WHOLE-LIFE CARBON IMPLICATIONS OF THE PASSIVHAUS STANDARD

ukpassivhaus conference 2017

UKPHC 24 Oct 2017

ECD Architects ENERGY CONSCIOUS DESIGN

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Content

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1. Introduction & Background

Water ingress and damage to timber frame

Lack of fire protection

Water penetration through cladding and balconies (leaks)

Gas & services leaks

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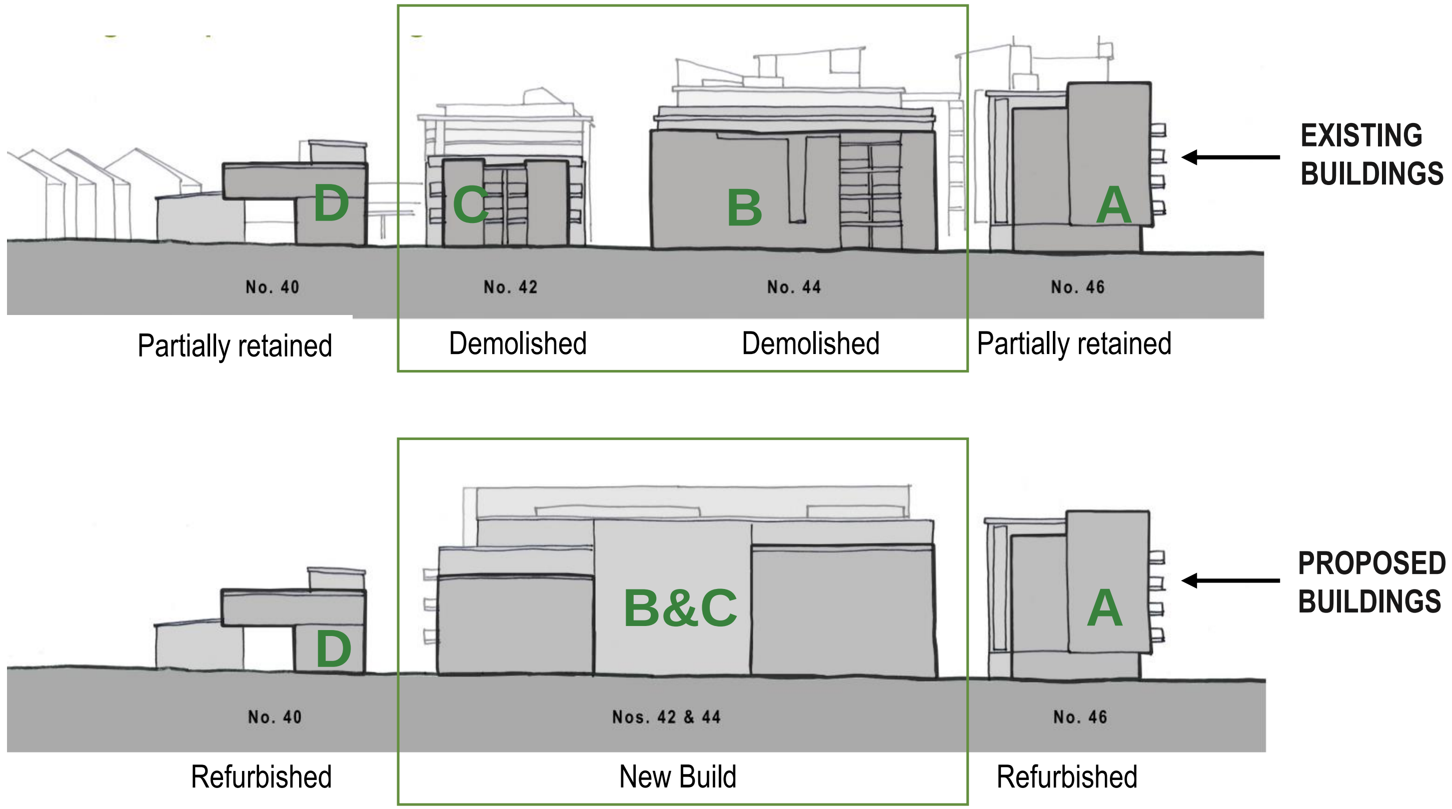
1. Introduction & Background

PROJECT
Refurbishment and New Build



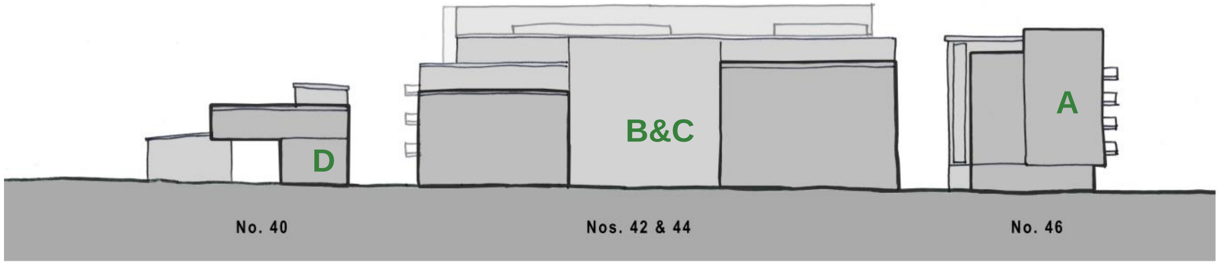
COMPARISON
Refurbished vs New Build (per sqm)

Strip-out + Refurbish = Total
275 + 324 = **599 KgCO2/sqm**

Demolition + New Build = Total
316 + 406 = **722 KgCO2/sqm**

The New Build has used 20% more embodied carbon than the Refurbished, when taking into account the full demolition phases + the new phases.

Reason for the small difference:
Level of refurbishment (13% of EC retained)



Refurbished | New Build | Refurbished

1. Introduction & Background

WHY PASSIVHAUS?

Quality Control and Resident Comfort

How does achieving the Passivhaus Certification ensure quality?

1. Benchmarked standard with independent certification
2. Proven significant reduction in 'Performance Gap' compared to UK average
3. Measurement of airtightness before, during and after construction provides good indicator of build quality
4. Use of PH certified products ensures performance requirements of key building products
5. Reduced thermal bridging and improved ventilation will result in reduced condensation risk
6. Use of PHPP rather than SAP offers a more reliable tool in predicting energy performance
7. Provides a smoother transition on completion (Soft Landings) with better commissioning process
8. Provides the client with fixed standards which can be written into the contract

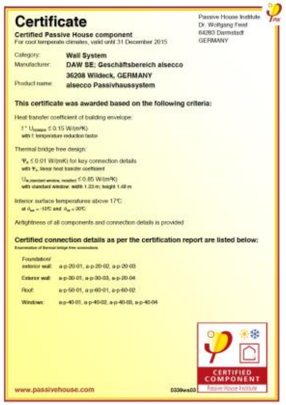
MIND THE PERFORMANCE GAP


Passivhaus Trust

Passivhaus Quality Assurance:
Large and Complex Buildings

March 2015

Sponsored by
Cocreate
Ecology Building Society
MEAD: Energy & Architectural Design Ltd
Warm: Low Energy Building Practice


Certificate

Certified Passive House component
For cool temperate climates, valid until 31 December 2015

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
GERMANY

Category: **Wall System**
Manufacturer: **DAW SE; Geschäftsbereich alsecco**
36208 Wildeck, GERMANY
Product name: **alsecco Passivhaussystem**

This certificate was awarded based on the following criteria:

Heat transfer coefficient of building envelope:

Thermal bridge free design:

Interior surface temperatures above 17°C

Airtightness of all components and connection details is provided

Certified connection details as per the certification report are listed below:

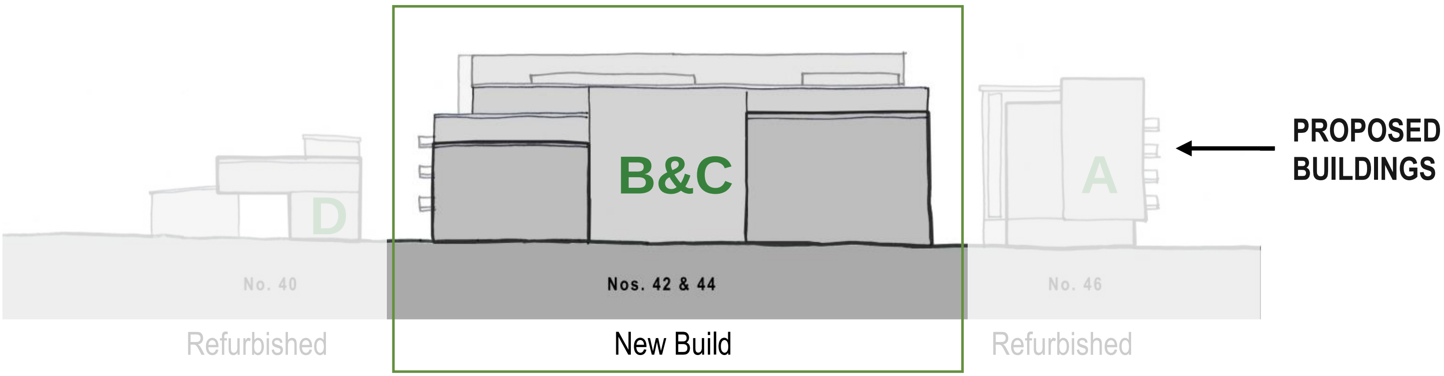
Foundation/ exterior wall:	a-p-20-01, a-p-20-02, a-p-20-03
Exterior wall:	a-p-30-01, a-p-30-03, a-p-20-04
Roof:	a-p-50-01, a-p-60-01, a-p-60-02
Windows:	a-p-40-01, a-p-40-02, a-p-40-03, a-p-40-04

CERTIFIED COMPONENT
Passive House Institute

www.passivehouse.com

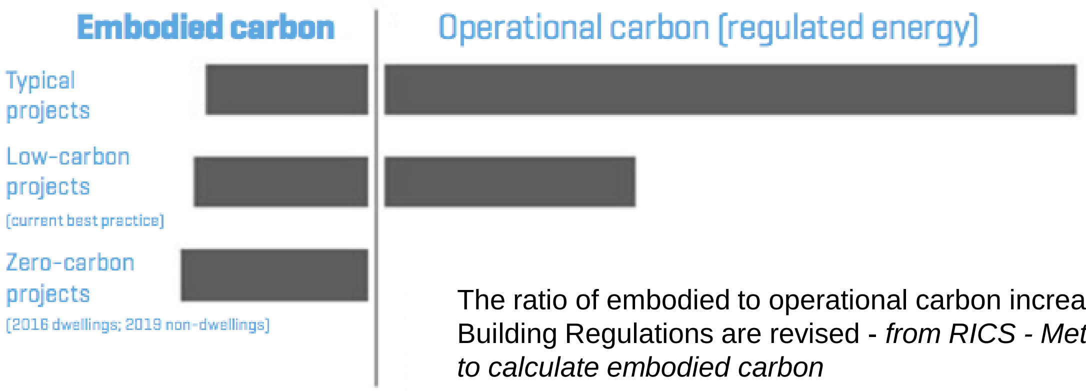
2. Aim of study & Terms of Reference

Whole life carbon implications (new build only)
B.Regs Part L vs Passivhaus

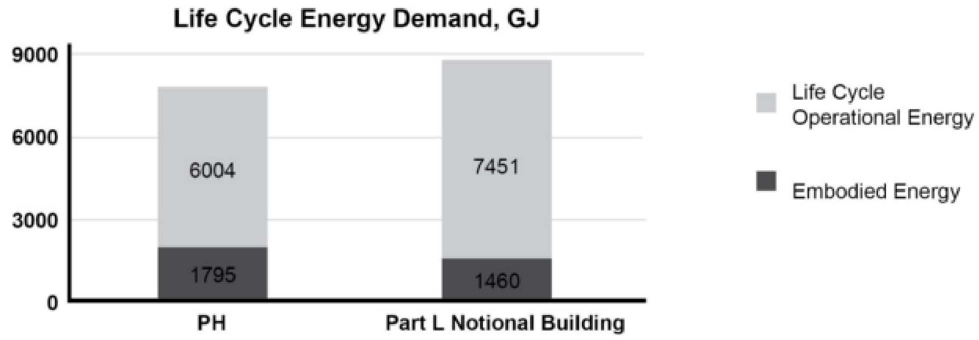


2. Aim of study & Terms of Reference

While operational carbon is still much greater than embodied carbon, as we design and build to higher fabric standards, proportionally the embodied carbon will increase as the operational energy use reduces.



The ratio of embodied to operational carbon increases as Building Regulations are revised - *from RICS - Methodology to calculate embodied carbon*



Andreou, E. (2015) (50 year lifespan)

2. Aim of study & Terms of Reference

Whole life carbon implications
B.Regs Part L vs Passivhaus

- Reference study period (RSP): 60 years
- Only KgCO2e has been assessed (carbon dioxide equivalent)
- Only elements that are different between a nominal Part L and Passivhaus construction were included

From the "RICS Whole life carbon measurement: Implementation in the Build Environment" document we identified the minimum scope:

- Life Stages: (Product Stage [A1 – A3], Construction process stage [A4-A5] and Operational Energy Use [B6])

Product Stage [A1 – A3]
Materials assessed:
- Insulation to walls and roofs (different thicknesses)
- Double vs triple glazed windows

Carbon Difference = B.Regs Part L – Passivhaus

Carbon Difference = B.Regs Part L ([A1+A2+A3] + [A4] + [A5] + [B4+B6]) - Passivhaus ([A1+A2+A3] + [A4] + [A5] + [B4+B6])

This is not a full **Life Cycle Assessment**, as it does not include aspects such as resources, water, toxicity, waste and recycling, etc.
A comprehensive Life Cycle Assessment should include the triple bottom line: social, economic and environmental sustainability.

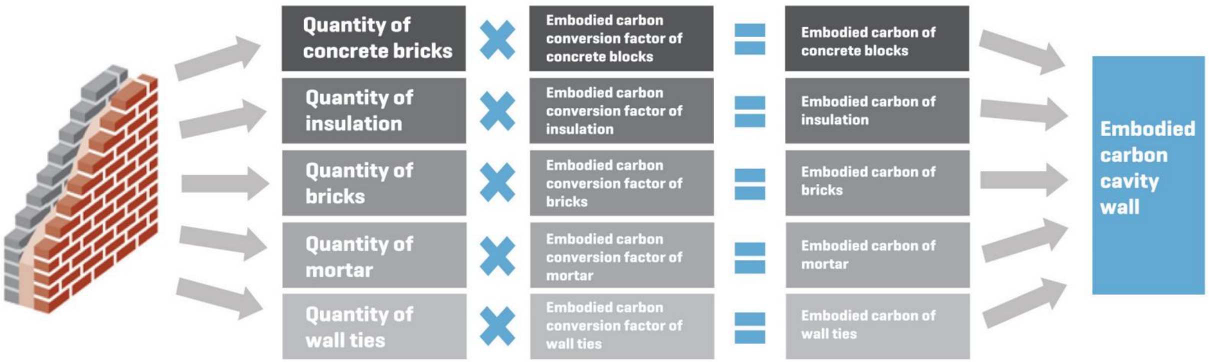
3. How to calculate Embodied Carbon?

Summary

Volume (m^3) = area (m^2) x thickness (m)

Mass = volume (m^3) x density (kg/m^3);

Embodied Carbon (kgCO2) = Mass (kg) x Embodied carbon factor (kgCO2/kg)



Approach to cradle-to-gate carbon calculations:
a cavity wall is broken down to its components

Source: RICS - Methodology to calculate embodied carbon, 1st edition.

4. Embodied Carbon and LCA databases and tools

Databases and Software

- **EPDs** - Environmental Product Declarations - reports transparently on Life cycle assessment, including embodied carbon by manufacturers in accordance with ISO 14015 http://www.environdec.com/
- **IMPACT** - (Integrated Material Profile and Costing Tool) is an IES LCA/LCC plug-in utilising BIM generated quantities - www.impactwba.com/
- **Bath University Inventory of Carbon and Energy (ICE)**
- **OneClick LCA** - www.oneclicklca.com
- **Rapiere** - http://rapiere.net
- **Tally** - http://choosetally.com/
- **IES** - www.iesve.com
- **Butterfly** - www.blpinsurance.com/added-services/life-cycle-costing/
- **Open LCA** - free LCA software www.openlca.org
- **SimaPro** & EcoInvent - http://www.simapro.co.uk/
- **Gabi** (& Ecoinvent) - http://www.gabi-software.com/databases/

Calculating Embodied Carbon in real-time
Embodied carbon factor attached to building elements

AUTODESK® REVIT®

1. Select Project Parameter under Management tab

2. Add a new Project Parameter for Global Warming Potential (GWP/m2)

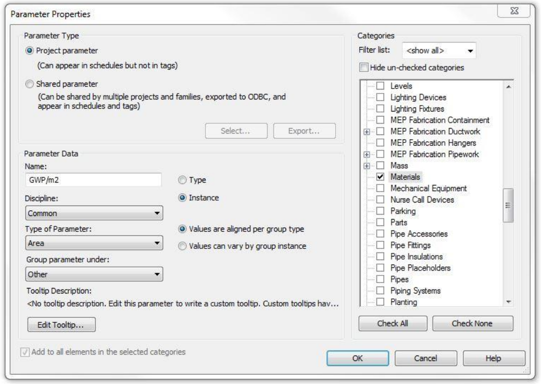
3. Create new Material Take-Off from Schedule dropdown menu
Create separate schedules for walls, windows, curtain wall elements, floors, roofs, etc.

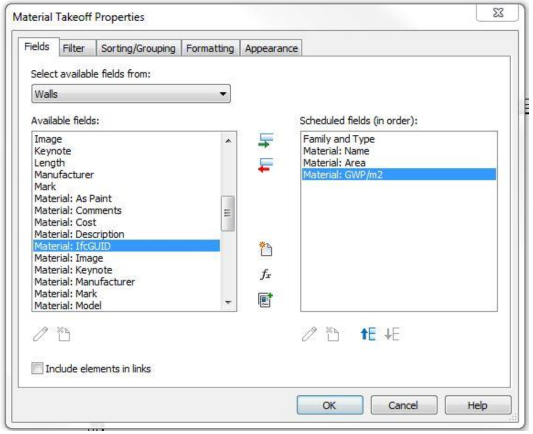
4. Select the following fields:
Family and Type
Material: Name
Material: Area
Material: GWP/m2 (new parameter)

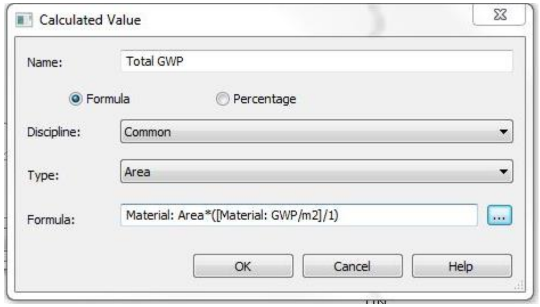
5. Create a calculated value for Total GWP
Material: Area*([Material:GWP/m2]/1)

6. Filter to show the desired materials.

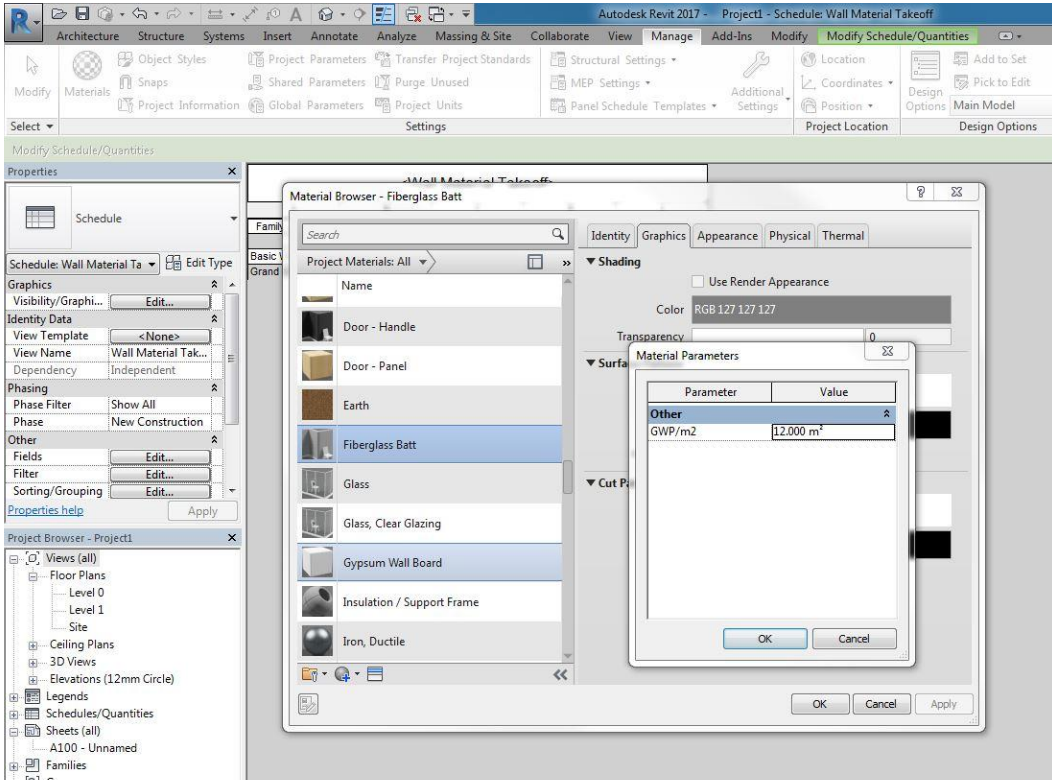
7. Select Grand Totals and sort as required.



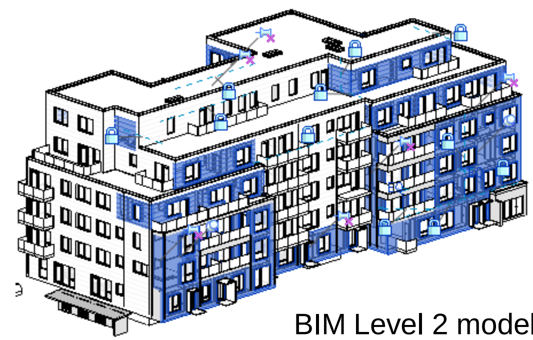




5. Using Revit/BIM



8. Add GWP/m2 value within the Material Browser under Custom Parameters or by typing in the schedule directly (data from EPDs)



BIM Level 2 model

<Wall Material Takeoff Part L>

A	B	C	D	E
	Material: Name	Material: Area	Material: GWP/m2	Total GWP
Basic Wall: Ext-MS-F00-Stud100.Tiles.03.TBC	Insulation	98.6 m^2	12.0	1183.7
Basic Wall: Ext-MS-F60-Stud100.ACM.02.450.5	Insulation	1619.1 m^2	12.0	19429.6
Basic Wall: Ext-MS-F60-Stud100.ACM.02.516.5	Insulation	4.4 m^2	12.0	52.7
Basic Wall: Ext-MS-F60-Stud100.ACM.02.528	Insulation	4.6 m^2	12.0	55.5
Basic Wall: Ext-MS-F60-Stud100.Brick.447	Insulation	84.8 m^2	12.0	1017.7
Basic Wall: Ext-MS-F60-Stud100.Brick.516.5	Insulation	126.9 m^2	12.0	1522.3
Basic Wall: Ext-MS-F60-Stud100.BrickSlip.450.5	Insulation	192.4 m^2	12.0	2308.3
Basic Wall: Ext-MS-F60-Stud100.BrickSlip.516.5	Insulation	23.4 m^2	12.0	280.8
Basic Wall: Ext-MS-F60-Stud100.BrickSlip.528	Insulation	20.9 m^2	12.0	251.4
Basic Wall: Ext-MS-F60-Stud250.ACM.04.600	Insulation	78.2 m^2	12.0	938.2
74		2253.3 m^2		27040.0

9. Real-time schedules with results, per component type.

6. Results

Product Stage	Construction Stage Transport	Construction Stage Installation	Operational Energy use
A1/A2/A3	A4	A5	B6

6. Results

Product Stage	Construction Stage Transport	Construction Stage Installation	Operational Energy use
A1/A2/A3	A4	A5	B6

A1-A3 Product Stage

A1-A3 Product Stage

Building Regulations Part L	Quantity			Density			Mass	GWP		Product Stage	
	Length	Area	Volume							A1/A2/A3	A1/A2/A3
Material Description	m	m2	m3	Kg/m	Kg/m2	Kg/m3	Kg	KgCO2E/m2	KgCO2E/Kg	kgCO2	TonnesCO2
1 Mineral Wool Insulation (Wall) 150mm		2253						12		27039.60	
2 Window - Glass (Double Glazed)		1290						0.417		537.93	
3 Window - Frame (Aluminium)	2337.023			1.83			4276.8		8.4	35924.72	
4 Roof Insulation PU foam 120mm		819.2						14.8		12124.16	
										75,626.41	**75.63**

Passivhaus	Quantity			Density			Mass	GWP		Product Stage	
	Length	Area	Volume							A1/A2/A3	A1/A2/A3
Material Description	m	m2	m3	Kg/m	Kg/m2	Kg/m3	Kg	KgCO2E/m2	KgCO2E/Kg	kgCO2	TonnesCO2
1 Mineral Wool Insulation (Wall) 200mm		2253						15		33799.50	
2 Window - Glass (Triple Glazed)		1935						0.417		806.90	
3 Window - Frame (Aluminium)	2337.023			1.94			4533.8		8.5	38537.51	
4 Roof Insulation PU foam 200mm		819.2						24.6		20152.32	
										93,296.22	**93.30**

Difference (TonnesCO2) - 17,669.82 - 17.67

6. Results

Product Stage	Construction Stage Transport	Construction Stage Installation	Operational Energy use
A1/A2/A3	A4	A5	B6

A4 Transport Stage

A4 Transport Emissions

Building Regulations Part L	Quantity			Density			Mass	GWP		Transport Distance	Source of Dist. Data	Vehicle Type	Carbon Conversion Factor	Transport Emissions	
Material Description	Length m	Area m2	Volume m3	Kg/m	Kg/m2	Kg/m3	Kg	KgCO2E/m2	KgCO2E/Kg	Km	EPD or RICS averages	DEFRA	Source: DEFRA	A1/A2/A3 kgCO2	A1/A2/A3 TonnesCO2
1 Mineral Wool Insulation (Wall) 150mm		2253						1.3			EPD			2929.29	2.93
2 Window - Glass 3mm (Double Glazed)		1290						0.417			EPD			537.93	0.54
3 Window - Frame (Aluminium)	2337.023			1.83			4276.75			1500	RICS	HGV Diesel	0.076	487.55	0.49
4 Roof Insulation PU foam 120mm		819.2						0.289			EPD			236.75	0.24
														4,191.52	**4.19**

Passivhaus	Quantity			Density			Mass	GWP		Transport Distance	Source of Dist. Data	Type	Carbon Conversion Factor	Transport Emissions	
Material Description	Length m	Area m2	Volume m3	Kg/m	Kg/m2	Kg/m3	Kg	GWP/m2	GWP/Kg	Km	EPD or RICS			A1/A2/A3 kgCO2	A1/A2/A3 TonnesCO2
1 Mineral Wool Insulation (Wall) 200mm		2253						1.7			EPD			3830.61	3.83
2 Window - Glass (Triple Glazed)		1935						0.417			EPD			806.90	0.81
3 Window - Frame (Aluminium)	2337.023			1.94			4533.82			1500	RICS	HGV Diesel	0.076	516.86	0.52
4 Roof Insulation PU foam 200mm		819.2						0.48			EPD			393.22	0.39
														5,547.58	**5.55**

Difference (TonnesCO2) - 1,356.06 - 1.36

6. Results

Product Stage	Construction Stage Transport	Construction Stage Installation	Operational Energy use
A1/A2/A3	A4	A5	B6

A5 Construction/ Installation Stage

A5 Construction/Installation Emissions		
Building Regulations Part L	**Quantity**	**Units**
RICS average data		
Project value	Confidential	
Average Carbon emission / £100,000 of project value	1,400	KgCO2
Total emissions A5	Confidential	KgCO2
Total emissions A5 (tonnes)	**Confidential**	TonnesCO2
Passivhaus	**Quantity**	**Units**
RICS average data		
Project value	Confidential	
Average Carbon emission / £100,000 of project value	1,400	KgCO2
Total emissions A5	Confidential	KgCO2
Total emissions A5 (tonnes)	**Confidential**	TonnesCO2
Difference [A5]	**2.38**	**TonnesCO2**

6. Results

Product Stage	Construction Stage Transport	Construction Stage Installation	Operational Energy use
A1/A2/A3	A4	A5	B6

B6 Operational Energy Use

B6 Operational Energy Use

	Building Regulations Part L	Quantity	Units
	SAP data from MEP Engineers		
	Part L (B.Regs 2013) Base Case		
a	Regulated Energy (per year)	64.57	TonnesCO2
	x 60 years	3874.2	TonnesCO2
b	Unregulated Energy	66.52	TonnesCO2
	x 60 years	3991.20	TonnesCO2
a+b	Regulated + Unregulated Energy over 60 years	**7,865.40**	TonnesCO2

	Passivhaus	Quantity	Units
	SAP data from MEP Engineers		
	Passivhaus		
a	Regulated Energy (per year)	50.31	TonnesCO2
	x 60 years	3018.6	TonnesCO2
b	Unregulated Energy	66.52	TonnesCO2
	x 60 years	3991.20	TonnesCO2
a+b	Regulated + Unregulated Energy over 60 years	**7,009.80**	TonnesCO2
	Difference [B6]	**855.60**	**TonnesCO2**

6. Results

Totals

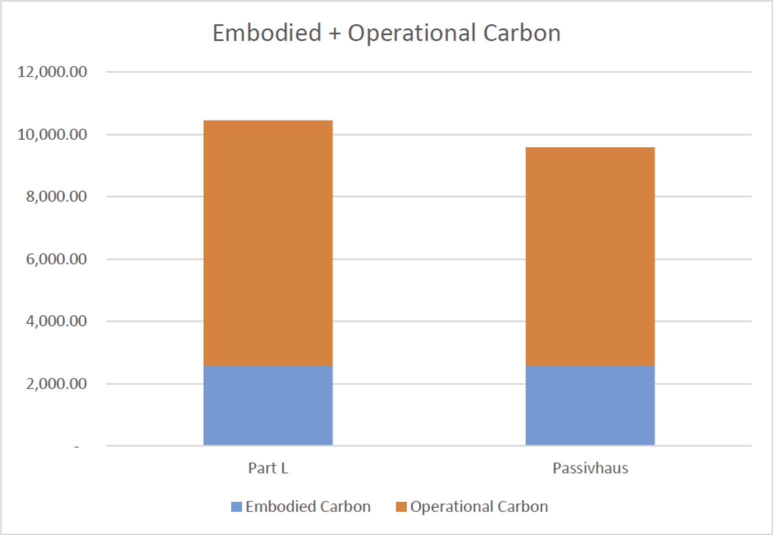
Comparison of different materials and components only

	Product Stage A1/A2/A3 TonnesCO2	+ Construction Stage Transport A4 TonnesCO2	+ Construction Stage Installation A5 TonnesCO2	+ Operational Replacement B4 TonnesCO2	Operational Energy use B6 TonnesCO2	= Total Emissions A1-A5, B6 TonnesCO2
Part L	75.63	4.19	224.00	36.46	7,865.40	8,205.68
Passivhaus	93.30	5.55	226.38	39.34	7,009.80	7,374.37
Carbon difference	**17.67**	**1.36**	**2.38**	**2.88**	- 855.60	- 831.31 TonnesCO2

Embodied + Operational Carbon
Part L vs Passivhaus

(Whole building embodied carbon from previous study)

Product Stage A1/A2/A3 + Operational Energy use B6



6. Conclusions

Limitations/Exclusions of the study

- Lack of sufficient LCA data available for products (EPDs), inc. electrical & mechanical systems.
- We excluded the replacement of any components that remained the same for both scenarios, but included the replacement of components that were different, ie. windows.

BIM

- Future use of BIM models for whole life carbon.
- Increase knowledge of whole life carbon within the practice.

Whole life carbon

- High quality design and construction (**durability and long life expectancy of the construction**) is really essential to reduce carbon emissions.
- **Deep refurbishments** (strip-out to the main structure) may not provide significant carbon savings when compared to a new build but there may be other reasons to refurbish instead of re-build.
- To build to the **Passivhaus Standard**, as opposed to only Building Regulations Part L requirements, have numerous significant benefits, including whole life carbon reductions.
- As Operational Carbon will continue to decrease in the future, designers should take into account Embodied Carbon when designing low-energy buildings in order to achieve **significant carbon reductions**.

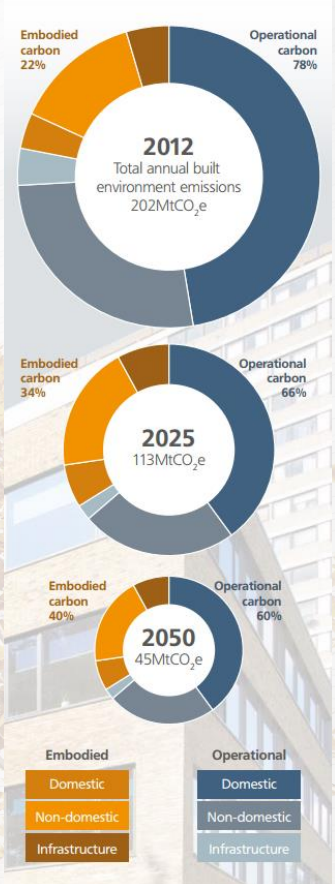


Figure 1 Increasing significance of embodied carbon (in 80% emissions reduction scenario)[10]

Source: UKGBC Developing a Client Brief

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Thank you

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