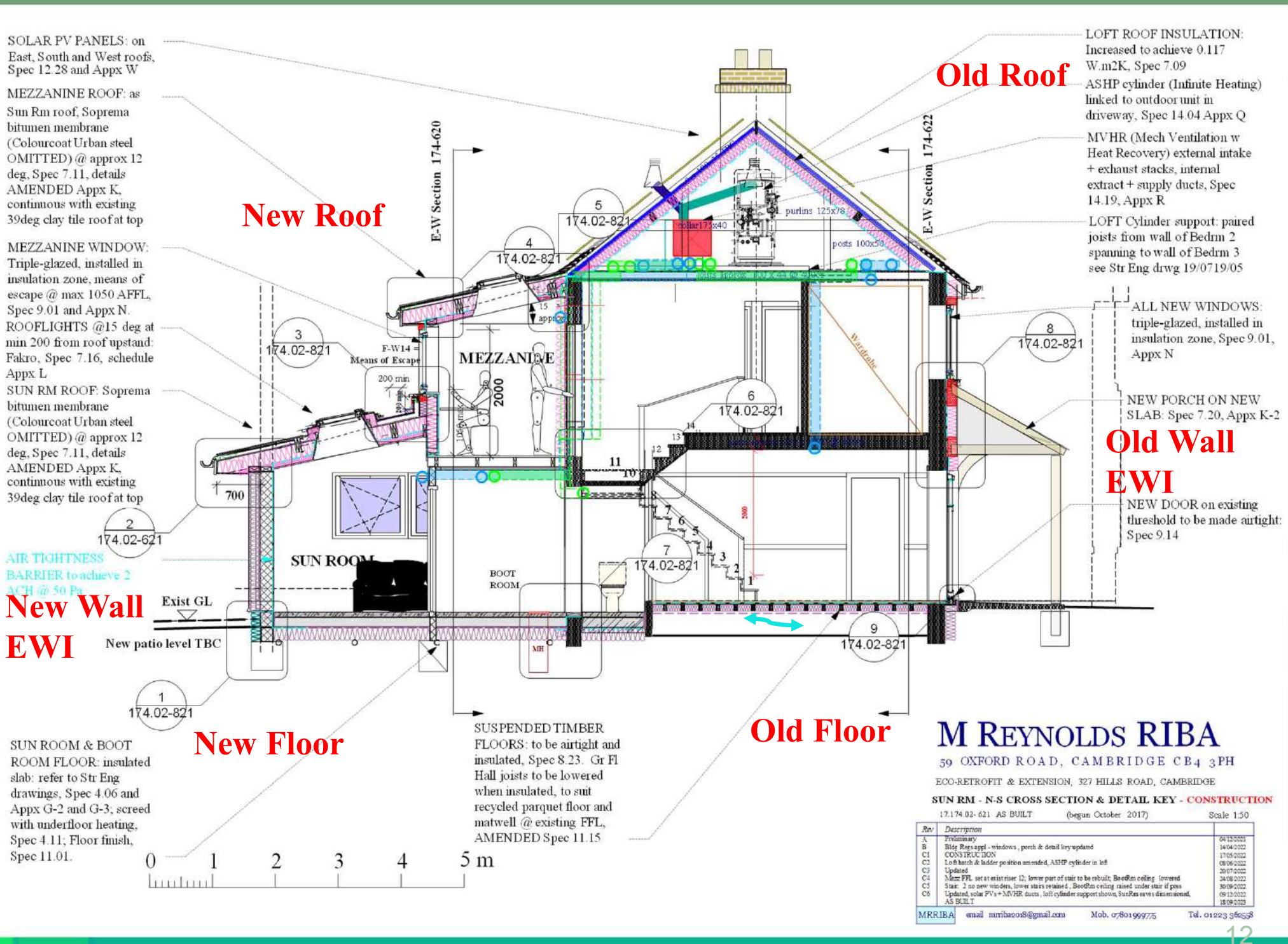
Hills Rd Retrofit – Passiv Haus

Testing w PHPP

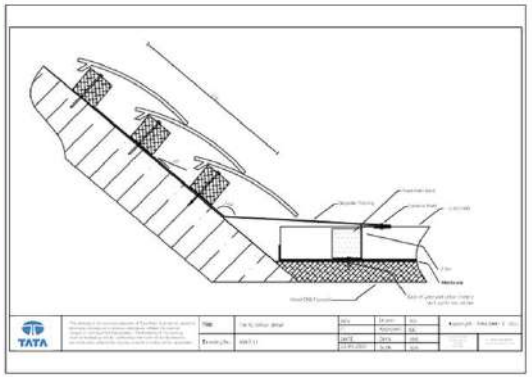
- EWI materials, thickness, below DPC
- Susp Timb floor, keep or replace w concrete
- Loft: insulated? Materials + positions
- New window + door attributes from mfr
- MVHR: Zehnder attributes from mfr
- Lower carbon material λ values, thickness
- Design stage, in construction, back in use

Low-carbon strategies

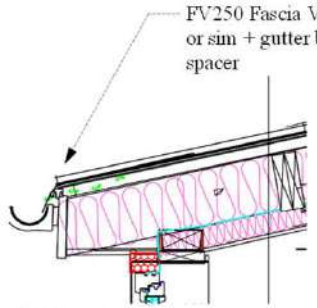
- Insulation
- Ventilation
- Air tightness



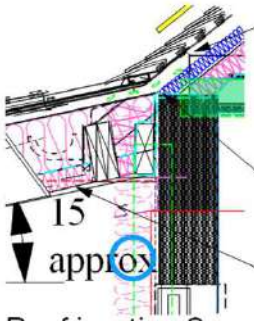
Insulation Strategies



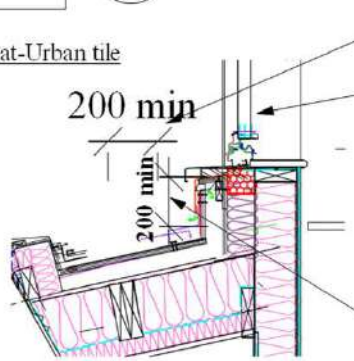
10 Soprema junction similar to Colourcoat-Urban tile
Scale: NTS



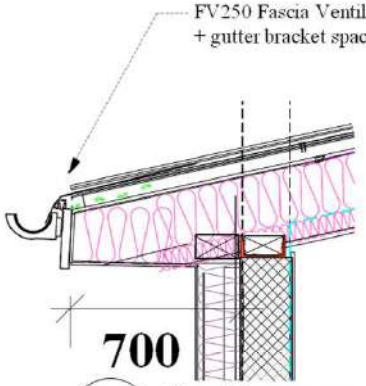
4 Mezzanine eaves
Scale: 1:20



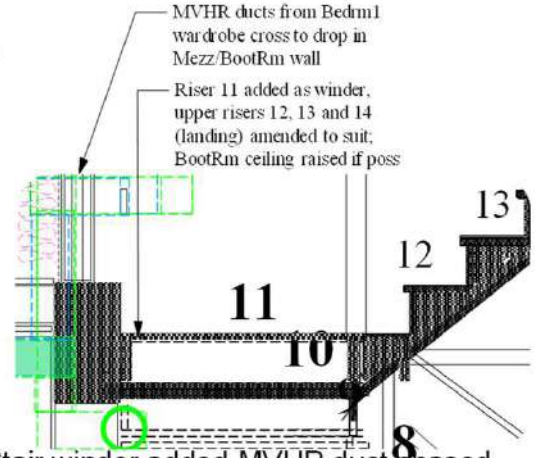
5 Roof junction Soprema to tiles
Scale: 1:20



3 Rooflight, Roof vent & Mezz window
Scale: 1:20

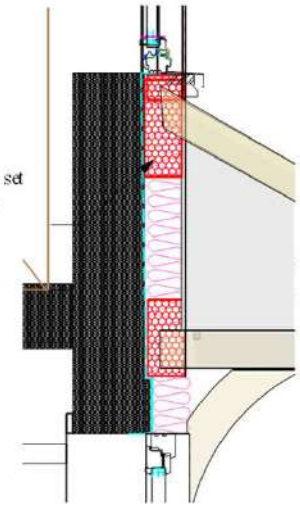


2 Sun Rm eaves
Scale: 1:20

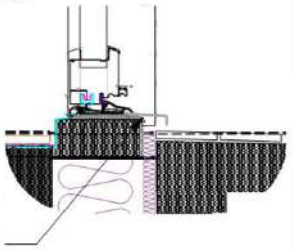


6 Stair winder added MVHR duct chased
Scale: 1:20

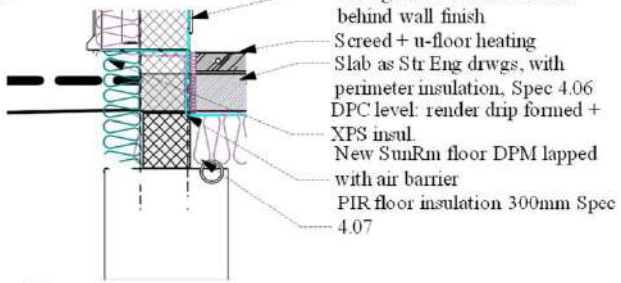
New structural insulation set
in EW insulation zone to
support new porch roof



8 New porch fixing
Scale: 1:20

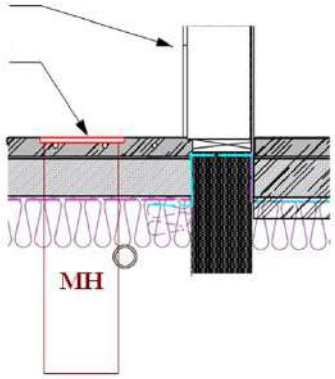


9 Front door threshold
Scale: 1:10



1 Founds to SunRm
Scale: 1:20

New door set in former
external wall.
New floor finish set into
new cover to existing
manhole



7 New BootRm doorway + MH cover
Scale: 1:20

M REYNOLDS RIBA

59 OXFORD ROAD, CAMBRIDGE CB4 3PH

ECO-RETROFIT & EXTENSION, 327 HILLS ROAD, CAMBRIDGE

SUN ROOM - S-N SECTION DETAILS

121.174.02. 821 AS BUILT (begun December 2021) Scale 1:50

Rev	Description	
A	Preliminary	25/02/2022
B	Updated	15/06/2022
C1	GBS ULTRA window details; front door threshold	04/07/2022
C2	Updated	20/07/2022
C3	Updated w Colourcoat-Urban instructions (5) & details (10)	26/07/2022
C4	MVHR ducts shown, chase dat Mezz/ BootRm wall; stair amended at Mezz door	01/12/2022
	AS BUILT	12/09/2023

MRRIBA email mrriba2018@gmail.com Mob. 07801 999775 Tel. 01223 362558

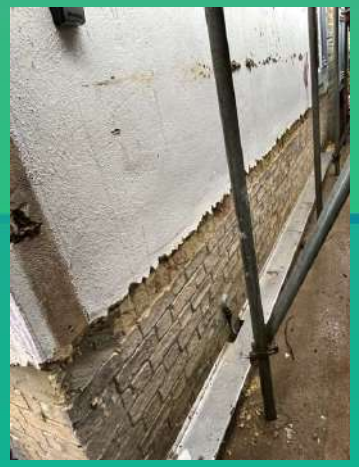
Insulation - EWI

SB exp polystyrene EPS 0.031 W/mK

Kingspan Kooltherm Phenolic 0.021 W/mK

EPS over Phenolic

New wall: chose masonry lined with old for EWI



Wall surface made even for EWI

Plastic brick slips NOT USED

Some exist cavity wall insulation; void to be closed

Front concrete canopy removed

More insulation added to eaves

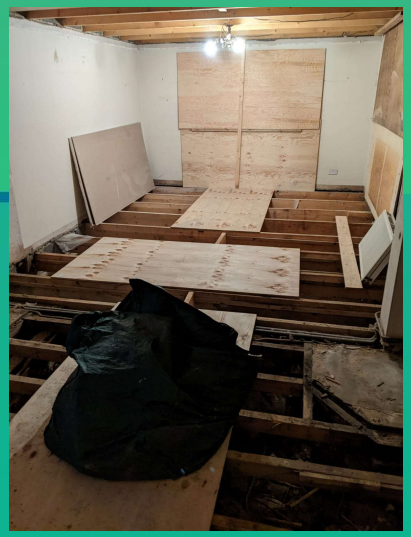
Insulation – roof + floors

Loft roof: 50 Rockwool Flexi (λ= 0.035)
+ 150 PIR Celotex (λ= 0.022) + airtight OSB

New SunRm solid fl
250mm IKO Enertherm
PIR insulation

EWI (XPS)
below DPC to
foundations

Service penetrations
made airtight



Kitchen floorboards lifted to
insulate

Rockwool Flexi 100
(λ= 0.038) in
Lounge floor

Windows

Trial window installed w Struct Insulation in External Wall insulation zone

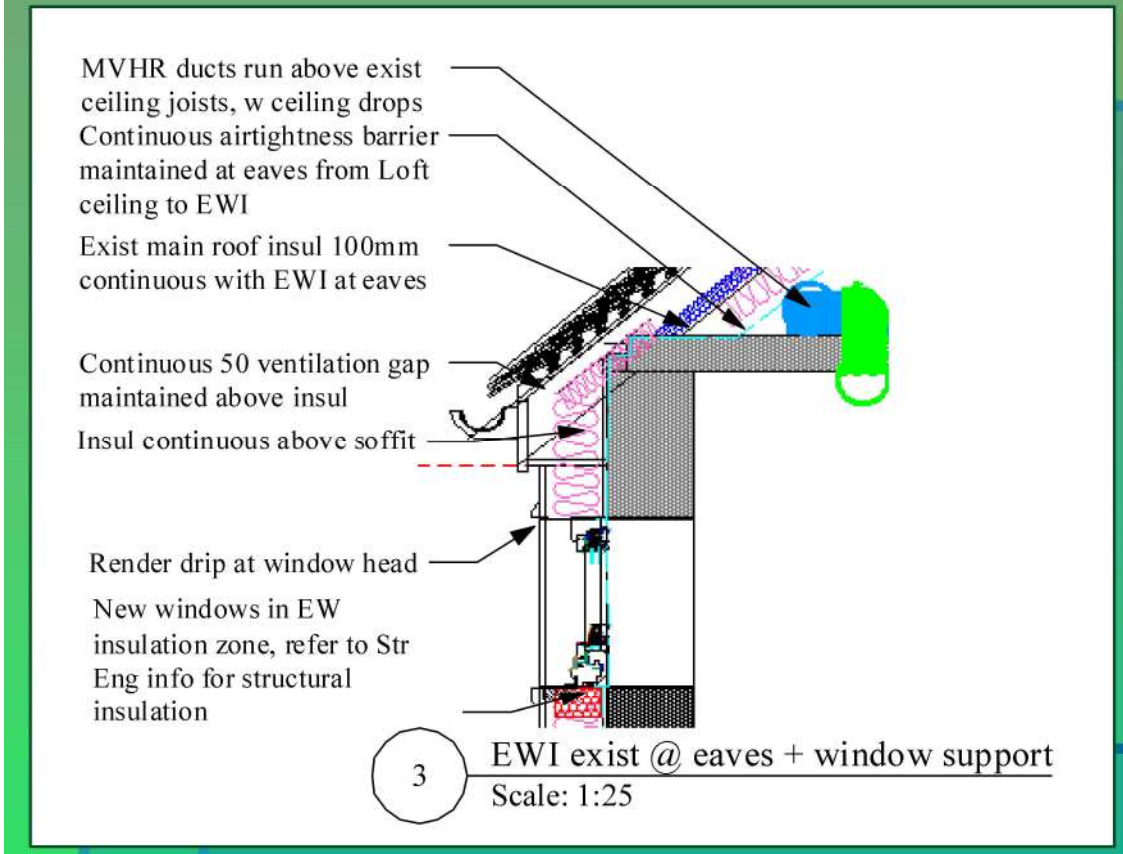
Structural Insulation supporting windows in External Wall insulation zone, temporary rain covers

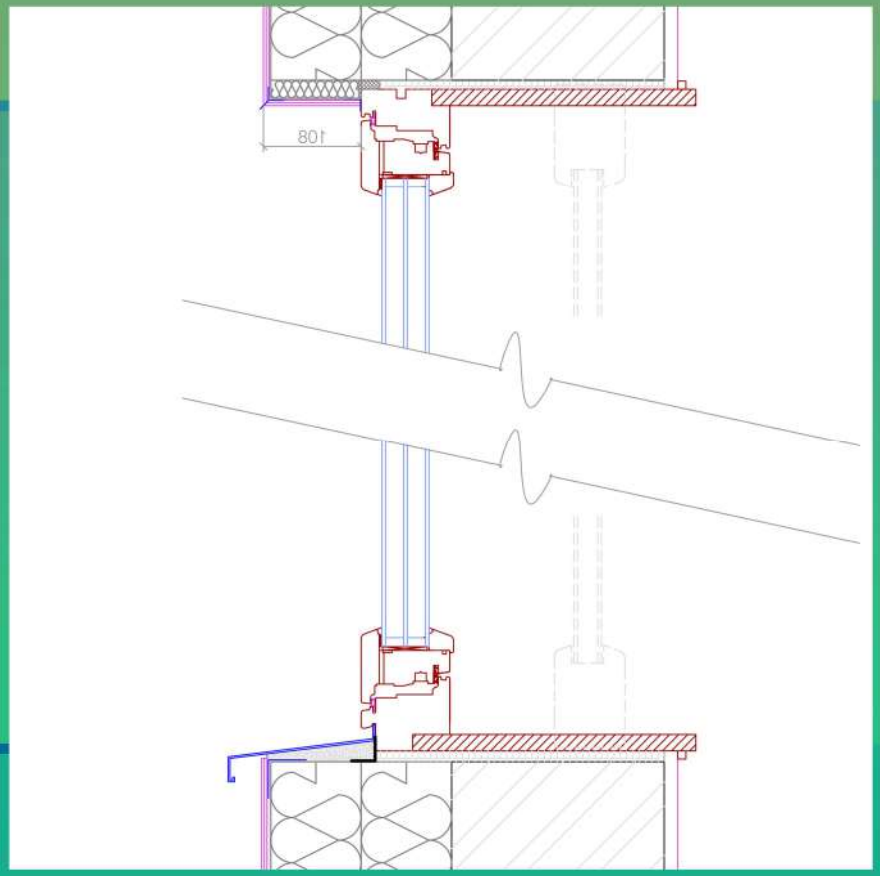
Structural insulation - Partel Alma Vert – from recycled bottles

Windows Green Building Store
Ultra 0.6 kWh/m2K
(Passiv Haus standard)

Old windows sold on eBay

Windows in EXTERNAL Insulation Zone





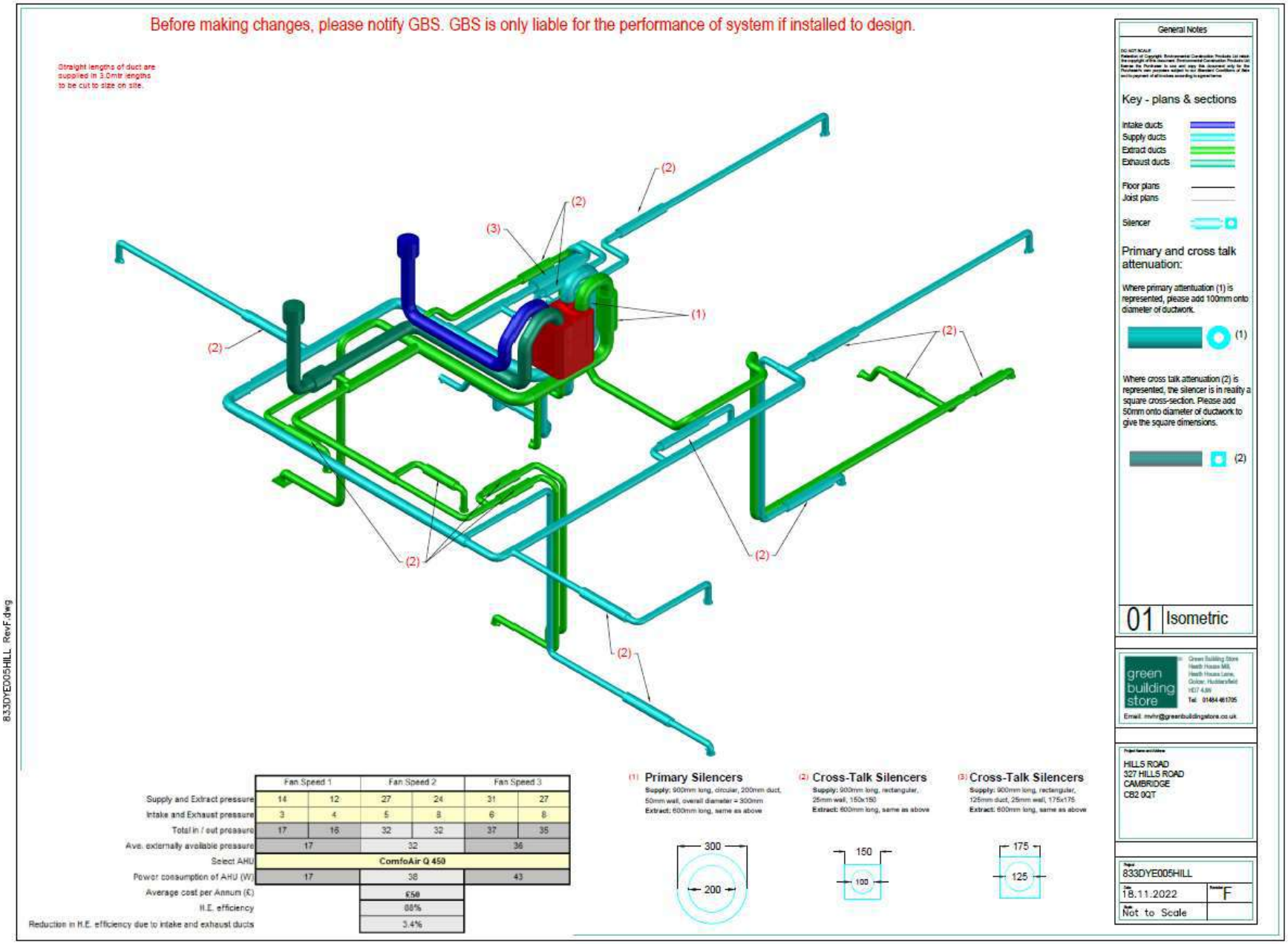
Structural insulation support

New window to EWI, retrofit installation

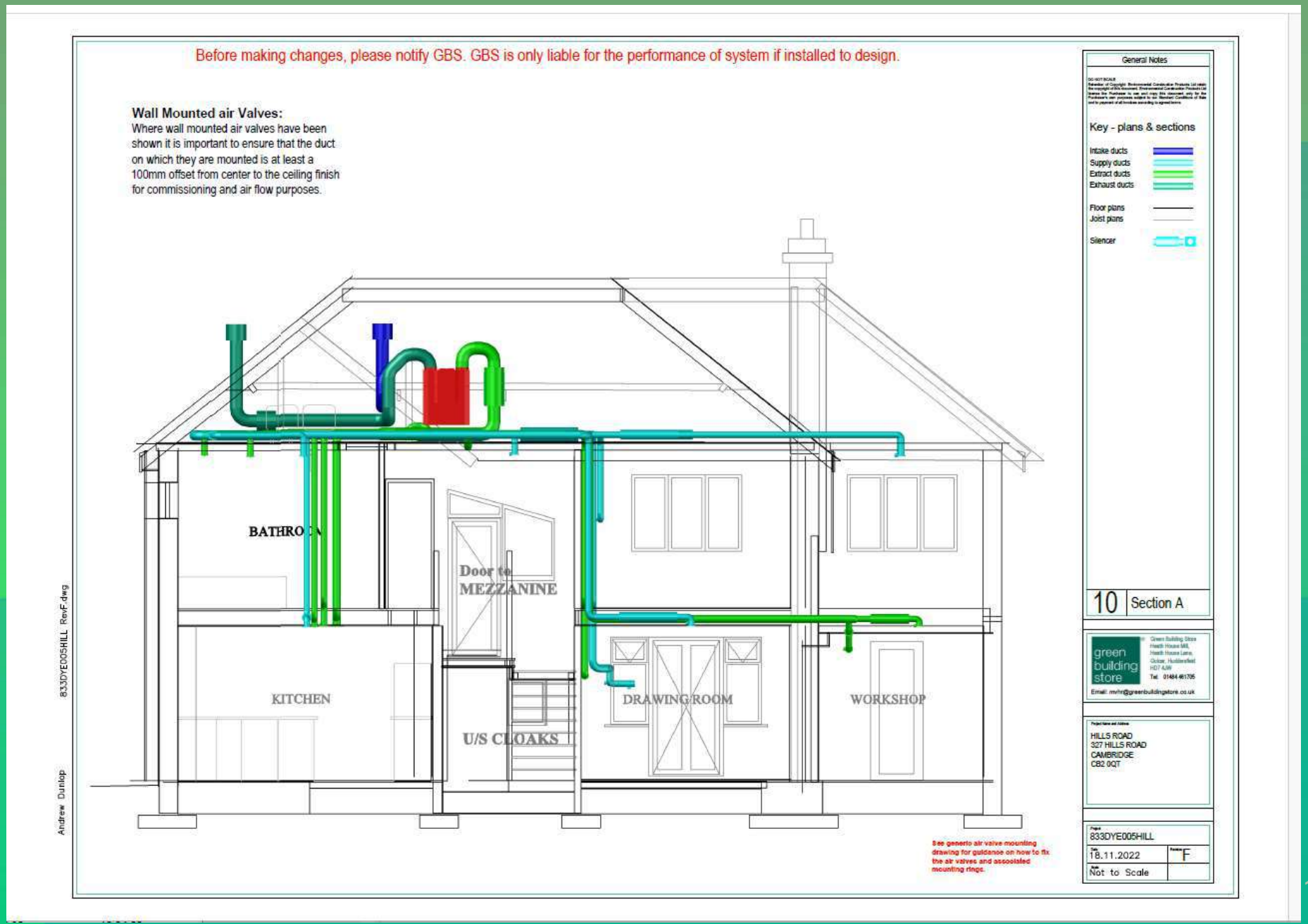
Retrofit Pattern Book

https://retrofit.support/detail/75/

Ventilation Strategy: MVHR - ACTIVE



Ventilation Strategy: MVHR

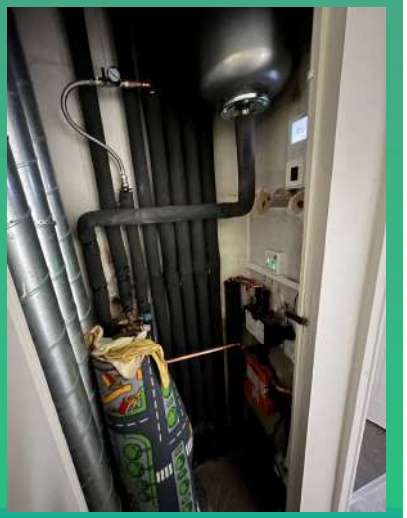


Ventilation ACTIVE

LOFT

WALLS

MVHR ducts tunnelled thru old fabric



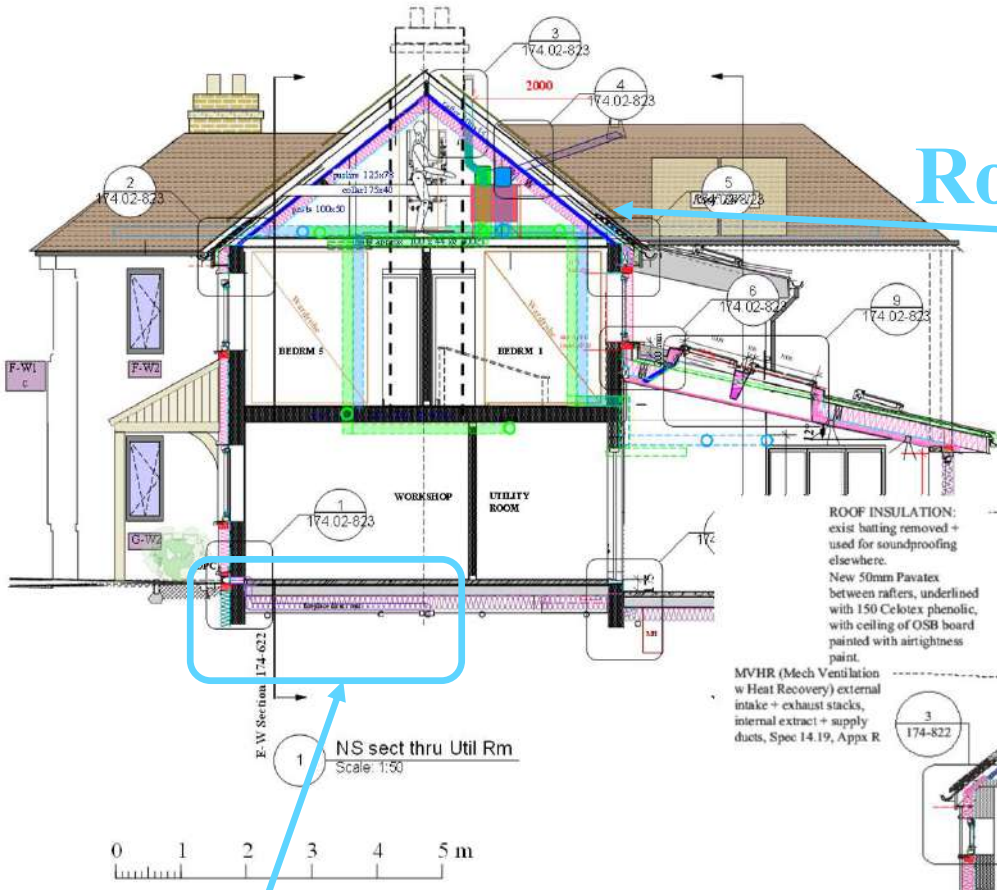
SUPPLY OUTLETS/ EXTRACTS

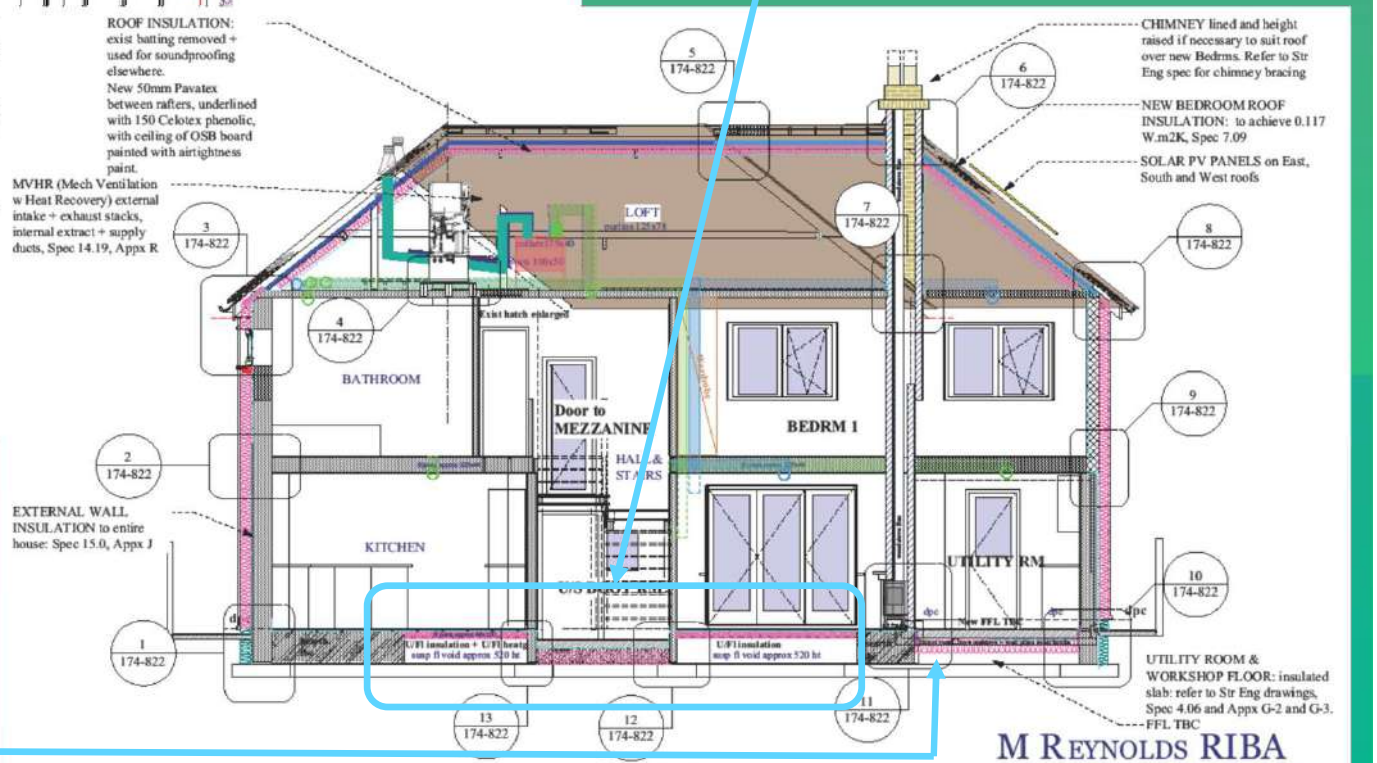
Ventilation: PASSIVE

Roof voids

Air bricks + floor void - sealed

Wood Stove Direct Vent, Chimney repointed to seal





Ventilation – PASSIVE

NEW ROOF

FLOOR

Air bricks to floor void

Airbricks in EWI
below DPC to founds

Direct Vent hit-miss
cover for vermin

Below concrete slab: vent pipes
for susp floor running under
direct vent pipe for wood stove

Direct vent to woodstove taking
air from outside, but sealed
inside for air tightness

Direct vent
in place outside

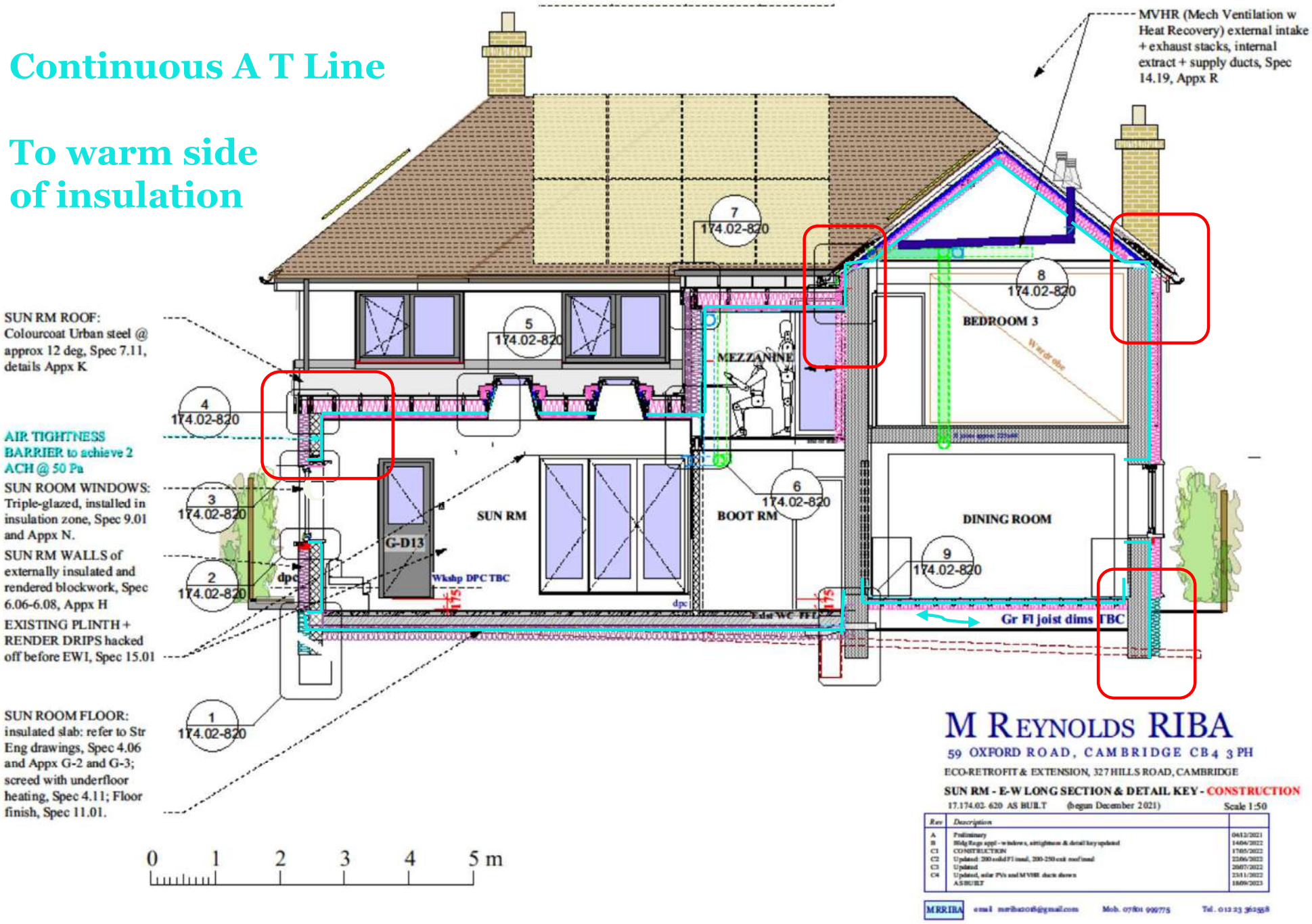
Direct vent airtight
hearth connection

Air Tightness specification

- Spec: - Air Tightness < 2 ACH + testing
- Training / Air Tightness “Manager”
- Intermediate tests

Continuous A T Line

To warm side of insulation



Air tightness strategies

Roof AT

New bedrms roof: fibrous AT
paint on steel chimney bracing

Loft: AT OSB Zero + foam

Exist bedrm 2: AT paint at eaves;
(old insulation stored for reuse)

New bedrms roof: AT paint at eaves

New bedrms roof: tape, OSB Zero, AT paint + foam at eaves

Bedrm 3 exist roof: tape, OSB Zero, AT paint + foam at eaves

Bedrm 3 exist roof: tape, OSB Zero, AT paint + foam at eaves

ShowerRm: OSB Zero, AT paint + foam at eaves

1sr Fl & roof: tape, OSB Zero, AT paint + foam at eaves

New bedrms roof: OSB Zero, AT paint + foam at eaves

Hills Rd Retrofit – Passiv Haus model

- **PHPP BASE FILE 2018–**

  assumed 123.2 kWh/m2 (total w HW: 155 kWh/m2)

  existing airtightness: 4.98 ACH

- **PHPP model proposed 2022:**

  reduction to 14.1 kWh/m2, AT: <1 ACH

- **AS-BUILT PHPP file 2024:**

  shows 19.9 kWh/m2, with AT = 1.69 ACH measured

- **MEASURED 2024: 33 kWh/m2 incl HW – say HW=15%, so 28 kWh/m2/ye [= 23% of existing]**

Dyer Retrofit – OEH numbers

- ***BEFORE renovation (if applicable)***
- **Total (Gas & Elec) =** **155 kWh/m^2 pa**
- **Electricity:** **5,670 kWh pa**
- **Gas:** **22,557 kWh pa (19,106 kWh + 3451 kWh for Hot Water)**
- **Other fuel** : N/A **kWh pa**
- ***Water:*** ***216 cubic metres pa (148 l per person per day).***

- ***AT PRESENT:***
- **Total (Gas & Elec) =** **33.7 kWh/m^2 pa** **[22% of BEFORE -78% reduction]**
- **Electricity:** **8973 kWh pa (est. including PV self-consumption, removed EV charging)**
- **Gas:** **0 kWh pa** Gas appliances and meter removed from property
- **Other fuel** : 0 **kWh pa** N/A have a log burner but not yet used.
- **Water:** ***167 cubic metres pa (115 l per person per day)*** **[77% of BEFORE]**

Hills Road Retrofit

For Open Eco Homes

10 October 2024

Margaret Reynolds,
Architect & Retrofit Coordinator (retired)
M Reynolds RIBA

mrriba2018@gmail.com
http://uk.linkedin.com/in/margaretreynoldsriba

Your next steps

- Find out how you can get started with your retrofit
- Book another tour or talk
- Research our past case studies
- Book a training session and borrow a thermal imaging camera
- Use Transition Cambridge's personalised home energy advice tool
- Please complete the event feedback at the end of this talk

Can you help us?

Make a donation to help us run more Open Eco Homes tours:

cambridgecarbonfootprint.org/donate

Share your experiences on social media: #OEH2024

Thank you for your support!