



# Making early decisions count, understanding embodied carbon from the outset

**Dr. Joe Jack Williams - Partner - Fielden Clegg Bradley Studios**

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# IT'S NOT A BOLT ON: THE IMPORTANCE OF EARLY DECISIONS

JOE JACK WILLIAMS, PARTNER

SPACES STUDY DAY  
11 JULY 2024

**1962**  
*Silent Spring* by Rachel Carson published; widely credited with launching the environmental movement by exposing the dangers of uncontrolled use of pesticides.



**1968**  
*First Whole Earth Catalogue* published. Described later by Apple's Steve Jobs as "Google in paperback", the cover photo from Apollo 4's 1967 mission showed Earth as a finite entity isolated in space.

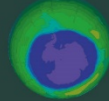


**1973**  
 First oil shock precipitated by Yom Kippur War - petrol rationing in UK.

**1975**  
 Centre for Alternative Technology opens in Machynlleth, Mid Wales.

**1979**  
 Second oil shock: precipitated by Iran/Iraq war.

**1985**  
 British Antarctic Survey identifies hole in ozone layer.



**1987**  
*Brunland Report* set out the fundamental definition of sustainable development.

**1990**  
 BREEAM (Building Research Establishment Assessment Method) established.

**BREEAM®**

**1997**  
 Kyoto Protocol negotiated.

**2002**  
 UK Government Energy Review: set a target of 60% reduction in CO2 emissions by 2050.

**2003**  
 Record UK summer temperature (38.5°C) -10 of the planet's hottest years have occurred since 1990.



**2000**

**2005**  
*Avoiding Dangerous Climate Change*: international symposium suggests a significant reduction of the 'safe' maximum concentration figure for greenhouse gases.



**2006**  
*The Stern Review*: Climate Change as the biggest market failure ever.

**2006**  
*An Inconvenient Truth*: Al Gore's Oscar-winning documentary on climate change released.



**PARIS 2015**  
 COP21

**2015**  
 The Paris Agreement to set a goal of limiting global warming to less than 2 °C compared to pre-industrial levels, agreed by 55 countries representing 55% of the world

**2010**

**2016**  
 UK vote to leave the EU. Leaving the EU renders the status of the UK's 2020 renewable energy targets uncertain. The Government must recommit to the 2020 targets or, if necessary, set replacement targets.

**2019**  
 signed the Architects Declare open letter, declaring a climate and biodiversity emergency and committing to making changes to ensure our industry has a more positive impact on our planet.



**2021**  
 The UK Emissions Trading Scheme (UK ETS) went live on 1 January 2021, replacing the UK's participation in the EU ETS. Under the Ireland/Northern Ireland Protocol, electricity generators in Northern Ireland remained within the EU ETS.

**2032**  
 Ministers are expected to announce that the UK will cut carbon emissions by 57%

**2050**  
 The 2008 act commits the UK to reducing emissions by at least 80% in 2050 from 1990 levels.

**2020**

**Future**



**1960**

**1970**

**1980**

**1990**

**2003**  
 FCBS the first architectural practice to win a **Queen's Award for Sustainable Development**.



**2007**  
*Feldden Clegg Bradley - The Environmental Handbook* published: the practice's work plus a sustainability primer.



**2007**  
**EMV Social Housing**: selected as an example of good practice and a model for increasing energy efficiency and sustainability through the use of innovative material and systems on an experimental basis.

**2010**  
 FCBS' **Woodland Trust HQ** completes. Its cross-laminated timber will save almost 400 tonnes of carbon dioxide.



**2011**  
 The **Neo-Natal Intensive Care Unit** at Bath's Royal United Hospital has created a "Space to Grow" with sustainability at its heart through a dedicated new building and the refurbishment of



**2019**  
**Trinity E3** represents the creation of new curricula in engineering and the sciences, developed to address the global challenge of sustainable technological



**2021**  
**Paradise** will transform a neglected and disused site into 60,000sqft of net carbon zero work and maker space.



**2016**  
**Pea Soup House** aims to 'construct communities' by bringing them together through food whilst creating awareness of air pollution in cities, specifically London.

**2016**  
 FCBS support Bioregional in developing online platform for **One Planet Living**.

**2023**  
**Craft Gardens** targets a 100-year design life, the scheme uses high-quality materials which emanate a sense of permanence.



**2012**  
**The Hive, Worcester** will reduce CO2 emissions by 50% and is designed to address climate change to 2050. Aiming to obtain BREEAM 'Outstanding'.

**2014**  
 The bold Public Realm Plan will see **Church Street and Paddington Green** set new standards in the UK as a retrofitted climate change adapted



**2009**  
**One Brighton** - a high density mixed-use development adjacent to Brighton Rail Station is completed. The scheme is the first 'One Planet Living Community' - based on ten guiding principles of sustainability developed by BioRegional and WWF



**2005**  
**The National Trust Headquarters**: integrated roof design avoids the need for artificial lighting for 80% of working hours, provides natural ventilation and a significant proportion of the building's energy.



**1999**  
**Earth Centre, Doncaster**: exhibition space cooled by labyrinth, largest UK PV array supported on distorted Scottish larch space frame.

**1992**  
 Green Guide to Specification published, comparing overall environmental impacts of typical construction methods.

**1998**  
**The New Environmental Office, Building Research Establishment**: Naturally ventilated, low energy, external glass louvres, borehole cooling, first UK installation of TS lighting and vertical thin film silicone PV array.



**1983**  
**Cleveland Reach, Bath**: our self-financed development incorporating triple glazing, whole house ventilation with heat recovery and experimental Trombe walls.

**1986**  
**2 Mile Ash, Milton Keynes**: super insulated housing - heating demand is 80% lower than standard.  
**1988**  
**Solar Courtyard houses, Milton Keynes**: quadruple glazed passive solar houses for the Energyworld exhibition opened by Margaret Thatcher!

**1978**  
 Feilden Clegg Design first established in Bath.

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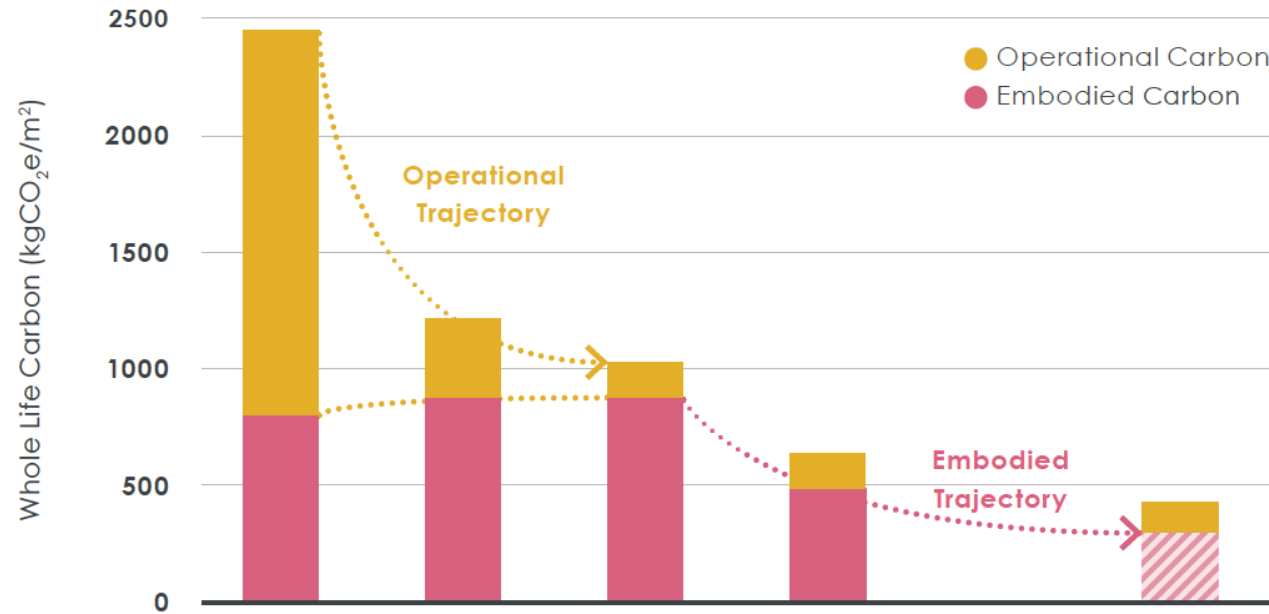
**REDUCING CARBON SINCE 1978**

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# WHY FOCUS ON EMBODIED CARBON?

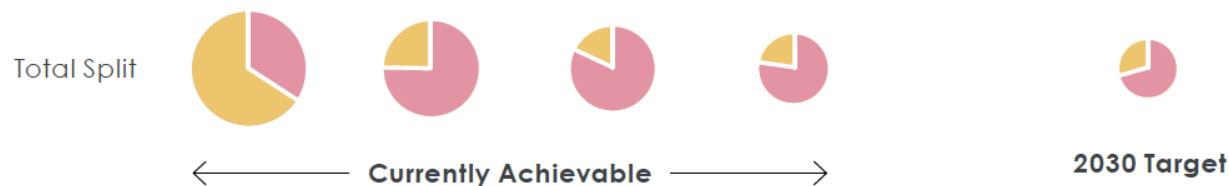
UNDERSTANDING THE CHANGING CARBON  
LANDSCAPE

# EMBODIED VS. OPERATIONAL CARBON

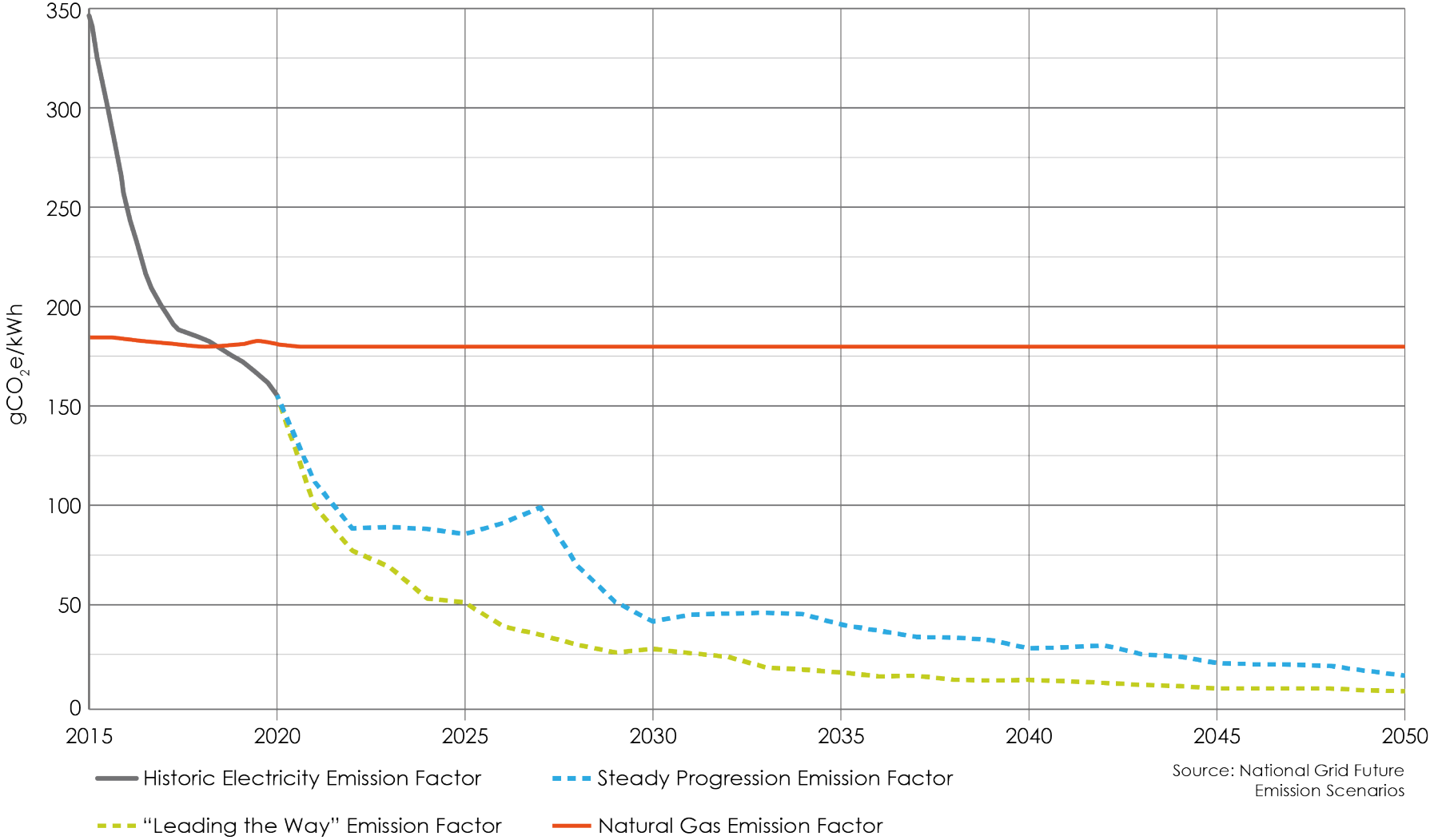


<b>Operational Carbon Scenario</b>	Current Building Regulations	Ultra-low energy with Gas Boiler	Ultra-low energy with Heat Pump	Ultra-low energy with Heat Pump	Ultra-low energy with Heat Pump
<b>Embodied Carbon Scenario</b>	Not considered	Not considered	Not considered	Embodied Carbon Reductions	Future Embodied Benchmark

As, buildings become more efficient, the operational energy proportion will decrease, **shifting the focus to embodied carbon.**



# THE GRID IS CHANGING FOR THE BETTER



# UNDERSTANDING EMBODIED CARBON

# HOW TO CALCULATE EMBODIED CARBON

Embodied carbon (kgCO<sub>2</sub>e) =

$$\sum \left( \text{Quantity (kg)} \times \text{Carbon factor (kgCO}_2\text{e/kg)} \right)$$

Sum for all materials

*Data quality and availability depend on design stage*

- *Estimated BOQ*
- *Detailed BOQ*
- *Actual quantities used*

*For each life cycle module*

*(exceptions: site activities in A5 estimated based on project cost; demolition and deconstruction in C1 estimated based on GIA)*





### 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

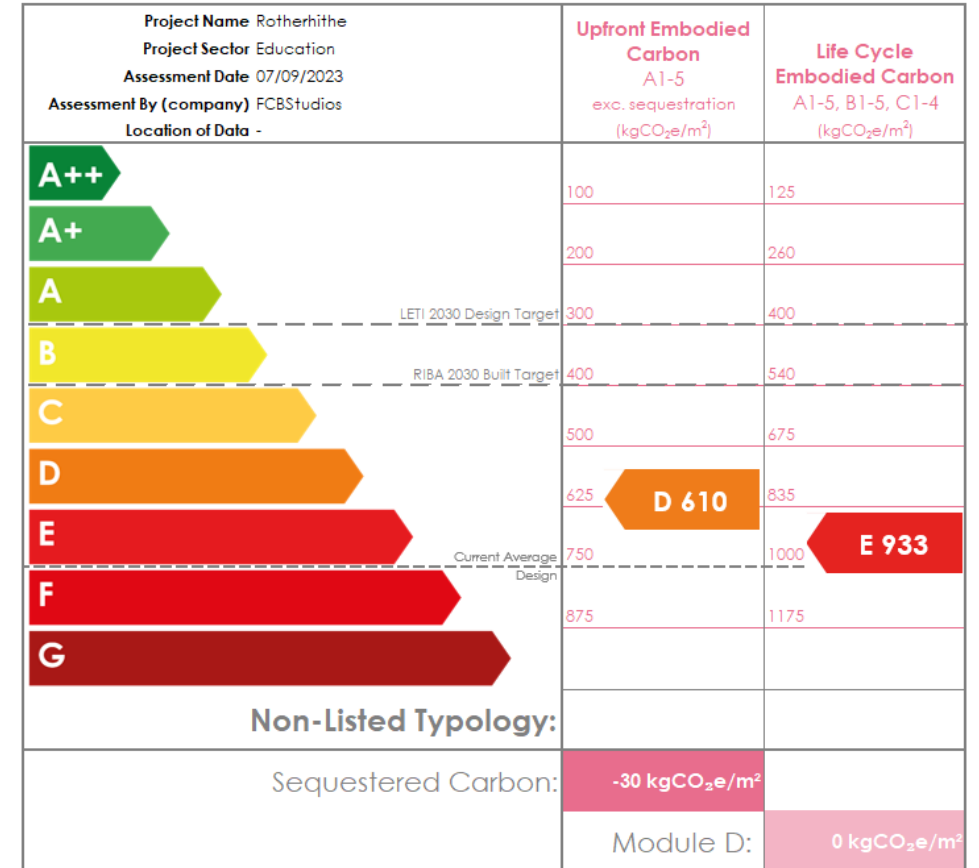
LETI 2030 Design Target

LETI 2020 Design Target

### 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

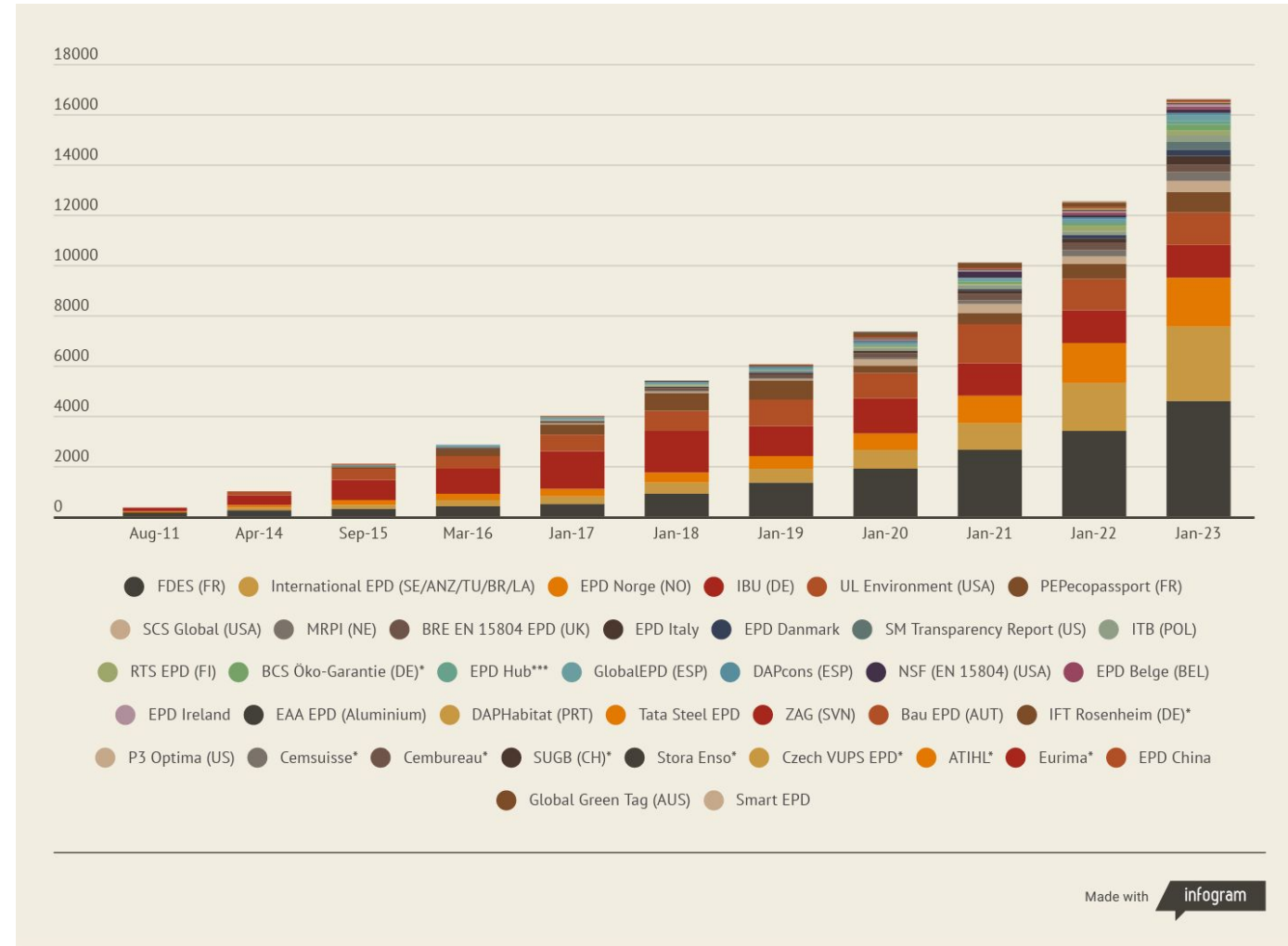
RIBA 2030 as Built Target



# DATA ON EMBODIED CARBON

There are nearly 130,000 EPDs that can be used in the UK.

Growth is significant, with the majority coming from Europe.



<https://infogram.com/constructionlcas-2023-guide-to-epd-1h0n25yvdgz7l6p?live>

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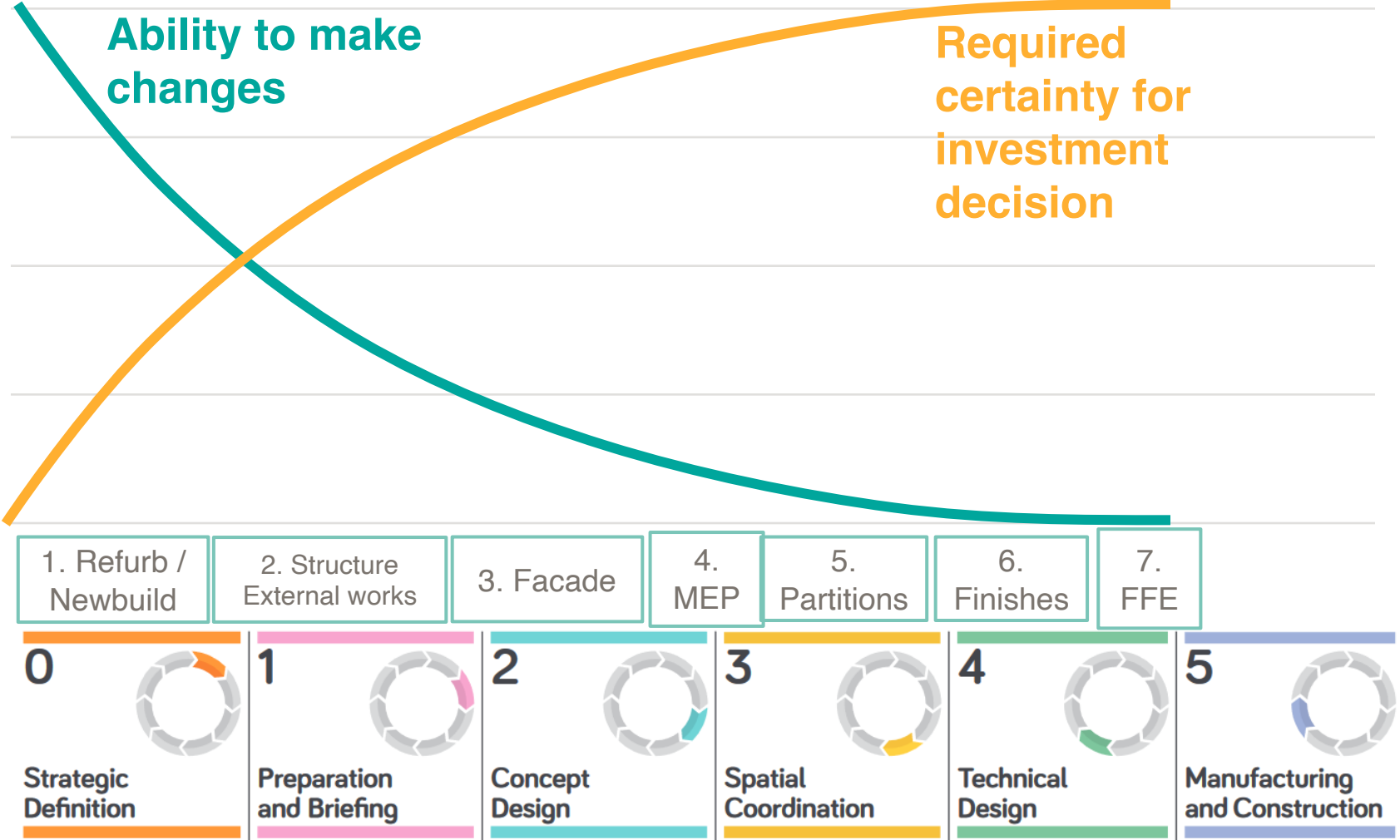
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*For each life cycle module*

*(exceptions: site activities in A5 estimated based on project cost; demolition and deconstruction in C1 estimated based on GIA)*

# EARLY DECISIONS MAKE THE BIGGEST IMPACT



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# EARLY DESIGN DECISIONS

# SCALE AND MASSING

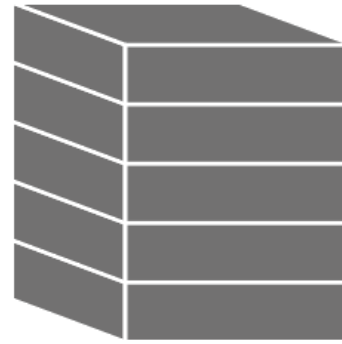
It sets limits on common low carbon approaches



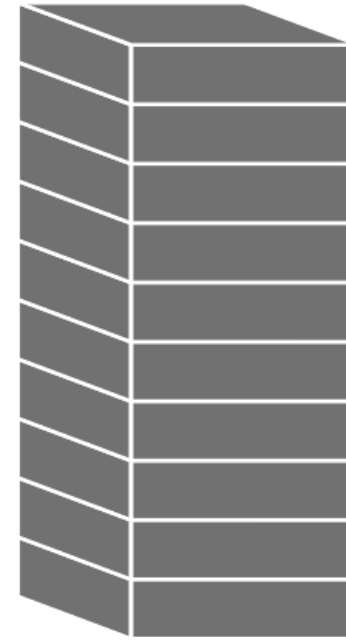
Individual Homes



Terraced Homes



Midrise Apartments



Highrise Apartments

Simple Timber Frames:



Mass Timber:



Raft Foundations:

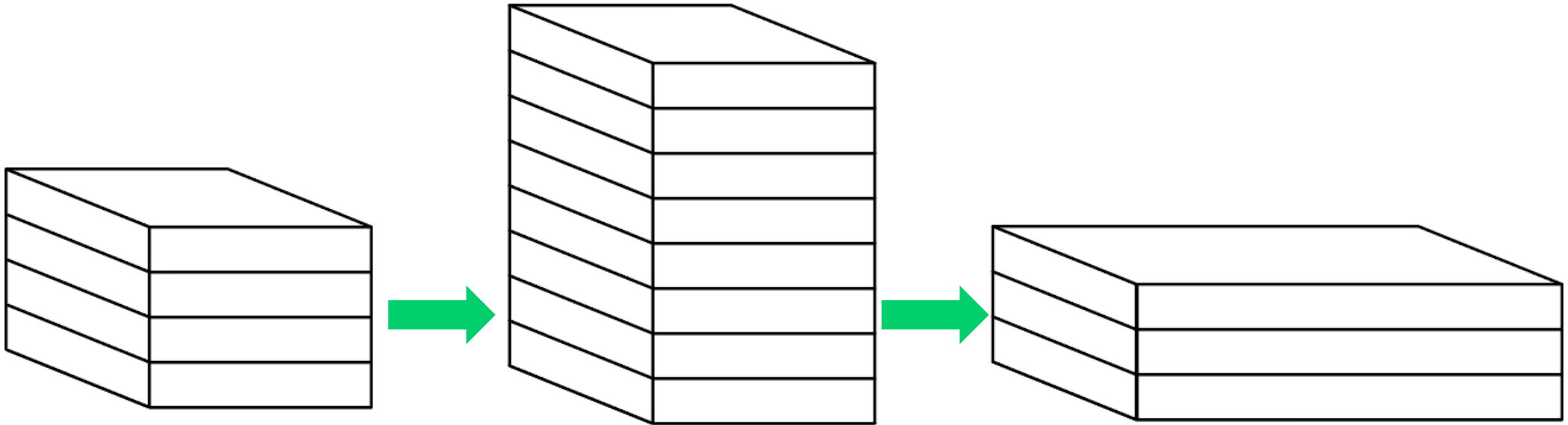


Load-bearing Façade:



# SECONDARY CORES

Additional cores may be needed

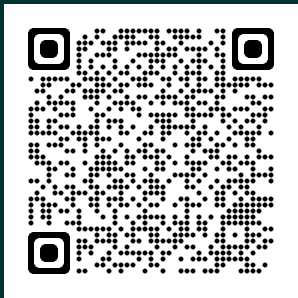


As the building height  
increases

As the travel distances  
increase

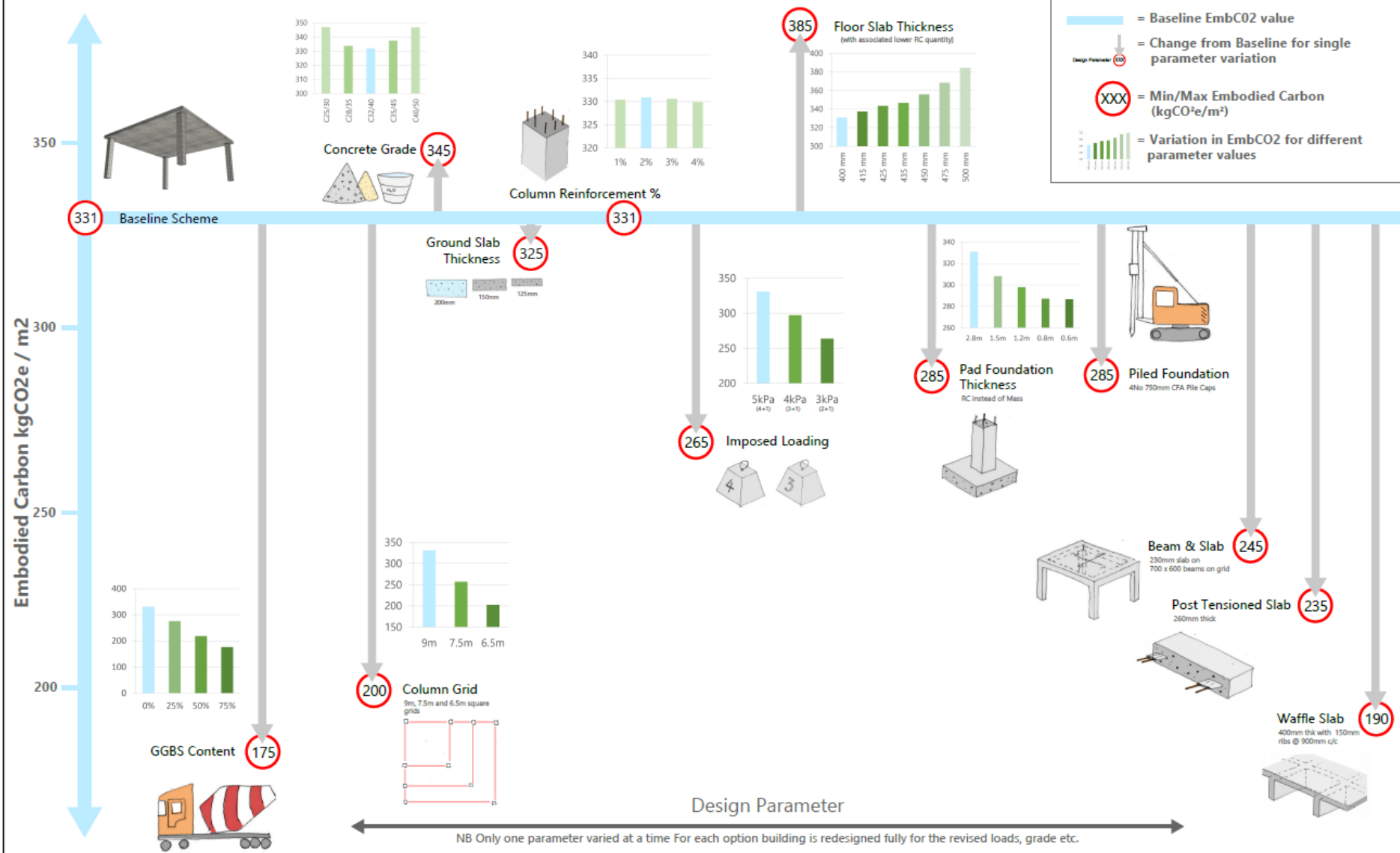
# GRID SIZE

Changing the grid size can reduce structural carbon by **40%** in a concrete frame



<https://www.istructe.org/resources/case-study/embodied-carbon-structural-sensitivity-study/>

## Embodied Carbon Routes to Reduction - Concrete Frame



<b>BUROHAPPOLD ENGINEERING</b>	Project: Embodied Carbon System Parameter Study	Project Number: 00XXXX	Status: FOR GUIDANCE		
	Sketch Title: ....	Sketch Number: ....	Date: 13/02/20	Initials: HG	Revision: 0005

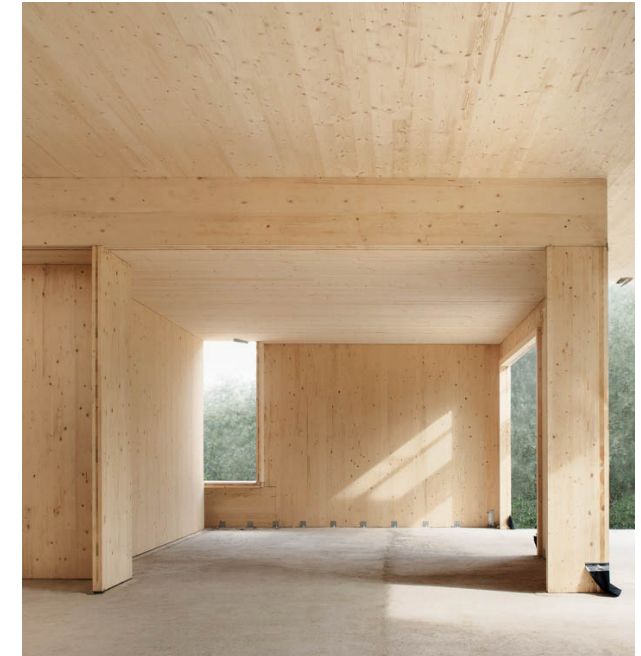
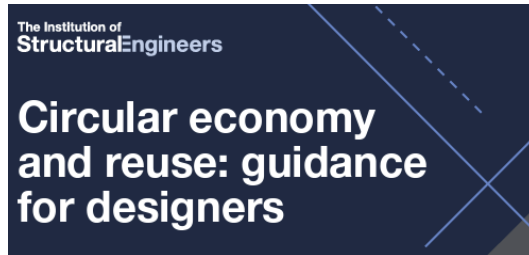
Copyright © 1976-2019 BuroHappold Engineering. All Rights Reserved



# GRID SIZE – ENABLING DESIGN FREEDOM

With a smaller grid size, designs can include:

Cross section		Limits	Buckling curve	
			Buckling about axis	S 235 S 275 S 355 S 420 S 460
Rolled sections		$t_f \leq 40 \text{ mm}$	y-y x-x	a b
		$40 \text{ mm} < t_f \leq 100$	y-y z-z	b a
		$t_f \leq 100 \text{ mm}$	y-y z-z	b a
		$t_f > 100 \text{ mm}$	y-y z-z	d c
Welded I-sections		$t_f \leq 40 \text{ mm}$	y-y x-x	b c
		$t_f > 40 \text{ mm}$	y-y z-z	c d
Hollow sections		hot finished	any	a
		cold formed	any	c
Welded box sections		generally (except as below)	any	b
		thick welds: $a > 0.5t_f$ $b/t_f < 30$ $h/t_w < 30$	any	c
U, T, and solid sections			any	c
L-sections			any	b



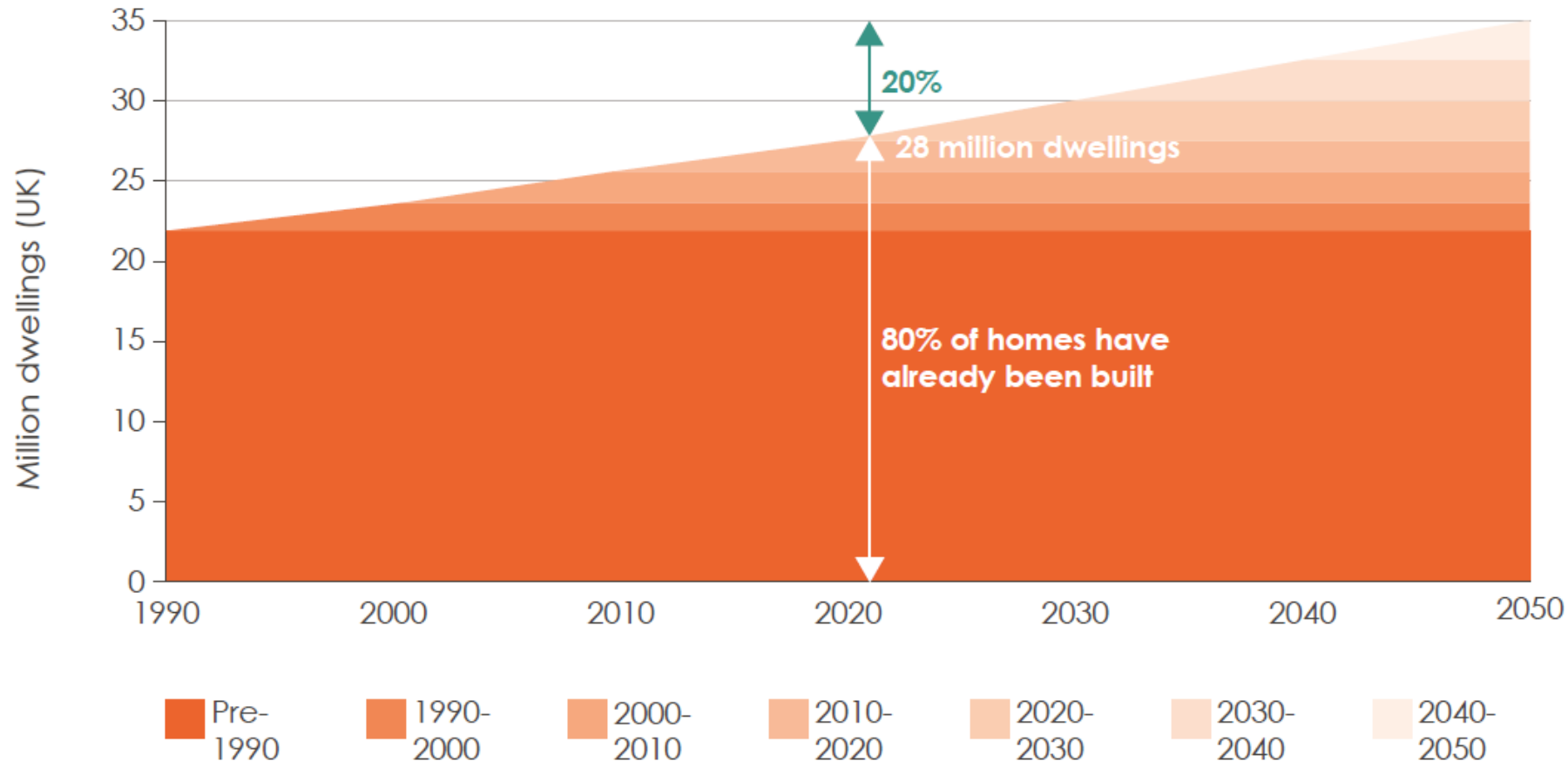
→ Standard steel sections from low carbon EAF sources

→ Reclaimed steel sections

→ Mass timber (CLT/ Glulam/ LVL/ etc.)

**DO YOU NEED TO BUILD ANYTHING?**  
**WHAT CAN YOU REUSE?**

# BUILDINGS IN 2050

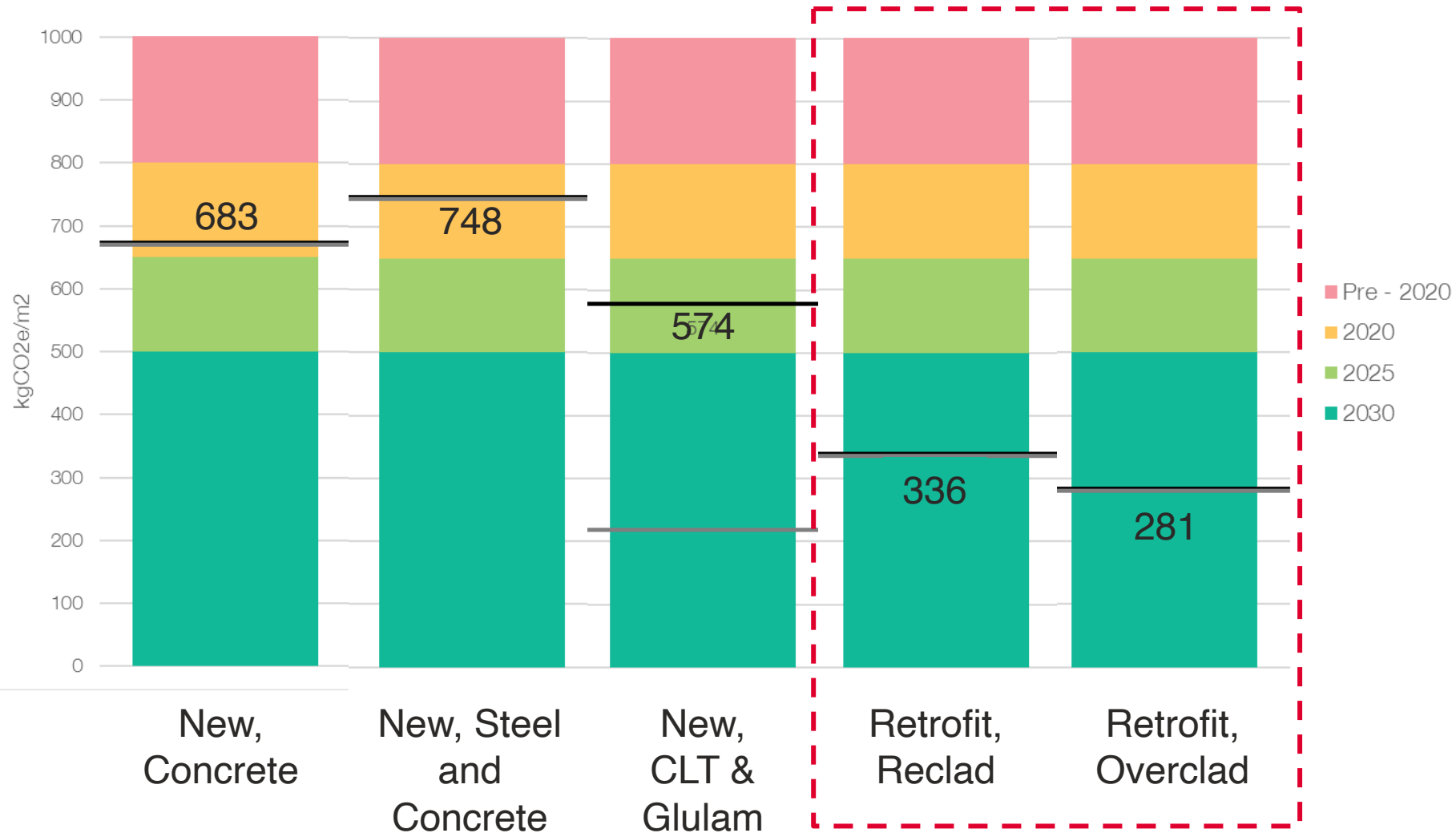


80% of the buildings we need already exist, for both domestic and non-domestic

**Figure 1.4** - Millions of dwellings built in the UK from pre-1990 to 2050. Note: demolition has been ignored in this table as the relatively small amount of domestic demolition is usually followed with replacement.

Source: LETI Climate Emergency Retrofit Guide, 2022

# HOW DOES RETROFIT STACK-UP?



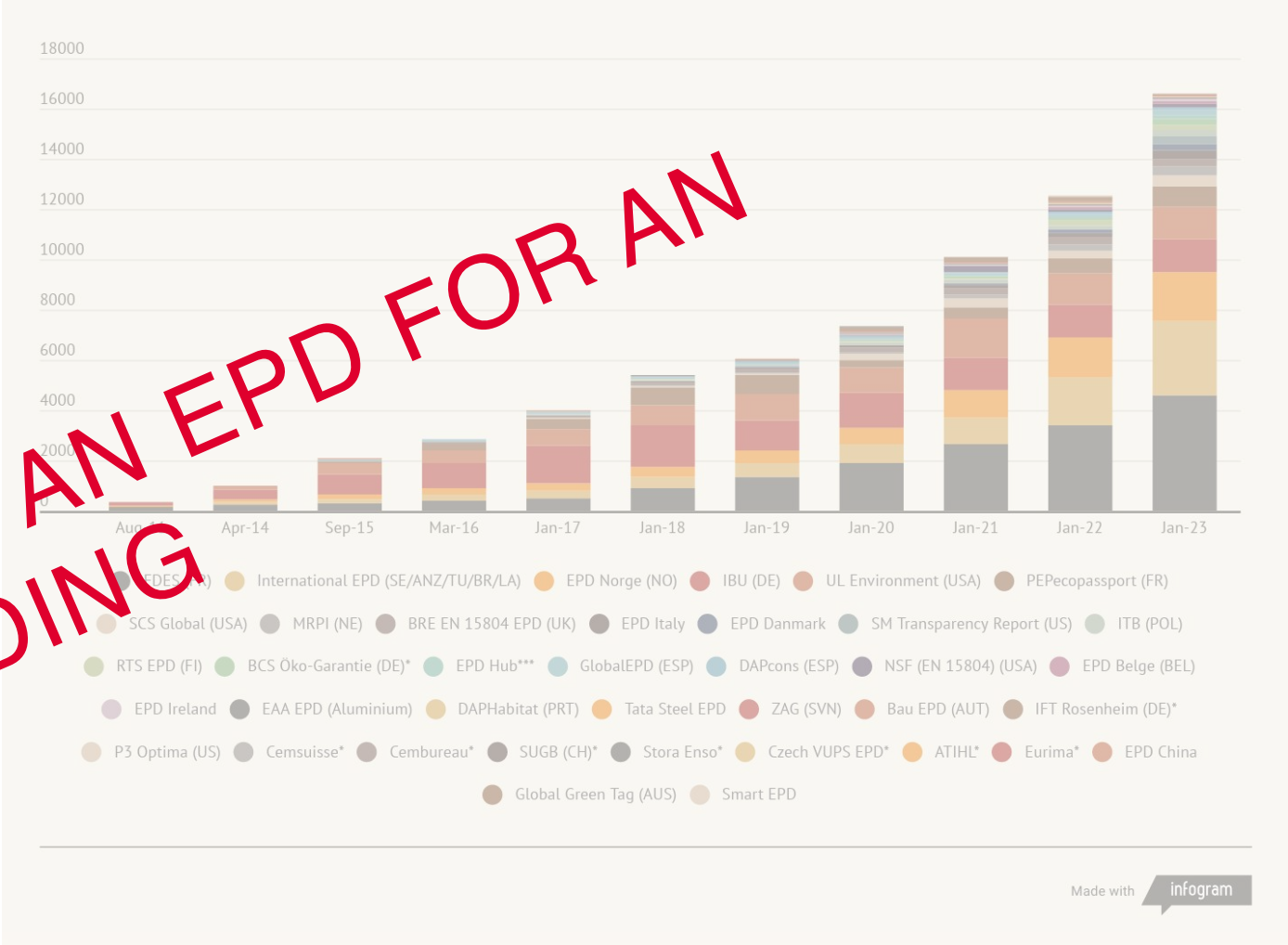
Retrofit is the easiest way to achieve the RIBA 2030 targets.

# DATA ON EMBODIED CARBON

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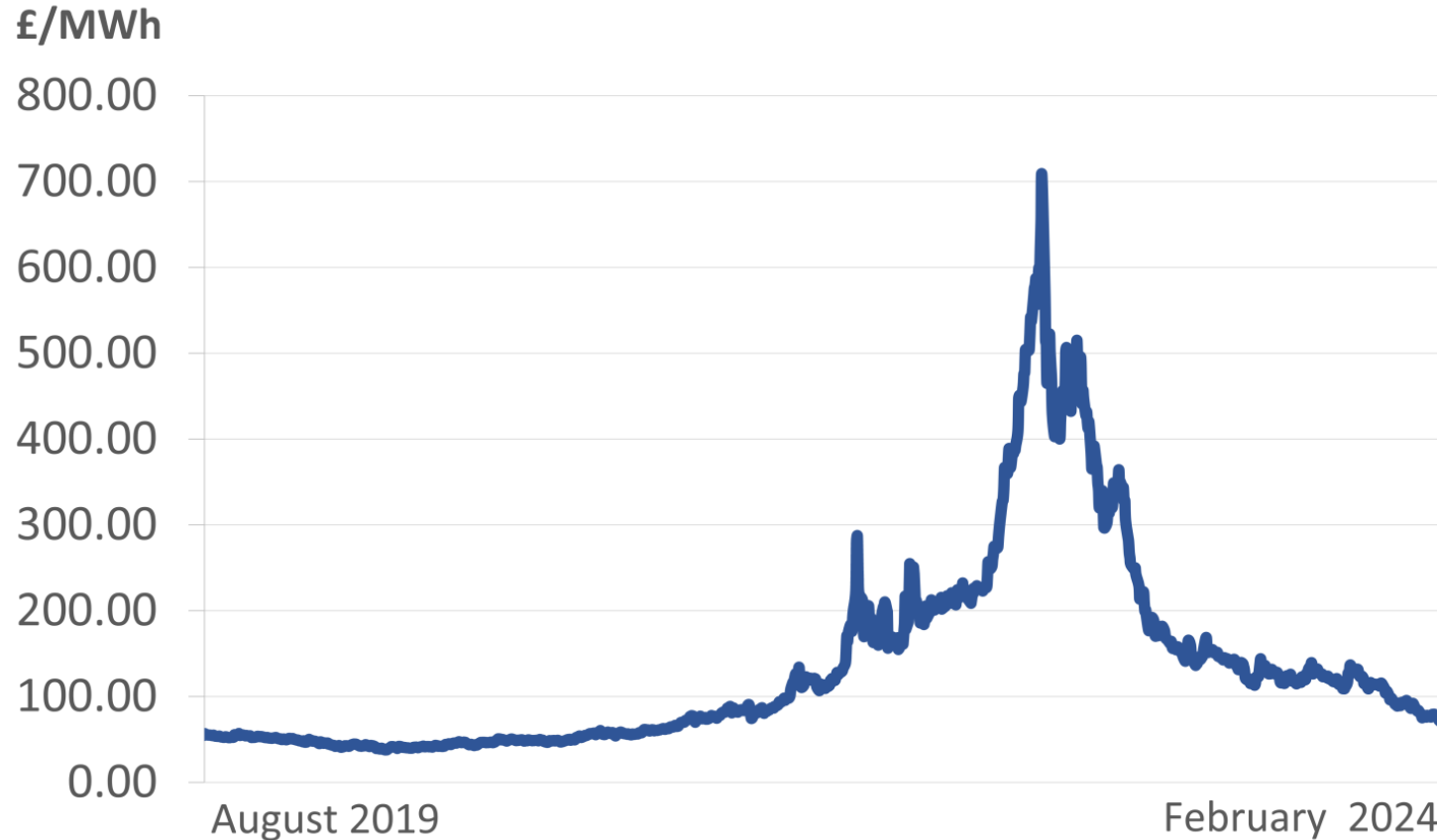
**WE DON'T NEED AN EPD FOR AN EXISTING BUILDING**



<https://infogram.com/construction/cas-2023-guide-to-epd-1h0n25yvdgz7l6p?live>

# ENERGY IS NOT JUST CARBON

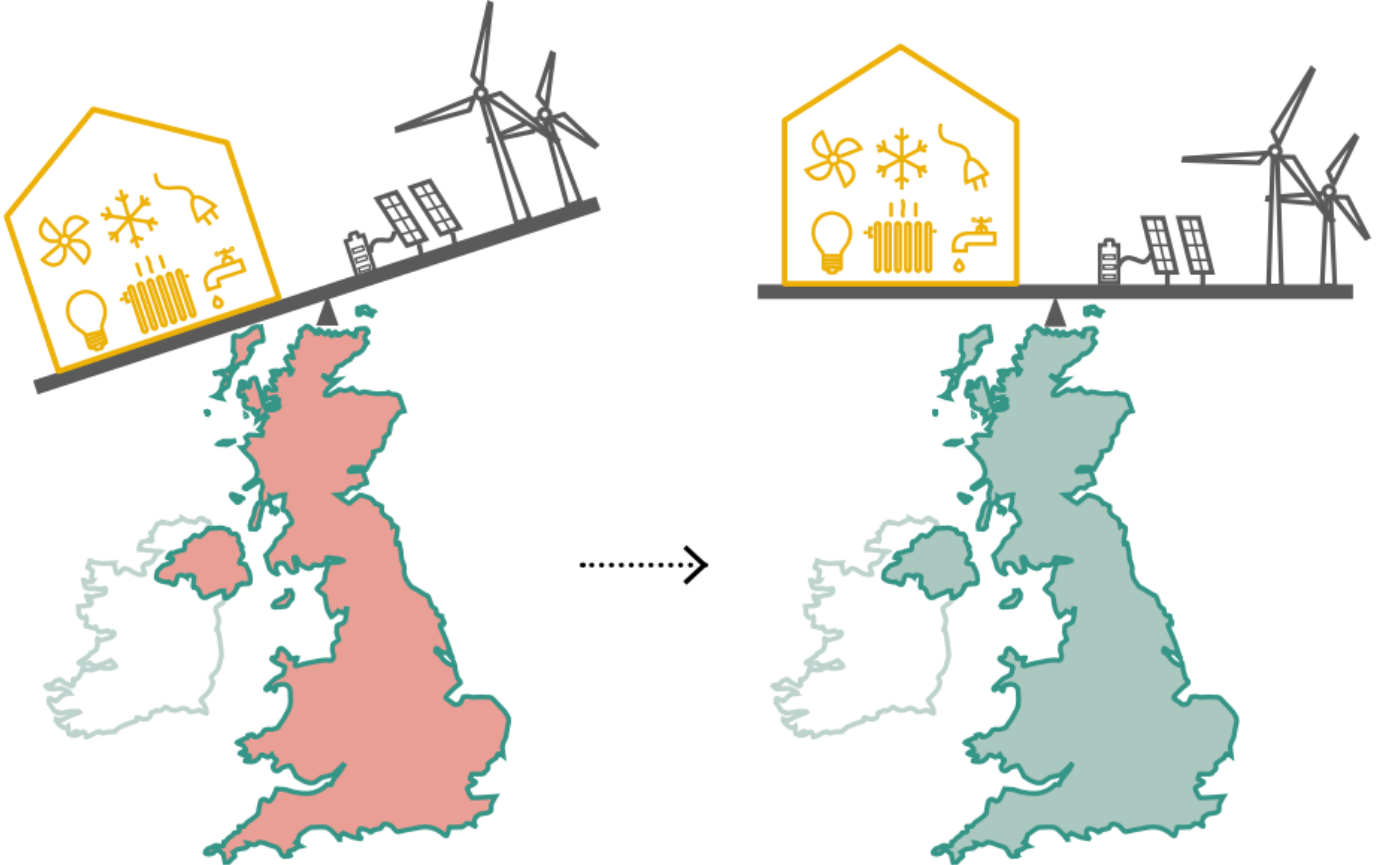
Electricity wholesale costs in the energy price cap,  
by pound (£) per megawatt hour (MWh)



Energy prices affect us all  
and are a **significant risk** to  
our finances.

Source: <https://www.independent.co.uk/news/uk/home-news/ofgem-energy-price-cap-april-2024-b2500799.html>

# OUR AVAILABLE RENEWABLE ENERGY



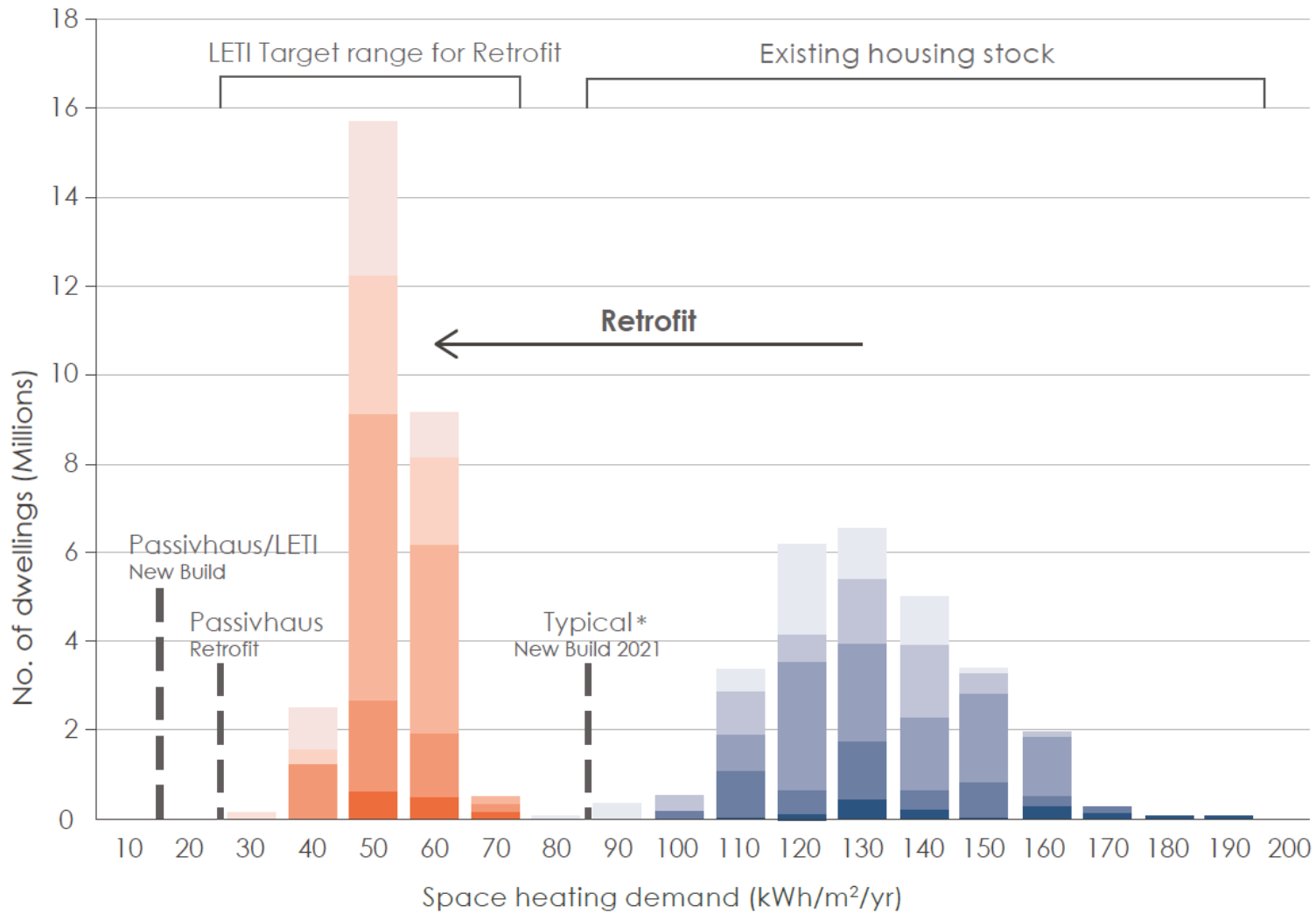
We need to reduce our energy consumption so that we all have low carbon energy

**energy consumption** > renewable energy production

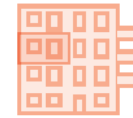
**energy consumption** = renewable energy production

Source: LETI

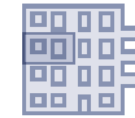
# WHAT CAN WE DO?



Stock distribution after 62% reduction across all dwellings



Existing stock distribution



Flat



Mid-terrace



Semi-detached



Detached



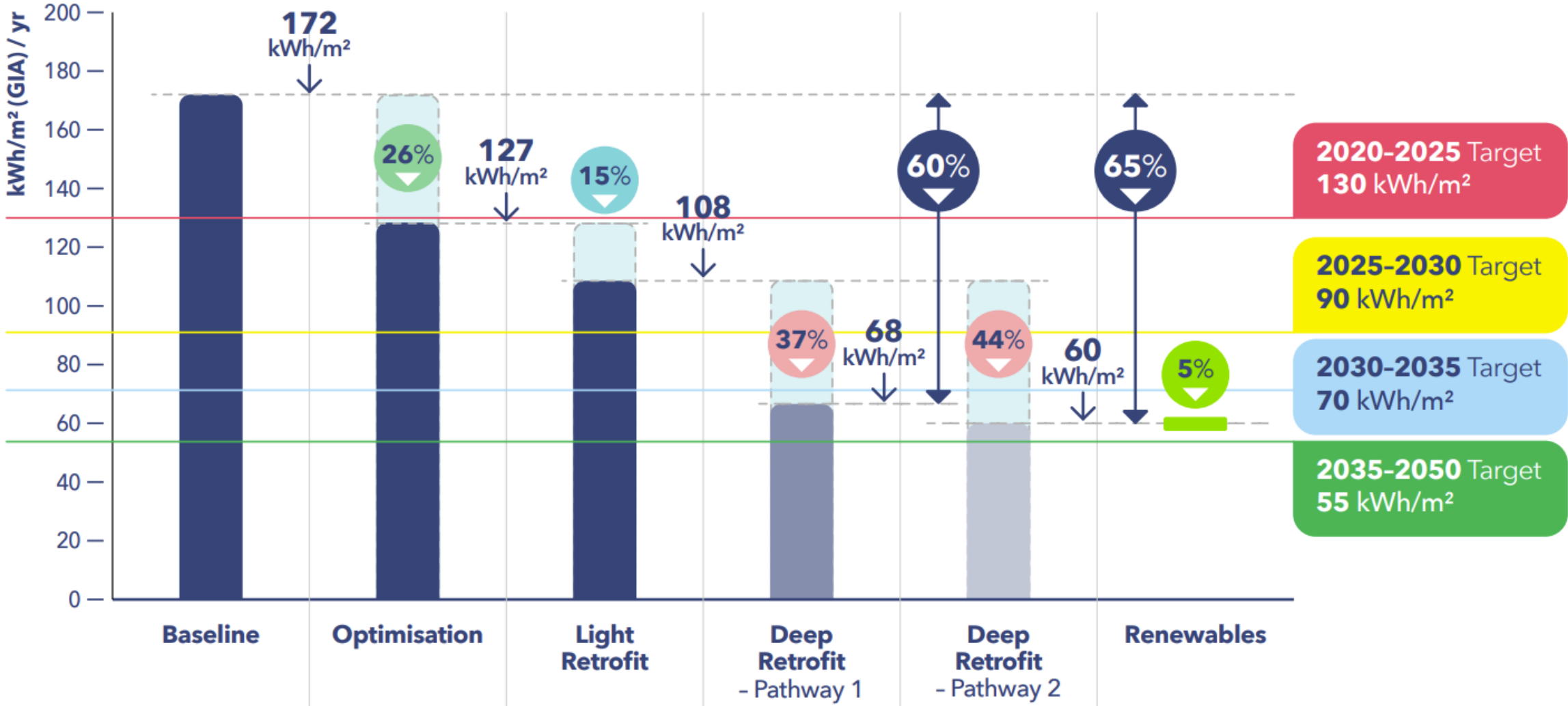
Bungalow

\* Includes for an assumed performance gap

Source: LETI Climate Emergency Retrofit Guide, 2022

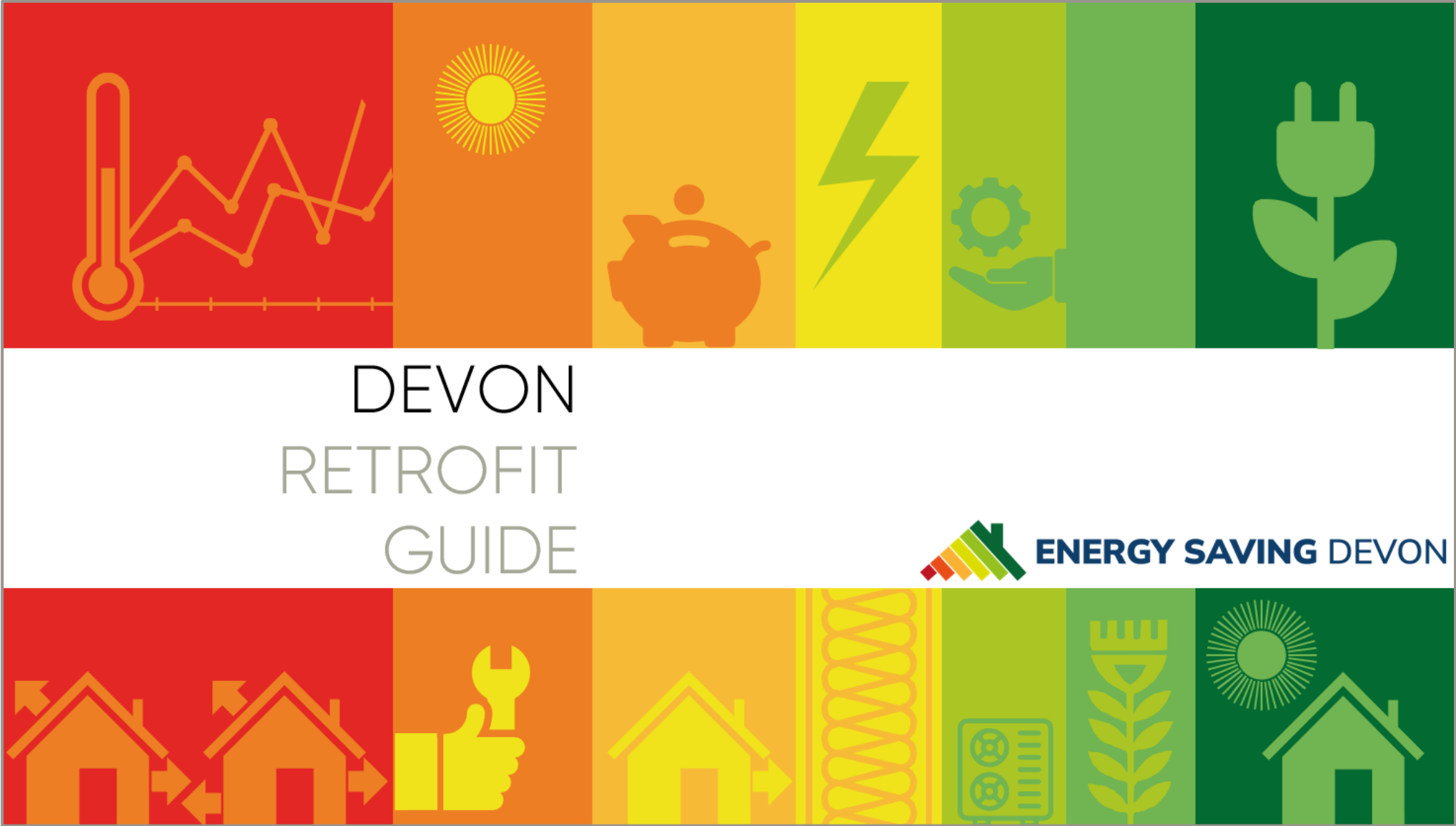


# WHAT SHOULD WE BE TARGETING?

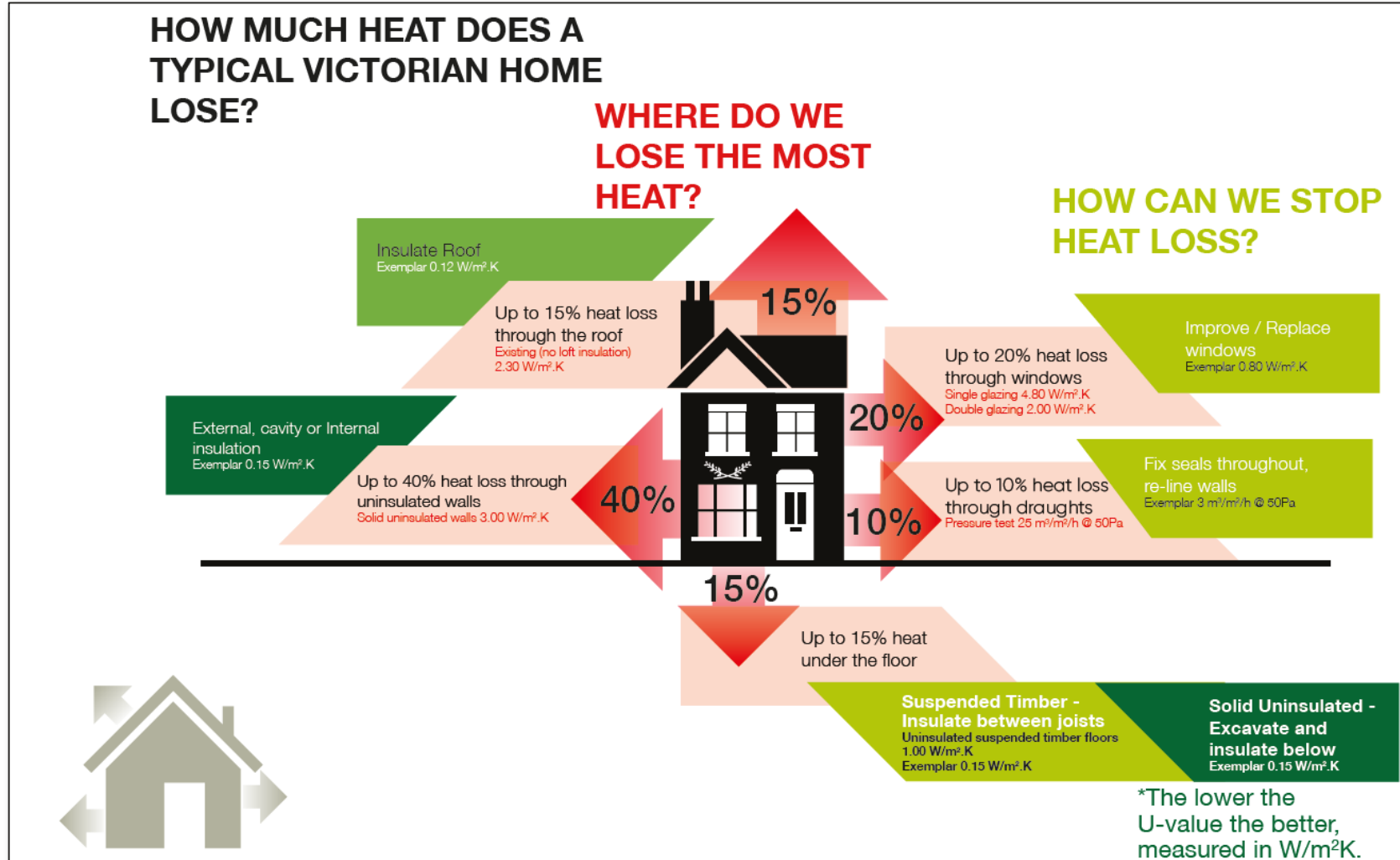


Source: UKGBC – Retrofitting Office Buildings

# RETROFIT NEEDS TO BE THE NORM



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DETAILED GUIDANCE ON IMPLEMENTATION  
OF RETROFIT MEASURES  
BOTH FABRIC AND BUILDING SERVICES

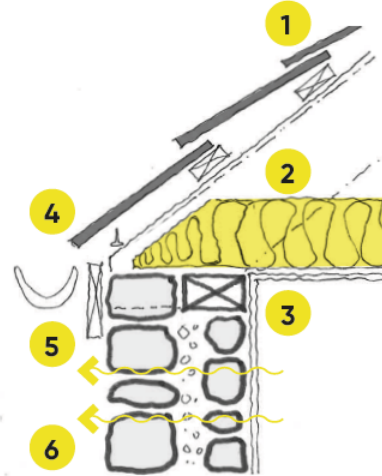


## 4.4 Victorian Granite Detached: Roof - Eaves

Insulation applied internally

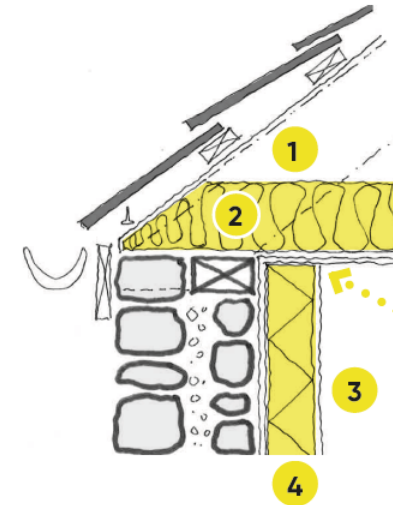
### Typical condition

1. Slate/tiles on battens on roofing felt/membrane.
2. Ventilated roof with insulation at rafter level. Note: some roofs may not be insulated - ventilation conditions may vary.
3. Rafter supported on timber wall plate
4. Rainwater goods fixed to timber fascia board
5. Flush timber fascia board protecting rafter
6. Wall resists moisture penetration by shedding bulk water at the surface and by absorbing, storing, and later releasing moisture via evaporation in dry weather.



### Proposed solution

1. Insulation to be provided in plane of ceiling joists. Replace painted timber fascia fixed to the ends of the rafters and rafter ventilation tray to ensure necessary airflow within roof void.
2. Insulation in ceiling to be continuous with new insulation line on inside of wall. Additional insulation to be added to loft as required (depending on existing amount)
3. Wall to be lined internally with insulation and plasterboard. Path for heat loss removed.
4. Consideration to be given to incorporation of a vapour control layer between the insulation and the plasterboard, especially where vapour closed insulation is used.



### Key points to note

- New internal insulation should ideally be breathable to permit moisture migration through the construction towards the outside.
- Thickness of insulation needs to be considered in relation to the need to permit some of the internal heat energy to get into the solid external wall. This assists in mitigating the risk of interstitial condensation and the gradual increase in moisture within the masonry. U-values of less than 0.4 W/m<sup>2</sup>K require expert input.
- Continuity of insulation between wall plane and ceiling plane is critical to prevent a cold bridge and the resultant risk of condensation and mould growth.
- A full understanding of the roof ventilation air flow is critical to eliminate the risk of condensation within the roof structure located outside of the thermal line.

# RETROFIT NEEDS TO BE THE NORM

This is a guide to start the discussion on retrofit for both homeowners and small contractors.

Homeowners can start to ask for it, and plan it in as they upgrade their homes.

Small contractors feel confident to suggest upgrades as they engage in other works. It focuses on the typical buildings of Devon.

It is free, and released under creative commons.



Mid Century - Cavity detached



Victorian Granite Detached



Victorian Cob House

Mid Century - Semi detached



Target Audience:  
**Homeowners**  
Small  
**Contractors**

# HERITAGE IS NOT A BARRIER – SHREWSBURY FLAX MILL



**RETROFIT HAS TO BE THE PRESUMPTION  
WE ALL NEED TO LEARN TOGETHER**

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**THANK YOU**

JOE JACK WILLIAMS

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