Thermal Testing

Building Regulations

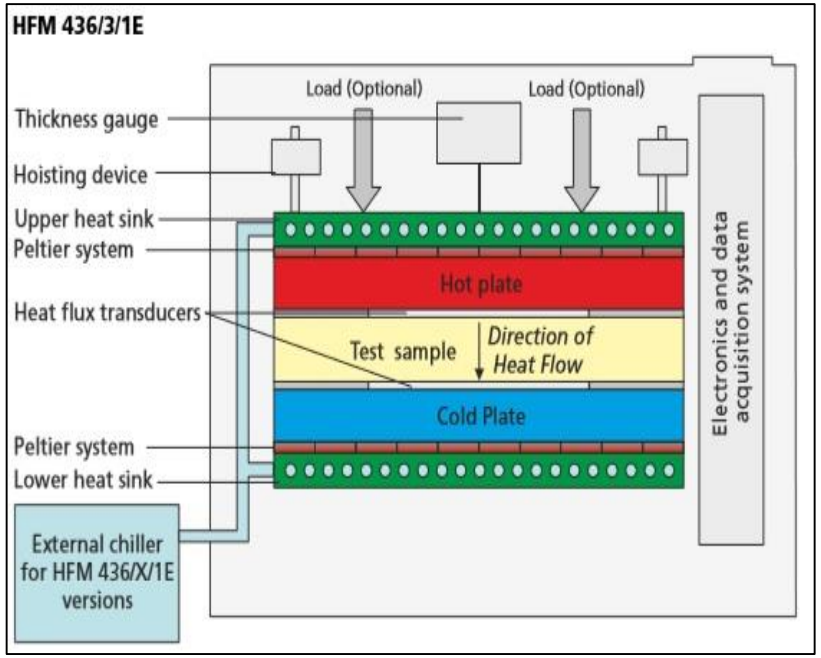
U Values

Life Cycle Assessment

Nassim Sebaibi, Jim Carfrae, Karim Touati

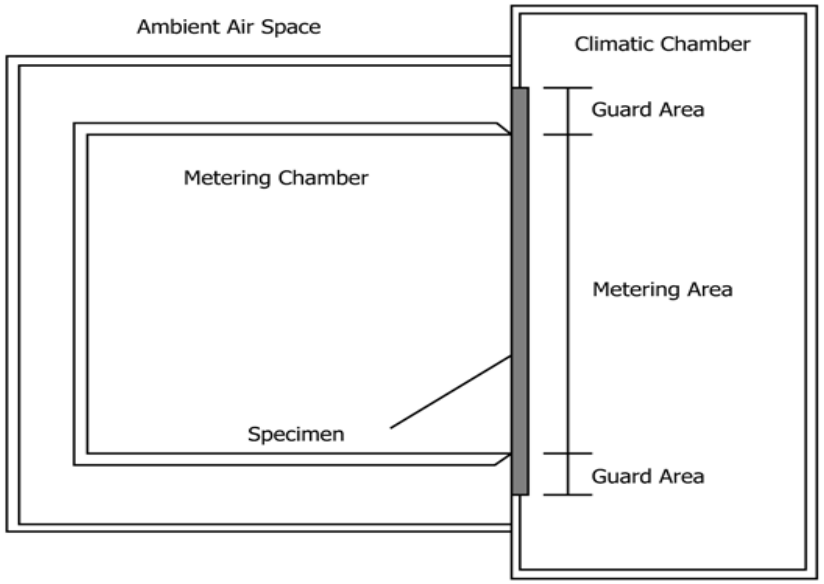
Interreg France (Channel Manche) England
EUROPEAN UNION
CobBauge
European Regional Development Fund

Thermal Testing: In laboratory

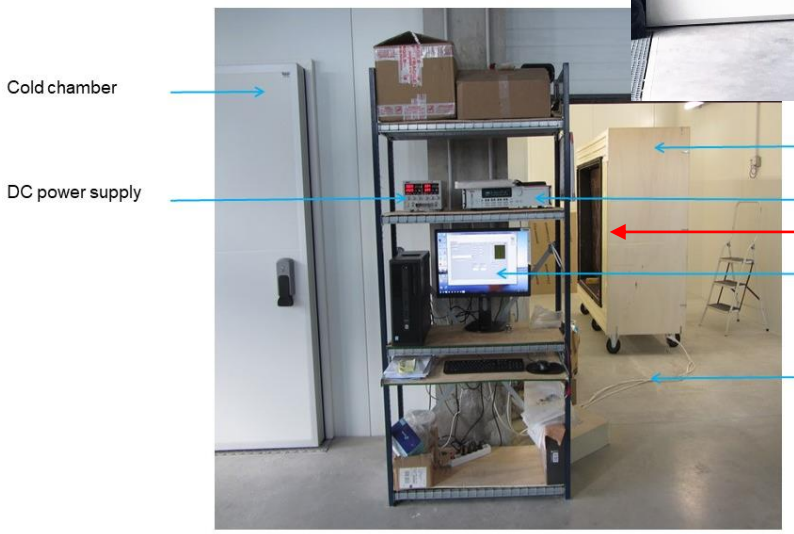


Heat Flow Meter

Thermal Testing: In laboratory at real scale

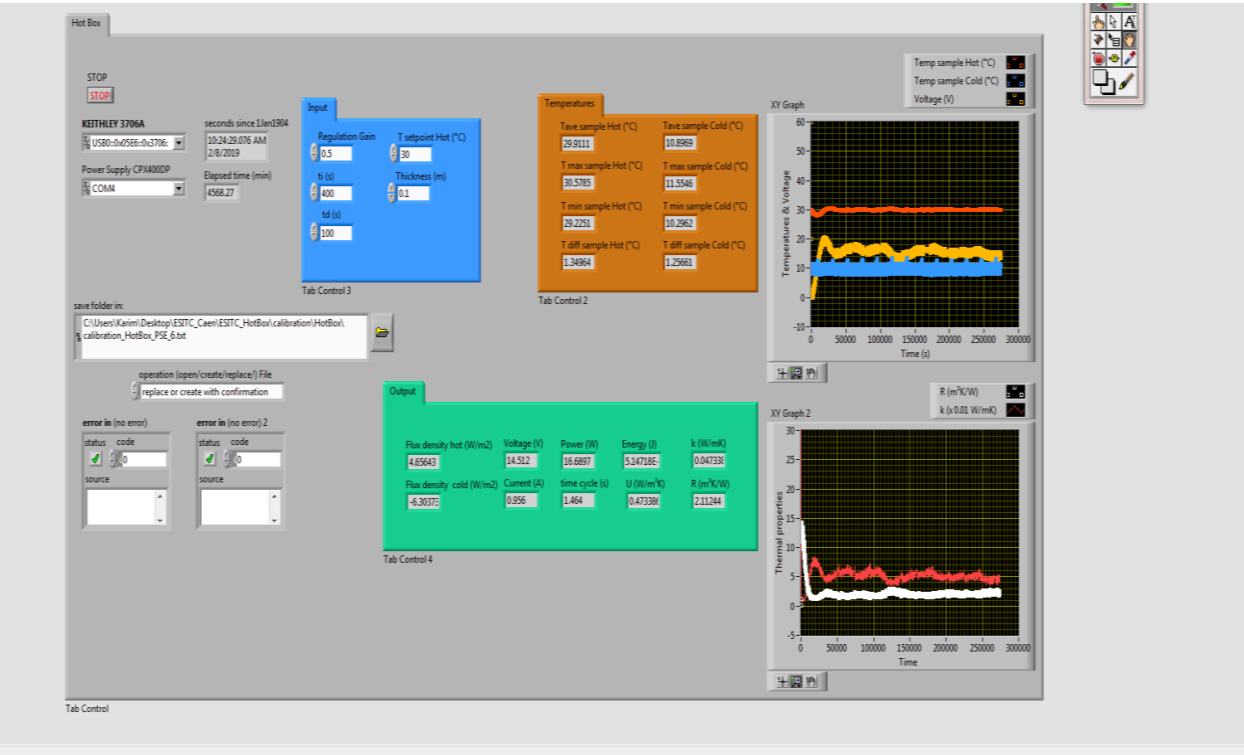


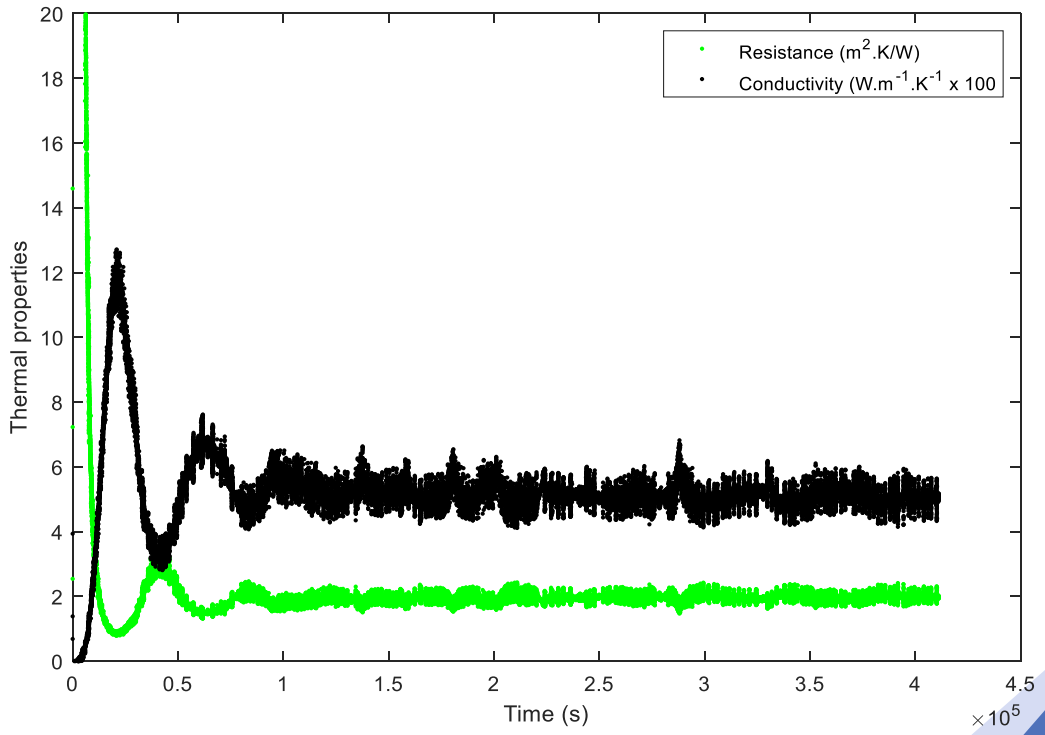
Typical Hot Box apparatus schematic [ASTM C1363]



Overview of the experimental device used for thermal characterization of cob wall

Thermal Testing: In laboratory at real scale





UK Building regulations: Part L1 A

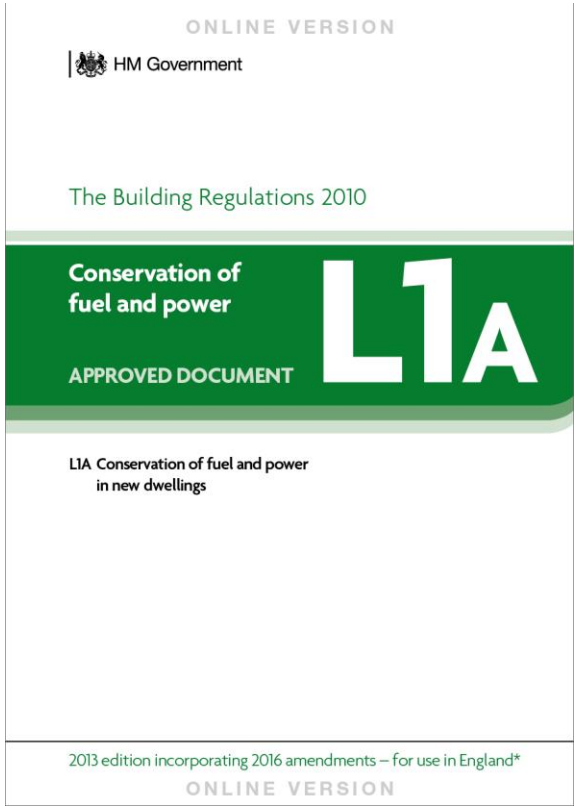


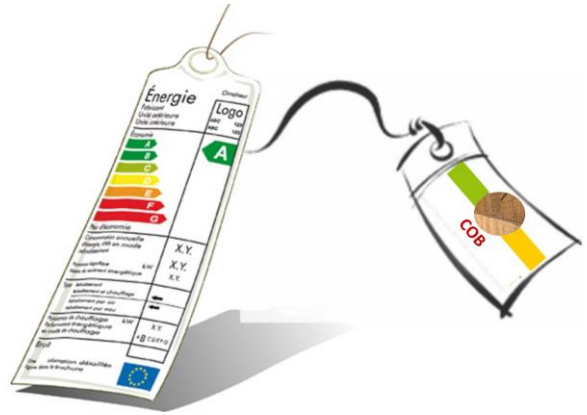
Table 2 Limiting fabric parameters

Roof	0.20 W/(m²·K)
Wall	0.30 W/(m²·K)
Floor	0.25 W/(m²·K)
Party wall	0.20 W/(m²·K)
Swimming pool basin[1]	0.25 W/(m²·K)
Windows, roof windows, glazed roof-lights[2], curtain walling and pedestrian doors	2.00 W/(m²·K)
Air permeability	10.0 m³/(h·m²) at 50 Pa

FR Building regulations: RT2012

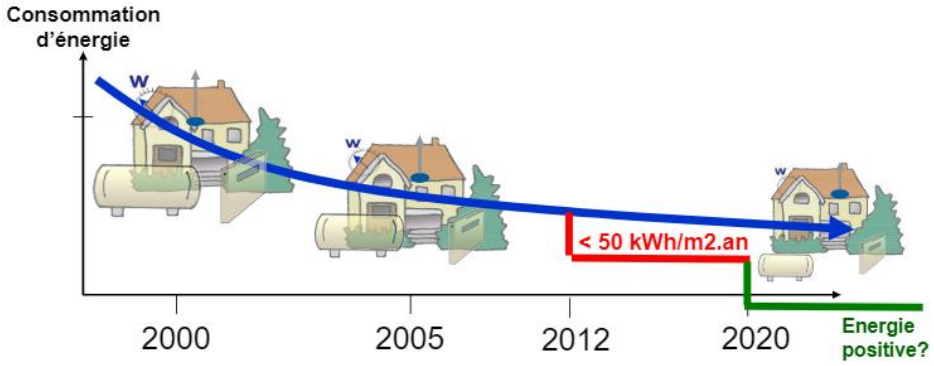
Thermal regulation 2012 “RT 2012”: These are three performance requirements:

- The maximum energy efficiency of the building
- A maximum consumption primary energy of **50 kWh/m²/year**
- Summer thermal comfort on conventional indoor temperature



The expected “U” for the walls :

U ≤ 0,36 W/m².K → R ≥ 2,77 m².K/w



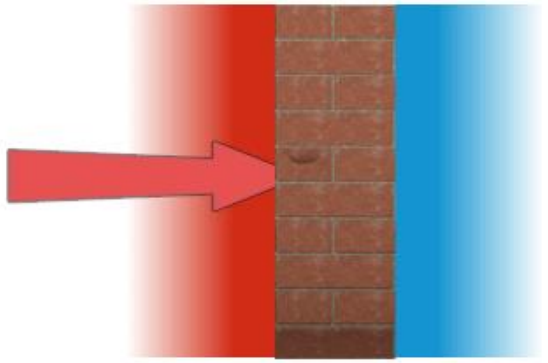
Cob and U Values

The **U-value** of an insulating layer depends on the **thermal conductivity (λ)** of the material and its **thickness (e)**:

$U = \lambda / e$.

FR SOIL	Thermal Conductivity W/(m·K)	U Value (m²·K)/W
1	0,168104	1,800
2	0,175374	1,710
3	0,180617	1,666

UK SOIL	Thermal Conductivity W/(m·K)	U Value (m²·K)/W
1	0,196145	1,530
2	0,18902	1,600
3	0,196319	1,530



[Source: Weber]

Cob and U Values

Traditional Cob	Density	Thickness m	Cond. W/m K	Resistance m2 K/W
Internal surface		n/a	n/a	0.12
Cob	1600	0.700	0.64	1.09
External Surface		n/a	n/a	0.06
Total Resistance				1.27
U-Value				**0.79**

Has to be .30

How thick would a traditional cob wall have to be to pass regulations?

Traditional Cob	Density	Thickness m	Cond. W/m K	Resistance m2 K/W
Internal surface		n/a	n/a	0.12
Cob	1600	2.00	0.64	3.13
External Surface		n/a	n/a	0.06
Total Resistance				3.30
U-Value				**0.30**

Two metres!

Cob and U Values

How light would a cob wall have to be to pass regulations?

Light Cob	**Density kg/m3**	**Thickness m**	**Cond. W/m K**	**Resistance m2 K/W**
Internal surface		n/a	n/a	0.12
Cob 25% fibre	673	0.600	0.183	3.28
External Surface		n/a	n/a	0.06
Total Resistance				3.46
U-Value				**0.29**

Less than half the density

Unfortunately, this lightweight cob wall could not support a second floor or a roof

Cob and U Values

The solution – A composite cob wall

Composit Cob	**Density kg/m3**	**Thickness m**	**Cond. W/m.K**	**Resistance m2 K/W**
Internal surface		n/a	n/a	0.12
Dense Cob UK6 5% Hemp straw	1600	0.300	0.45	0.67
Lightweight Cob UK3 50% Hemp shiv	340	0.300	0.11	2.73
External Surface		n/a	n/a	0.06
Total Resistance				3.57
U-Value W/m2K				**0.28**

Table 2 Limiting fabric parameters

Roof	0.20 W/(m²·K)
Wall	0.30 W/(m²·K)
Floor	0.25 W/(m²·K)

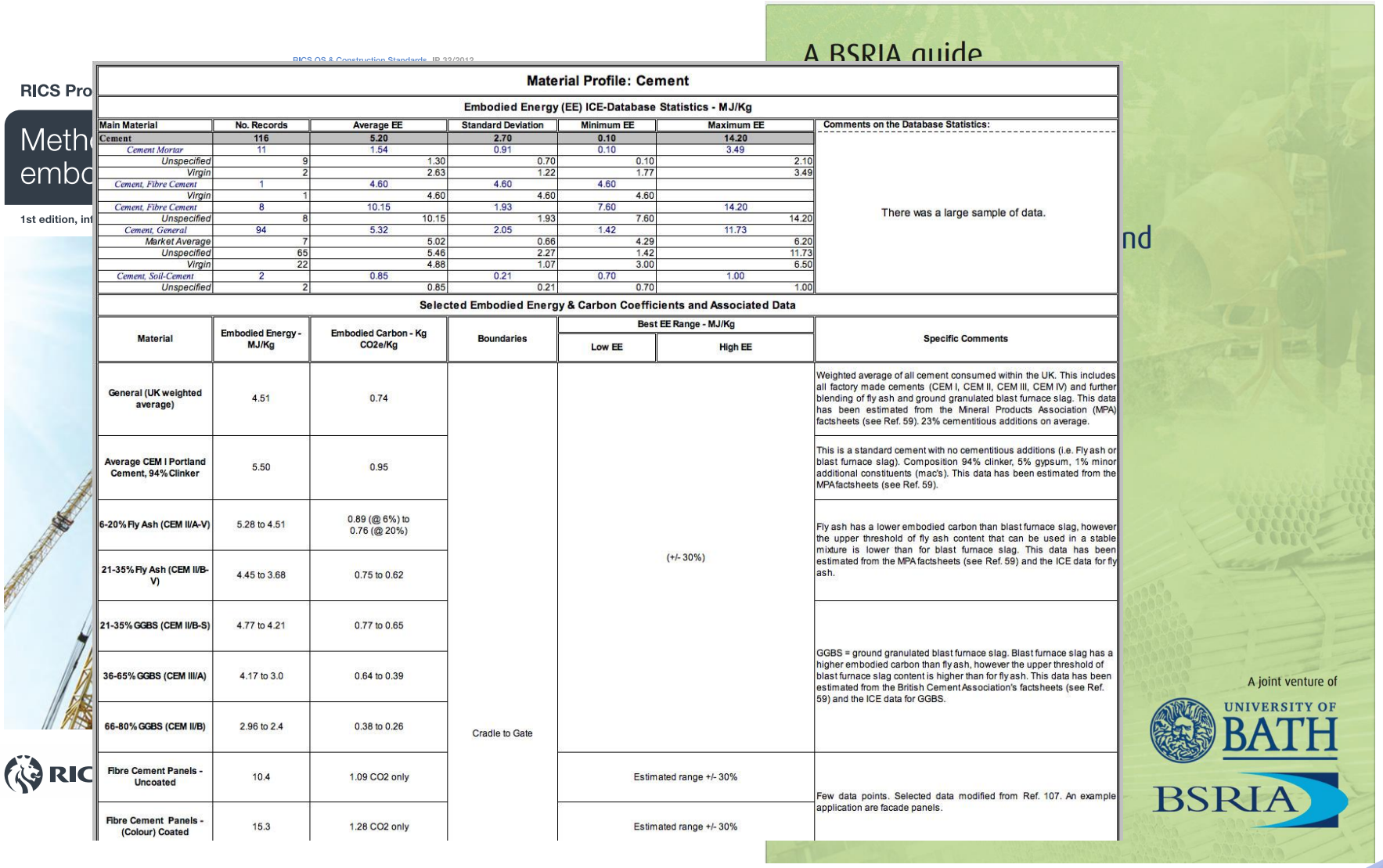
Cob and U Values

The CobBauge wall with finishes

Composite Cob + finishes	**Density kg/m3**	**Thickness m**	**Cond. W/m.K**	**Resistance m2 K/W**
Internal surface		n/a	n/a	0.12
Internal earthen plaster		0.03	0.44	0.07
Dense Cob UK6 2.5% Hemp straw	1423	0.250	0.44	0.57
Lightweight Cob UK3 50% Hemp shiv	340	0.300	0.11	2.73
Lime render		0.03	0.60	0.05
External Surface		n/a	n/a	0.06
Total Resistance				3.59
U-Value W/m2K				**0.28**

The same U value, standard finishes, and is now 556mm thick

Life Cycle Assessment – Embodied Energy



RICS QS & Construction Standards, IP 32/2012

RICS Pro

Meth
embo

1st edition, int

A BSRIA guide

nd

Material Profile: Cement

Embodied Energy (EE) ICE-Database Statistics - MJ/Kg

Main Material	No. Records	Average EE	Standard Deviation	Minimum EE	Maximum EE	Comments on the Database Statistics:
Cement	**116**	**5.20**	**2.70**	**0.10**	**14.20**	There was a large sample of data.
Cement Mortar	11	1.54	0.91	0.10	3.49	
Unspecified	9	1.30	0.70	0.10	2.10	
Virgin	2	2.63	1.22	1.77	3.49	
Cement, Fibre Cement	1	4.60	4.60	4.60		
Virgin	1	4.60	4.60	4.60		
Cement, Fibre Cement	8	10.15	1.93	7.60	14.20	
Unspecified	8	10.15	1.93	7.60	14.20	
Cement, General	94	5.32	2.05	1.42	11.73	
Market Average	7	5.02	0.66	4.29	6.20	
Unspecified	65	5.46	2.27	1.42	11.73	
Virgin	22	4.88	1.07	3.00	6.50	
Cement, Soil-Cement	2	0.85	0.21	0.70	1.00	
Unspecified	2	0.85	0.21	0.70	1.00	

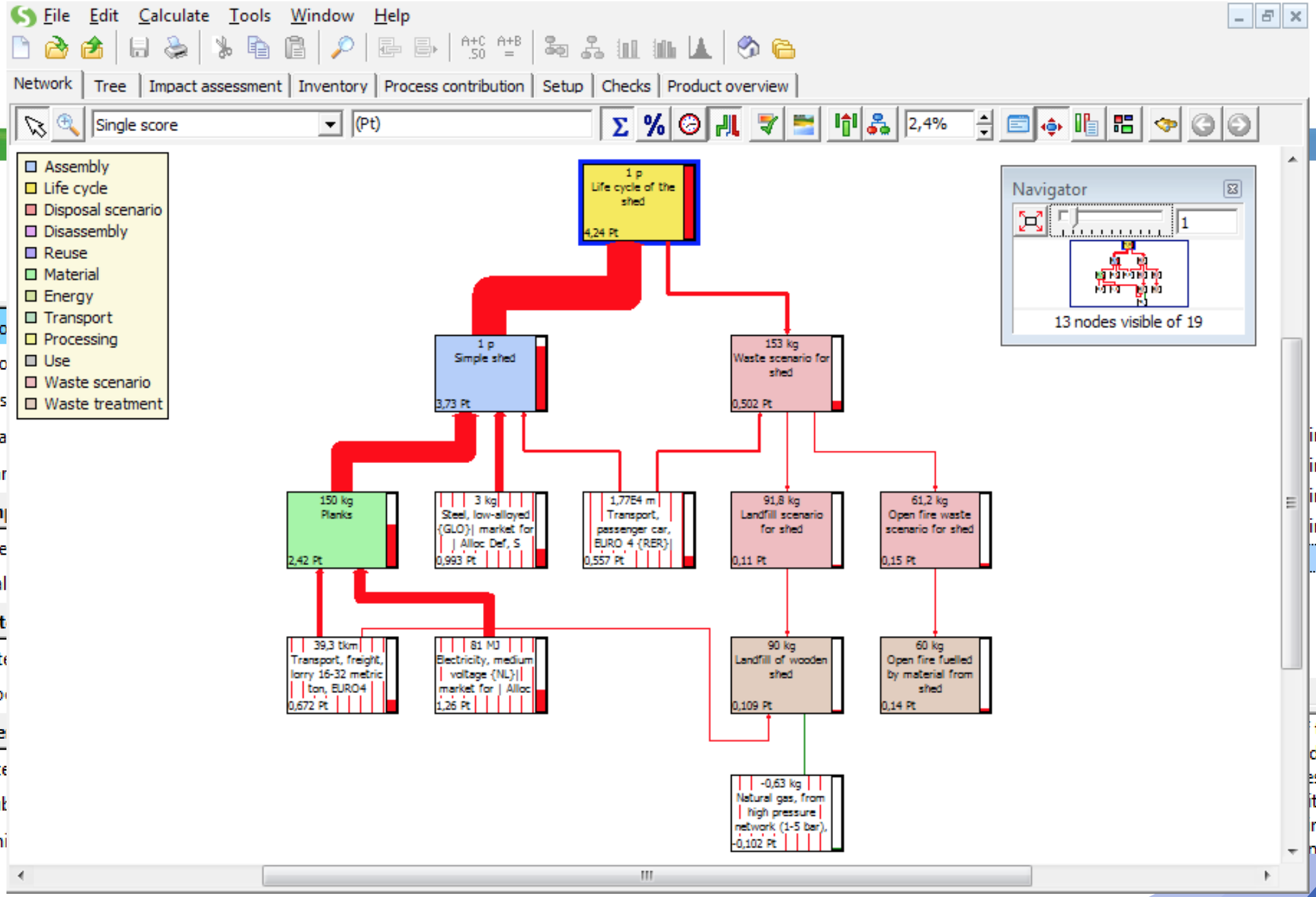
Selected Embodied Energy & Carbon Coefficients and Associated Data

Material	Embodied Energy - MJ/Kg	Embodied Carbon - Kg CO2e/Kg	Boundaries	Best EE Range - MJ/Kg		Specific Comments
				Low EE	High EE	
General (UK weighted average)	4.51	0.74	Cradle to Gate	(+/- 30%)		Weighted average of all cement consumed within the UK. This includes all factory made cements (CEM I, CEM II, CEM III, CEM IV) and further blending of fly ash and ground granulated blast furnace slag. This data has been estimated from the Mineral Products Association (MPA) factsheets (see Ref. 59). 23% cementitious additions on average.
Average CEM I Portland Cement, 94% Clinker	5.50	0.95				This is a standard cement with no cementitious additions (i.e. Fly ash or blast furnace slag). Composition 94% clinker, 5% gypsum, 1% minor additional constituents (mac's). This data has been estimated from the MPA factsheets (see Ref. 59).
6-20% Fly Ash (CEM II/A-V)	5.28 to 4.51	0.89 (@ 6%) to 0.76 (@ 20%)				Fly ash has a lower embodied carbon than blast furnace slag, however the upper threshold of fly ash content that can be used in a stable mixture is lower than for blast furnace slag. This data has been estimated from the MPA factsheets (see Ref. 59) and the ICE data for fly ash.
21-35% Fly Ash (CEM II/B-V)	4.45 to 3.68	0.75 to 0.62				
21-35% GGBS (CEM II/B-S)	4.77 to 4.21	0.77 to 0.65				GGBS = ground granulated blast furnace slag. Blast furnace slag has a higher embodied carbon than fly ash, however the upper threshold of blast furnace slag content is higher than for fly ash. This data has been estimated from the British Cement Association's factsheets (see Ref. 59) and the ICE data for GGBS.
36-65% GGBS (CEM III/A)	4.17 to 3.0	0.64 to 0.39				
66-80% GGBS (CEM II/B)	2.96 to 2.4	0.38 to 0.26				
Fibre Cement Panels - Uncoated	10.4	1.09 CO2 only		Estimated range +/- 30%		Few data points. Selected data modified from Ref. 107. An example application are facade panels.
Fibre Cement Panels - (Colour) Coated	15.3	1.28 CO2 only		Estimated range +/- 30%		

A joint venture of

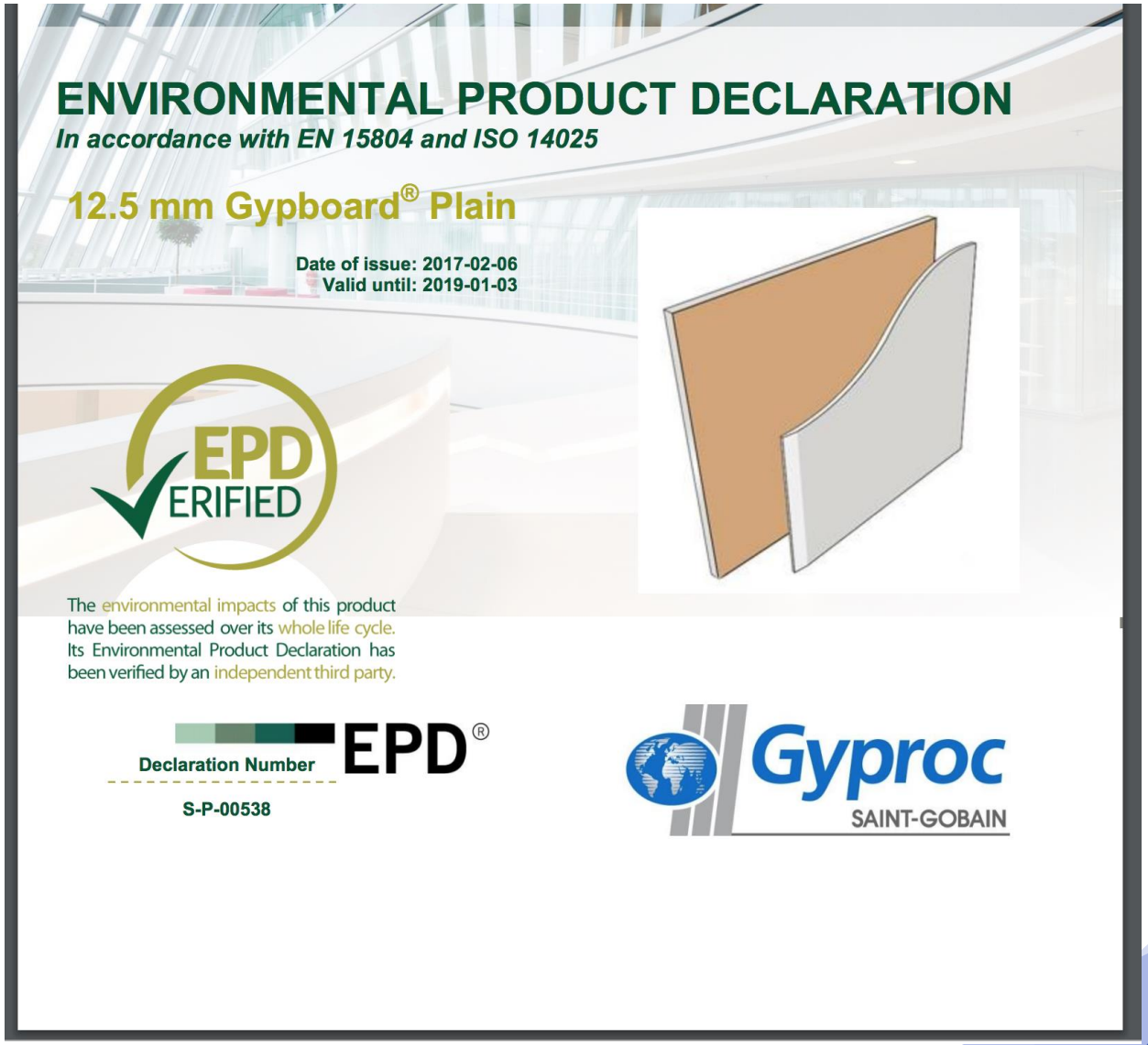
UNIVERSITY OF BATH

BSRIA

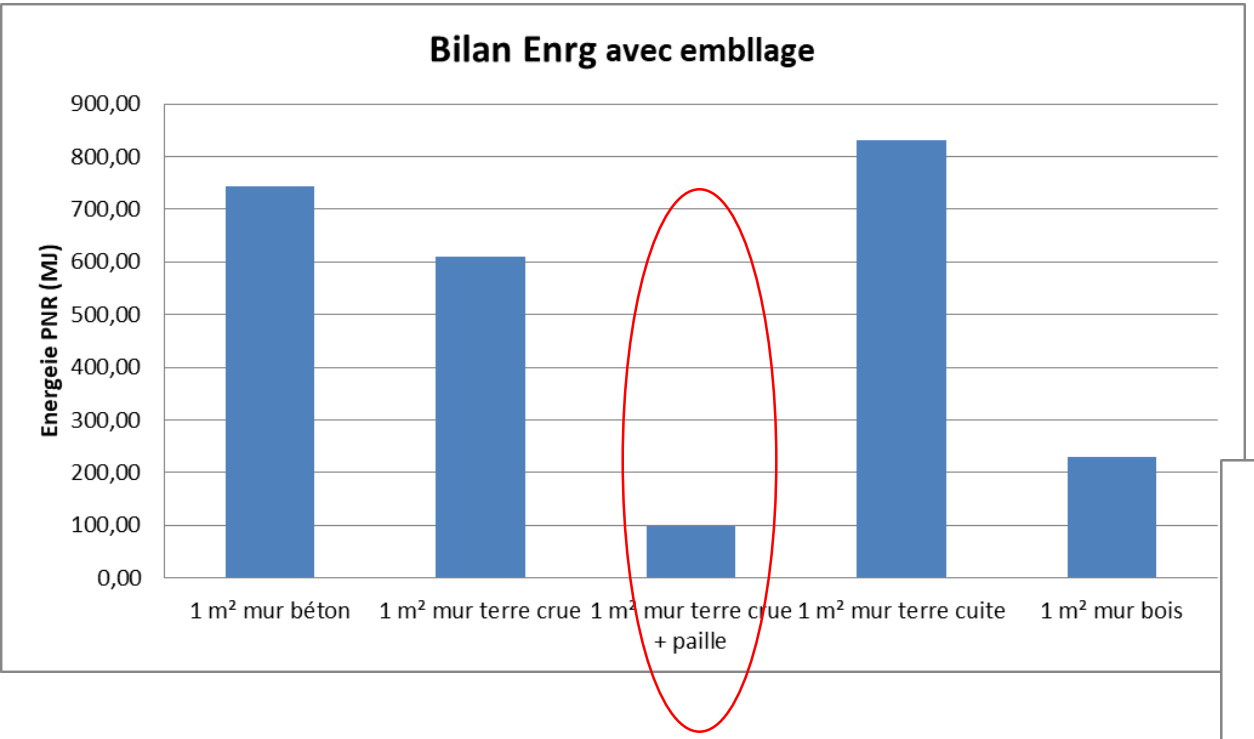

File Edit Calculate Tools Window Help
Network Tree Impact assessment Inventory Process contribution Setup Checks Product overview
Single score
(Pt)
2,4%
Assembly
Life cycle
Disposal scenario
Disassembly
Reuse
Material
Energy
Transport
Processing
Use
Waste scenario
Waste treatment
1 p
Life cycle of the shed
4,24 Pt
1 p
Simple shed
3,73 Pt
153 kg
Waste scenario for shed
0,502 Pt
150 kg
Planks
2,42 Pt
3 kg
Steel, low-alloyed {GLO}| market for | Alloc Def, S
0,993 Pt
1,77E4 m
Transport, passenger car, EURO 4 {RER}|
0,557 Pt
91,8 kg
Landfill scenario for shed
0,11 Pt
61,2 kg
Open fire waste scenario for shed
0,15 Pt
39,3 tkm
Transport, freight, lorry 16-32 metric ton, EURO4
0,672 Pt
81 MJ
Electricity, medium voltage {NL}| market for | Alloc
1,26 Pt
90 kg
Landfill of wooden shed
0,109 Pt
60 kg
Open fire fuelled by material from shed
0,14 Pt
-0,63 kg
Natural gas, from high pressure network (1-5 bar),
-0,102 Pt
Navigator
1
13 nodes visible of 19

Calculating LCA - SimaPro

Output:
European Product Declaration
for CobBauge



New French Regulation RE2020



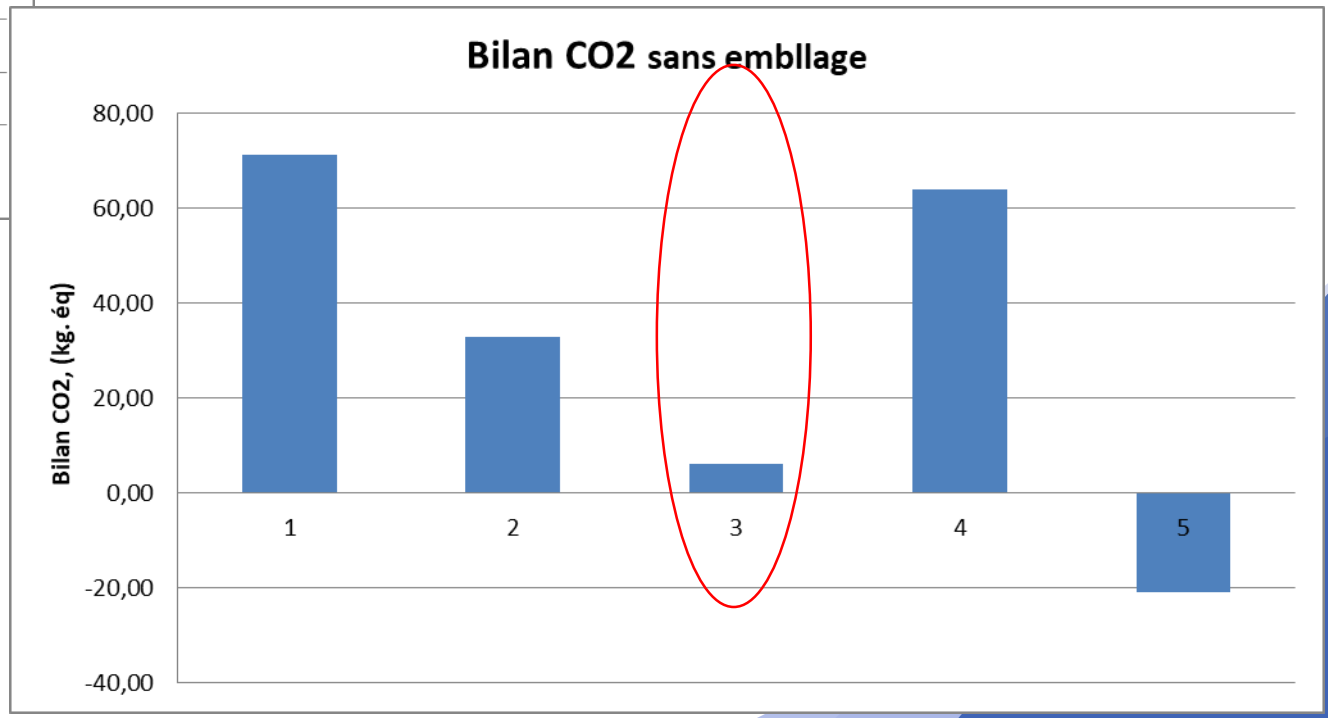
Scenario 1 : 1 m² wall of concrete blocs

Scenario 2 : 1 m² wall of soil

Scenario 3 : 1 m² wall of soil + straw

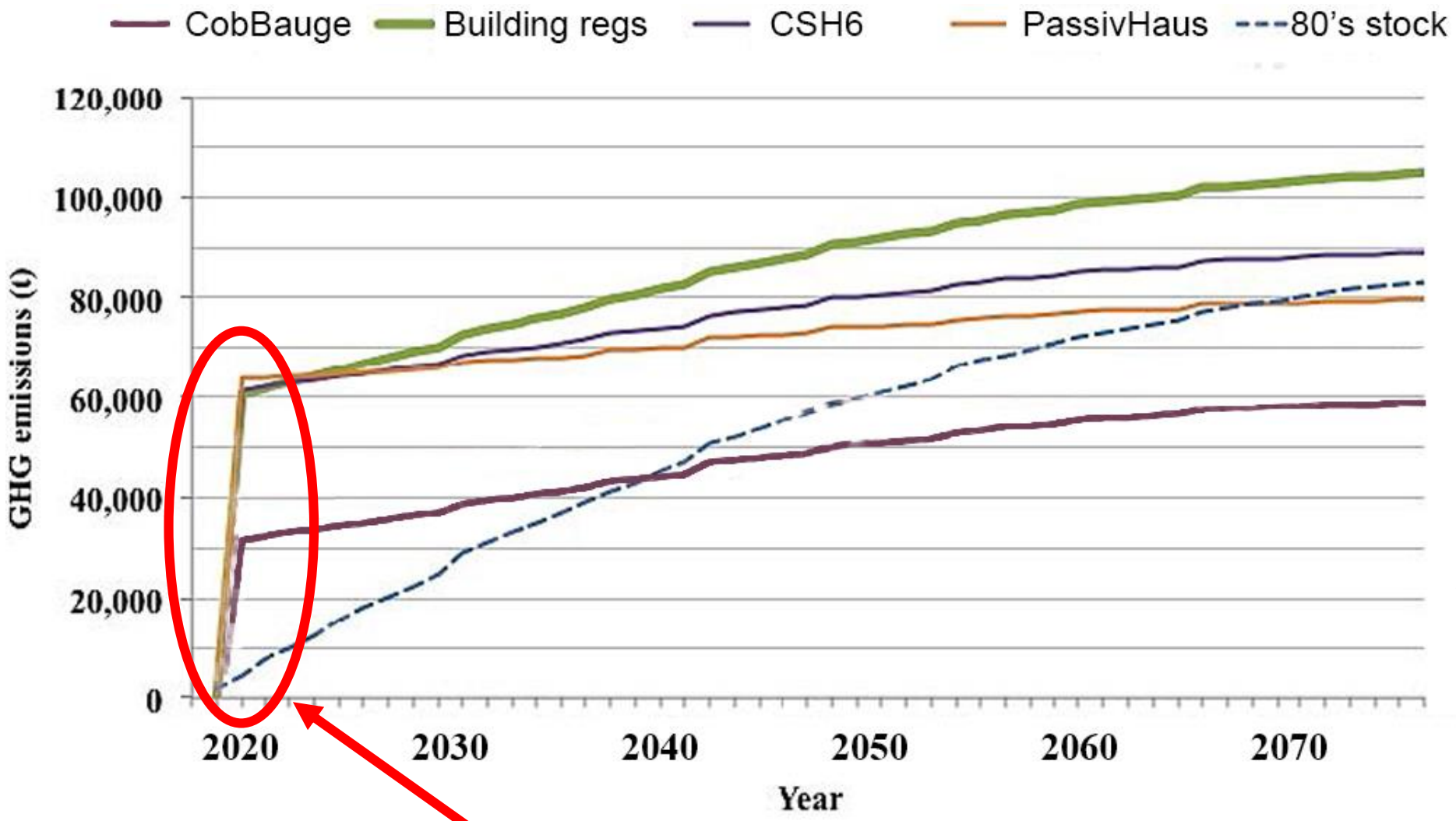
Scenario 4 : 1 m² wall of bricks

Scenario 5 : 1 m² wall of wood



BOUTOUIL, 2016, Students work, LCA courses

Life Cycle Assessment – Why is this important?



This is happening now!

Adapted from Jukka Heinonen

Thank you


Interreg
EUROPEAN UNION
France (Channel Manche) England
CoBBauge
European Regional Development Fund


ENVIRONMENTAL
BUILDING
RESEARCH
WITH
PLYMOUTH
UNIVERSITY


ESITC
CAEN
Ecole Supérieure d'Ingénieurs
des Travaux de la Construction


ebuki
FOSTERING EARTH BUILDING
IN THE UK AND IRELAND


Parc
naturel
régional
des Marais du
Cotentin et du Bessin


UNICAEN
UNIVERSITÉ
CAEN
NORMANDIE


HUDSON Architects