UNIVERSITY OF CAMBRIDGE

UNIVERSITY OF BATH

Energy Cost Metric – methodology to reduce Whole Life Energy in Construction

re·c·be

Friday, 29th January 2021

Civil Engineering Building

GRIMSHAW

smithandwallwork engineers

RAMBOLL

MAX FORDHAM

AECOM

sdc

MAX FORDHAM

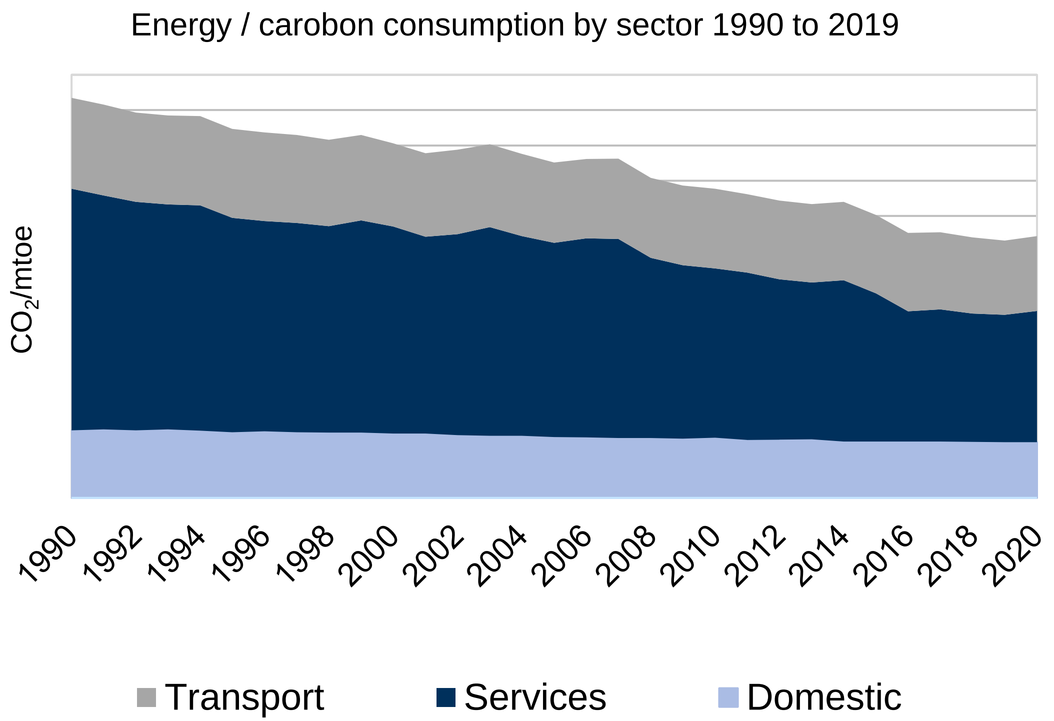
Size: 4,000 sqm, 3 storeys

Started: September 2017
Completted : May 2019
Construction Cost: £ 18M

BREEAM 'Excellent'.

www.sdc.co.uk

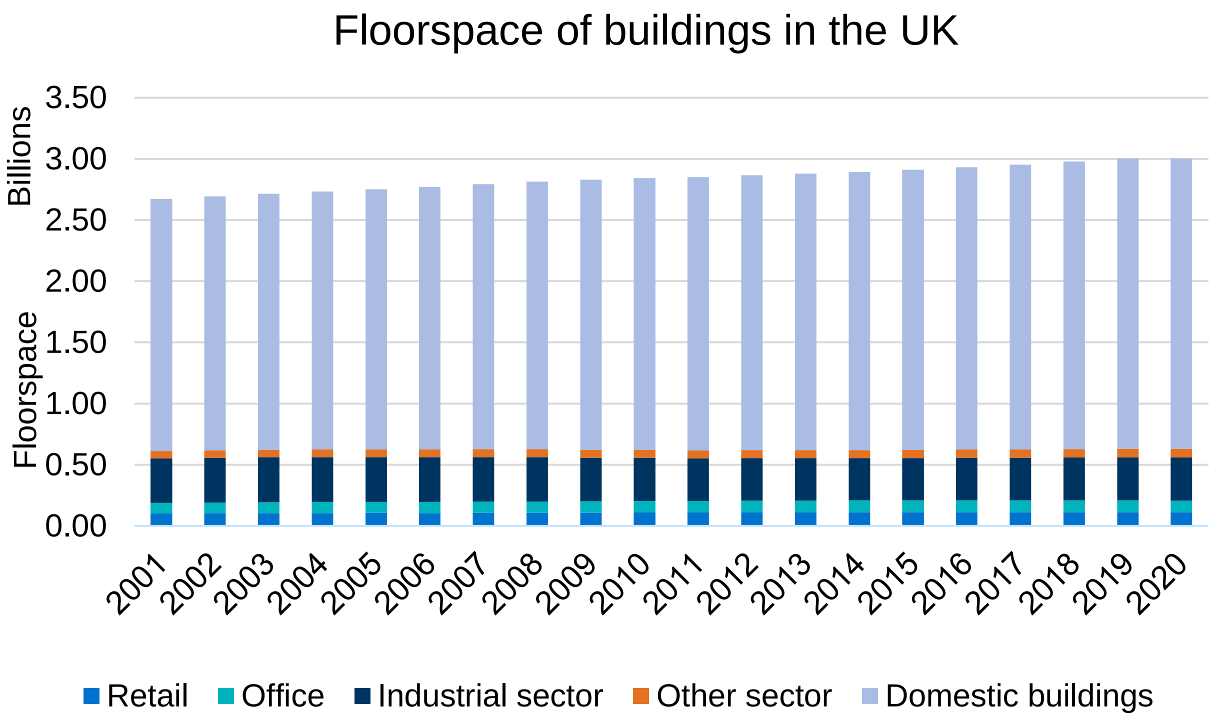
Motivation



Services - agriculture, public administration and commercial

Energy Consumption in the UK (ECUK), BEIS 2019

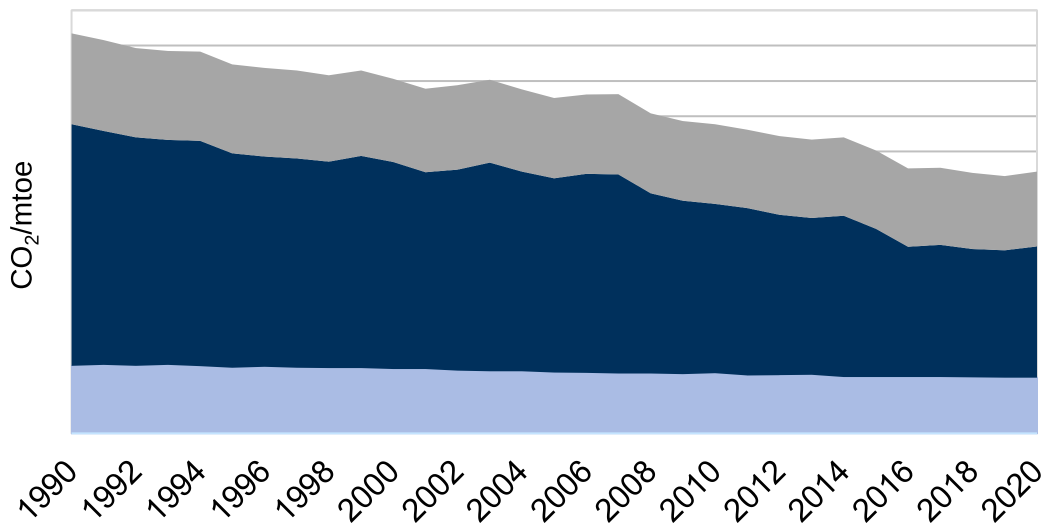
Provisional UK greenhouse gas emissions national statistics BEIS 20120



Non-domestic rating: Stock of properties including business floorspace, VOA
Live tables on dwelling stock, MHCLG
England and Wales values scaled up to UK by population

Motivation

Energy / carobon consumption by sector 1990 to 2019



Services - agriculture, public administration and commercial

Energy Consumption in the UK (ECUK), BEIS 2019

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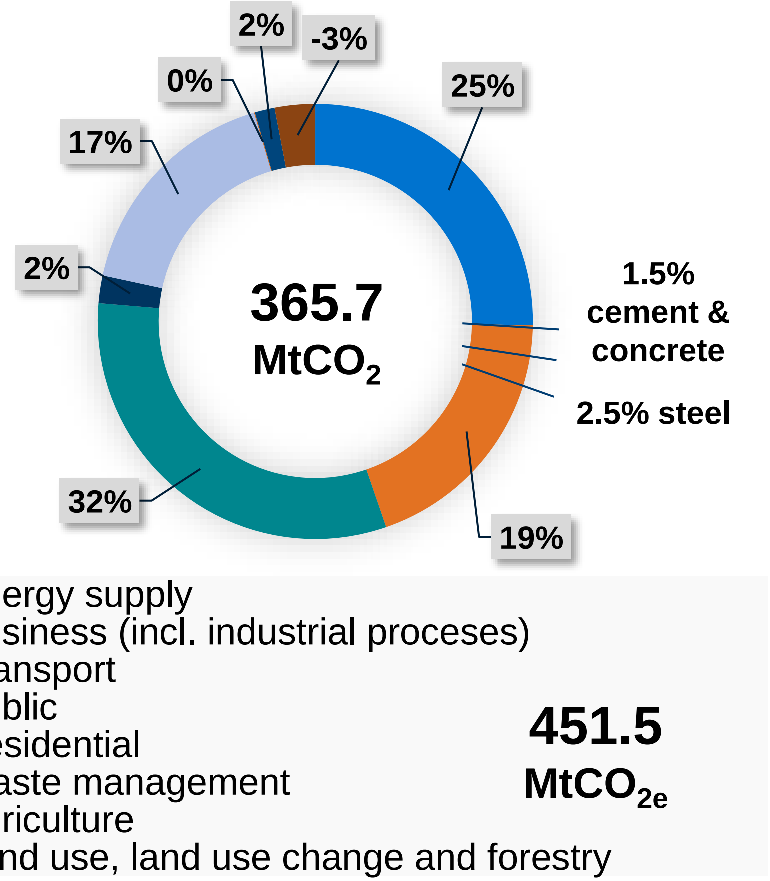
UK annual CO2 emissions (2018)



Motivation

Energy minimisation - the default solution towards minimising emissions.

ECM

19 March 2015

Energy Brief by David MacKay
“Very-low-energy; pleasant; zero-bling; upgradeable; and well measured.”

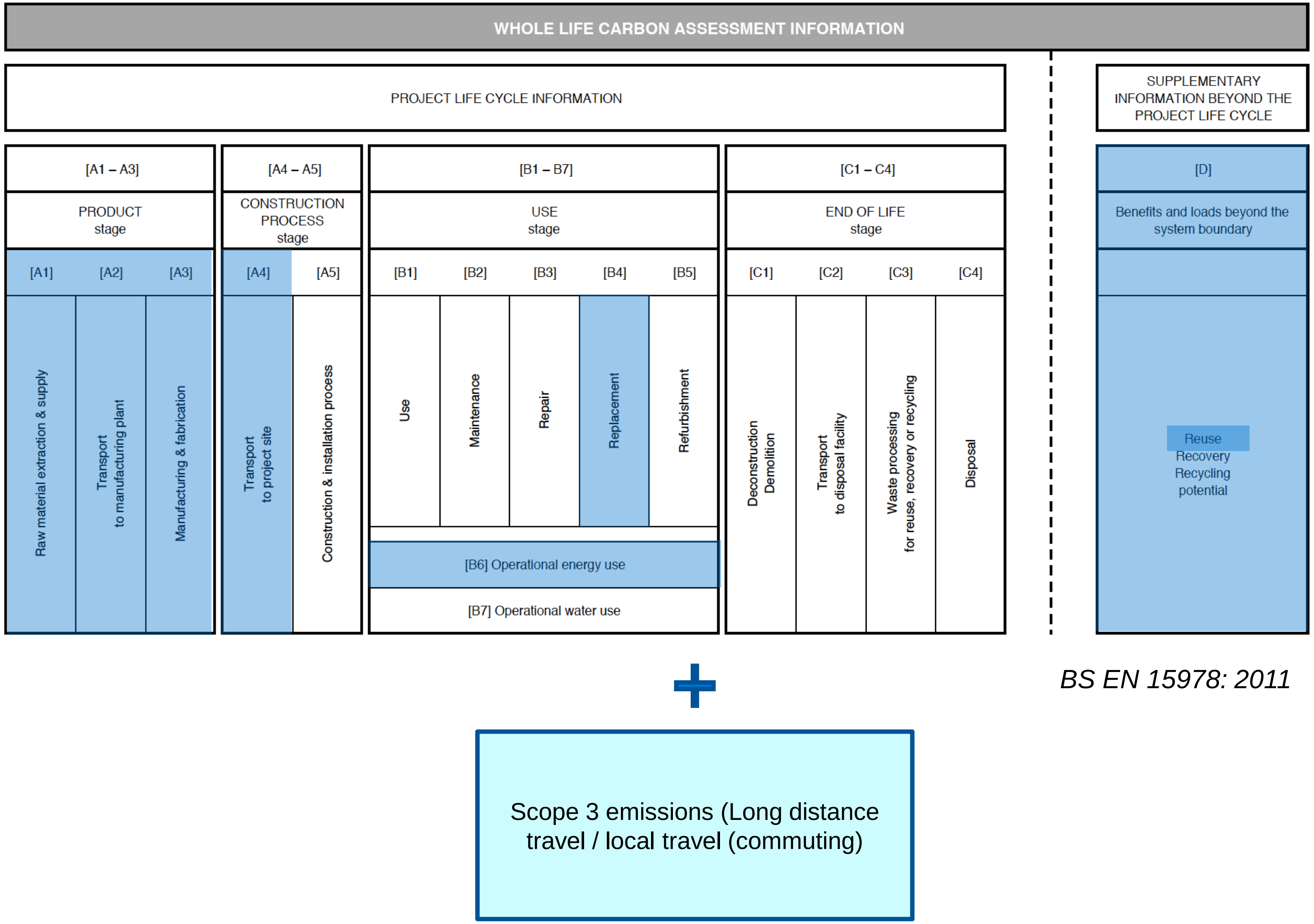
$$F = E + C/\alpha$$

E the annual whole-life energy (kWh/yr)

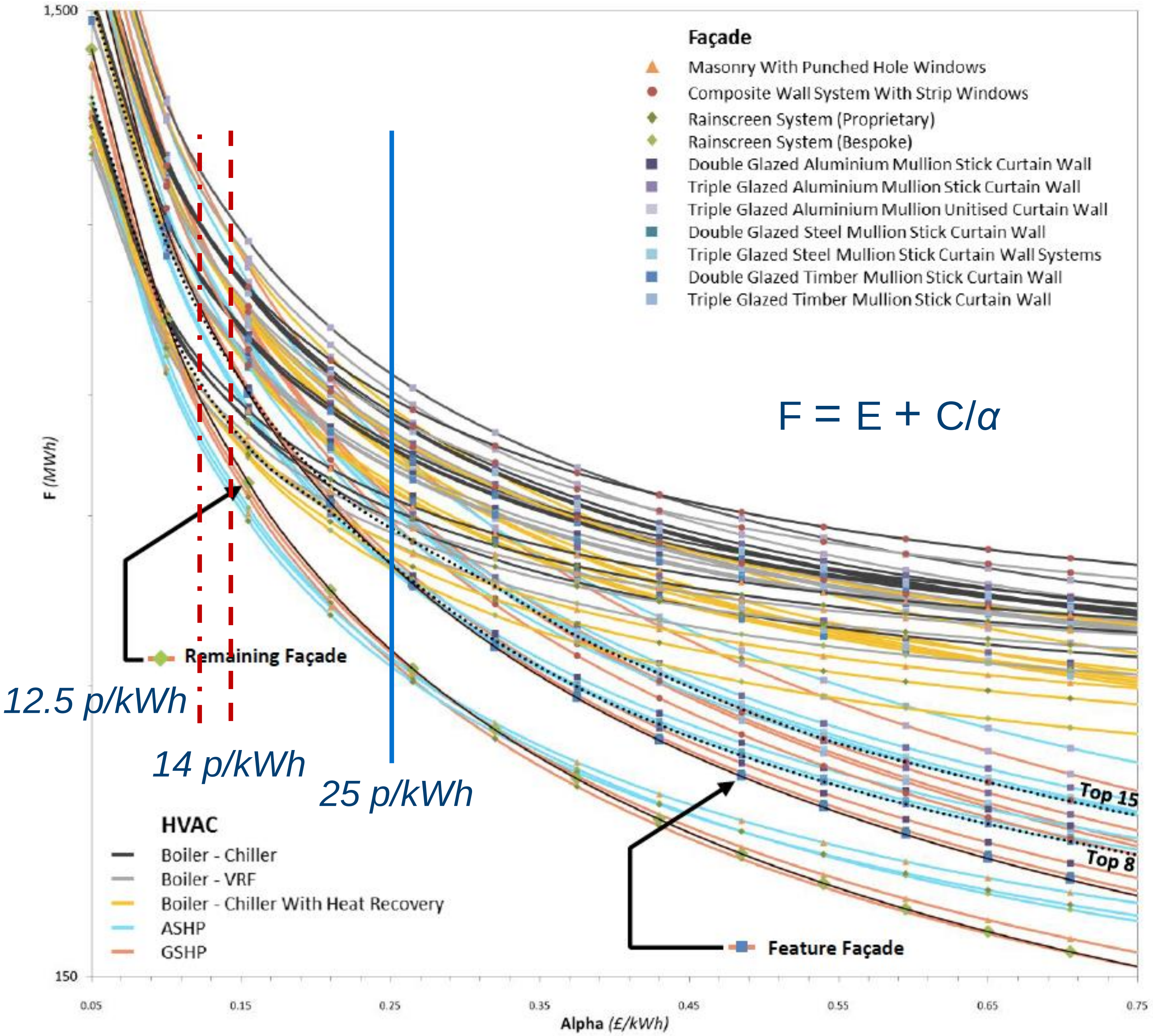
C the building cost (£/yr)

α a value of energy weighting (£/kWh)

50 years



BS EN 15978: 2011



"It is necessary to decide on and set a value of α"

Value α is a weight

"An absolute minimum justifiable value for α would be the average future expected retail price of energy to the University (e.g. 12.5 p/kWh or so); that might be appropriate if we did not care about sustainable resource use or climate change action"

"cost should be factored into ethical decision-making to achieve carbon neutralization"

"society should put a higher price on energy, especially unsustainably sourced"

$\alpha = 25p/kWh$

ECM

ECM is a methodology that **connects the most energy intensive** whole-life components with the (project + operational) cost

min | max | min | min

embodied energy

- **structure**
- **façade**

energy credit for future reuse

measured energy in-use

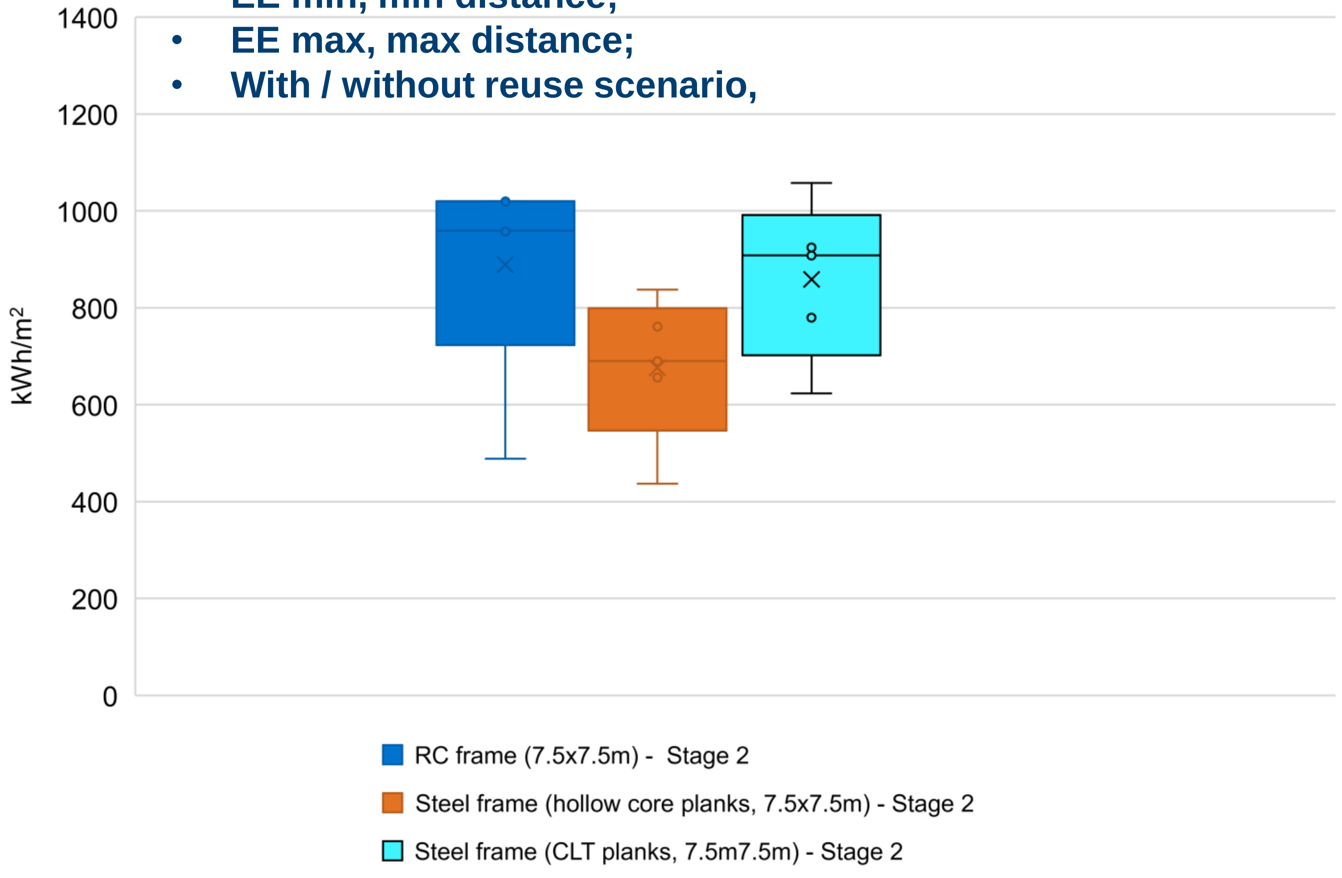
transport

- **material transport (to and from site)**

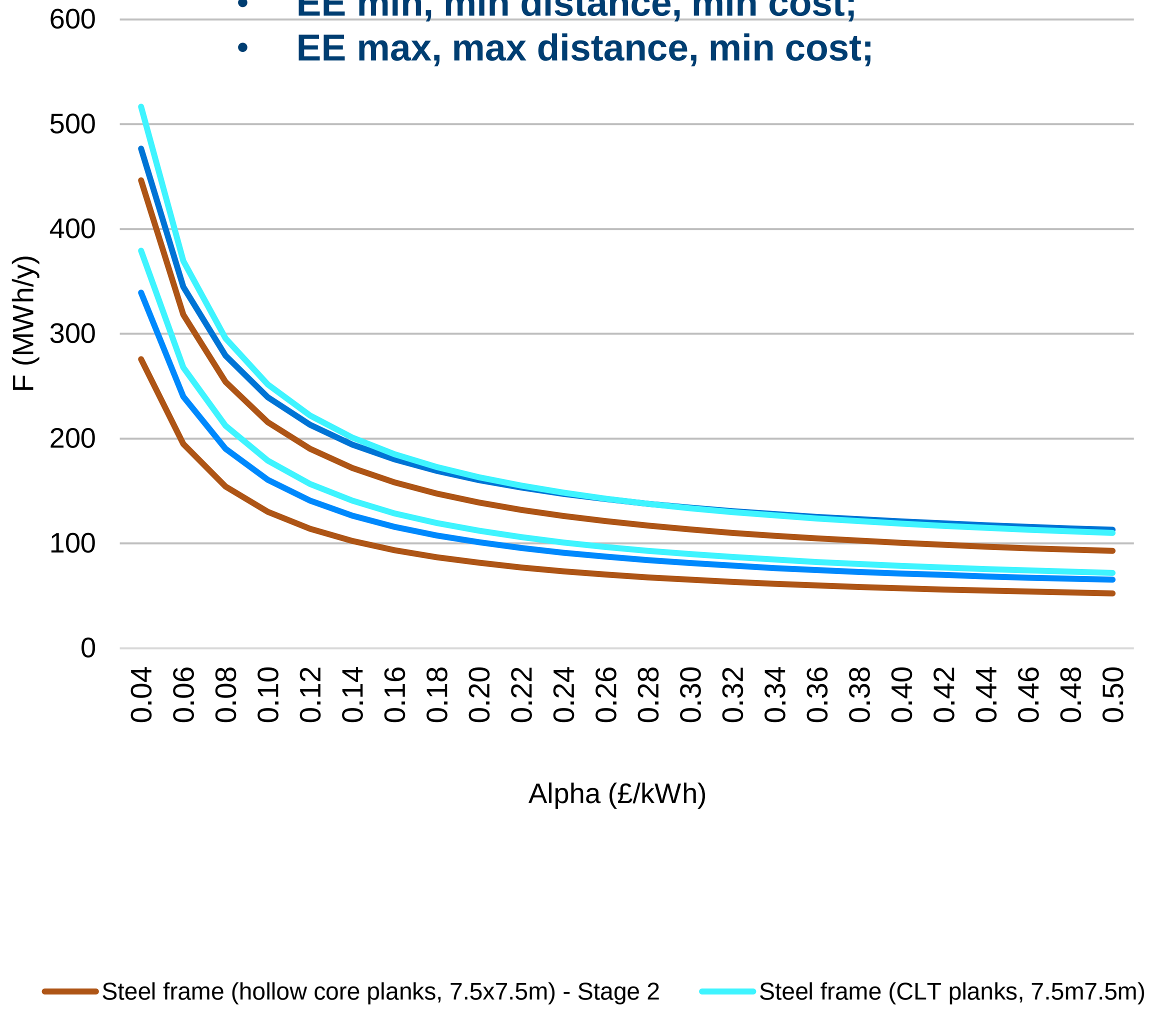
Structure

Structure

- **EE min, min distance;**
- **EE max, max distance;**
- **With / without reuse scenario,**

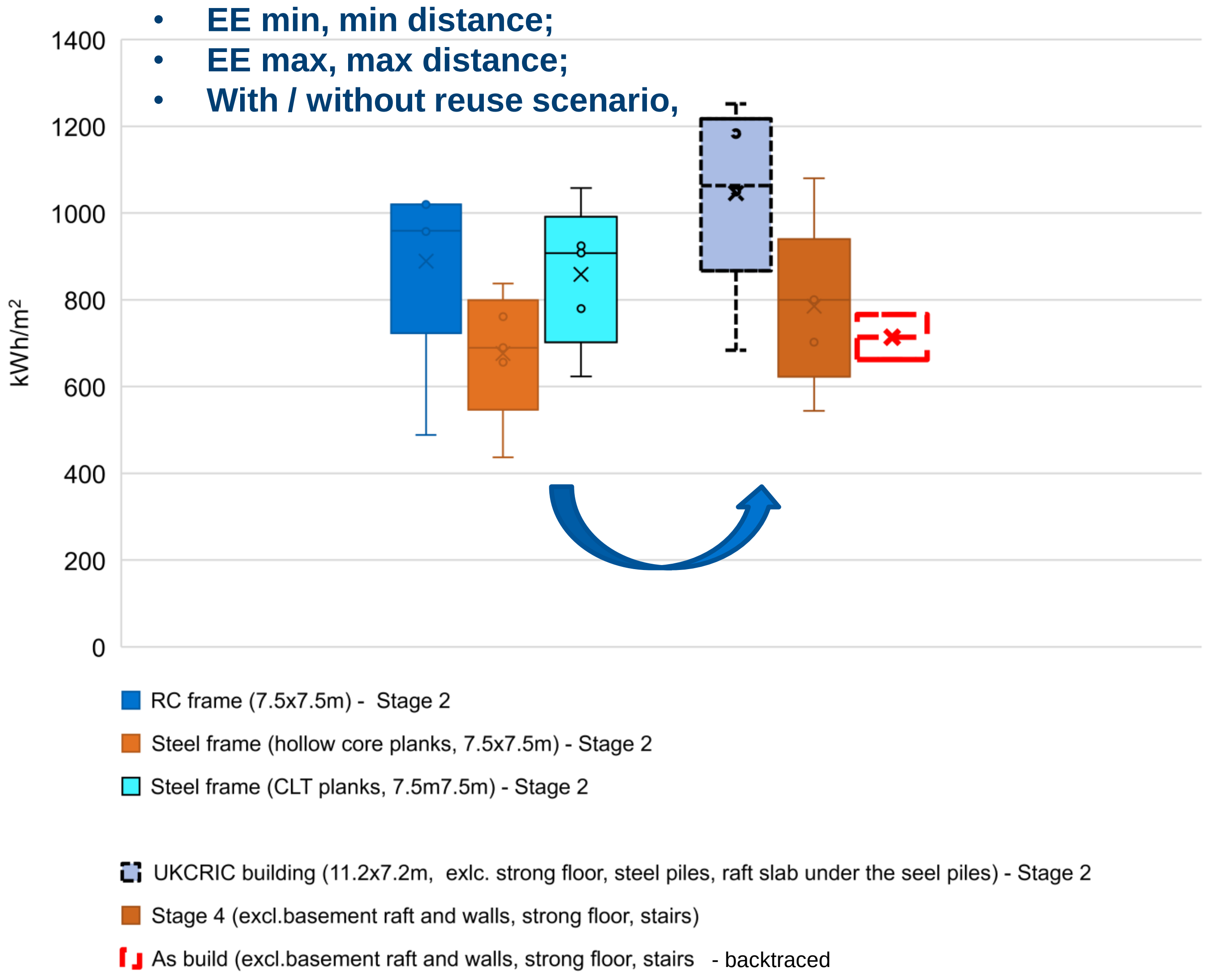


- **EE min, min distance, min cost;**
- **EE max, max distance, min cost;**

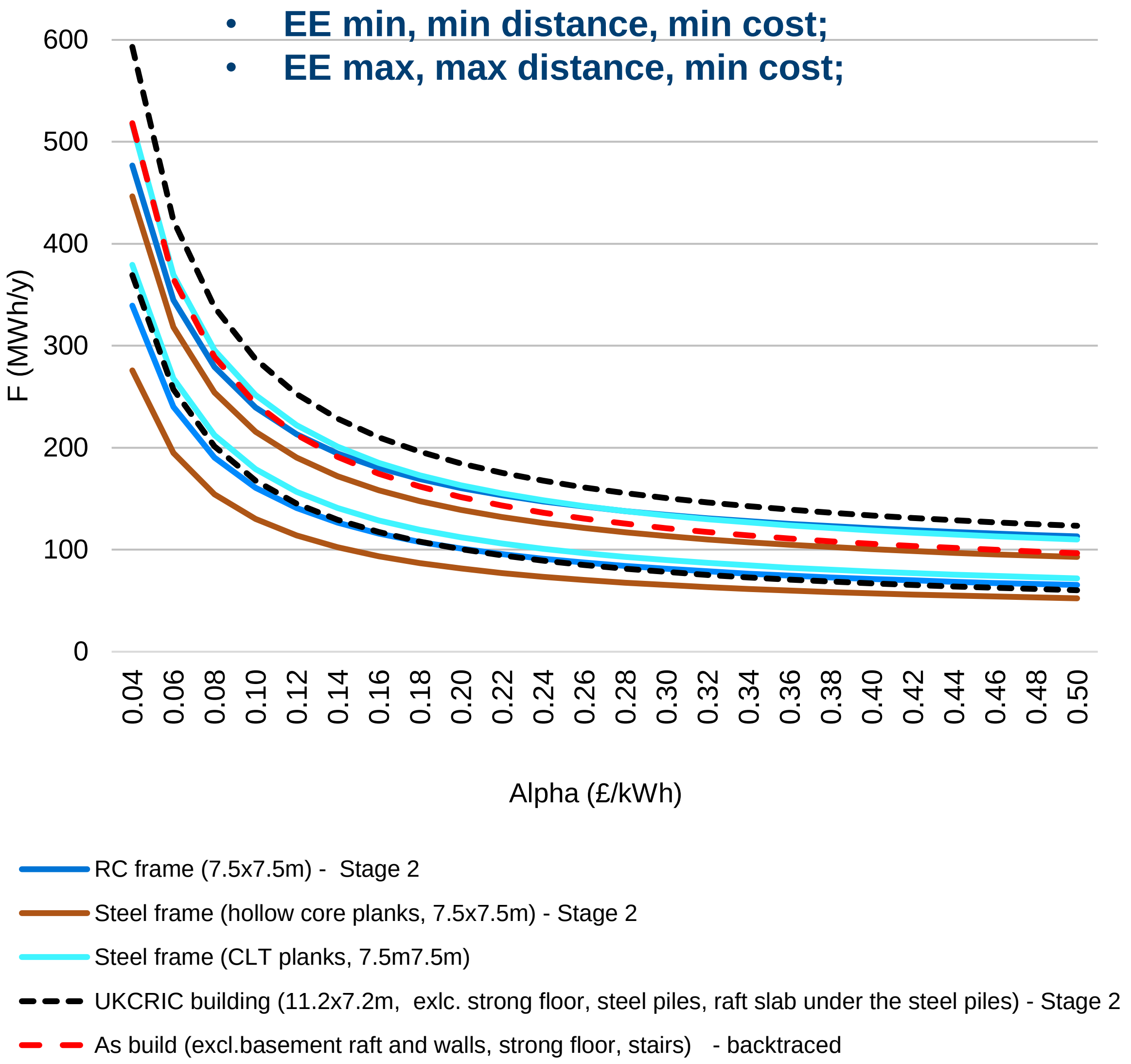


EE values – ICE 2.0

Structure



• EE min, min distance;
• EE max, max distance;
• With / without reuse scenario,
1400
1200
1000
800
600
400
200
0
kWh/m²
RC frame (7.5x7.5m) - Stage 2
Steel frame (hollow core planks, 7.5x7.5m) - Stage 2
Steel frame (CLT planks, 7.5m7.5m) - Stage 2
UKCRIC building (11.2x7.2m, exlc. strong floor, steel piles, raft slab under the seel piles) - Stage 2
Stage 4 (excl.basement raft and walls, strong floor, stairs)
As build (excl.basement raft and walls, strong floor, stairs - backtraced



• EE min, min distance, min cost;
• EE max, max distance, min cost;
600
500
400
300
200
100
0
F (MWh/y)
0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28 0.30 0.32 0.34 0.36 0.38 0.40 0.42 0.44 0.46 0.48 0.50
Alpha (£/kWh)
RC frame (7.5x7.5m) - Stage 2
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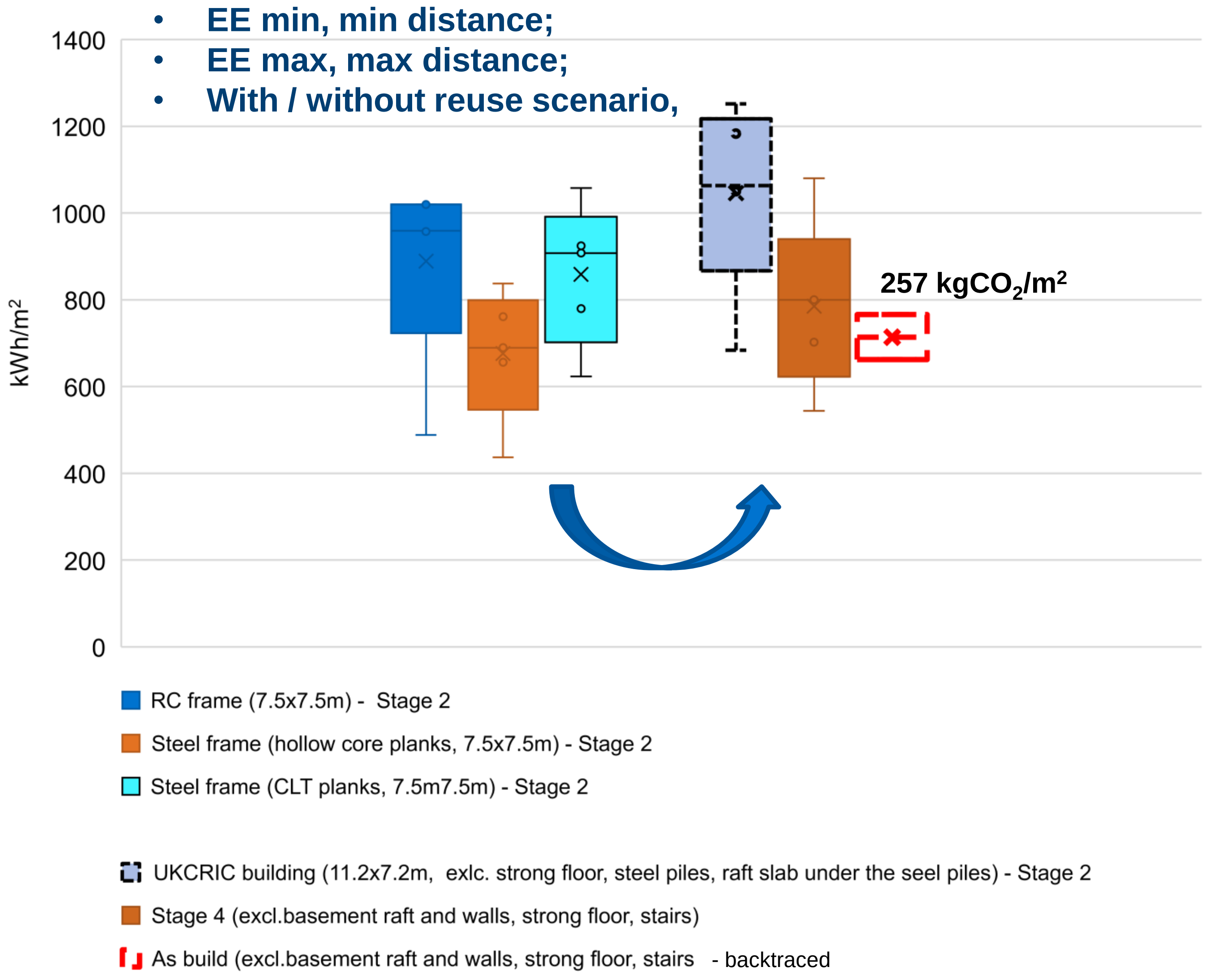
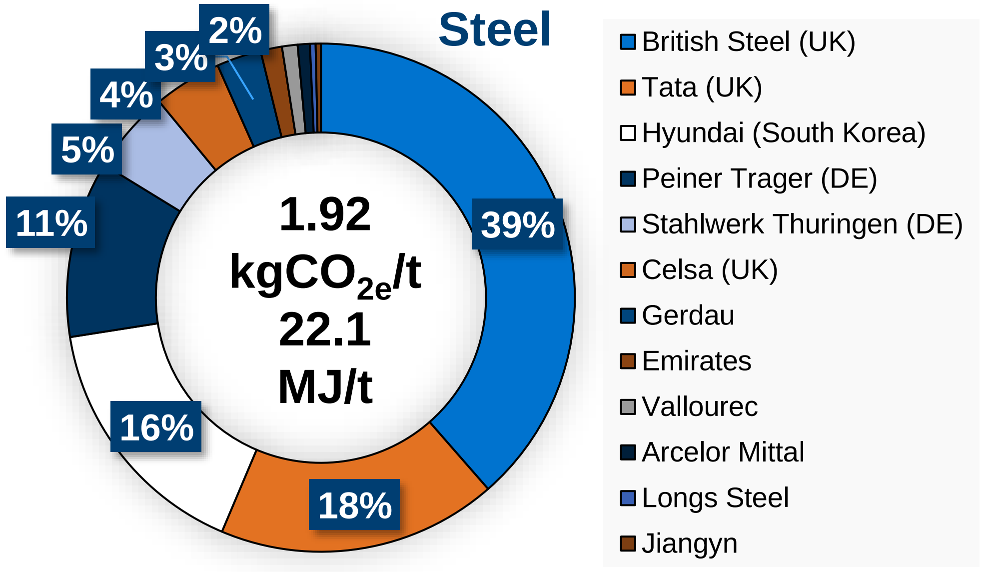
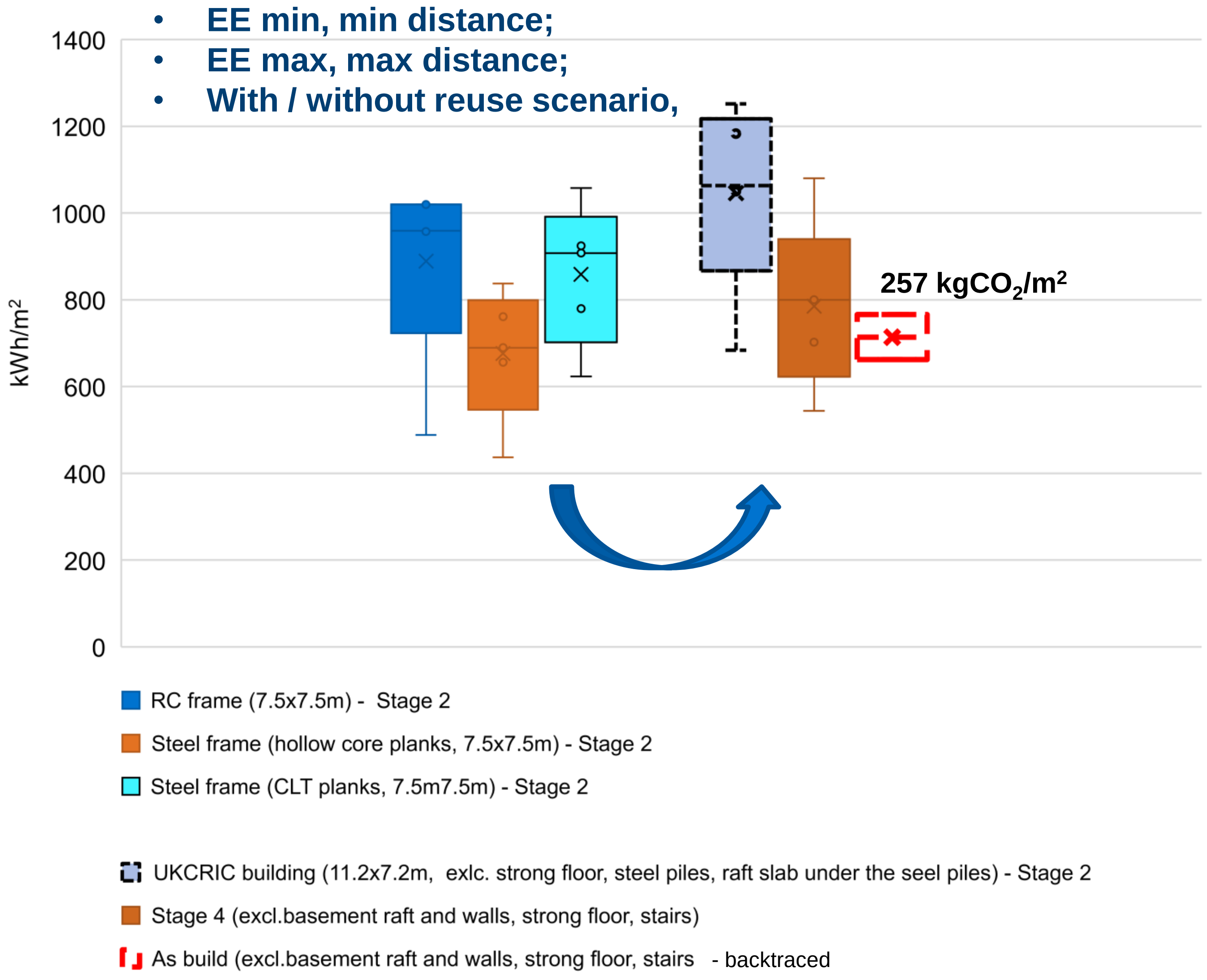
Structure





Reinforcement – EAF, Spain

Structure



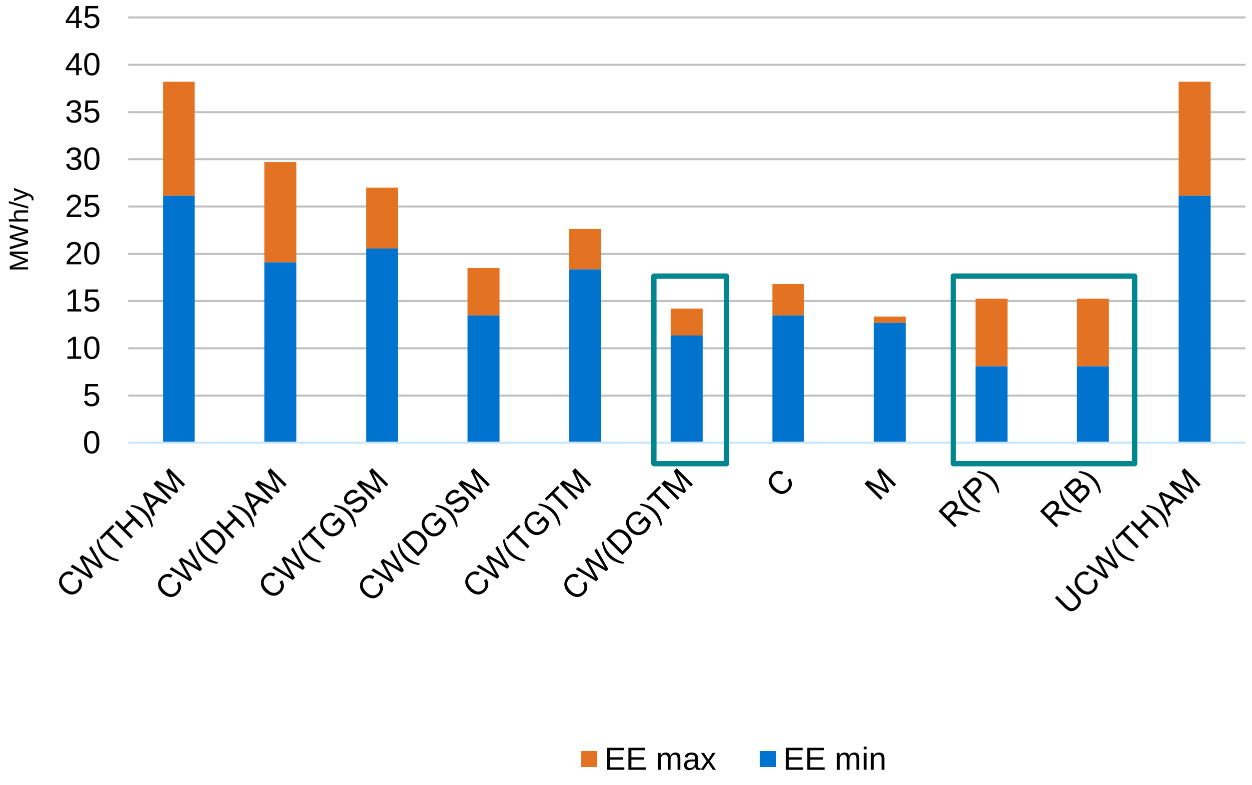
"Energy credit for embodied energy that will credibly be reclaimed"

	Stage 2	Stage 2 (UKCRIC bespoke planks)	As build
Concrete (in situ)	0	-	0
Concrete (prestressed)	10%	0;100%	0
Structural steel	25%	35%,100%	45%
Glulam Timber	25%	-	-

Façade

Façade

- **EE min, max**

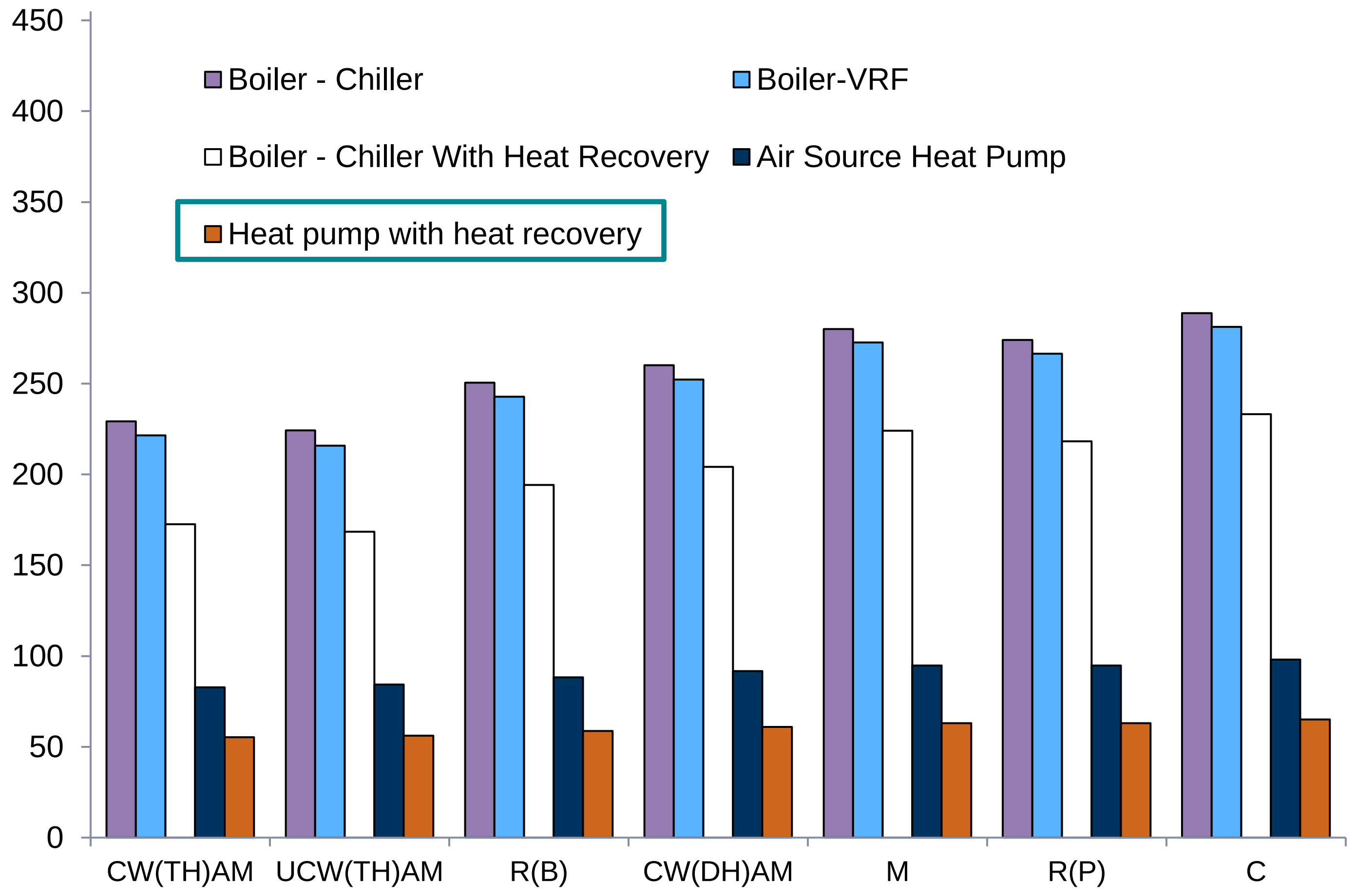


50 years

CW(TH)AM	(AM) Stick curtain wall systems (triple glazed)
CW(DH)AM	(AM) Stick curtain wall systems (double glazed)
CW(TG)SM	(SM) Stick curtain wall systems (triple glazed)
CW(DG)SM	(SM) Stick curtain wall systems (double glazed)
CW(TG)TM	(TM) Stick curtain wall systems (triple glazed)
CW(DG)TM	(TM) Stick curtain wall systems (double glazed)
C	Composite wall system with strip windows
M	Masonry with punched hole windows
R(P)	Rainscreen systems (proprietary)
R(B)	Rainscreen systems (bespoke)
UCW(TH)AM	Unitised curtain wall systems

Heating ang cooling

Operational energy



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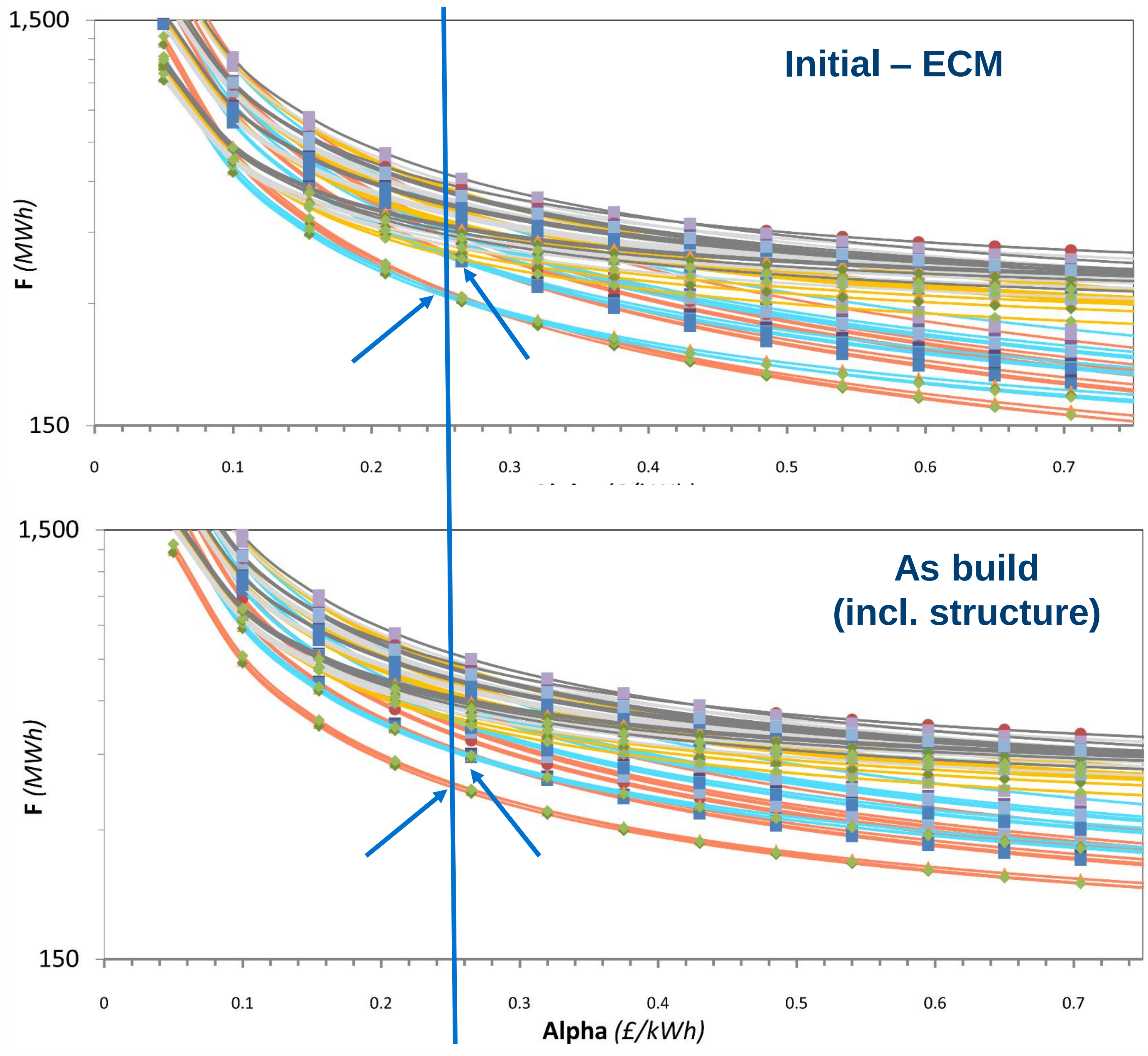
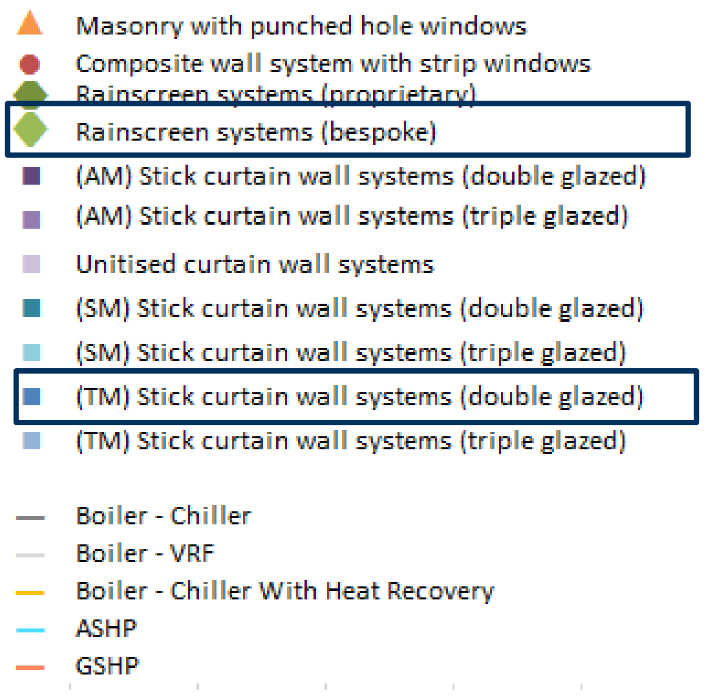
Results

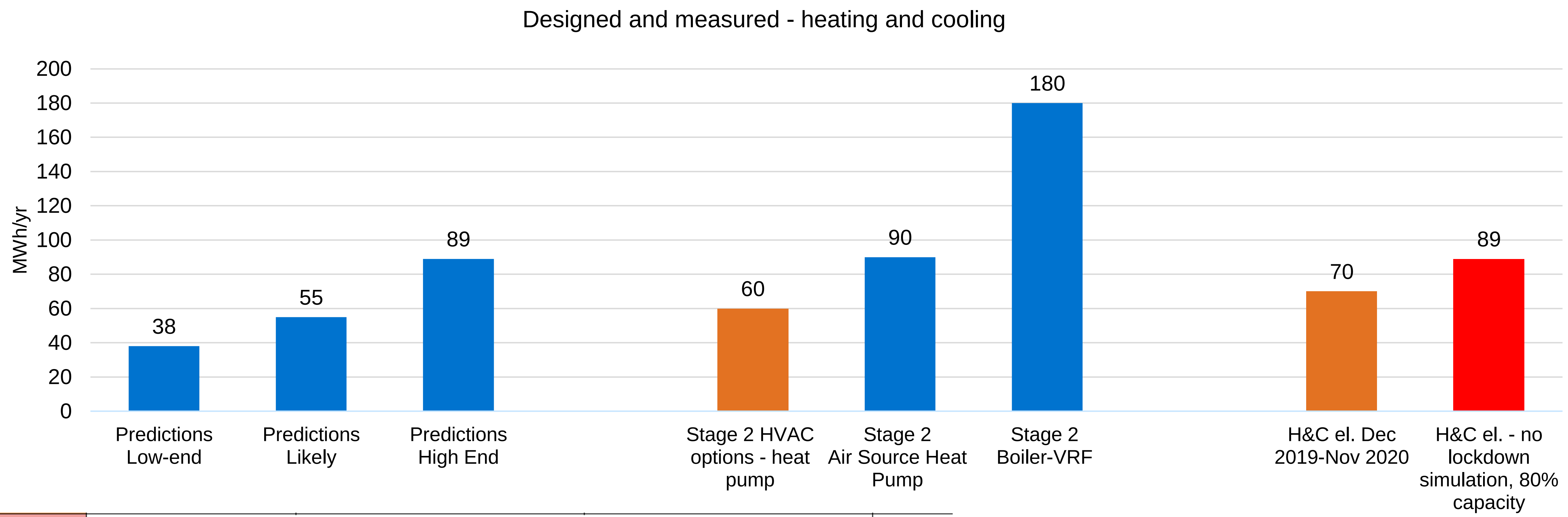




GSHP
+
Rainscreen system
or
masonry

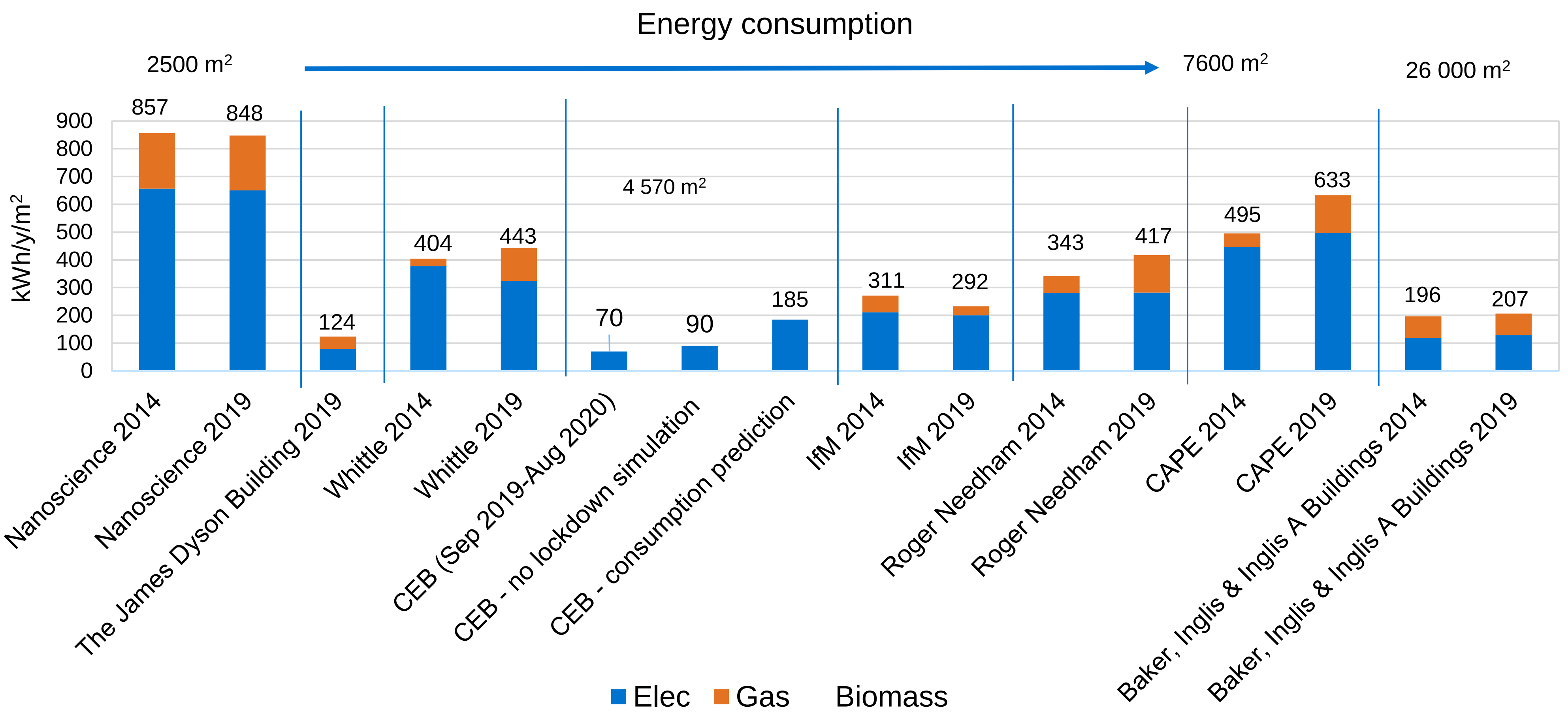
Measured values

Operation Energy



○ **Heating/Cooling**	Part L *(38 MWh/yr)*	Airtightness=3m^3/m^{2}h@50Pa U-value=0.65W/m^{2}K 3/4 quoted HVAC efficiency *(55 MWh/yr)*	Airtightness=3m^3/m^{2}h@50Pa U-value=0.95W/m^{2}K 2/3 quoted HVAC efficiency *(89 MWh/yr)*	13%

Operation Energy



Conclusions

Miminising energy, we minimise emissions

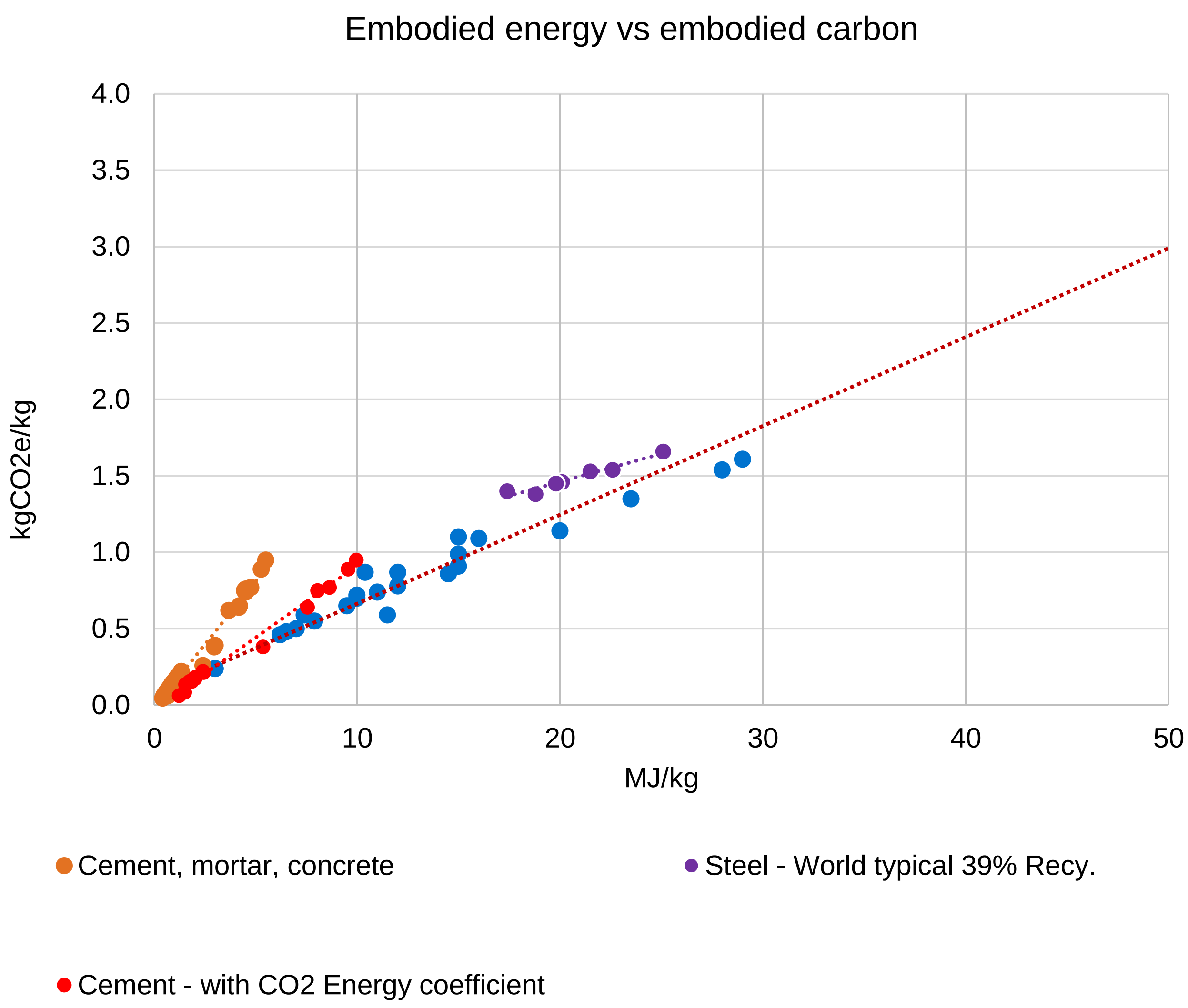
ECM allows to design low embodied and operational energy building (within the accepted limits)

ECM allows to combine whole life energy and cost

Expanding the boundaries will increase the impact

Values transparency (energy / cost) is critical

We can find a correlation between embodied energy and embodied carbon – even for cement using CO2 energy coefficient



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