GREENCORE

construction

building a low carbon future

Hawthorns, Kingston Road, Frilford, Abingdon · Oxfordshire · OX13 5NX

Aiming for “Zero-Carbon”

- Who are Greencore Construction?
- Cellulose based materials
- Our way forward
- Case studies

Mission Statement

Greencore Construction is a company dedicated to delivering inspirational, exemplar "low & zero carbon buildings" to discerning clients as part of a significant contribution to the decarbonising of the built environment.

A discerning client is:-

- One who understands the low carbon agenda
- One who takes an holistic view of construction
- One who pays running costs as well as construction cost
- One who employs us!

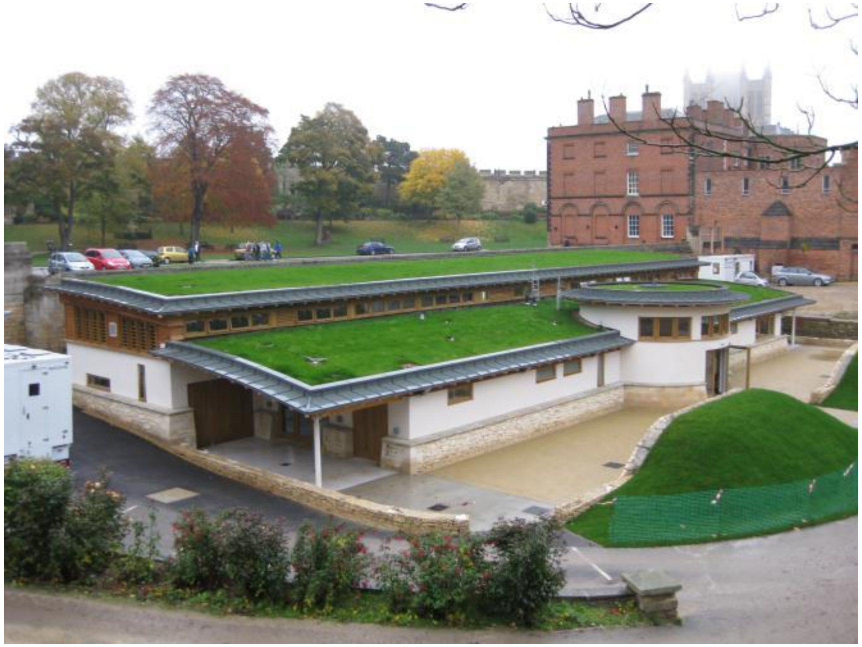
Affordable Housing

Affordable Housing

Private Houses

Non-domestic Buildings

Non-domestic Buildings



Introduction

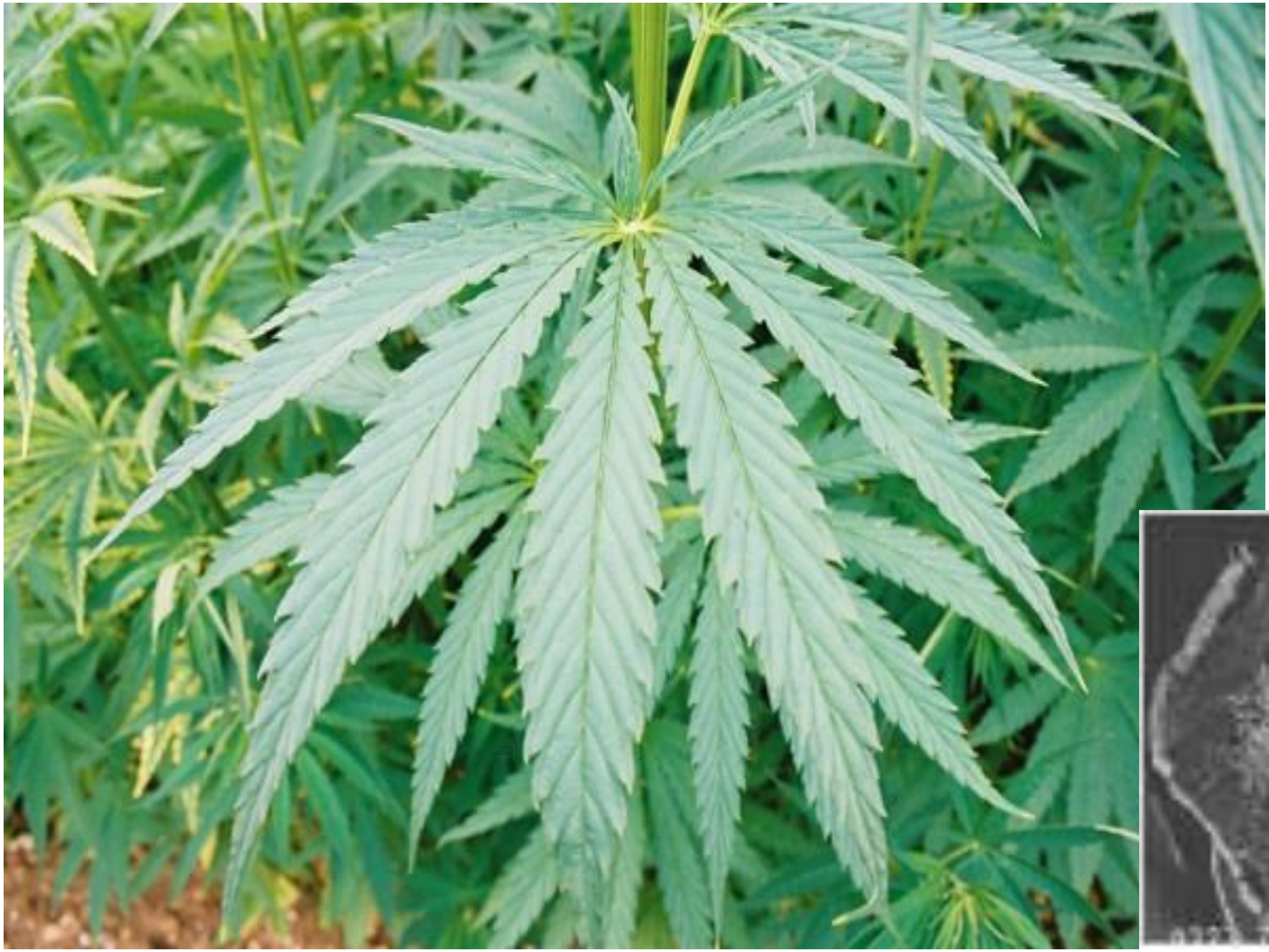
- In the quest to reduce CO_2 emissions and produce "nearly zero-carbon buildings" most designers and builders are focussed on low operational emissions, even if it means emitting more carbon in the construction process

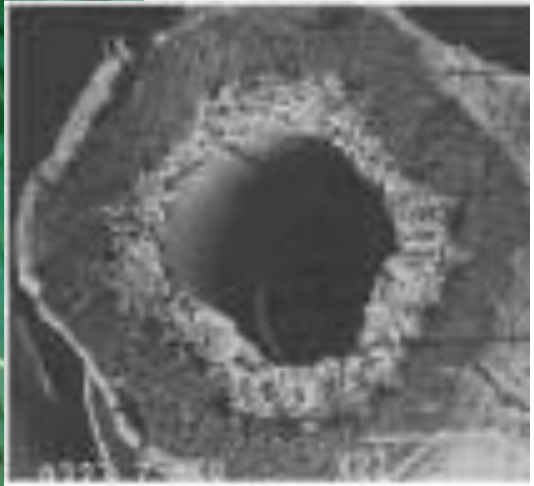
- This presentation examines the impact of using natural, cellulose based materials to reduce the embodied carbon ***as well as*** reducing the operational emissions

Cellulose based materials

- Timber & timber products
  - Carcassing timber
  - Structural boards (OSB, chipboard & ply)
  - Engineered timber flooring
  - I-joists
  - Glulams, LVL & CLT
  - Wood fibre board and quilt
- Hemp
  - Shiv (in Hemp-Lime)
  - Fibre insulation quilt

Industrial Hemp





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Natural Fibre Insulation Quilt

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BMW – Door Panels (from fibre)

Lotus Eco-Elise body shell (from fibre)

Hemp-Lime (from shiv)

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Original Use

Cast-on-site Hemp-Lime

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DEFRA – LINK Project

- Hemp-Lime has exceptional thermal performance when it is fully dry (5% to 7% moisture content)
- Getting Hemp-Lime fully dry is much harder than previously thought - it can take several years!
- The solution is pre-dried, factory-made panels

Hempcell Panel Construction

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Site Construction

M&S – Cheshire Oaks

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M&S – Cheshire Oaks

M&S – Cheshire Oaks

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M&S – Cheshire Oaks

The Greencore approach to “Zero-Carbon”

1. Good design
2. Thermal modelling to identify how well the building will perform **BEFORE** you build it.
3. Good sub-structure and plinth details - U-value of 0.1W/m2.K and design out thermal bridging
4. Hempcell building system - excellent thermal performance, with natural, breathable materials
5. Minimise, or eliminate, thermal bridges in ALL parts of the building

The Greencore approach to "Zero-Carbon"

6. Triple glazed timber windows
7. Air-tightness – target of < 1 air change/hr at 50Pa. Tests should be carried out **BEFORE** the finishes are applied and again at the end of the project.
8. Care is the most important element.
9. Services - MVHR and appropriate services strategy
10. Commissioning and monitoring
    you will only know if it works if you measure it!

Design

- Before buildings were architecturally designed, they were built to tried and tested patterns that suited the needs of the user and using forms that suited the palette of local materials (vernacular buildings).
- Flint buildings tend to have brick or stone quoins because flint is not easy to use to form a corner.
- Thatch roofs have steep pitches because they need to shed water as fast as possible.
- Cob buildings have masonry plinths and wide eaves/verges to protect the earth walls.

Design

- The ***new vernacular*** will be dictated by the properties of the materials and the need for low-carbon emissions
- Greencore houses will be constructed using the Hempcell “off-site” panel systems insulated with Hemp-Lime and natural fibre insulation.
- We are “architecturally neutral”, but want to see high quality design, whether traditional or contemporary that is site specific.

Finishes

- Hempcell panels optimise the thermal insulation and inertia by having a 300mm thick panel made up of natural insulation materials. This is best combined with relatively thin external finishes:-
- Wood fibre board and render
- Timber cladding
- Other rain-screen claddings
- Where masonry finishes are required, brick slips or mathematical tiles are preferred to a full masonry skin.

Roof

- It is well known that all external finishes (particularly render and timber) last longer if fully protected by a good roof overhang.
- We want to see decent eaves and verges to maximise weather protection and solar shading.
- We want to avoid parapets and concealed gutters.
- Our roof make up typically includes 350mm of insulation, so the roof design needs to accommodate this without the roof looking bulky.

Windows

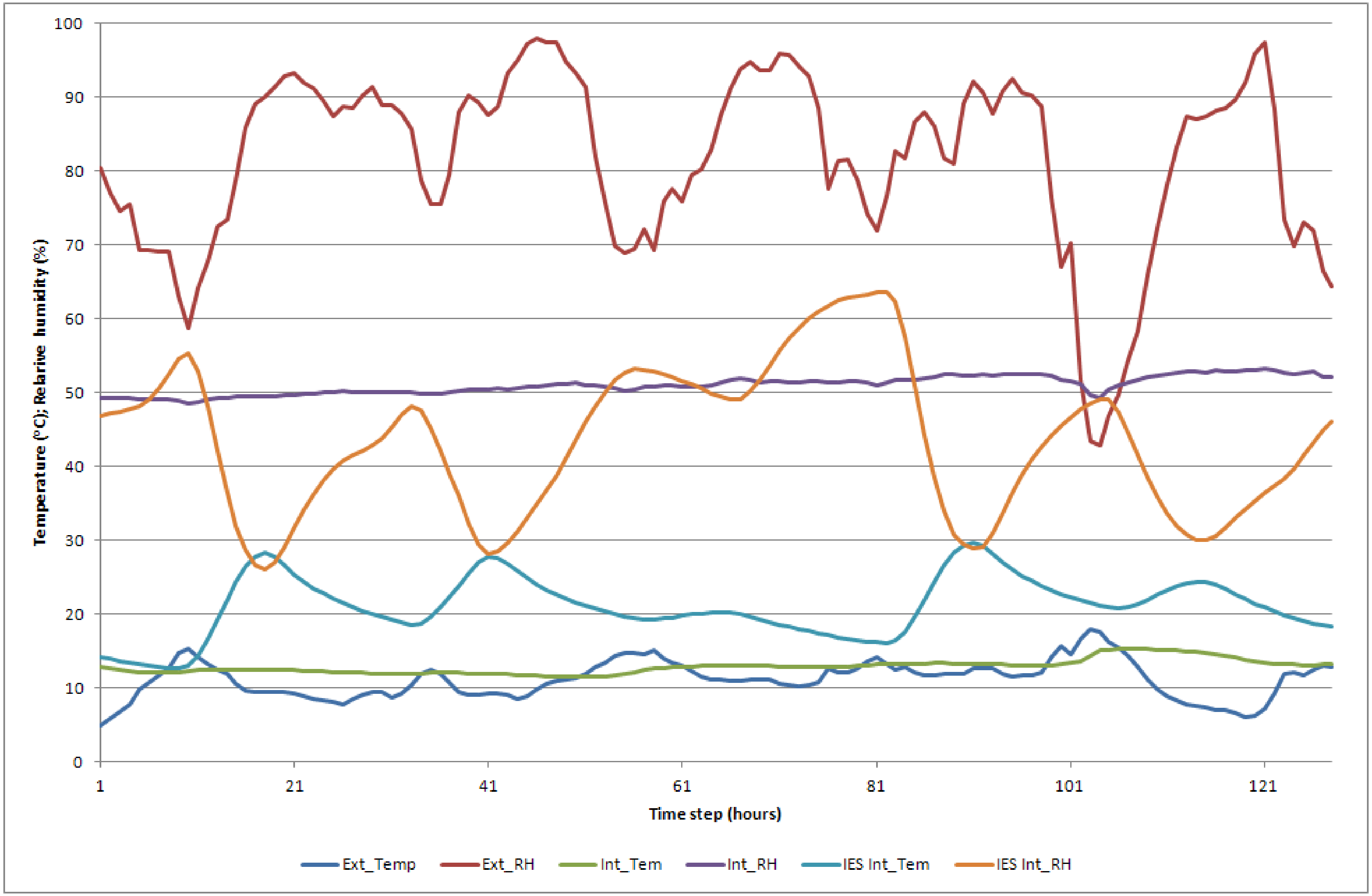
- Vertical windows (portrait) work better in structural and thermal terms than horizontal (landscape) windows.
- We suggest a total glazed wall area of around 15% to 20%. This may be increased to 25% to 30% on the south elevation (subject to design and shading) in order to maximise winter solar gains.
- We want to use triple glazed timber windows.

Form

- We prefer to see a compact form to the house with the surface area (walls & roof) to floor ratio as low as possible
- We prefer two storey buildings to single storey.
- Floor spans are best kept to a maximum of 6m in order to minimise extra structure.
- High thermal efficiency means that a chimney is not required.

Thermal modelling

Inaccurate Thermal Modelling



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Experimental Panel

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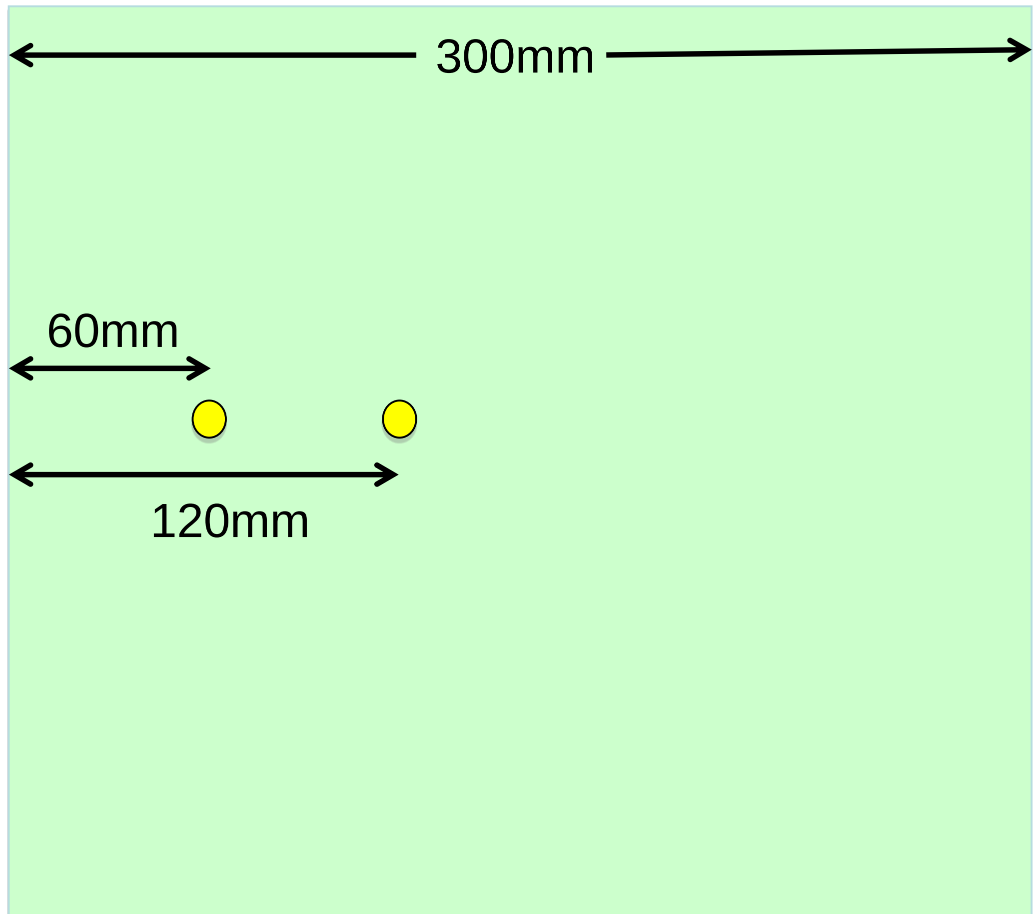
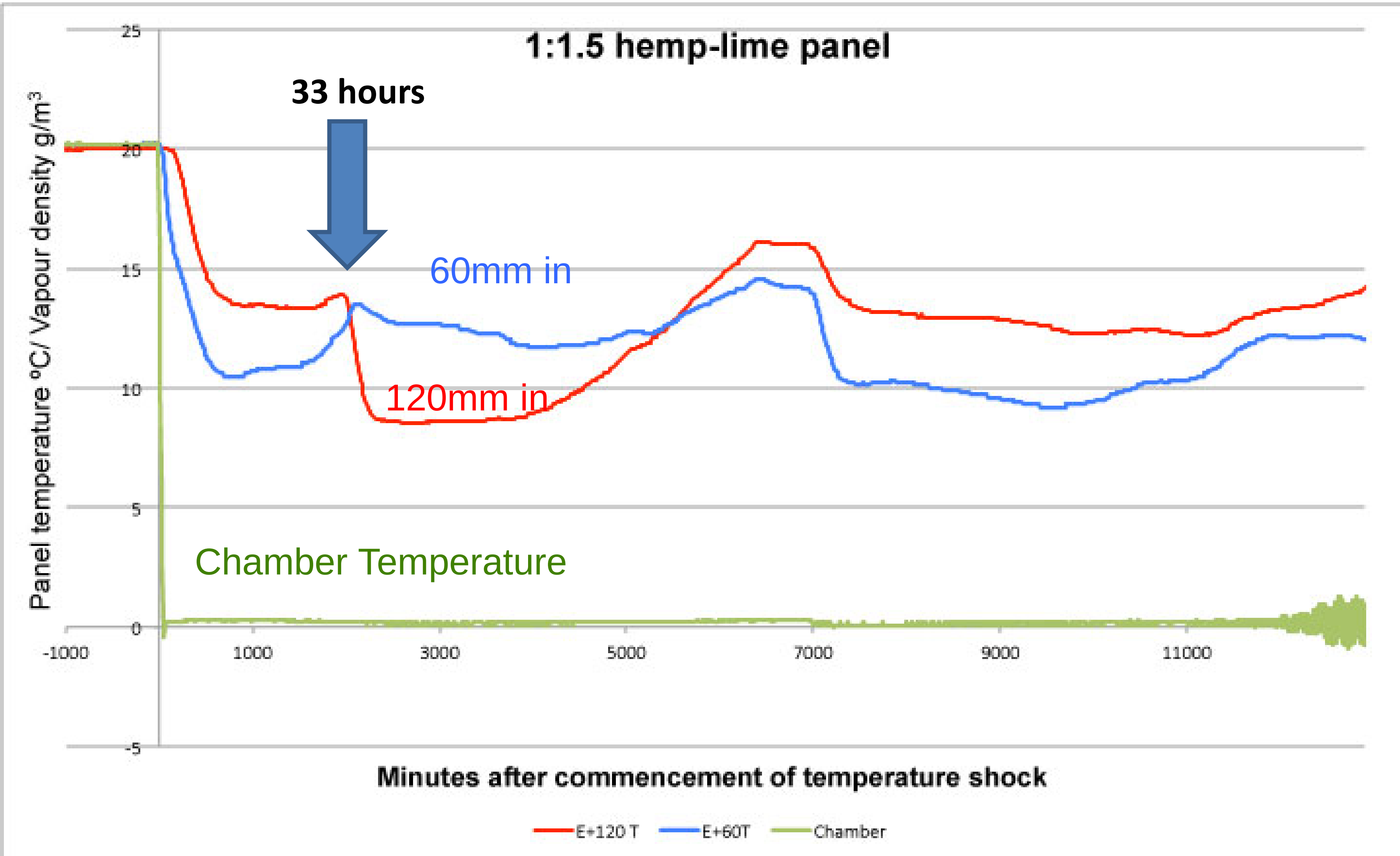
Phase Change in Hemp-Lime

Sudden shock from 20ºC to 0ºC

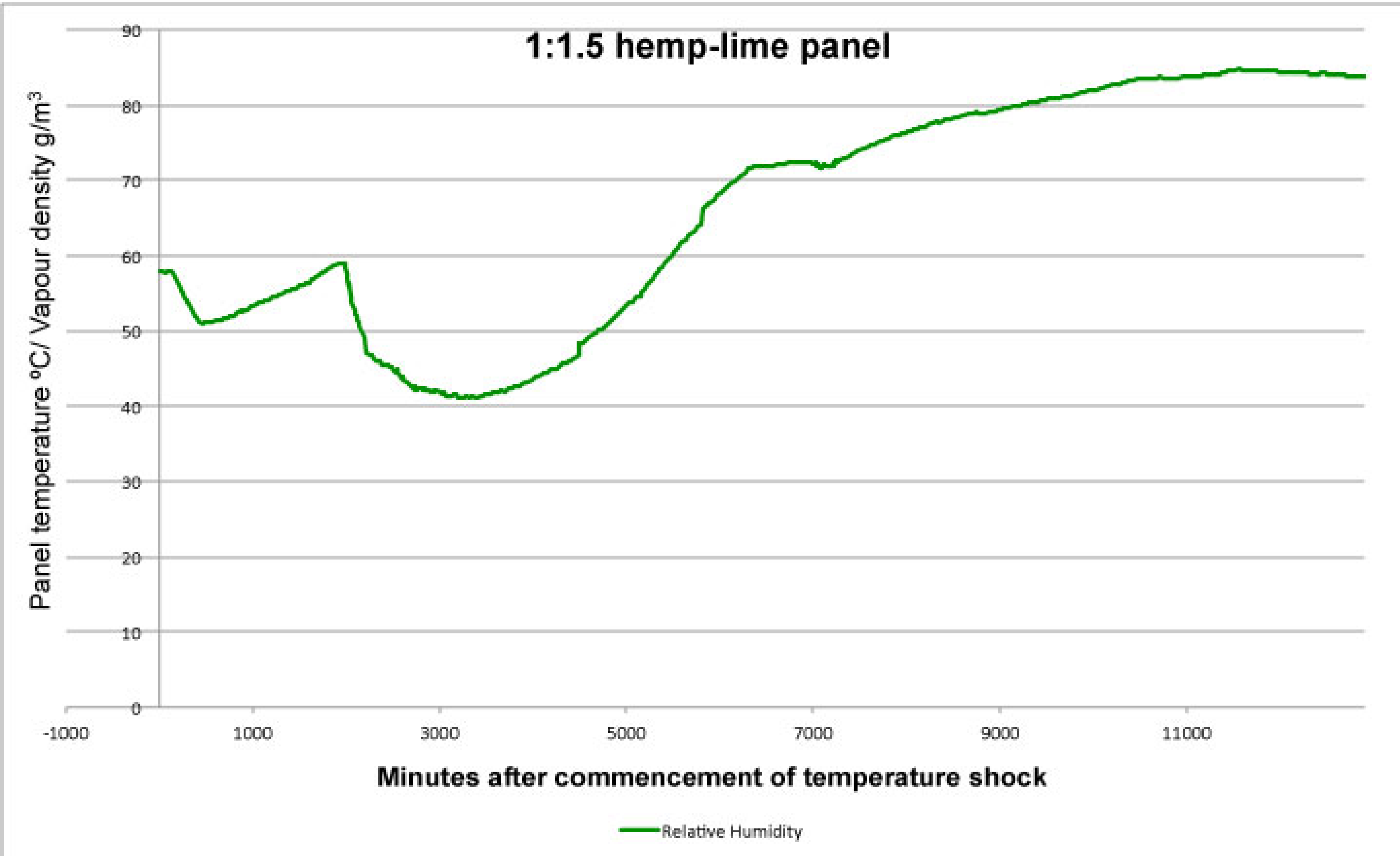


20ºC
60%RH

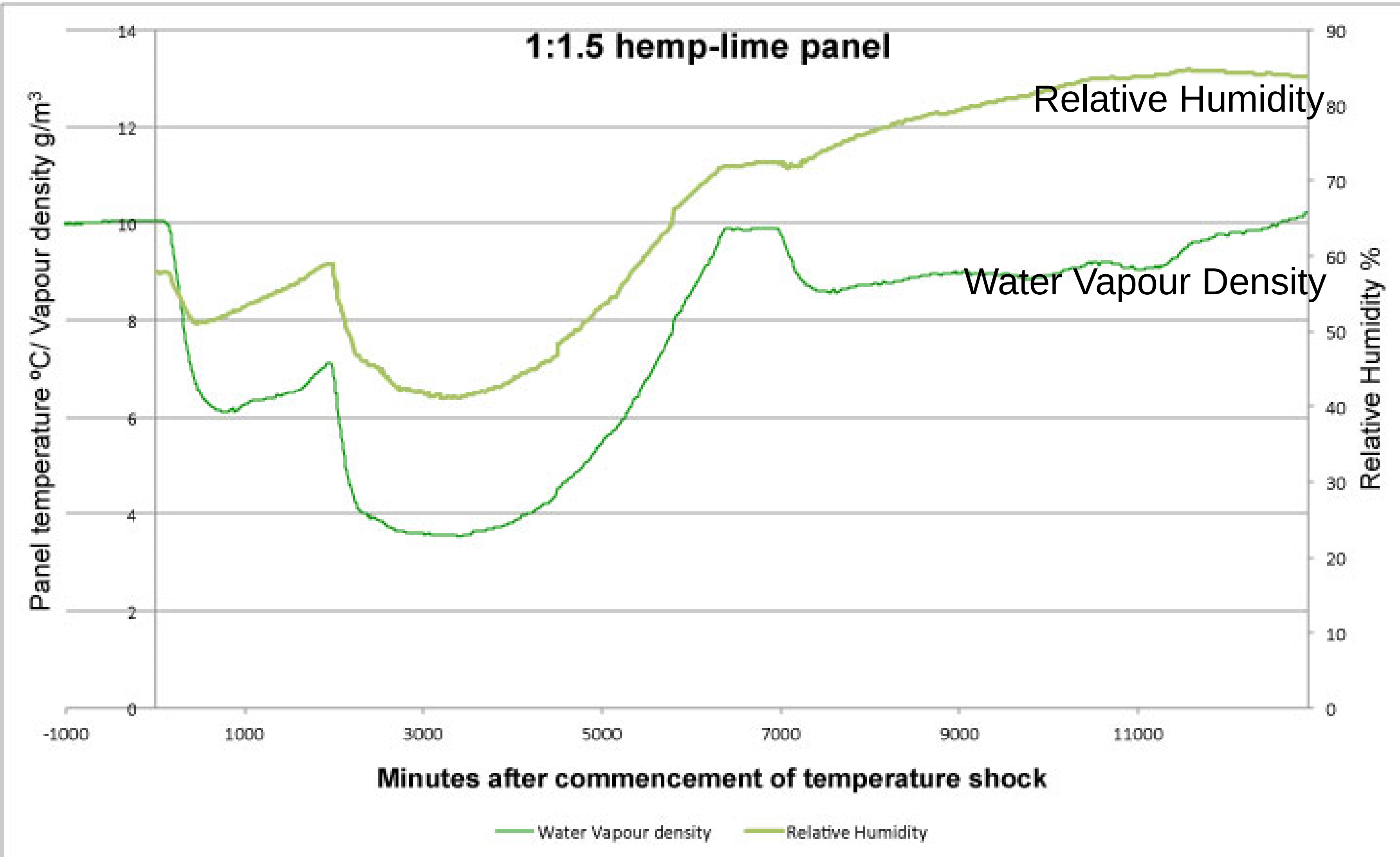
Cycle 1 – 9 days



Relative Humidity @120mm



RH & WVD @120mm

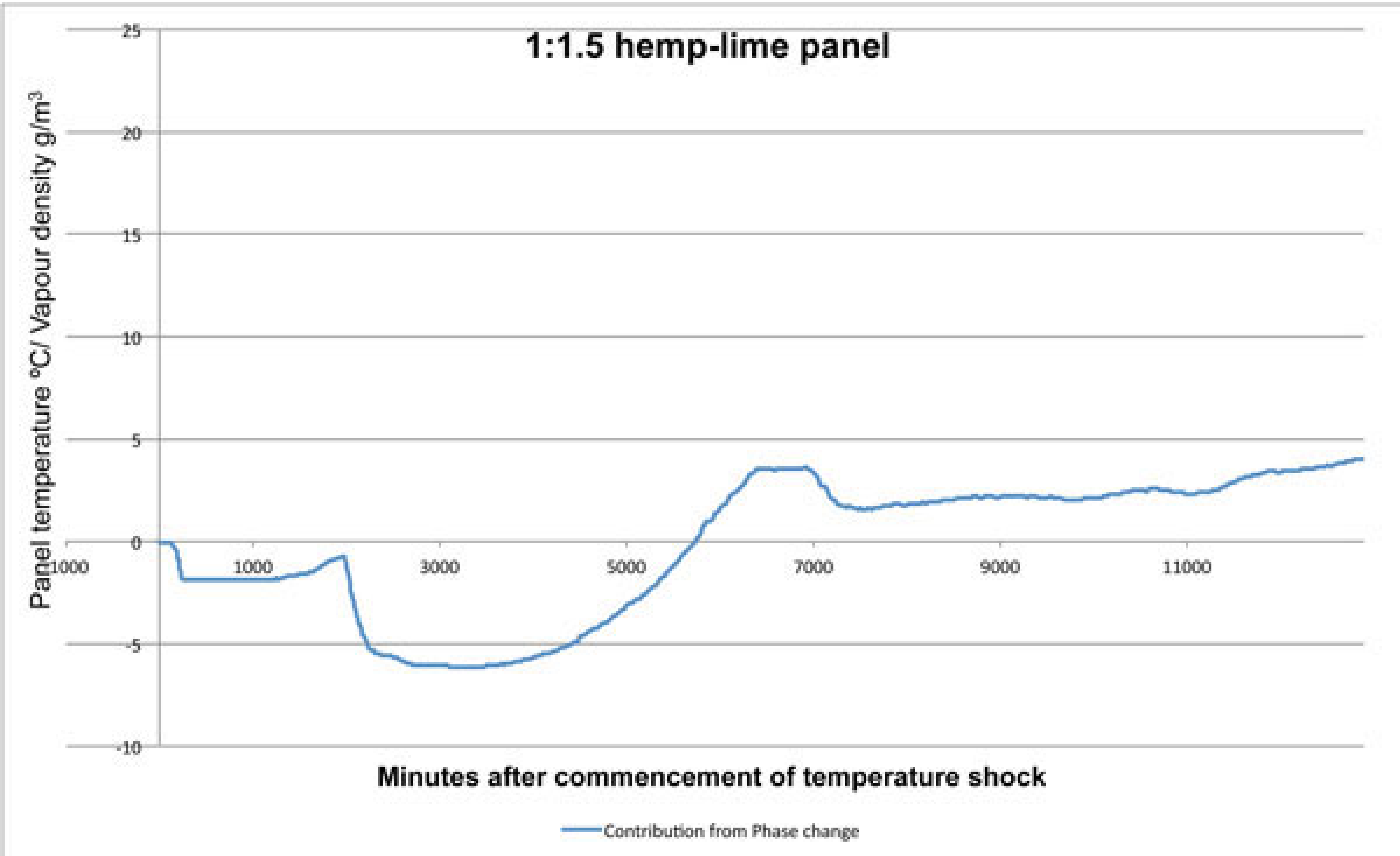


1:1.5 hemp-lime panel
Relative Humidity
Water Vapour Density
Panel temperature °C/ Vapour density g/m³
Relative Humidity %
14
12
10
8
6
4
2
0
90
80
70
60
50
40
30
20
10
0
-1000
1000
3000
5000
7000
9000
11000
Minutes after commencement of temperature shock
Water Vapour density
Relative Humidity

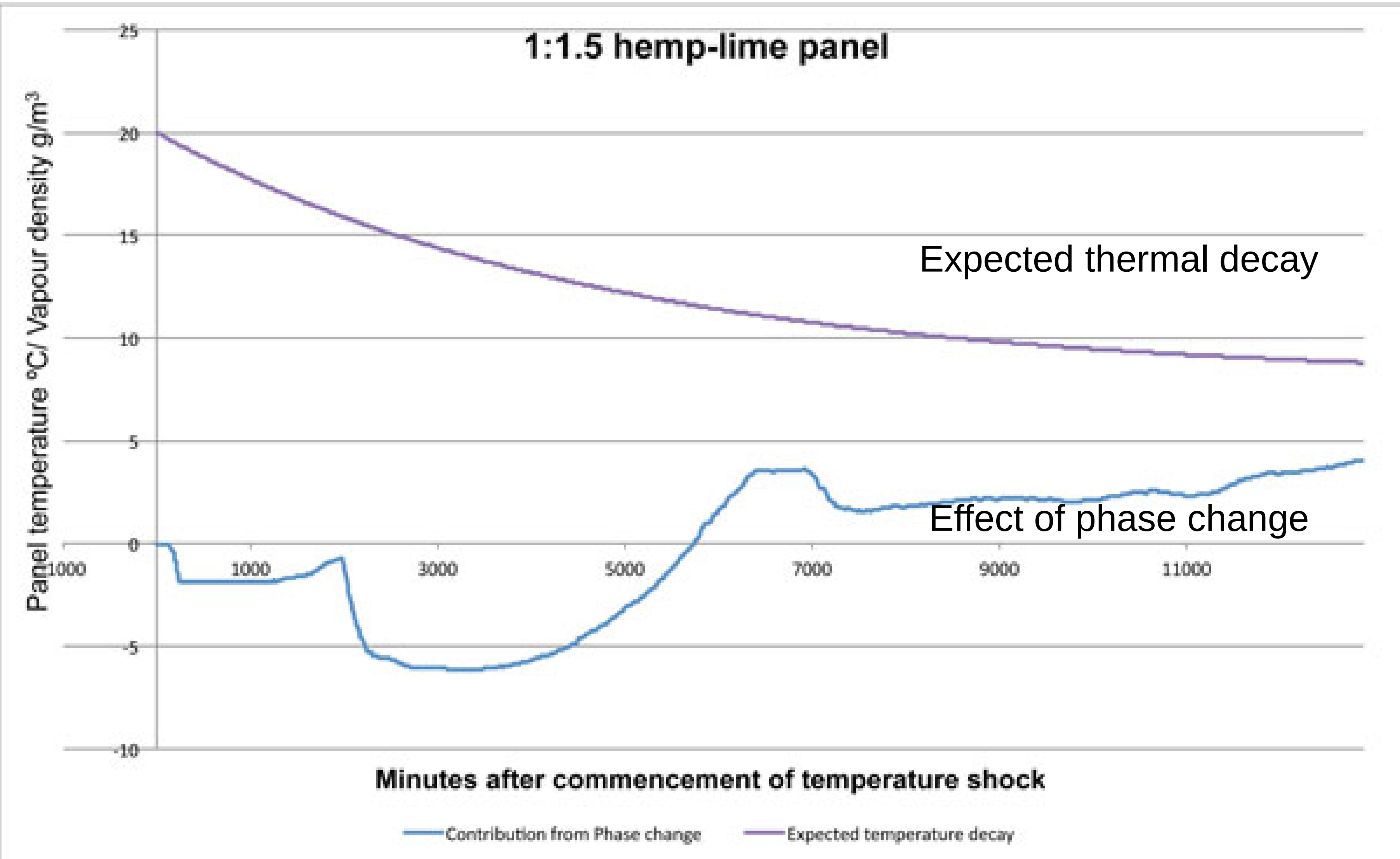
Evaluate effect of phase change

- If you accept that phase change phenomena occur in Hemp-Lime, then any change in measured RH% in the air around the HL must, in part, be produced by condensation (loss of RH%) or evaporation (increase in RH%)
- Assume a portion of change in WVD is adsorbed/desorbed by hemp shiv involving no phase change(76%)
- Assume a portion of change in WVD is a result of evaporation/condensation (24%)

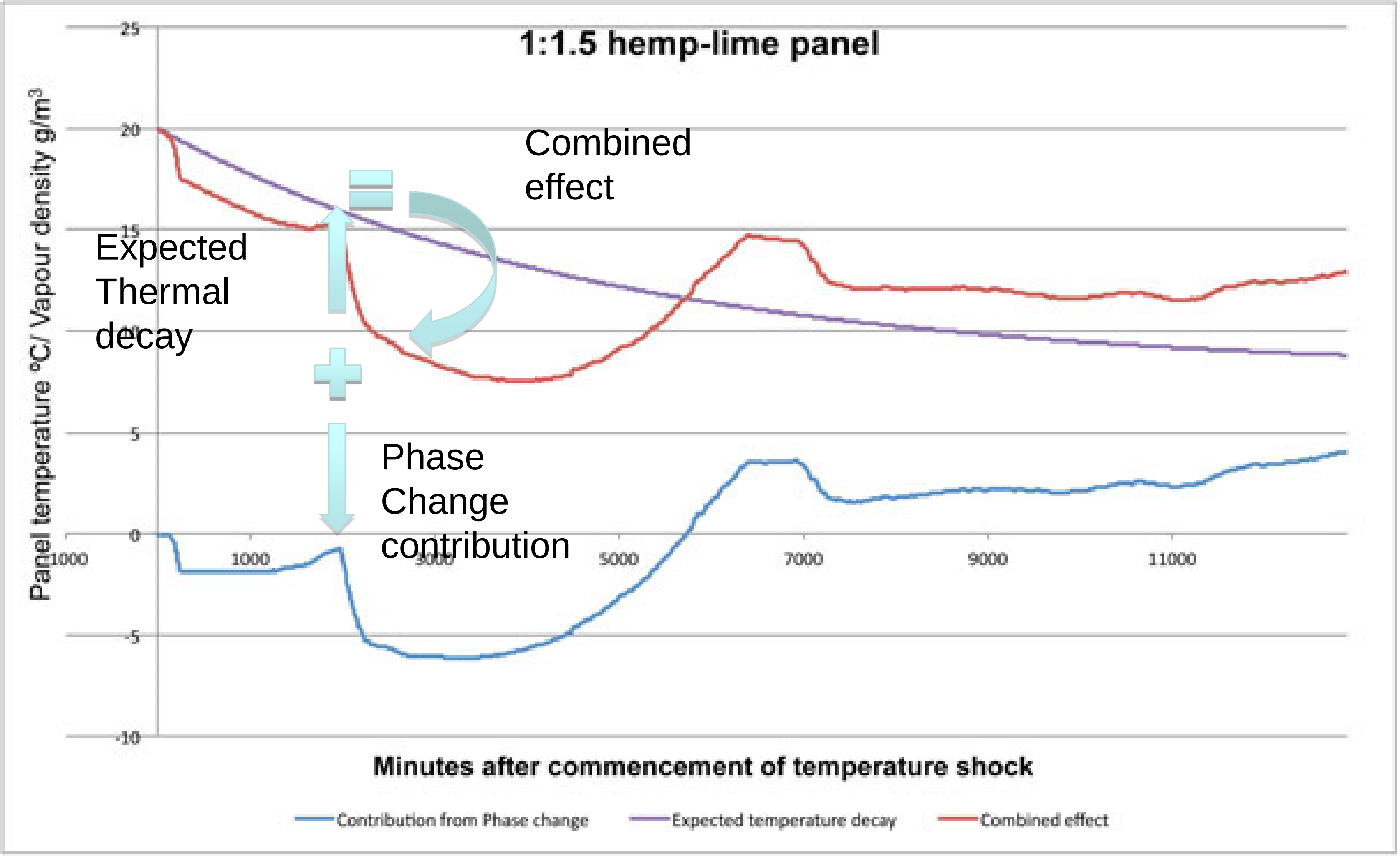
Temperature effect of phase change @120mm



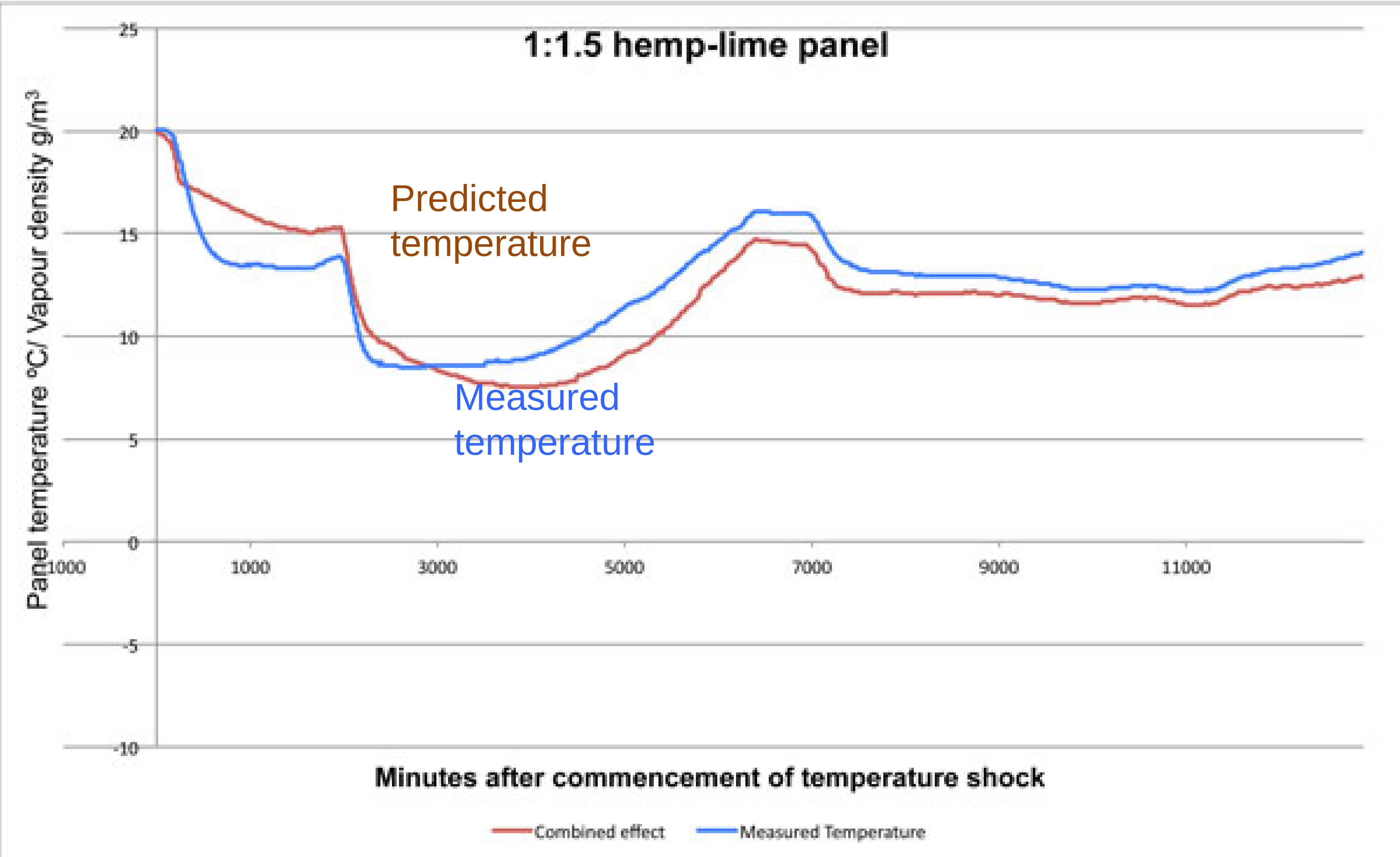
Add exponential temperature decay



Add the two effects together



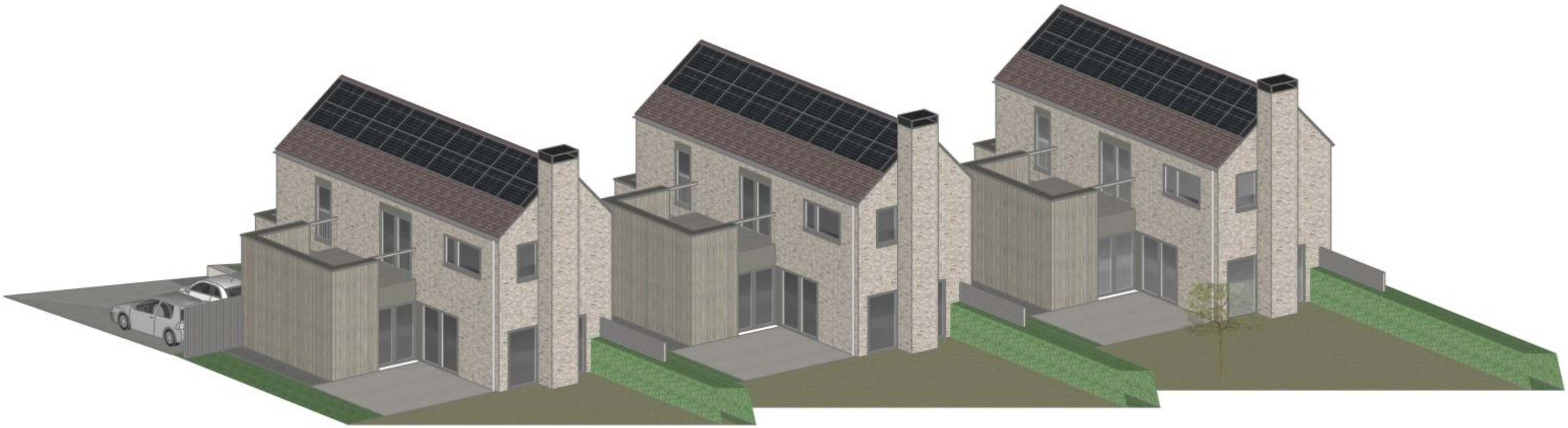
Compare with measured temperature



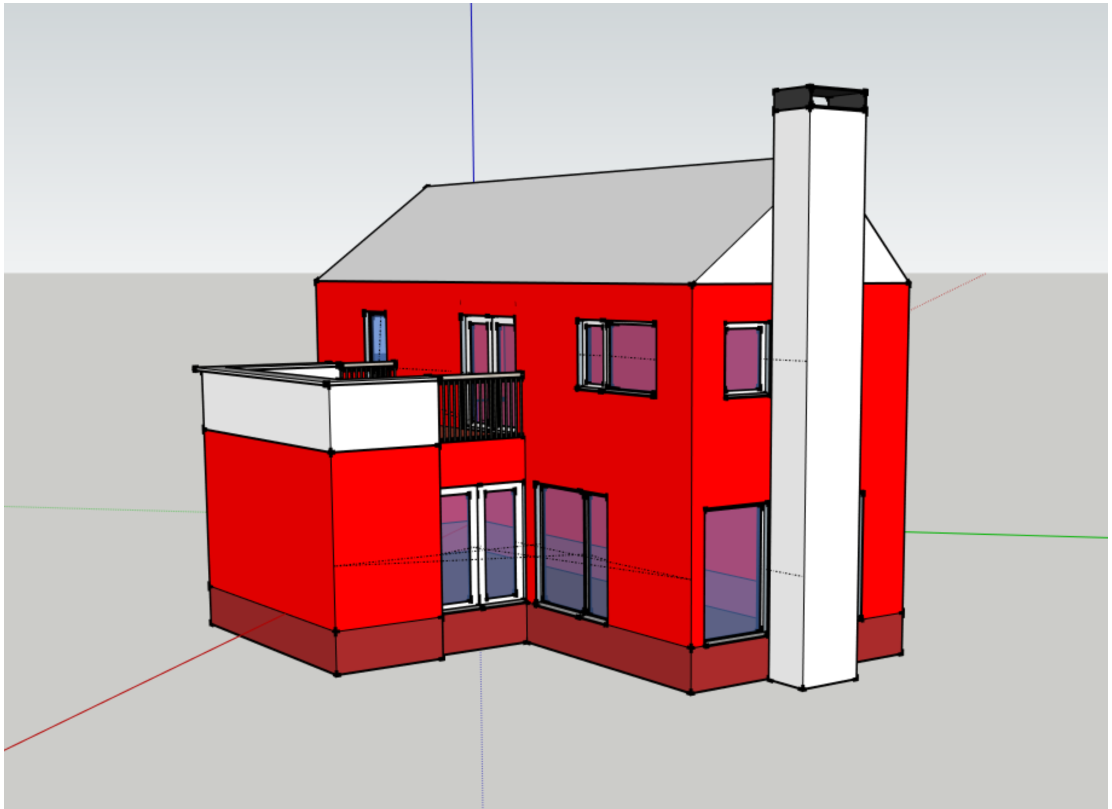
Thermal Modelling

- Hemp-Lime is difficult to model (due to the phase change) – it always performs better than expected
- This is a ***Positive Performance Gap***
- We have developed innovative modelling tools to help predict the real performance
- IES with Fourrier Filter (slow and expensive)
- Passivhaus Planning Package PHPP (easier, but less accurate)
- PH Criteria – 15kWhrs/m^2/yr or 10W/m^2

Thermal Analysis



Thermal Analysis



Thermal envelope of the building

Non thermal element

Fabric U values (W/m2K):

- Floor Slab: 0.116
- External Wall: 0.147
- Roof: 0.109
- Windows: 0.79

Non Fabric Specifications:

- Infiltration 0.6

(Air changes per hour @n50)

MVHR Efficiency 70.4%

Thermal Analysis

Specific building demands with reference to the treated floor area					
	Treated floor area	101.7	m^2	**Requirements**	**Fulfilled?***
Space heating	Heating demand	**24**	**kWh/(m^2a)**	15 kWh/(m²a)	**no**
	Heating load	**14**	**W/m^2**	10 W/m²	**no**
Space cooling	Overall specif. space cooling demand		**kWh/(m^2a)**	-	**-**
	Cooling load		**W/m^2**	-	**-**
	Frequency of overheating (> 25 °C)	32.1	%	-	**-**
Primary energy	Heating, cooling, dehumidification, DHW, auxiliary electricity, lighting, electrical appliances		**kWh/(m^2a)**	120 kWh/(m²a)	
	DHW, space heating and auxiliary electricity		kWh/(m^2a)	-	**-**
	Specific primary energy reduction through solar electricity		kWh/(m^2a)	-	**-**
Airtightness	Pressurization test result n_{50}	**0.6**	**1/h**	0.6 1/h	**yes**

* empty field: data missing; '-': no requirement

Thermal Analysis - Summary

- This could not get Passivhause certification
- This is close to delivering Passivhaus performance because of the ***positive performance gap*** provided by the Hempcell system (up to 50% better than predicted in PHPP)
- PV's could produce up to 65% of energy demand (subject to orientation)
- Peak heat demand of 1.8kW per house

Construction

- Well insulated sub-structure
- Off-site manufacture of super-structure
- Air-tightness
- Care

Off-site Construction

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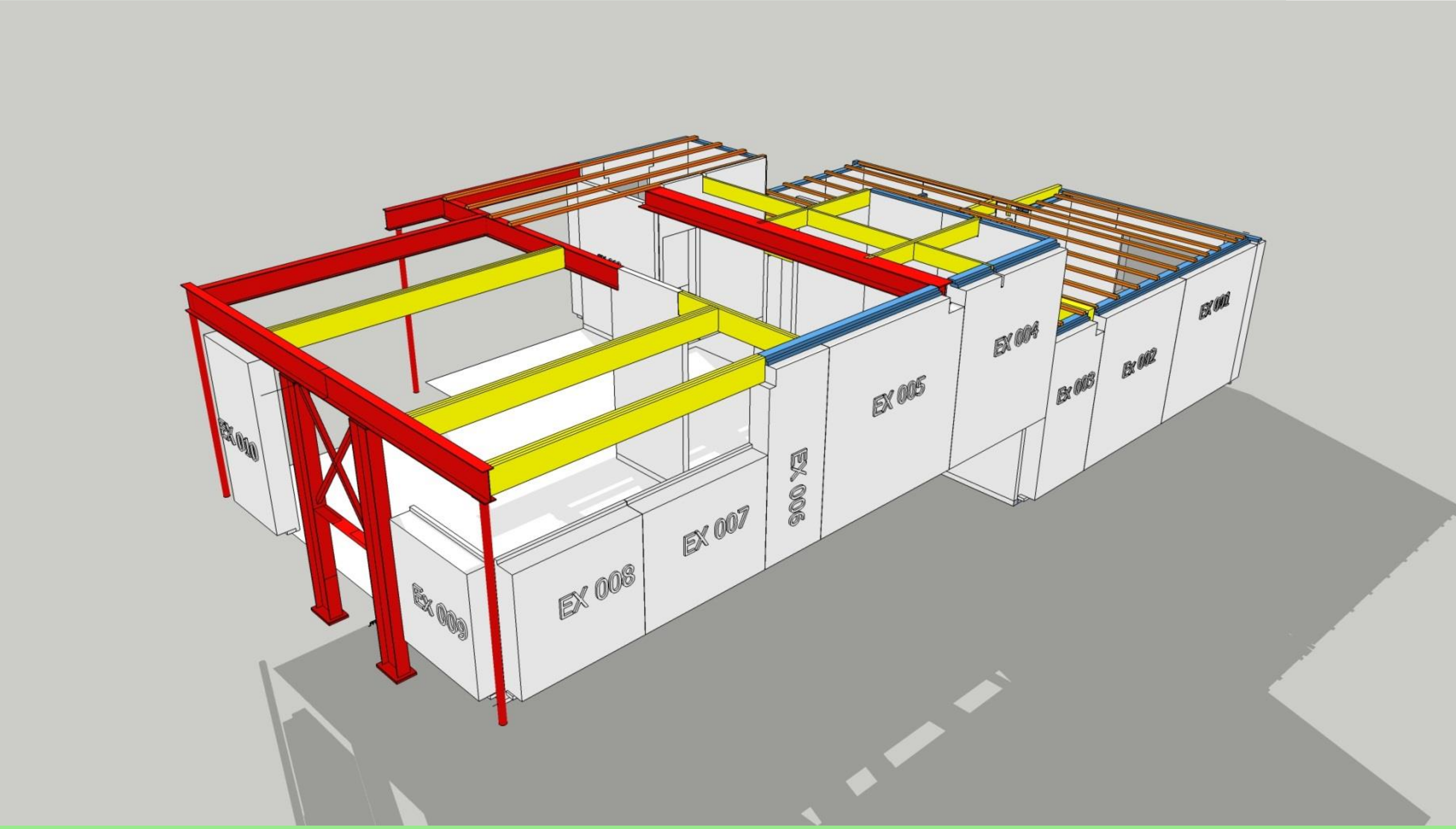
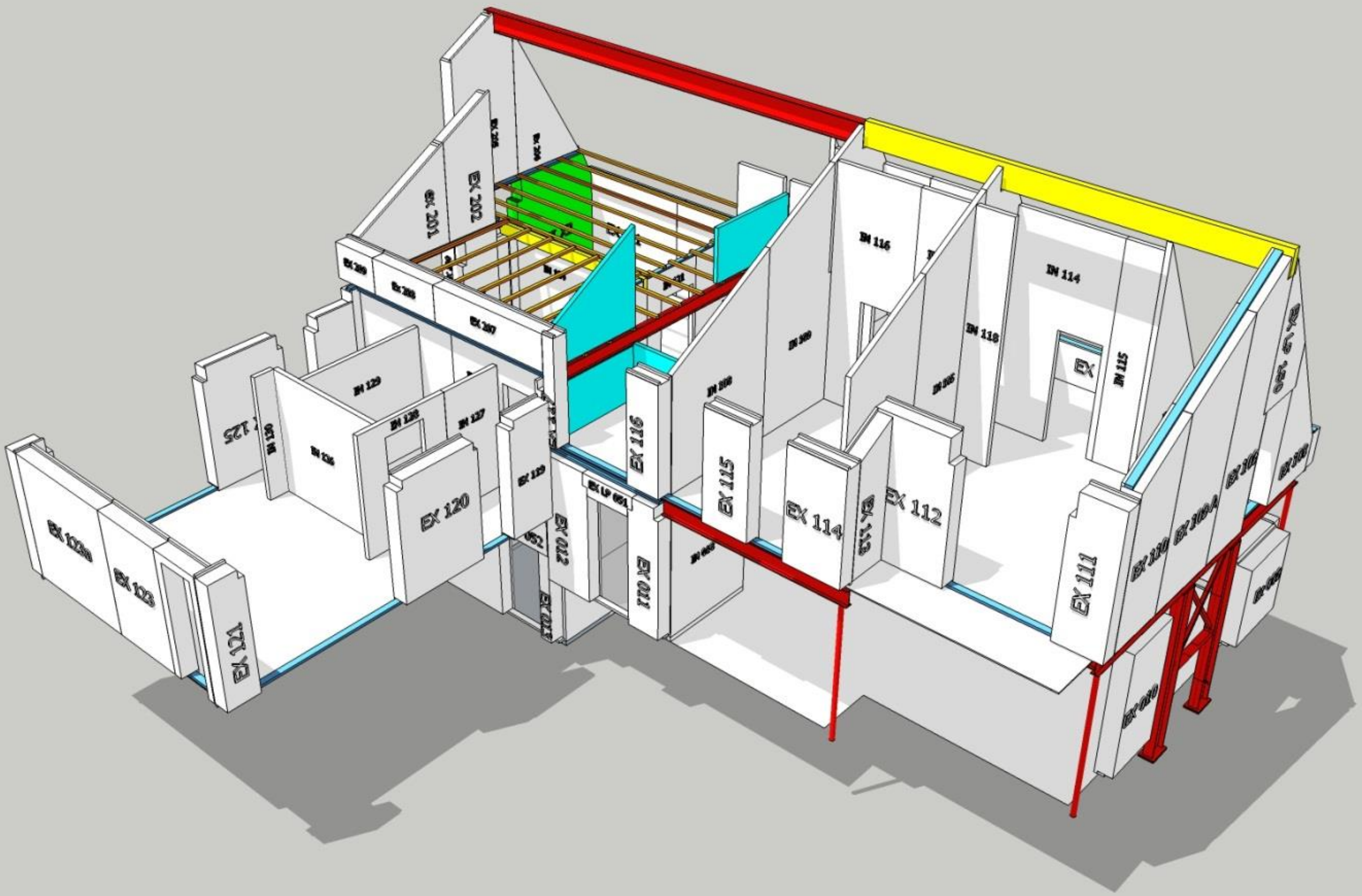
Off-site Construction



Off-site Construction



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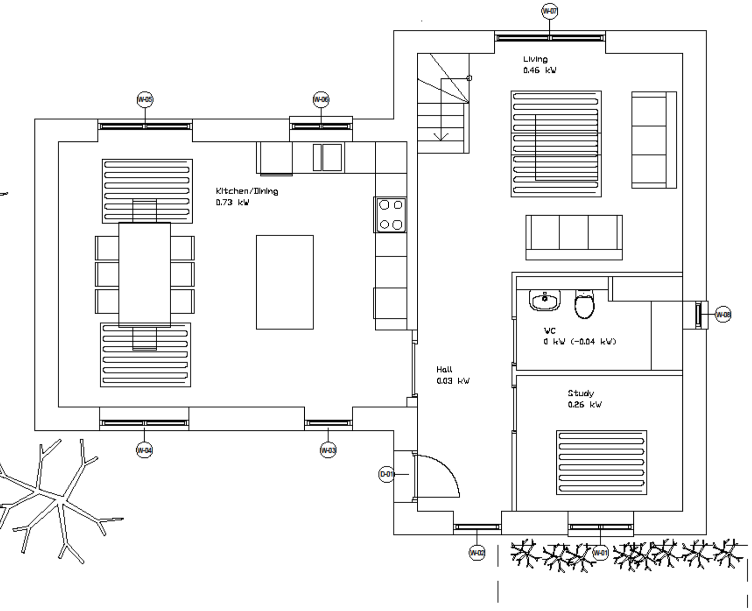
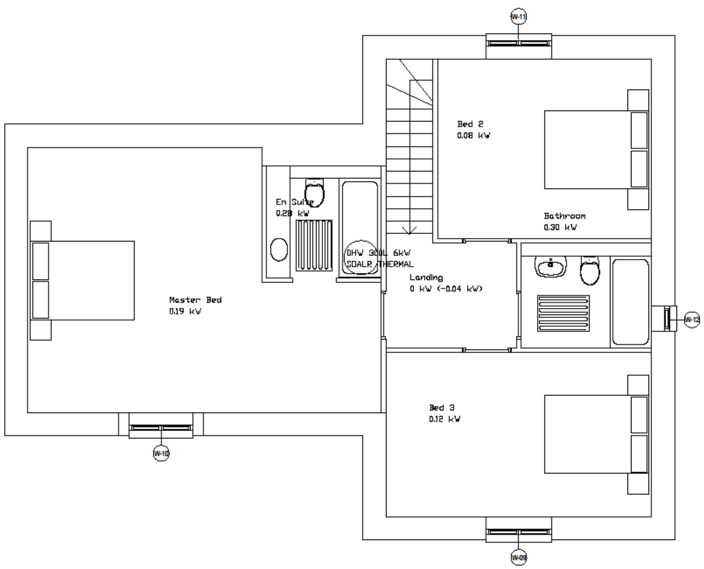
Off-site Construction

https://www.youtube.com/watch?v=Msfz8k_AVQM&feature=youtu.be

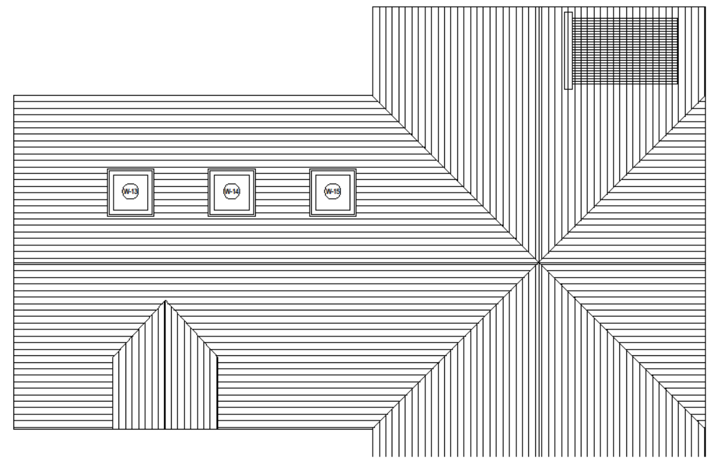
M&E Systems

- We have a very low heat demand – 10 to 15W/m^2
- Services strategy is now driven by hot water requirement rather than heating
- We aim for low cost simple solution
  - MVHR for ventilation
  - 50% heat supplied through fresh air (via MVHR)
  - 50% heat supplied by electric UFH
  - Electric HW
  - Balanced by PV's (or solar thermal)





First floor plan



ROOM SCHEDULE

ROOM	DESIGN TEMP (°C)	CISBE HEAT LOSS (kW)	AIR SUPPLY @ MAX(1.4kW)	HEAT MAT AREA REQUIRED (M2) @ 100W/M2
WC	18	0	0	
STUDY	21	0.26	0.1	1.6
KITCHEN/DINING	21	0.73	0.37	3.6
HALL	18	0.03		
LIVING	21	0.46	0.22	2.4
LANDING	18	0		
BED 1	18	0.19	0.19	
EN SUITE	22	0.28		1.6
BED 2	18	0.08	0.08	
BED 3	18	0.12	0.12	
BATHROOM	22	0.3		1.7

ROOM SCHEDULE AIRFLOW DV96

ROOM	DESIGN TEMP (°C)	CISBE HEAT LOSS (kW)	AIR SUPPLY @ (0.9kW)	HEAT MAT AREA REQUIRED (M2) @ 100W/M2
WC	18	0		
STUDY	21	0.26	0.07	1.9
KITCHEN/DINING	21	0.73	0.25	4.8
HALL	18	0.03		
LIVING	21	0.46	0.15	3
LANDING	18	0		
BED 1	18	0.19	0.19	
EN SUITE	22	0.28		2.6
BED 2	18	0.08	0.08	
BED 3	18	0.12	0.12	
BATHROOM	22	0.3		2.71

Origin Arch.		Rev.	Cad Ref	
Origin Struc.		Rev.	Drawn by	JL

Standard Notes
1. DO NOT SCALE THIS DRAWING. WORK TO DIMENSIONS GIVEN.
2. ALL DIMENSIONS TO BE VERIFIED FROM SITE MEASUREMENT.
3. DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE STATED.

NOTES:

UNDERFLOOR HEATING MATS TO BE COVERED IN NO MORE THAN 10MM LEVELING COMPOUND

AIR SUPPLY TO BE PREHEATED THROUGH POST HEATER INSTALLED IN SUPPLY DUCTING AT MVHR UNIT.

INTEGRAL HEATER / FROST HEATER AIRFLOW UNIT AVAILABLE ON AIRFLOW DUPLEXVENT DV96 UNIT (900W)

CONTROL - MVHR TO PROVIDE 18°C BACKGROUND HEAT WITH THERMOSTATIC CONTROLS ON UFH TO PROVIDE ROOM BOOST

GLEDHILL STAINLESS LITE DIRECT STAINLESS STEEL UNVENTED SOLAR CYLINDER 300L ASL0080 WITH 6KW IMMERSION

SOLAR THERMAL COLLECTION SIZE TO PROVIDE 50%-60% OF TOTAL HOT WATER REQUIREMENT. EG VAILLANT AUROTHERM PLUS VTK1140

Rev.	Date	Description	By	Chkd

Drawing Status

encraft
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CV32 4YS
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E. enquiries@encraft.co.uk
www.encraft.co.uk

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Project
PRESTON CROWMARSH

Drawing Title
BUILDING SERVICES
HEATING AND
HOT WATER

Drg No.	Revision
P3092-A-101	P1

Scale	Date	Engineer	Checked

Commissioning and Monitoring

- M&E doesn’t always work first time
- You only find the problems if you look for them
- Thorough commissioning is essential
- Monitoring can also find the bugs
- We monitor the following:-
  - Heating energy
  - Hot water energy
  - Total energy use
  - Energy generated by PV’s

Embodied Carbon Audit

Item	X (m)	Y (m)	Area (m2)	Z (m)	Volume (m3)	Density (kg/m3)	Mass (kg)	Embodied CO2/unit	Total CO2	Notes
Example timber	0.089	0.038	0.003	4.000	0.014	350.000	4.735	-1.37	-6.49	kg/kg
Demolition of bungalow (deisel)			0.000		0.000		200.000	2.000	400.00	Estimate
			0.000		0.000		0.000		0.00	
Groundworks			0.000		0.000		0.000		0.00	
New concrete foundations			0.000		6.000	2240.000	13440.000	0.112	1505.28	GEN 3
Deisel for plant			0.000		0.000		50.000	2.000	100.00	Estimate
New conc blockwork	0.440	0.215	0.095	21.600	2.043	1800.000	3678.048	0.061	224.36	216 blocks
Mortar (site mixed 1:5)			0.000		0.000		1080.000	0.177	191.16	
New concrete slab			0.000		6.000	2240.000	13440.000	0.095	1276.80	
Timber formwork	0.047	0.100	0.005	21.000	0.099	350.000	34.545	0.400	13.82	later burned
Reinforcing mesh			43.200		0.000		95.904	1.770	169.75	A142
MOT type 1			0.000		0.000		10000.000	0.017	170.00	
DPM					0.000		0.000		0.00	
New strip foundations in existing slab			0.000		6.000	2240.000	13440.000	0.112	1505.28	GEN 3
Rebar							26.640	1.770	47.15	T12 - 30m
Deisel for plant			0.000		0.000		50.000	2.000	100.00	
Floor insulation			130.000	0.200	26.000	32.000	832.000	2.500	2080.00	
Screed			130.000	0.070	9.100	2240.000	20384.000	0.046	937.66	
Plastic sheet			130.000		0.000		34.450	1.940	66.83	
110 pipe PVC ground			0.000	80.000	0.000		91.200	2.500	228.00	
manhole			0.000		0.000		15.000	2.500	37.50	
Manhole cover			0.000		0.000		10.000	2.500	25.00	
Fittings			0.000		0.000		19.200	2.500	48.00	20 of
Geo textile			50.000		0.000		3.900	2.700	10.53	

- A value of -1.37kg CO_2e sequestered per kg of bio-mass was used

Feedback

- The results of each project are fed back into the design process for the next projects
- Construction issues
- Embodied carbon
- Energy use from monitoring

Case Study - 47 Preston Crowmarsh

47 Preston Crowmarsh

- PHPP modelling
- 0.6 ac/hr
- 27kWhrs/m^2/yr
- 13W/m^2
- Heating load verified by co-heating test

Passive House verification

Photo or Drawing

Building:	Preston Crowmarsh
Street:	
Postcode / City:	
Country:	
Building type:	
Climate:	[UK] - Thames valley (Silsoe) — Altitude of building site (in [m] above sea level): 48
Home owner / Client:	
Street:	
Postcode/City:	
Architecture:	
Street:	
Postcode / City:	
Mechanical system:	
Street:	
Postcode / City:	

Year of construction:		Interior temperature winter:	20.0	°C	Enclosed volume V_e m³:	
No. of dwelling units:		Interior temperature summer:	25.0	°C	Mechanical cooling:	
No. of occupants:	4.1	Internal heat sources winter:	2.1	W/m²		
Spec. capacity:	132 Wh/K per m² TFA	Ditto summer:	2.1	W/m²		

Specific building demands with reference to the treated floor area

				Requirements	Fulfilled?*
	Treated floor area	144.7	m²		
Space heating	Heating demand	27	kWh/(m²a)	15 kWh/(m²a)	no
	Heating load	13	W/m²	10 W/m²	no
Space cooling	Overall specif. space cooling demand		kWh/(m²a)	-	-
	Cooling load		W/m²	-	-
	Frequency of overheating (> 25 °C)	22.5	%	-	-
Primary energy	Heating, cooling, auxiliary electricity, dehumidification, DHW, lighting, electrical appliances		kWh/(m²a)	120 kWh/(m²a)	
	DHW, space heating and auxiliary electricity		kWh/(m²a)	-	-
	Specific primary energy reduction through solar electricity		kWh/(m²a)	-	-
Airtightness	Pressurization test result n_{50}	0.6	1/h	0.6 1/h	yes

* empty field: data missing; '-': no requirement

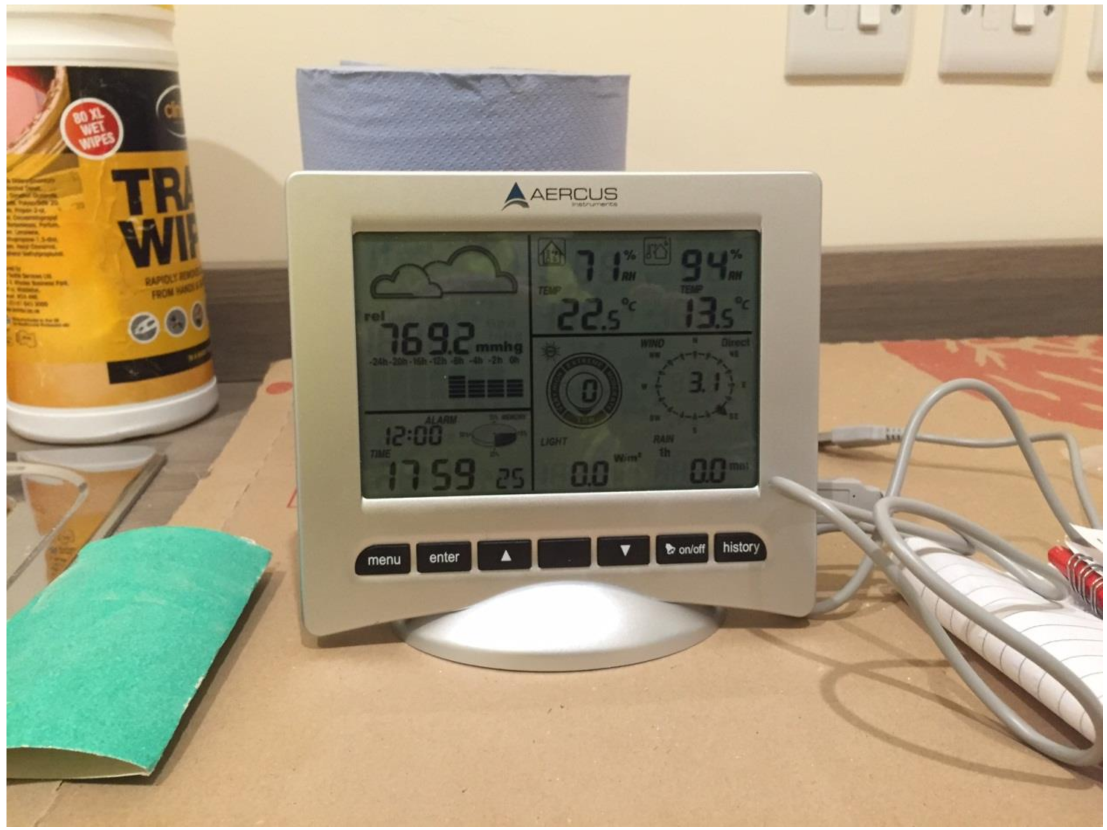
Passive House?

We 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 application.

Name:	Gabriela	PHPP Version 8.5	
Surname:	Lavatelli	Issued on:	01/02/2016
Company:	Hempsec Limited	Signature:	

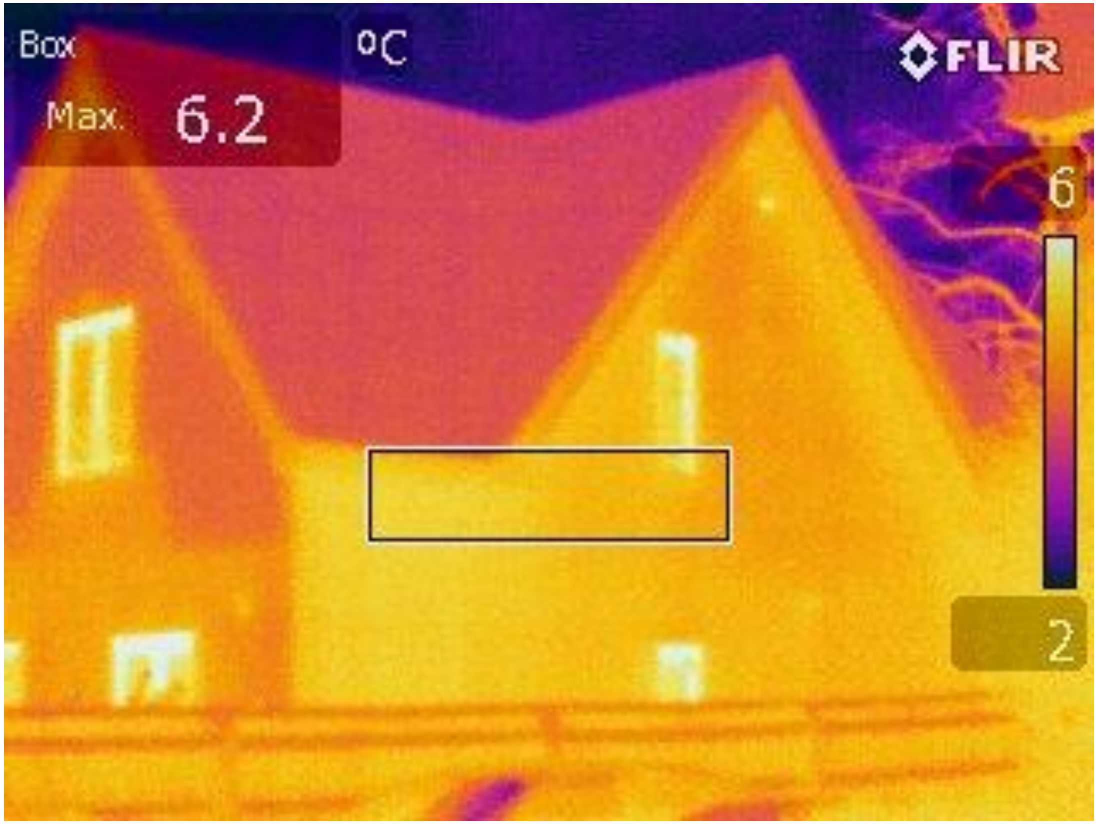
47 Preston Crowmarsh

- Co-heating test carried out 21st December 2015 to 3rd January 2016



47 Preston Crowmarsh

- Thermal images taken during the co-heating test



CASE STUDY - HAWTHORNS

- Pre-fabricated hemp wall panels (U-value 0.13W/m^2.K)
- Hemp fibre insulation to roof (U-value 0.1W/m^2.K)
- Re-used existing foundations and slab
- British cedar cladding and render
- Recycled rubber Eco-slate roof covering
- Rationel triple glazed timber windows
- Electric under-floor heating
- Electric hot water heating
- MVHR
- 4kWp of PV's added 12 months later

The Old Bungalow

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Demolition

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Demolition

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Ground Floor Panels

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Ground Floor Panels

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First Floor Joists

First Floor Decking

First Floor Panels

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Roof

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Eco-slates

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Cedar Cladding

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Rear Elevations

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Air-tightness membrane

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Scaffolding Down & Rendering

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Rain-water Pipes & Drains

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9 Months

9 Months

9 Months

Embodied Carbon Audit

Item	X (m)	Y (m)	Area (m2)	Z (m)	Volume (m3)	Density (kg/m3)	Mass (kg)	Embodied CO2/unit	Total CO2	Notes
Example timber	0.089	0.038	0.003	4.000	0.014	350.000	4.735	-1.37	-6.49	kg/kg
Demolition of bungalow (deisel)			0.000		0.000		200.000	2.000	400.00	Estimate
			0.000		0.000		0.000		0.00	
Groundworks			0.000		0.000		0.000		0.00	
New concrete foundations			0.000		6.000	2240.000	13440.000	0.112	1505.28	GEN 3
Deisel for plant			0.000		0.000		50.000	2.000	100.00	Estimate
New conc blockwork	0.440	0.215	0.095	21.600	2.043	1800.000	3678.048	0.061	224.36	216 blocks
Mortar (site mixed 1:5)			0.000		0.000		1080.000	0.177	191.16	
New concrete slab			0.000		6.000	2240.000	13440.000	0.095	1276.80	
Timber formwork	0.047	0.100	0.005	21.000	0.099	350.000	34.545	0.400	13.82	later burned
Reinforcing mesh			43.200		0.000		95.904	1.770	169.75	A142
MOT type 1			0.000		0.000		10000.000	0.017	170.00	
DPM					0.000		0.000		0.00	
New strip foundations in existing slab			0.000		6.000	2240.000	13440.000	0.112	1505.28	GEN 3
Rebar							26.640	1.770	47.15	T12 - 30m
Deisel for plant			0.000		0.000		50.000	2.000	100.00	
Floor insulation			130.000	0.200	26.000	32.000	832.000	2.500	2080.00	
Screed			130.000	0.070	9.100	2240.000	20384.000	0.046	937.66	
Plastic sheet			130.000		0.000		34.450	1.940	66.83	
110 pipe PVC ground			0.000	80.000	0.000		91.200	2.500	228.00	
manhole			0.000		0.000		15.000	2.500	37.50	
Manhole cover			0.000		0.000		10.000	2.500	25.00	
Fittings			0.000		0.000		19.200	2.500	48.00	20 of
Geo textile			50.000		0.000		3.900	2.700	10.53	

- A value of -1.37kg CO_2e sequestered per kg of bio-mass was used

Embodied Carbon Results

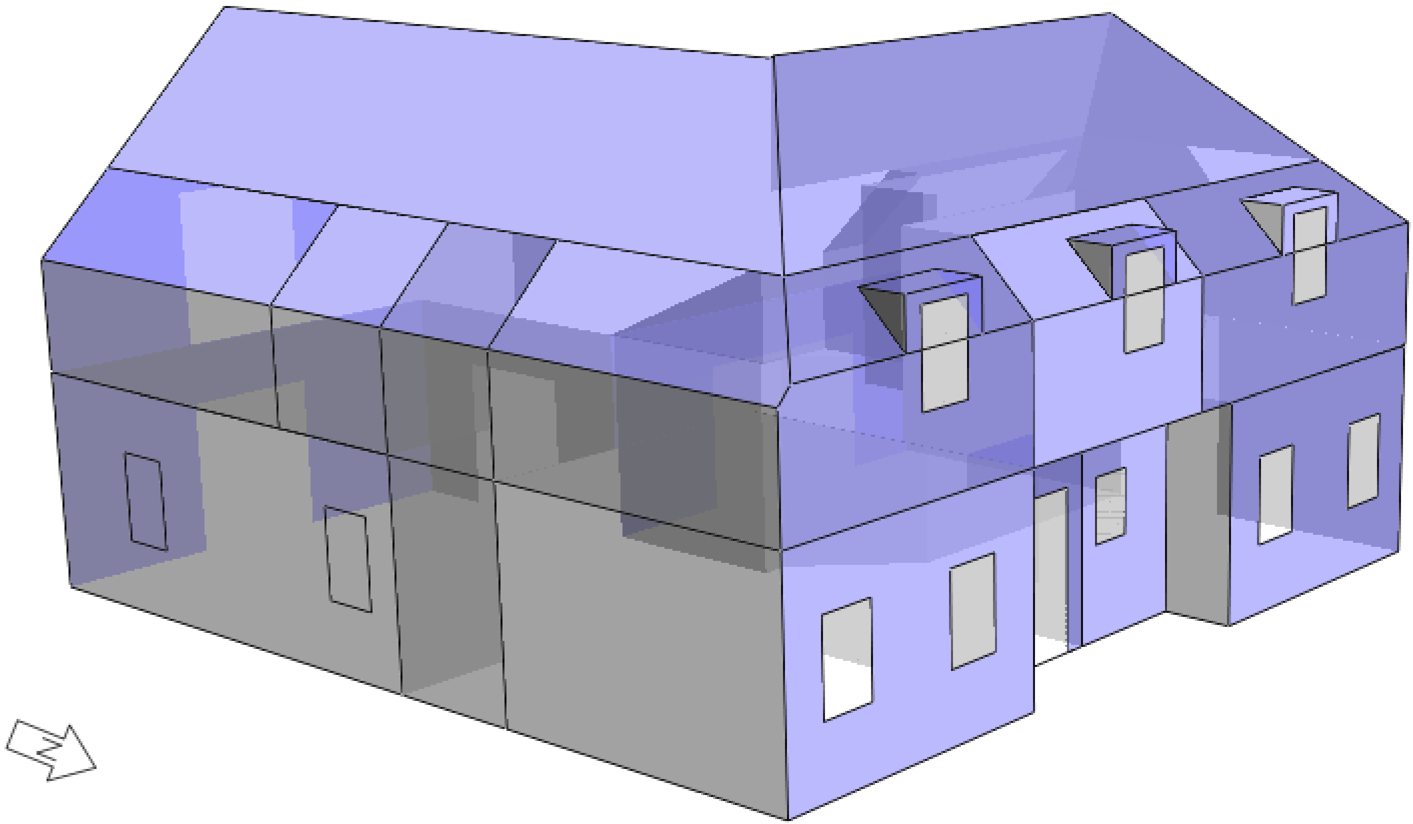
- Audit of the house as built
- -13,654kgCO_2e or -52kgCO_2e/m^2 of floor area

- Adding in a typical concrete foundation and slab
- -1,909kgCO_2e or -7.6kgCO_2e/m^2 of floor area

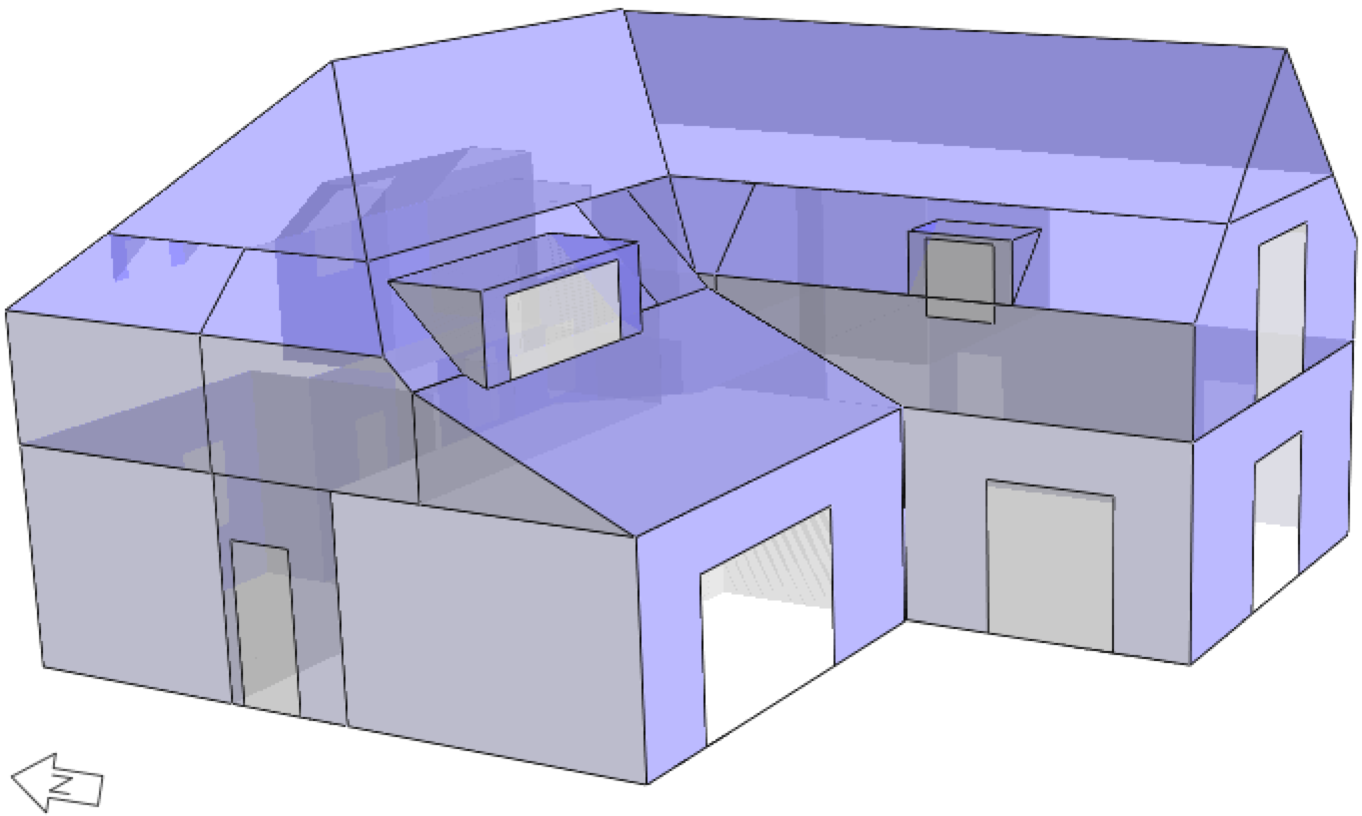
- Adding in a brick facing rather than timber/render
- +7,167kgCO_2e or +28.7kgCO_2e/m^2 of floor area

- UK average is +500 to 600kgCO_2e/m^2 of floor area

Thermal Modelling



Thermal Modelling



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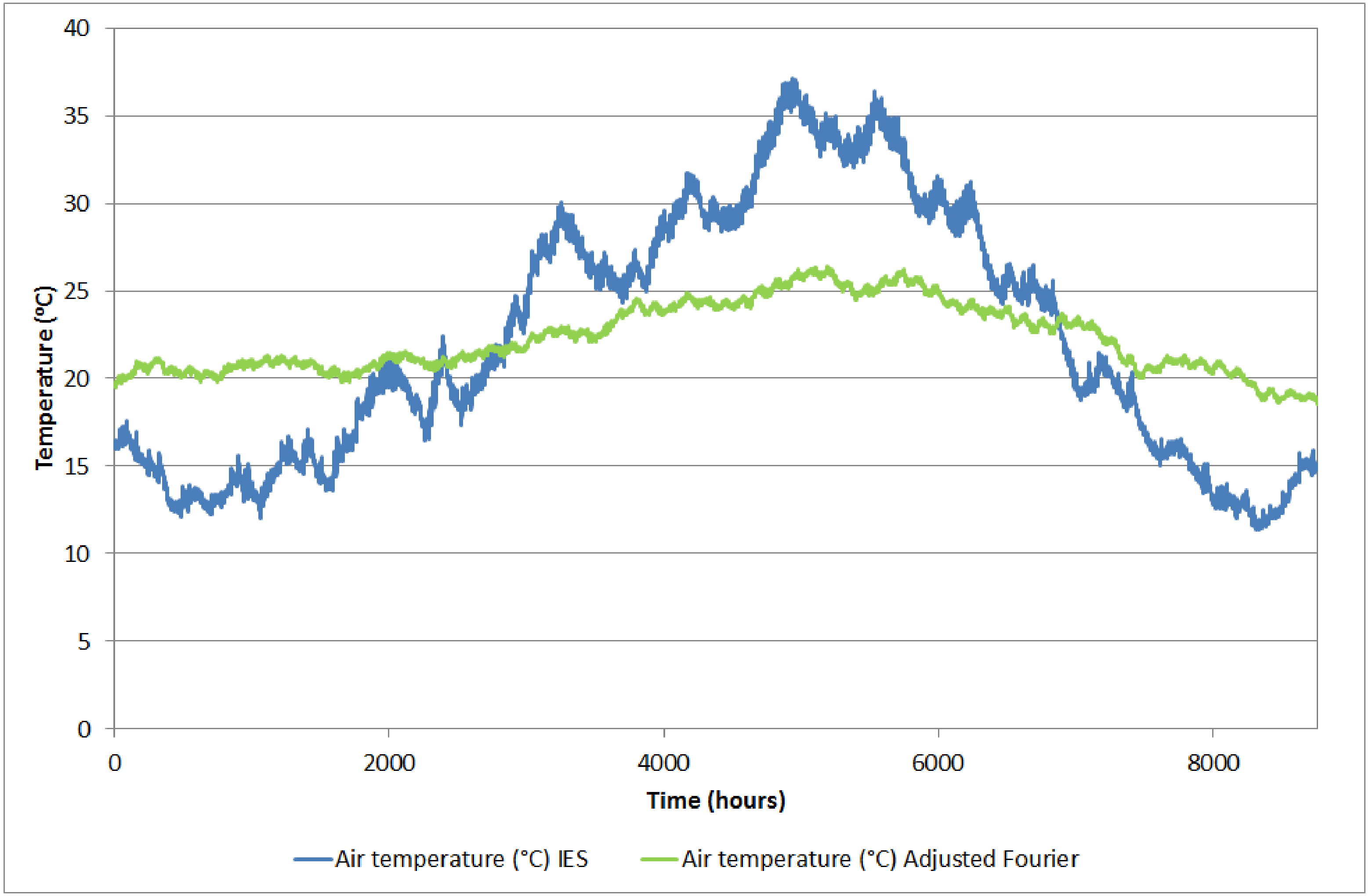
Thermal Modelling



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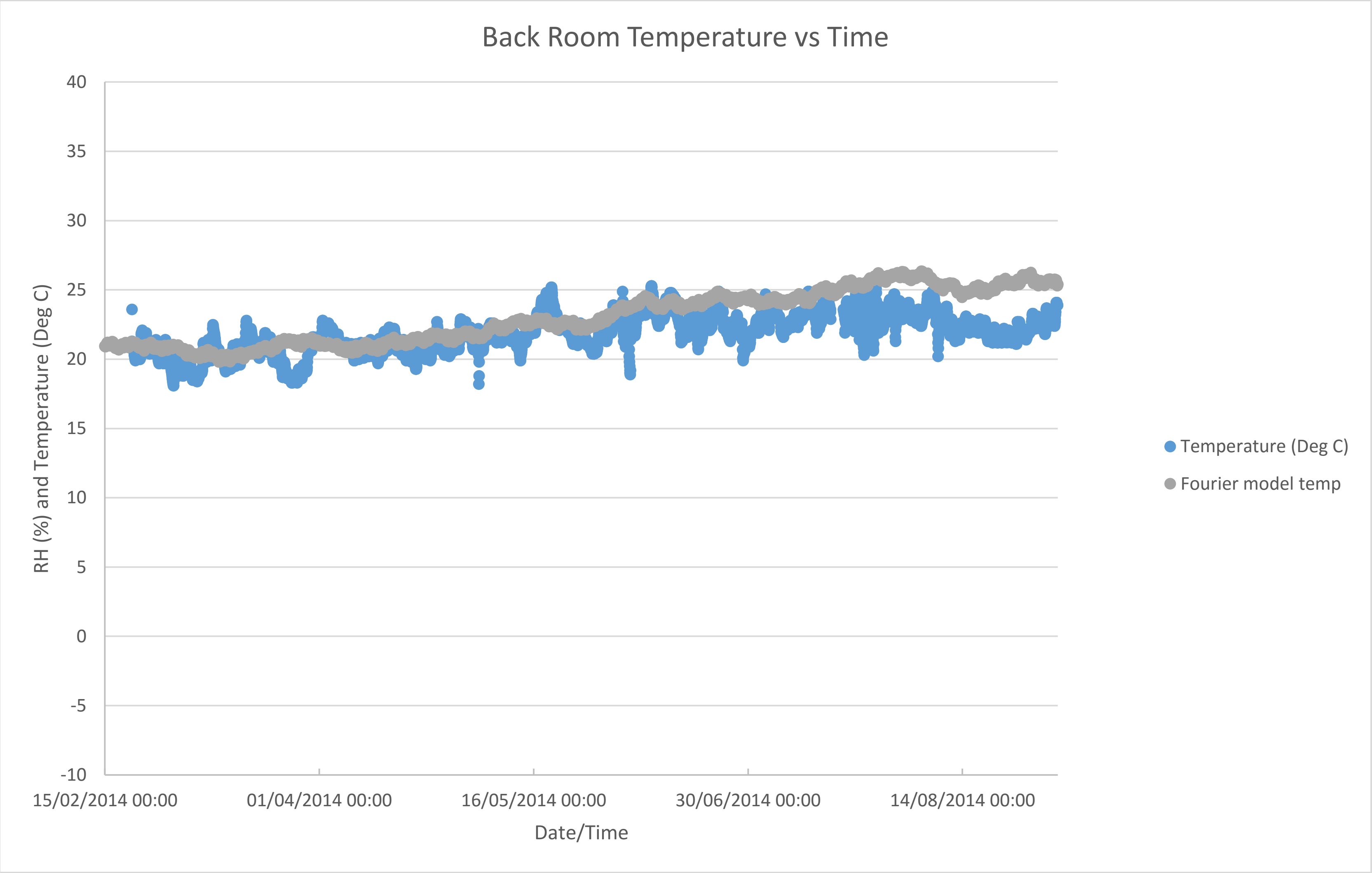
South-facing bedroom - monitoring



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PHPP Output

- The house was modelled in PHPP to predict thermal performance
- Predicted heating load 15W/m^2
- Predicted heating demand 26kWhrs/m^2/a

- 250m^2 house
- PHPP calculates the TFA as 208m^2
- (SAP calculates the floor area as 239m^2)

SAP

- SAP predicts the heating costs as £3,300 over 3 yrs or £1,100 per yr.
- SAP predicts the total cost for heating, lighting & hot water as £4,185 over 3 yrs or £1,395 per yr.
- This gives an EPC 'B' rating

Real Energy Use

- The house is almost totally electric. Only the hob is gas and its use/cost is negligible.
  - 278kWhrs (25m^3) of gas used in 30 months
  - 24,244kWhrs of electricity used in 30 months
  - 13,360kWhrs of electricity used in 18 months (because the PV electricity is free)
  - 4620kWhrs of electricity generated by the PV's in 18 months

Real Energy Use normalized to 12 months

- The house is almost totally electric. Only the hob is gas and its use/cost is negligible.
  - 111kWhrs ($10m^3$) of gas used in 12 months
  - 8,900kWhrs of electricity used in 12 months
  - 3080kWhrs of electricity generated by the PV's in 12 months
  - Total energy use 9,011kWhrs in 12 months

Real Energy Use normalized to 12 months

- Total energy use 9,011kWhrs in 12 months (43.3kWhrs/m^2/a) split as:-
- Heating 2590kWhrs (12.5kWhrs/m^2/a)
- Hot water, lighting, cooking, dish washer, washing machine, tumble drier and all appliances 6,421kWhrs (30.8kWhrs/m^2/a)

- **THIS BEATS THE PASSIVHAUS TARGETS AND SAP PREDICTIONS**

Real Energy Cost normalized to 12 months

- 111kWhrs (10m^3) of gas ~£50
- 8,900kWhrs of electricity ~£1,140 (inc. £330 heating)
- 3080kWhrs of electricity generated by the PV's ~-£470
- Net energy cost ~£720/a
- Potential to get this down to ~£600 if you can use all the energy generated by the PV's

CONCLUSION

- The Passivhaus target has been achieved
- 12kW of PV would make the house truly zero-carbon
- Even adding the cost of the PV this project could still be built for around £1,500 (subject to site specific costs and design)
- **This is a viable way forward**

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