

SUSTAINABLE BUILDING MATERIALS

AN LCA PERSPECTIVE

CASE STUDIES :

GRANGEGORMAN – WEST QUAD



MY BACKGROUND

- LIT Thesis 1998
- GHG Validation & Verification course 2011
- Developed internal carbon rate libraries 2012 – 2013 from ICE data base
- One Click LCA 2021
- Offering LCC services since 2018 & LCA services since 2021
- GGDA baseline study 2022 – 2023
- Construction Sector Group – Roadmap for The Circular Economy

WHAT DO WE MEAN BY 'SUSTAINABLE BUILDING MATERIALS'

- Sustainable building materials are about choosing materials manufactured from resource-efficient processes such as choosing materials of a low embodied energy content, using locally provided and renewable energy sources, as well as selecting materials that contribute fewer amounts of GHG emissions to the atmosphere.

THE RELEVANCE OF EMBODIED CARBON & LCA



Buildings contribute
37% of all CO₂
emissions



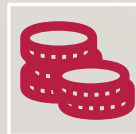
Embodied carbon in
buildings = 14%
CO₂



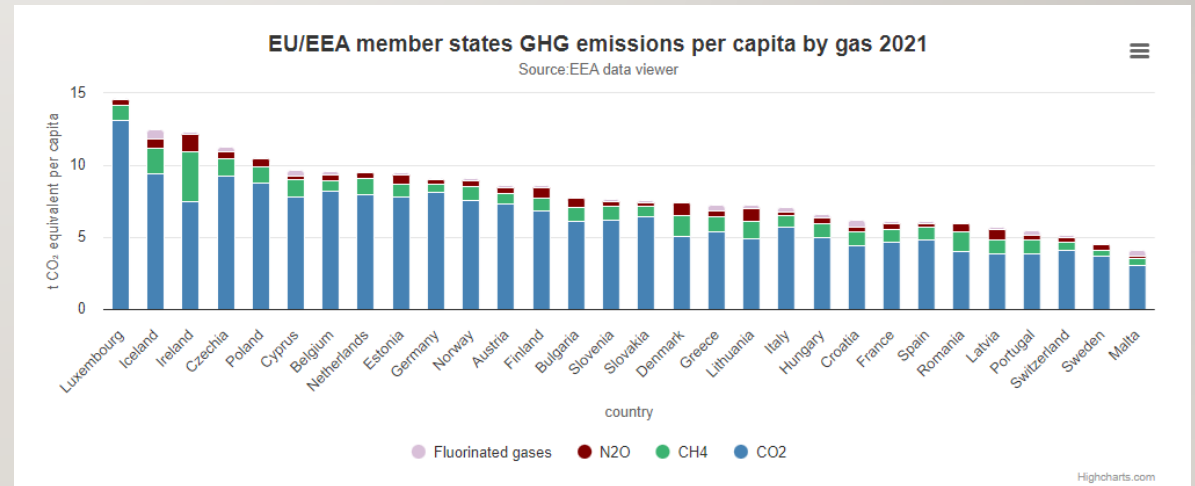
The Climate Action and
Low Carbon
Development
(Amendment) Act 2021



51% reduction by 2030
& Carbon neutral
economy by 2050



Sectoral 5 year carbon
budgets released April
2022

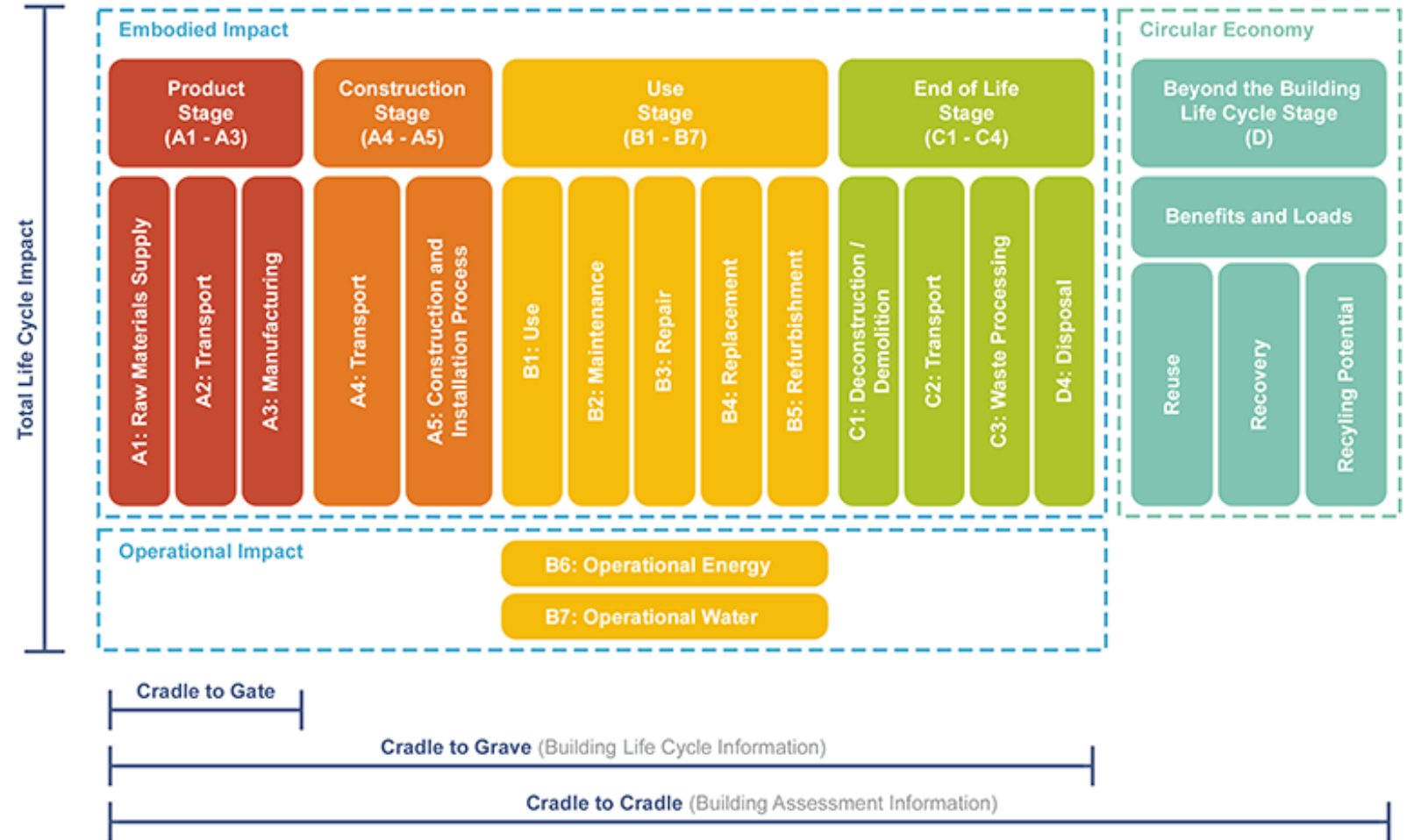


SECTORAL CO₂ REDUCTION TARGETS

- 50% approx reduction in CO₂ in buildings by 2030
- 65% reduction in embodied carbon = 5.5Mt CO₂ e

Sector	2018 Emissions (MtCO ₂ eq.)	2030 Target Emissions (MtCO ₂ eq.)	% Reduction Relative to 2018
Electricity	10.5	2-4	62-81%
Transport	12	6-7	42-50%
Buildings	9	4-5	44-56%
Industry	7(+ circa 0.9)***	5-6	23-37%
Agriculture	23	16-18	22-30%
LULUCF	4.8	2-3	37-58%
Unallocated Savings	N/A	4	N/A

EMBODIED IMPACT STAGES



RIAI / RIBA 2030 TARGETS

- 50% reduction on current benchmarks
- Undertake Whole Life Carbon Analysis
- Minimise off-setting
- Use Circular Economy principles

RIBA 2030 Climate Challenge target metrics for domestic buildings

RIBA Sustainable Outcome Metrics	Current Benchmarks	2020 Targets	2025 Targets	2030 Targets	Notes
Operational Energy kWh/m ² /y 	146 kWh/m ² /y (Ofgem benchmark)	< 105 kWh/m ² /y	< 70 kWh/m ² /y	< 0 to 35 kWh/m ² /y	UKGBC Net Zero Framework 1. Fabric First 2. Efficient services, and low-carbon heat 3. Maximise onsite renewables 4. Minimum offsetting using UK schemes (CCC)
Embodied Carbon kgCO ₂ e/m ² 	1000 kgCO ₂ e/m ² (M4i benchmark)	< 600 kgCO ₂ e/m ²	< 450 kgCO ₂ e/m ²	< 300 kgCO ₂ e/m ²	RICS Whole Life Carbon (A-C) 1. Whole Life Carbon Analysis 2. Using circular economy Strategies 3. Minimum offsetting using UK schemes (CCC)
Potable Water Use Litres/person/day 	125 l/p/day (Building Regulations England and Wales)	< 110 l/p/day	< 95 l/p/day	< 75 l/p/day	CIBSE Guide G

RIBA 2030 Climate Challenge target metrics for non-domestic buildings

RIBA Sustainable Outcome Metrics	Current Benchmarks	2020 Targets	2025 Targets	2030 Targets	Notes
Operational Energy kWh/m ² /y 	225 kWh/m ² /y DEC D rated (CIBSE TM46 benchmark)	< 170 kWh/m ² /y DEC C rating	< 110 kWh/m ² /y DEC B rating	< 0 to 55 kWh/m ² /y DEC A rating	UKGBC Net Zero Framework 1. Fabric First 2. Efficient services, and low-carbon heat 3. Maximise onsite renewables 4. Minimum offsetting using UK schemes (CCC)
Embodied Carbon kgCO ₂ e/m ² 	1100 kgCO ₂ e/m ² (M4i benchmark)	< 800 kgCO ₂ e/m ²	< 650 kgCO ₂ e/m ²	< 500 kgCO ₂ e/m ²	RICS Whole Life Carbon (A-C) 1. Whole Life Carbon Analysis 2. Using circular economy Strategies 3. Minimum offsetting using UK schemes (CCC)
Potable Water Use Litres/person/day 	>16 l/p/day (CIRA W11 benchmark)	< 16 l/p/day	< 13 l/p/day	< 10 l/p/day	CIBSE Guide G

CIRCULAR ECONOMY

[HTTPS://WORLDGBC.ORG/ARTICLE/CIRCULAR-BUILT-ENVIRONMENT-PLAYBOOK/](https://worldgbc.org/article/circular-built-environment-playbook/)

The Fundamental Principles of a Circular Economy



A Definition for a Circular Building is:

A circular building optimises the use of resources whilst minimising waste throughout its whole lifecycle. The building's design, operation and deconstruction maximise value over time using:

- Durable products and services made of secondary, non-toxic, sustainably sourced, or renewable, reusable or recyclable materials
- Space efficiency over time through shared occupancy, flexibility and adaptability

- Longevity, resilience, durability, easy maintenance and reparability
- Disassembly, reuse or recycling of embedded material, components and systems
- Lifecycle assessment (LCA), lifecycle costing (LCC) and readily available digital information (such as building material passports)¹².

WBCSD (2021) The business case for circular buildings:
Exploring the economic, environmental and social value

MEASURING EMBODIED CARBON

IN PUBLIC CONTRACTS

- ICMS 3 – Required from 2024
- LCAs – Required from 2024
- Life Cycle Costing – required from 2024
- Change from project life cycle to asset life cycle
- Allows cost & carbon assessment

ICMS 3

- Mandatory from 2024
- Replaces NSBE
- Reports cost & carbon from Stages A to D

Names of carbon assessment standard(s) adopted for the project	Greater London Authority, Whole Life-Cycle Carbon Assessments guidance Pre-consultation draft (2020); RICS Professional Statement: Whole Life Carbon Assessment for the Built Environment (2017); EN 15978:2011, Sustainability of Construction Works.
Names of carbon assessment tool(s) adopted for the project	One Click LCA
Source(s) of conversion factors (emission factors)	One Click LCA; Environmental Product Declarations; SAP 10

Code	Category	Buildings	
		Emissions (tCO ₂ e)	tCO ₂ e/Qty
	Project Quantity		29,127
	Quantity's Units of Measurement		m ²
	Total		
1.	Acquisition Carbon Emissions (AE) (where significant)	Not significant	Not significant
2.	Construction Carbon Emissions (CE)	15,678	0.538
3.	Renewal Carbon Emissions (RE)	7,180	0.246
4.	Operation Carbon Emissions (OE)	8,005	0.275
5.	Maintenance Carbon Emissions (ME)	9,100	0.312
6.	End of Life Carbon Emissions (EE)	759	0.026
7.	Benefits and loads beyond the system boundary	-2,106	-0.072

Table 3: Carbon breakdown by category for a proposed development (i.e. using Table H-1 of ICMS 3)

MEASURING EMBODIED CARBON & WLCA

LETI & RIBA TARGETS

Project Name Project Sector Assessment Date Assessment By (company) Location of Data -	Upfront Embodied Carbon A1-5 exc. sequestration (kgCO ₂ e/m ²)	Life Cycle Embodied Carbon A1-5, B1-5, C1-4 (kgCO ₂ e/m ²)
A++		
A+		
A		
B		
C		
D		
E		
F		
G		
Non-Listed Typology:		
Sequestered Carbon:	0 kgCO ₂ e/m ²	
	Module D:	0 kgCO ₂ e/m ²

Upfront Embodied Carbon, A1-5 (exc. sequestration)					
Band	Office	Residential (6+ storeys)	Education	Retail	
A++	<100	<100	<100	<100	
A+	<225	<200	<200	<200	
A	<350	<300	<300	<300	
B	<475	<400	<400	<425	
C	<600	<500	<500	<550	
D	<775	<675	<625	<700	
E	<950	<850	<750	<850	
F	<1100	<1000	<875	<1000	
G	<1300	<1200	<1100	<1200	

Life Cycle Embodied Carbon, A1-5, B1-5, C1-4					
Band	Office	Residential (6+ storeys)	Education	Retail	
A++	<150	<150	<125	<125	
A+	<345	<300	<260	<250	
A	<530	<450	<400	<380	
B	<750	<625	<540	<535	
C	<970	<800	<675	<690	
D	<1180	<1000	<835	<870	
E	<1400	<1200	<1000	<1050	
F	<1625	<1400	<1175	<1250	
G	<1900	<1600	<1350	<1450	

LCA REPORTING FRAMEWORK

EN 15978 : 2011 – Assessment of Environmental performance of buildings

EN 15804 + A2: 2019 - EPDs

RICS WLCA guidance statement 2017

LETI (London Energy Transition Initiative) established 2017

EU Level(s) Reporting format 1.2 (kg CO₂e/m²/yr)

ENVIRONMENTAL PRODUCT DECLARATION- EPDs



EPD Transparency Summary

COMPANY NAME

Spray Polyurethane Foam Alliance

PRODUCT TYPE

Building Envelope Insulation

PRODUCT NAME

Closed-Cell, Medium-Density Spray Polyurethane Foam Insulation

PRODUCT DEFINITION

Closed-cell, medium-density (2.0 lb/ft³) spray polyurethane foam insulation. Spray polyurethane foam is made on the jobsite by combining methylene-diphenylene diisocyanate (MDI or A-side) with an equal volume of a polyol blend (B-side).

PRODUCT CATEGORY RULE (PCR)

Building Envelope Thermal Insulation
ULE 2011

CERTIFICATION PERIOD

10/10/2013 – 10/10/2018

DECLARATION NUMBER

13CA29310.101.1



LIFECYCLE IMPACT CATEGORIES

The environmental impacts listed below were assessed throughout the product's lifecycle – including raw material extraction, transportation, manufacturing, packaging, use, and disposal at end of life.

ATMOSPHERE			WATER		EARTH	
						
Global Warming Potential refers to long-term changes in global weather patterns—including temperature and precipitation—that are caused by increased concentrations of greenhouse gases in the atmosphere.	Ozone Depletion Potential is the destruction of the stratospheric ozone layer, which shields the earth from ultraviolet radiation that's harmful to life, caused by human-made air pollution.	Photochemical Ozone Creation Potential happens when sunlight reacts with hydrocarbons, nitrogen oxides, and volatile organic compounds, to produce a type of air pollution known as smog.	Acidification Potential is the result of human-made emissions and refers to the decrease in pH and increase in acidity of oceans, lakes, rivers, and streams—a phenomenon that pollutes groundwater and harms aquatic life.	Eutrophication Potential occurs when excessive nutrients cause increased algae growth in lakes, blocking the underwater penetration of sunlight needed to produce oxygen and resulting in the loss of aquatic life.	Depletion of Abiotic Resources (Elements) refers to the reduction of available non-renewable resources, such as metals and gases, that are found on the periodic table of elements, due to human activity.	Depletion of Abiotic Resources (Fossil Fuels) refers to the decreasing availability of non-renewable carbon-based compounds, such as oil and coal, due to human activity.
27.6 kg CO ₂ -Equiv.	1.15E-08 kg CFC 11-Equiv.	0.18 kg O ₃ -Equiv.	0.78 mol H ⁺ Equiv.	8.99E-04 kg N-Equiv.		
ENV	TRAC					

FUNCTIONAL UNIT The functional unit of the product is 1 m² of insulation material with a thickness that gives a design thermal resistance RSI = 1 m² K/W and with a building service life of 60 years. Material Contents refers to B-side chemicals. The A-side is made from a blend of polymeric methylene diphenyl diisocyanate (pMDI).



Environment

ONE CLICK LCA

- Most comprehensive software available
- 11 third party certifications
- Verified for compliance with EN 15978
- Most up-to-date global & local EPD database

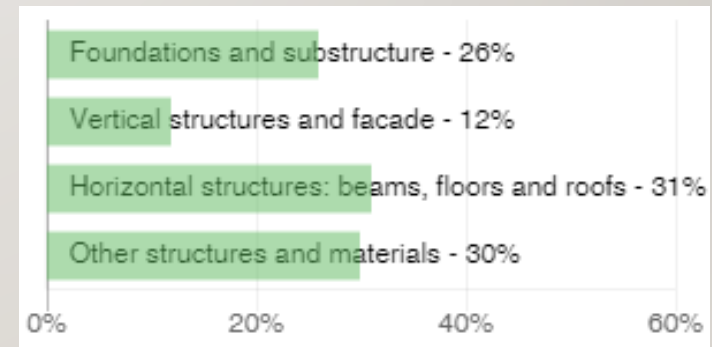
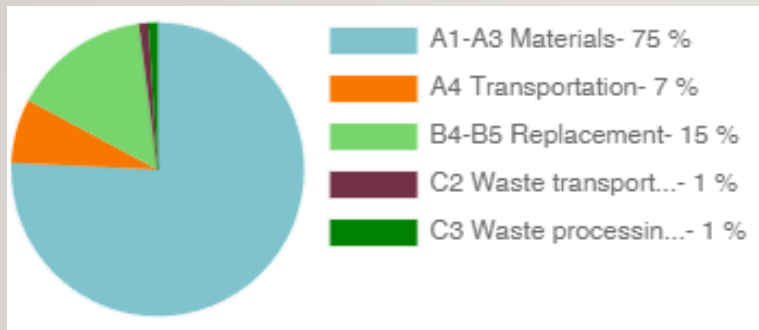


LCA SHOULD BE INTEGRATED INTO DESIGN

- Early-stage options
- Feasibility stage
- Consider different approaches
- Most scope in civil engineering
- Integrate LCA & LCC into each stage of design
- IGBC Baseline information
- Aim for maximum carbon reductions: between 50% & 70%

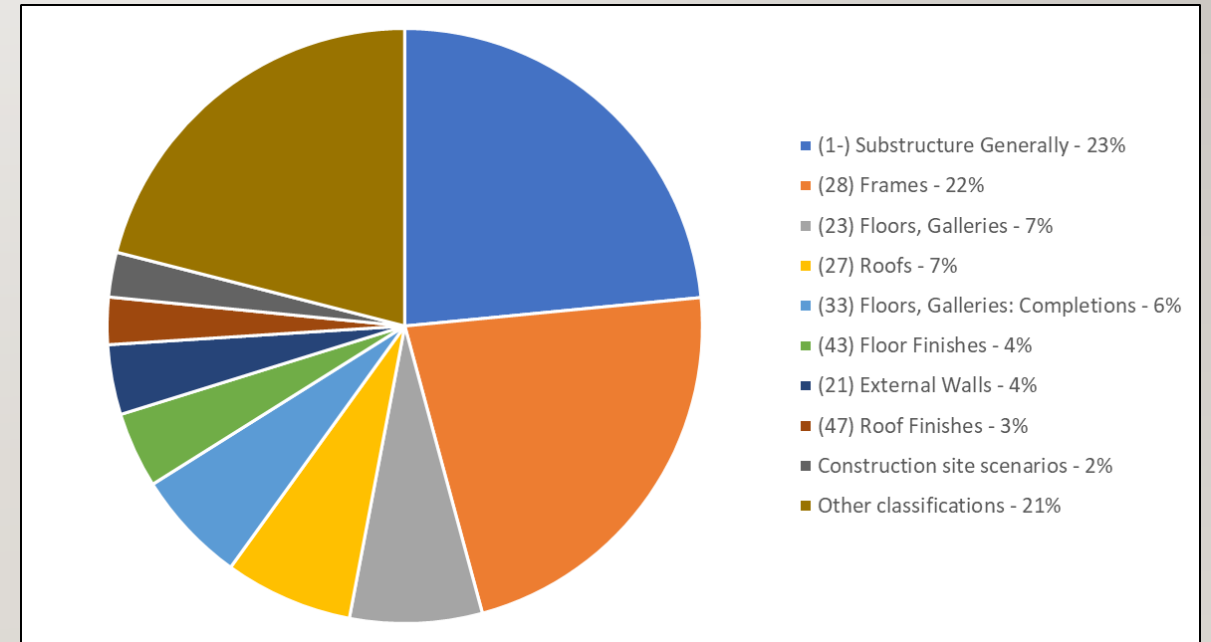


WEST QUAD BUILDING – 75% CO₂ IN MATERIALS



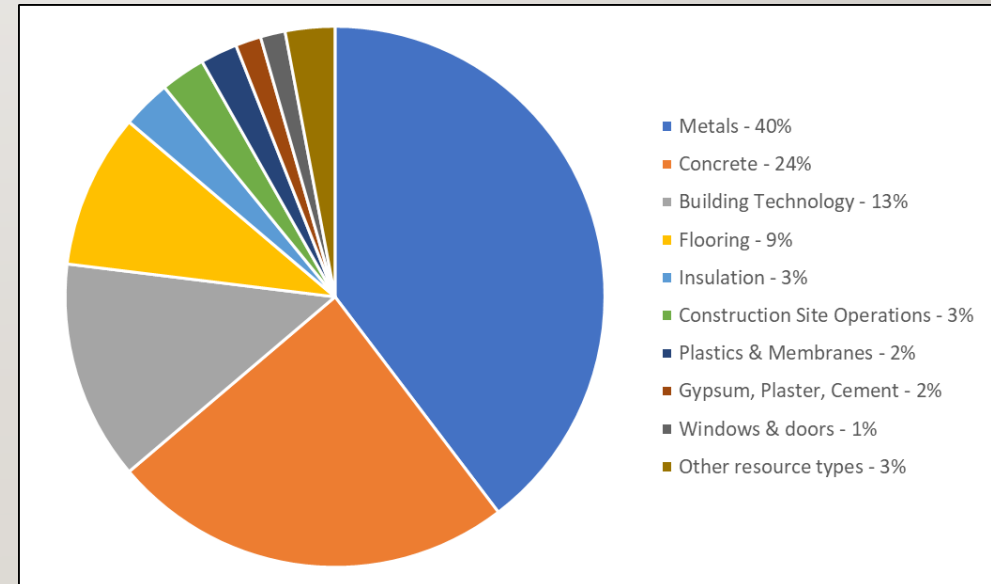
WEST QUAD -ELEMENTAL

- Substructures & superstructures = 60% of embodied carbon



WEST QUAD – MATERIAL TYPE

- 64% metals & concrete
- 34% reduction in CO₂ by using recycled binders and steel (10% overall)



BASELINE Vs IMPROVEMENT

22% REDUCTION OVERALL

Figure 8: LETI benchmark - baseline LCA

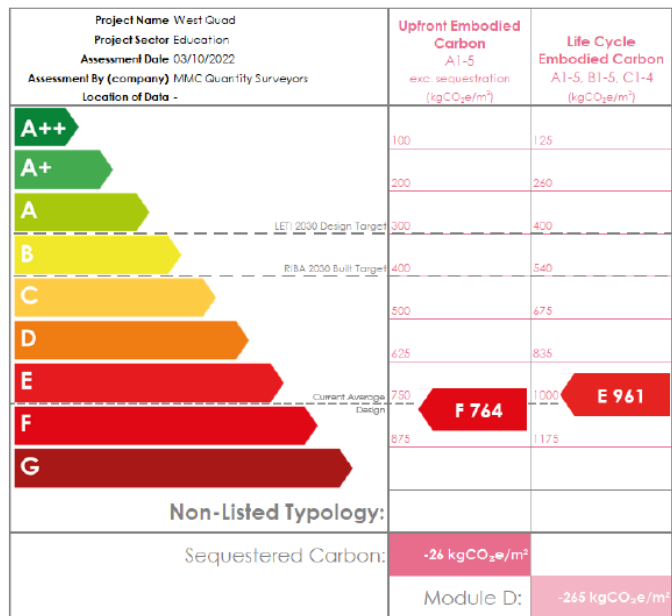
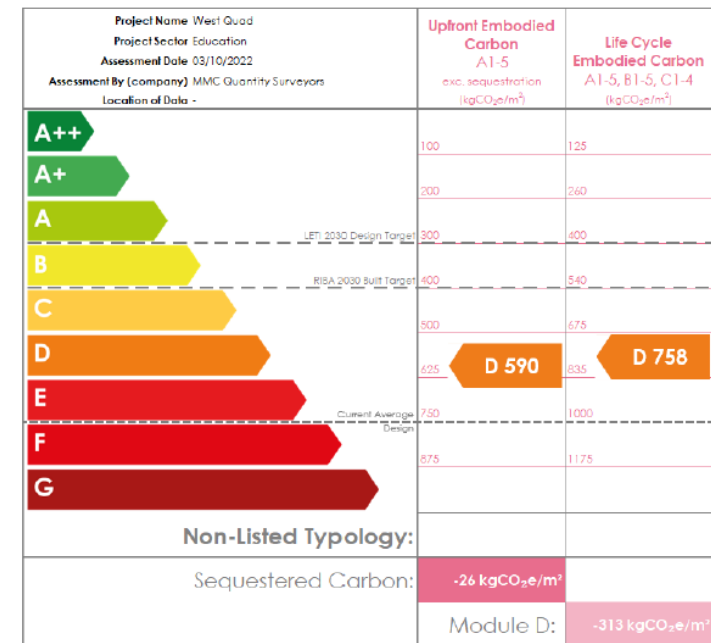


Figure 9: LETI benchmark - optimised LCA



HOW TO REDUCE EMBODIED CARBON IN BUILDINGS

- Think Circular: Use existing structures
- Identify hotspots
- Use biogenic materials where possible
- Use Light Gauge Steel
- Reduce concrete & use highest % GGBS where possible
- Reducing Aluminium
- Up to 65% of EC in structures
- 6% of West Quad carbon was in RAF
- Low carbon & carbon negative options
- Typically 80% recycled
- Concrete is most polluting material, accounting for 8% of total CO₂e
- Up to 20t CO₂/t: Use Alucad windows = 70% less EC

LOW CARBON EXAMPLES

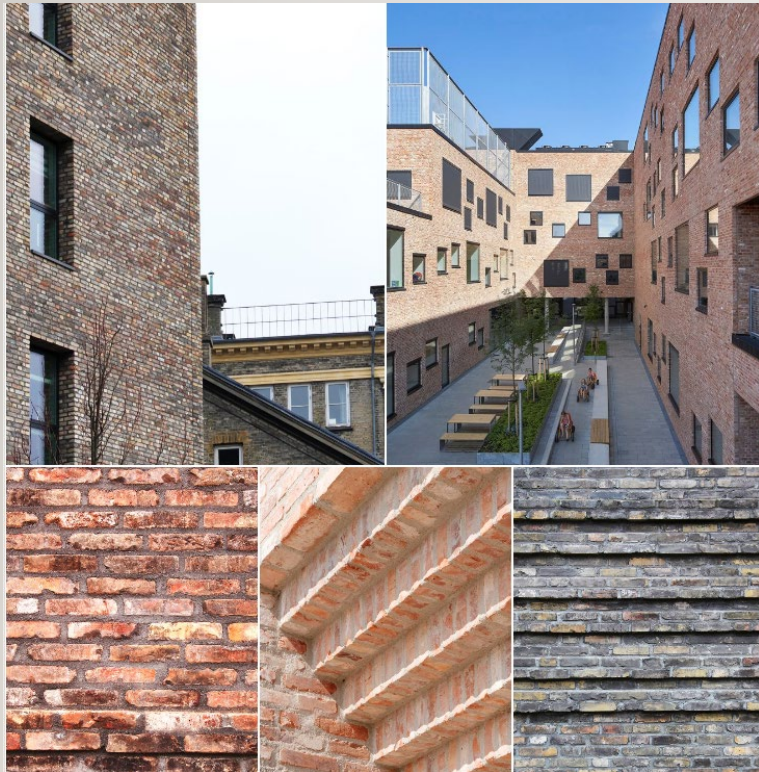
BIOGENIC MATERIALS



- School extension, Denmark
- Straw infill timber frame
- Fully circular (C2C certification)
- 6kg CO₂e/m²/yr
- 335kg CO₂e over 50 years
- Cost competitive with domestic timber & steel frame (one off housing)

LOW CARBON EXAMPLES

RECYCLED BRICK



- Recycled brick
- 0.5kg CO₂e/m²
- 30.5kg CO₂e/m² for new brick
- 98% CO₂ reduction
- Henning Larsen Architects



LOW CARBON EXAMPLES

- Stone bricks
- 1.5kg CO₂e/m²
- 30.5kg CO₂e/m² for clay brick
- 95% less CO₂
- €0.90 to €2.00 per brick

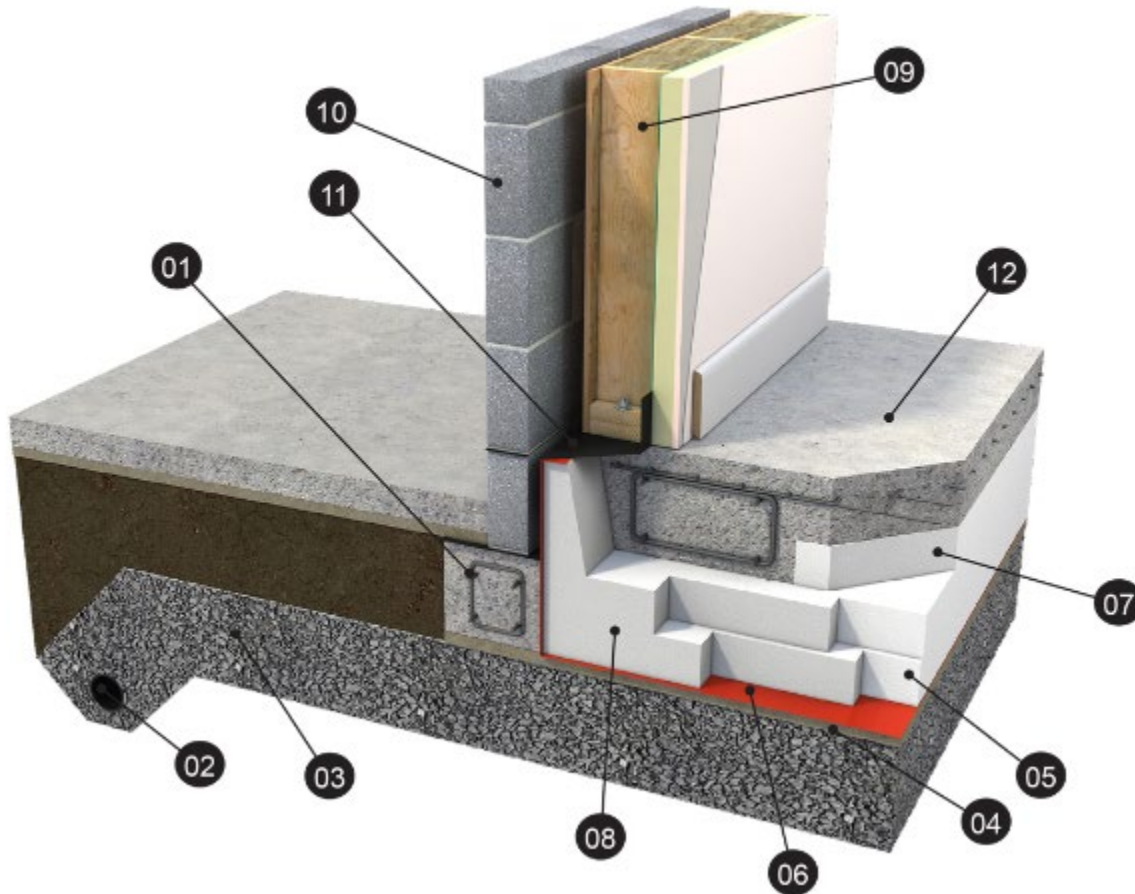
LOW CARBON EXAMPLES

MASS TIMBER



- Cross Laminated Timber (CLT)
- Glulam beams & columns
- Structural steel replacement
- Precast concrete replacement
- Significant carbon sequestration
- Excellent structural & fire properties

PASSIVE RAFT FOUNDATIONS



- 80% reduction in concrete in foundations
- Can reduce substructure costs by 20% in domestic construction
- Faster construction
- Eliminates Linear Thermal Transmittance



ALUCLAD WINDOWS

- 65% reduction on embodied carbon Vs aluminium windows
- 20t CO₂ per tonne aluminium

HEMP BASED PRODUCTS

- Hemp-crete
- Hemp insulation
- Hemp boards
- Hemp wood
- Beneficial for soil
- Grows to 3.5m in 120 days
- Requires changes to legislation & R&D





PARC HADEA, CARDIFF

- 38 zero carbon homes
- Sero Homes
- Zero embodied & operational carbon
- CLT
- Stone & timber cladding
- Energy self sufficient
- Community micro grid

SUMMARY

- Low carbon can be cost neutral.
 - Measuring sustainability is key
 - LCA & LCC
 - CO₂ reductions happen on day one
 - A lot of regulation and legislation change required to make it mandatory throughout.
- THANK YOU