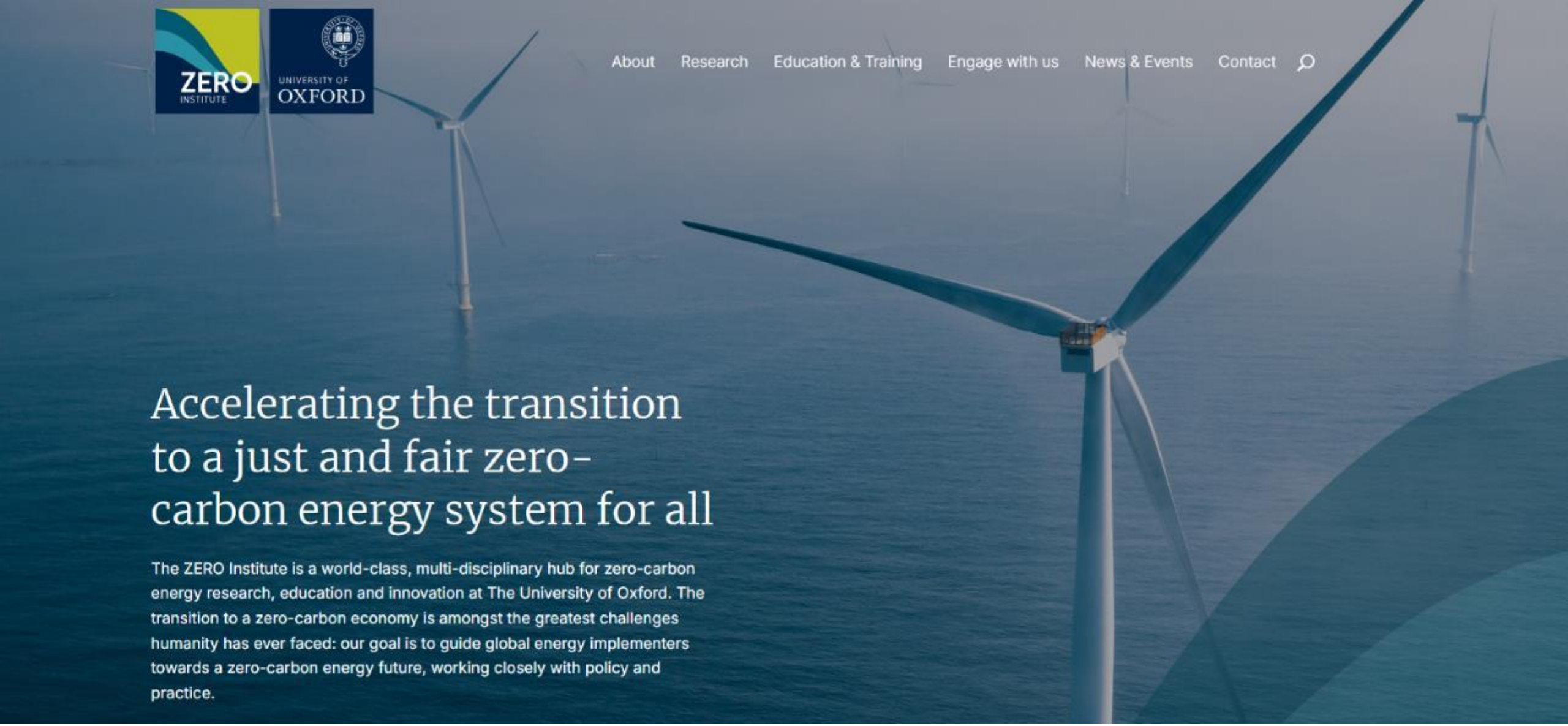
Beyond best practice: technological innovation and future standards for real-world net-zero carbon buildings

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Content

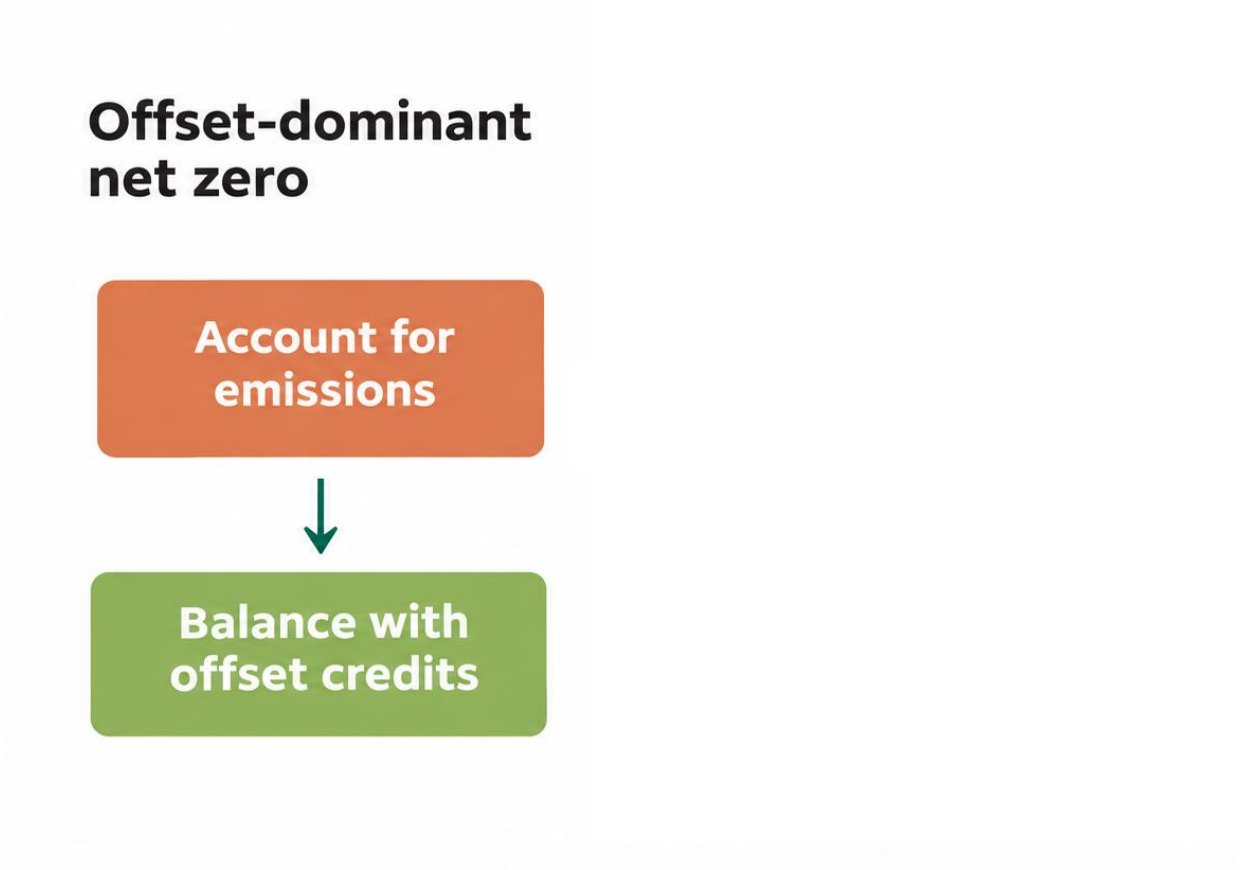
1. Introduction
2. Definition of net zero carbon buildings
3. Current best practise performance
4. Expert insights on the challenges and the opportunities
5. Panel discussion

What is a ‘Net Zero Carbon Building’?

Definitions of Net Zero Carbon Buildings

Institutions		Terms:
UKGBC (Green Building Council) - 2019	→	Net Zero Carbon Buildings Framework
European Union (EPBD, EU) – 2024	→	*Zero-emission buildings (ZEBs)*
US National Definition of a Zero Emissions Building (USNDZEB) - 2024	→	ZERO emissions Buildings (ZEBs)
China, the National technical standard for Zero Carbon Buildings (CNTSZCB)	→	Zero Carbon Buildings
Canada Green Building Council	→	Zero Carbon Buildings
UK NZCBS Standard - 2026	→	*Net Zero Carbon Buildings*

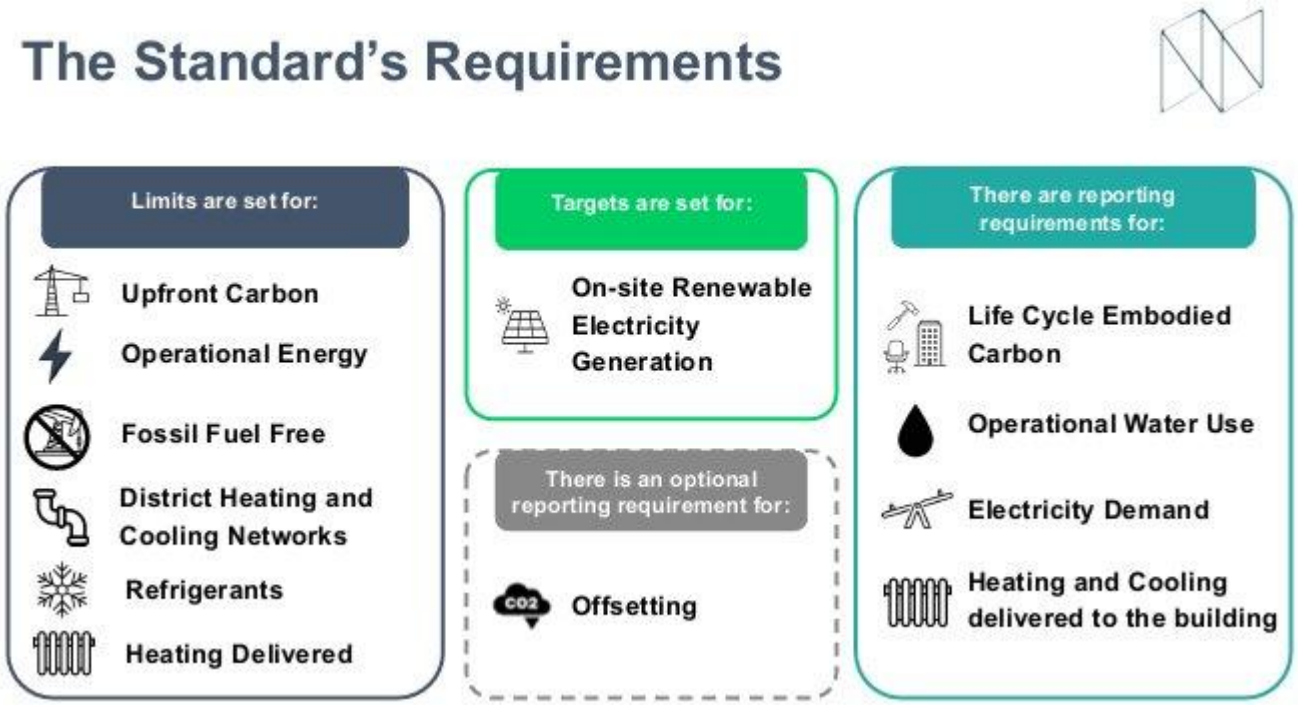
The Evolving Definition of NZCB



Chu, Y et al., (2026). From policy contexts to compliance pathways: A review of practical definitions of net-zero carbon buildings. Energy and Buildings, 373, 118318. https://doi.org/10.1016/j.enbuild.2026.118318

UK Net Zero Carbon Building Standard

- **Published in April 2026 to create a roadmap in terms of meeting the built environment's carbon and energy commitments.**





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UK Net Zero Carbon Building Standard

Annex A: Limits and targets

A1 Embodied carbon limits

Table EC-1 Upfront carbon limits, New Works

← Date of Commencement (see section 4.2.6)	Commercial Residential	Culture & Entertainment		Data Centres	Healthcare	Higher Education	Homes		Hotels	Offices			Retail	School	Science & Technology	Sport & Leisure	Storage & Distribution	
	All subsectors	Performance	Collection / Archives	All subsectors	All subsectors	All subsectors	Single family homes	Flats	All subsectors	Whole building	Shell and core + Cat A	Shell and core	All subsectors	All subsectors	All subsectors	All subsectors	Whole building	Shell and core
	kgCO$_2$e/m^{2}GIA																	
2025	580	855	570	745	790	640	430	565	670	805	595	520	715	585	755	820	635	415
2026	550	810	540	705	750	610	400	525	635	765	565	495	680	555	715	780	605	395
2027	525	770	515	670	710	575	375	490	605	725	535	470	645	530	680	740	570	375
2028	495	725	485	635	670	545	345	450	570	685	505	440	610	495	640	695	540	355
2029	465	685	460	600	635	515	320	420	540	645	475	415	575	470	605	660	510	330
2030	435	640	425	555	590	480	290	380	500	595	440	385	535	435	565	610	475	305
2031	405	595	400	520	550	445	270	355	470	565	415	365	500	405	525	575	445	290
2032	380	560	375	490	515	420	255	335	440	525	385	340	470	385	495	535	415	270
2033	350	510	340	445	475	385	235	305	400	485	355	310	430	350	450	490	380	250
2034	315	465	310	405	430	350	210	280	365	435	320	280	390	315	410	445	345	225
2035	285	420	280	365	390	315	190	250	330	395	290	255	350	280	370	405	315	205

Building Typology

Date of limit commencement

Limits set by the standard

Takeaway Messages

A net zero carbon building, does not mean being net zero now, **but to prepare to becoming one.**

It is **specific** to the **local context**, **policy frameworks**, and **challenges**.

Defining Net Zero Carbon Buildings is an **evolving concept.**

Are Best Practise Good Enough?

Is Best Practice Good Enough? – Acknowledgement





Jessica Ibanes

MSc in Energy Systems (2024 -2025)

Supervised by Prof. Jesus Lizana

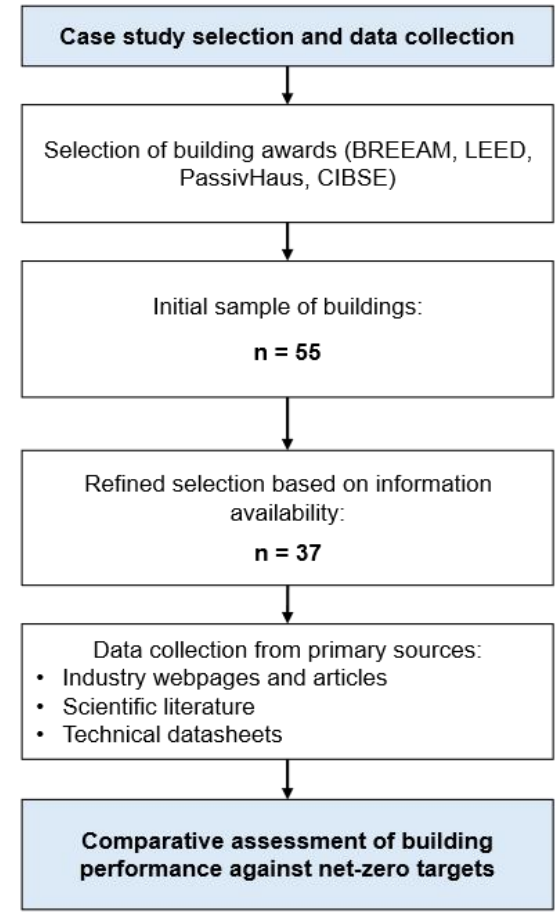
Title: Best practices and innovations in the heating sector to achieve net zero buildings by 2035 and 2050

Case Study Selection

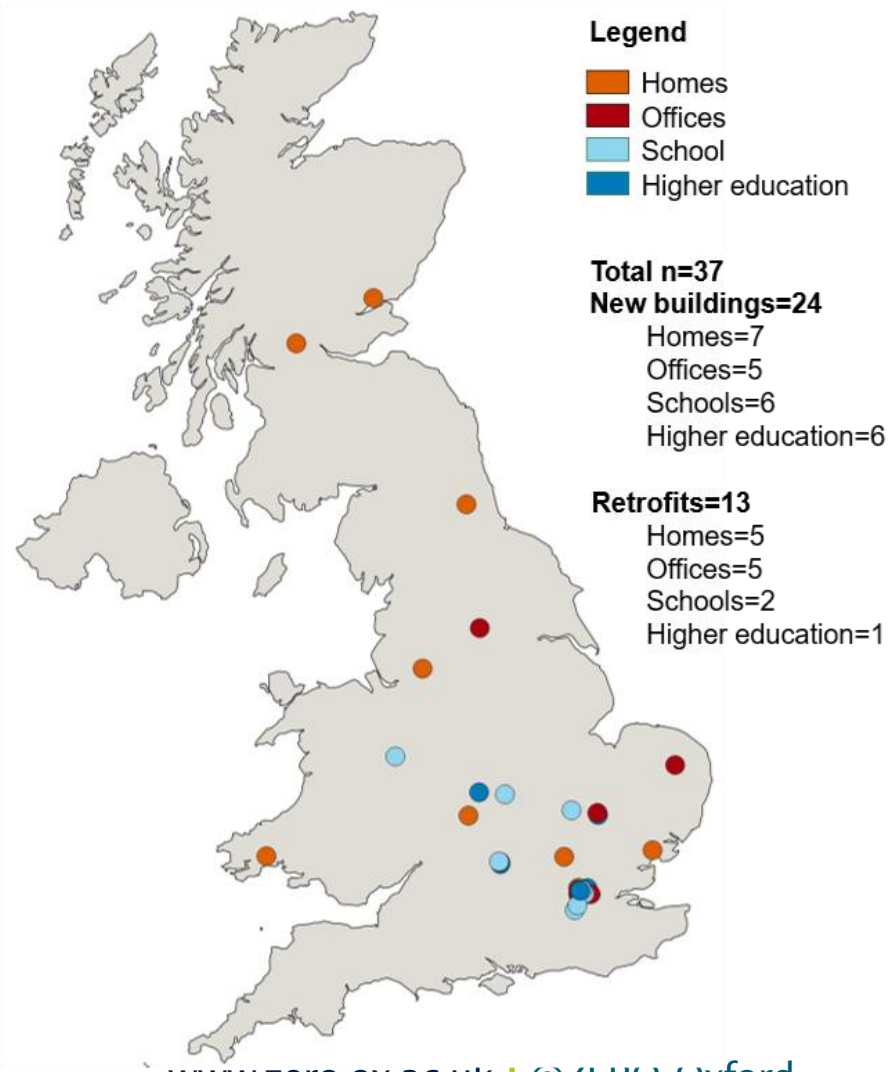
Energy use intensity (kWh/m² GIA/yr):

Upfront embodied carbon (kgCO₂e/m² GIA

a)



b)



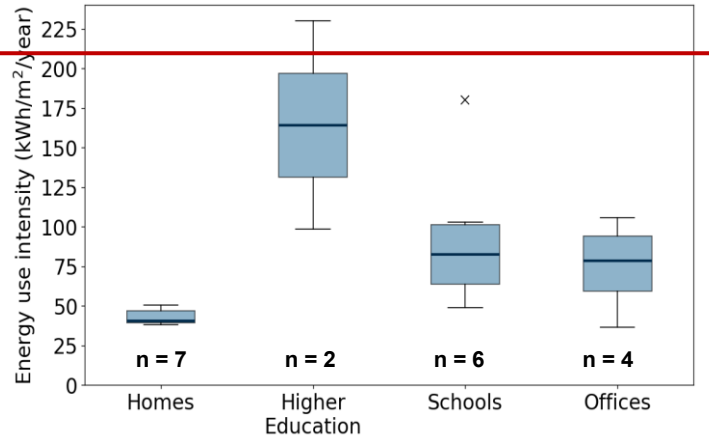
Based on work by Jessica Ibanes MSc Dissertation

Distribution of Case Studies

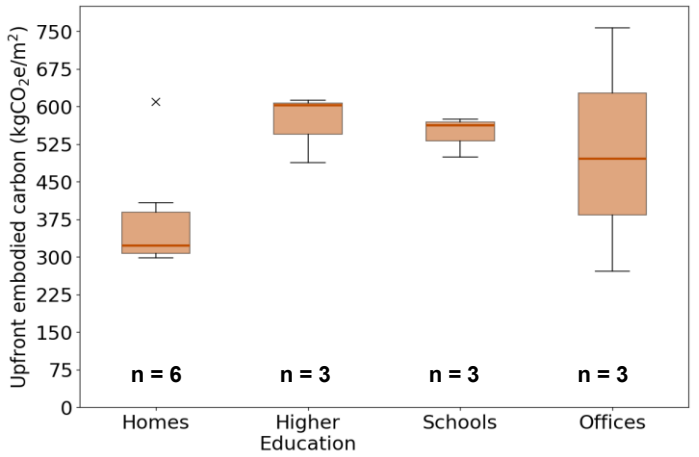
Legacy building median[1] / average[2]

New Buildings

(a.1)

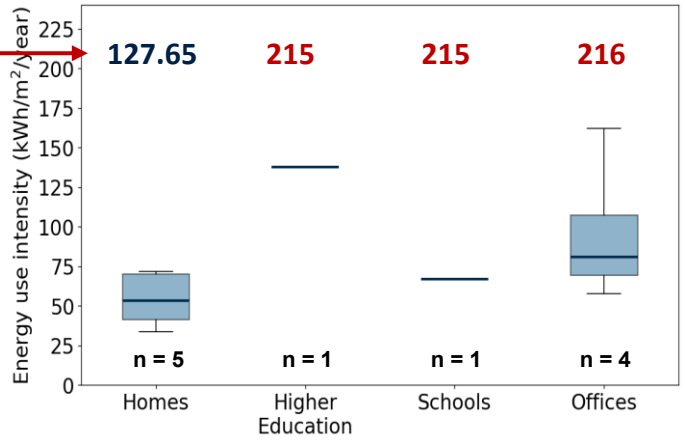


(b.1)

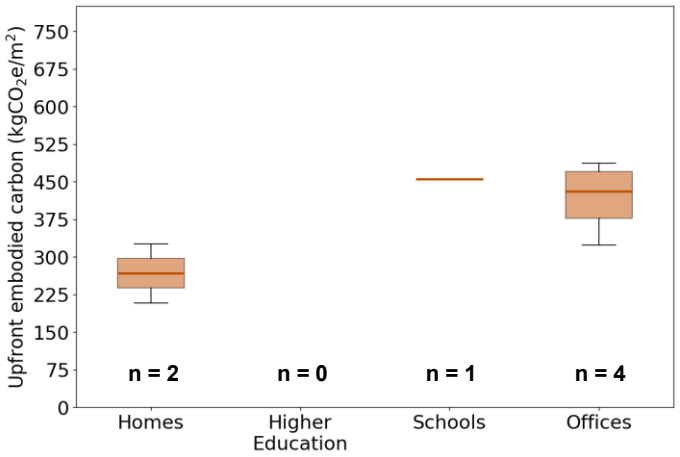


Retrofits

(a.2)



(b.2)

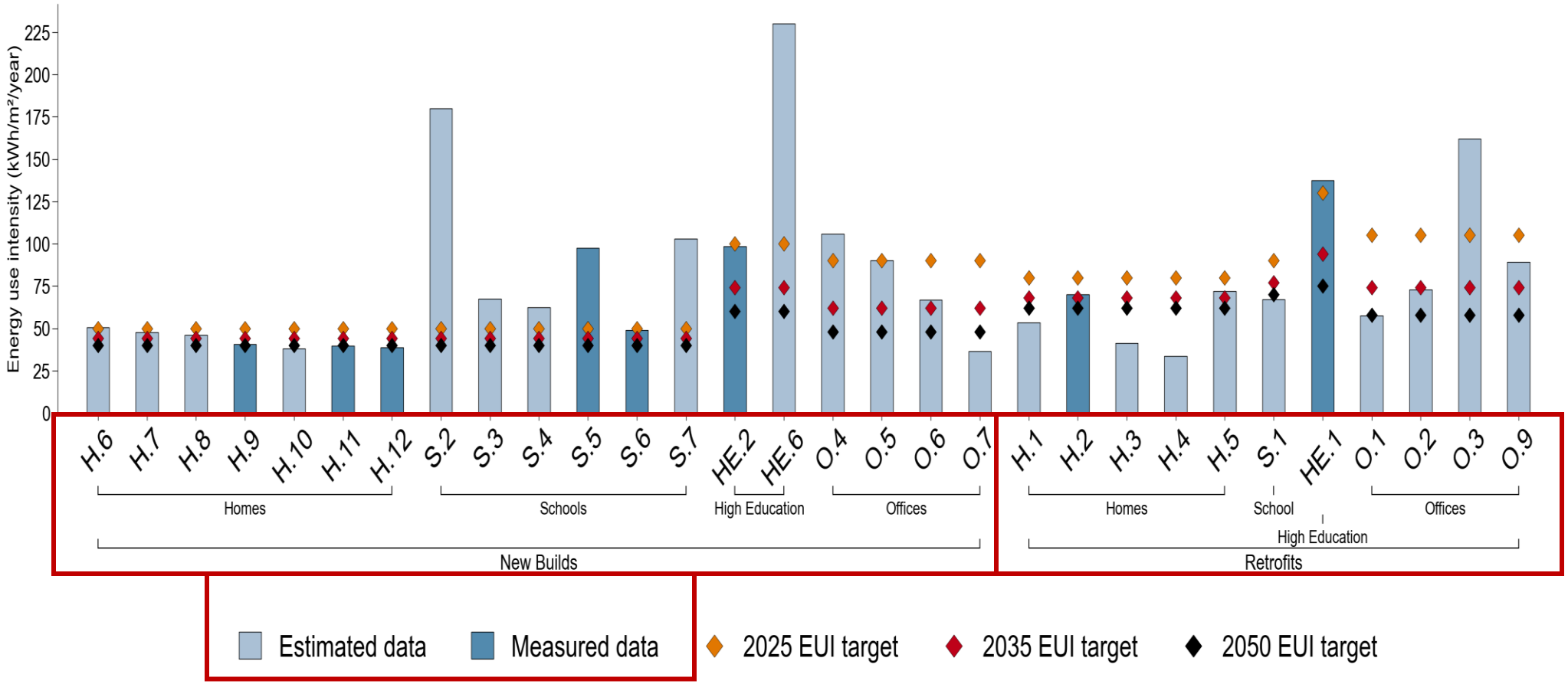


[1]DESNZ (2025) The Non-Domestic National Energy Efficiency Data-Framework 2025 (England and Wales).

[2]Ofgem (2026) Review of typical domestic consumption values.

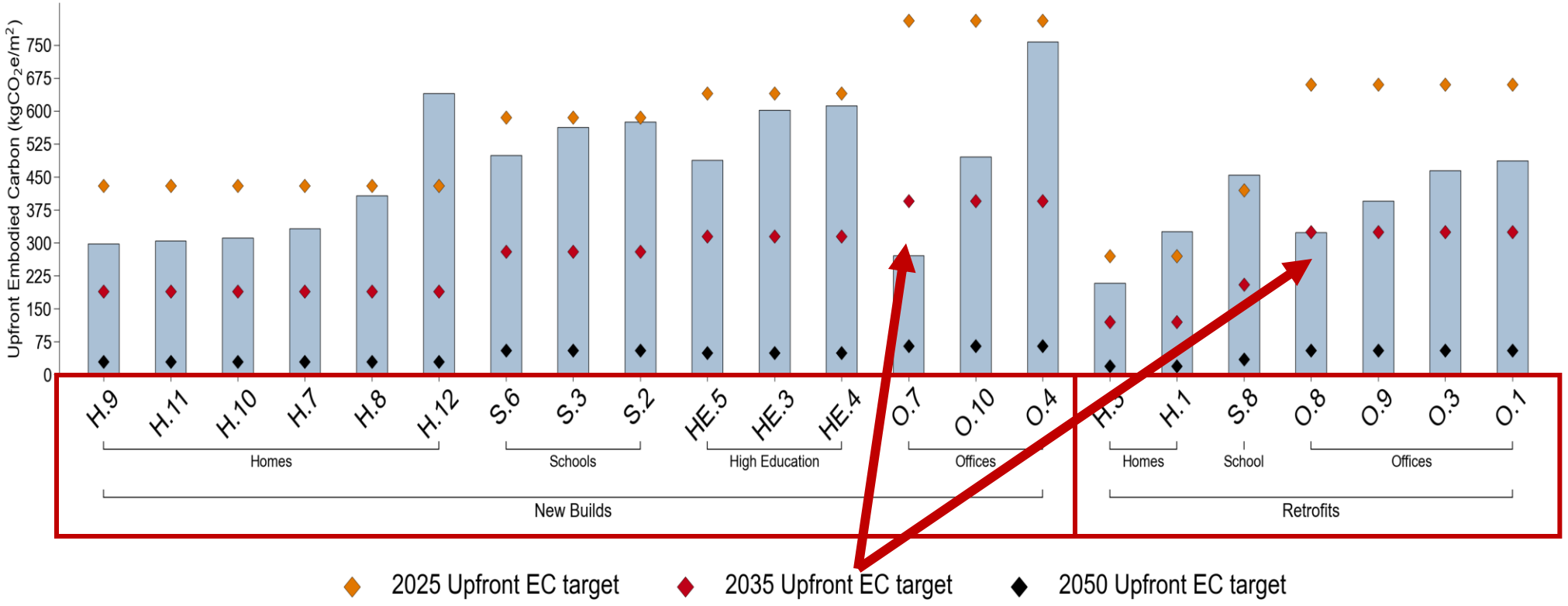
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Energy Use Intensity – Results



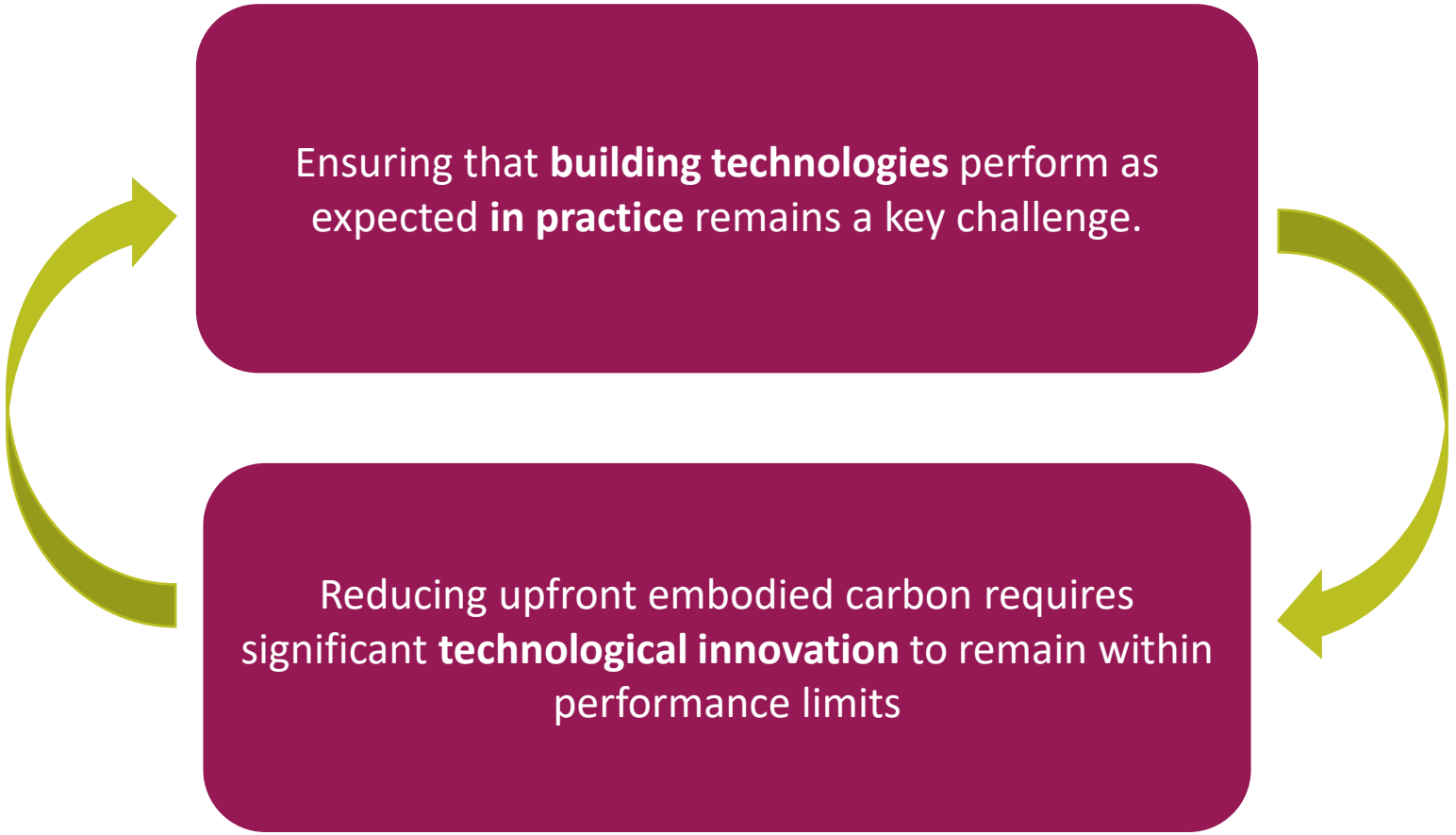
Based on work by Jessica Ibanes MSc Dissertation

Upfront Embodied Carbon – Results



Based on work by Jessica Ibanes MSc Dissertation

Takeaway Messages

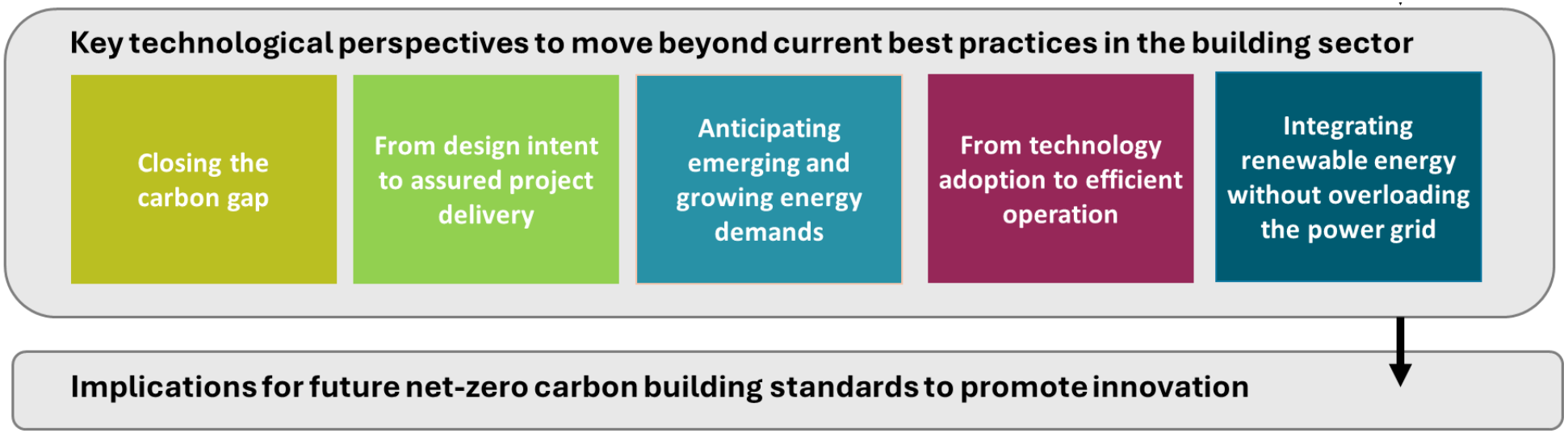


What do we need to do to move beyond best practise?

The ZERO Building Working Group – Acknowledgement

- **Prof Jesus Lizana** → Engineering Science/ ZERO Institute
- **Jessica Ibanes** → Engineering Science
- **Prof Barbara Rossi** → Engineering Science/ZERO Institute
- **Dr Marina Topouzi** → Environmental Change Institute
- **Prof Jan Rosenow** → Environmental Change Institute
- **Prof Thomas Morstyn** → Engineering Science
- **Tom Heel** → Estates Services
- **Dr Robin Morris** → Department of Materials /ZERO Institute
- **Dr Scot Wheeler** → Engineering Science
- **Prof Moritz Riede** → Department of Physics
- **Prof David Wallom** → Engineering Science/ Oxford e-Research Centre
- **Prof Regent Lee** → Nuffield Department of Surgical Sciences

The ZERO Building Working Group – Results Synthesis



Closing the Carbon Gap

From minimising upfront carbon to enabling material circularity

Current UK NZCBS approach

Provides limits for upfront embodied carbon

A0–A5

Upfront carbon

Set binding limits using consistent calculation methods and boundaries.

B1–B5

Embodied carbon in use

Assess maintenance, repair, replacement and refurbishment. Consider service life and adaptability.

D1

Material recovery potential

Report potential benefits and impacts of reuse, recycling and recovery beyond the building's boundary.

Assess these criteria separately so durability and material reuse inform design decisions.

From design intent to assured project delivery

Future standards should require quality checks and clear accountability.

Current UK NZCBS approach

Verify measured performance after at least 12 months in use, then reverify annually.

Proposed quality checks from design to operation



Design	Procurement	Construction	Commissioning	Operation
Confirm targets	Review substitutions	Inspect workmanship	Test system operation	Monitor and correct

Reward independent quality assurance audits to maintain a golden thread from design intent to in-use performance.

Anticipating emerging and growing energy demands

Future standards should address cooling and ICT alongside whole-building EUI.

The UK NZCBS sets operational energy use intensity (EUI) limits for buildings without addressing loads

Cooling in a warmer climate

Assess cooling needs using future weather files.

Annual cooling demand limit kWh/(m² GIA·yr)

Peak cooling demand limit W/m² GIA

UK cooling degree days rise by about 30% between 1.5°C and 2°C of global warming[1].

ICT and persistent background loads

Monitor and report ICT energy use separately.

Annual ICT energy use kWh/(m² GIA·yr)

ICT can account for up to 40% of the energy use in future net-zero buildings[2]

Prioritise passive cooling and plan heating and cooling together from the start.

[1]Miranda et al. (2023) 'Change in cooling degree days with global mean temperature rise increasing from 1.5°C to 2.0°C', Nature Sustainability, 6(11), pp. 1326–1330. doi:10.1038/s41893-023-01155-z.
[2]Lizana et al (2024), Integrated post-occupancy evaluation and intervention that achieve real-world zero-carbon buildings, Energy Build. 303.113766. https://doi.org/10.1016/j.enbuild.2023.113766.

From technology adoption to efficient operation

Future standards should pair whole-building energy limits with requirements to monitor and optimise systems in use.

Current UK NZCBS approach

Verify measured whole-building performance over successive 12-month reporting periods.

63% of buildings in our study with reported EUI missed both the 2035 and 2050 thresholds.

Proposed requirements for ongoing operation

Reward correct design

Eliminate and discourage oversizing. Systems are traditionally oversized by a **factor of 1.5 -2**[1,2]

Limits for seasonal efficiencies

Results from UK HP field trials:
SPF: **2.81** (428 HPs)[3]
SPF: **2.41** (293 HPs)[4]
SPF: **2.45** (15 HPs)[5]

Optimise Operation

Adjust controls and service plant

Systems (e.g. heat pumps) should be sized correctly, with appropriate control, and distribution temperatures

[1] ASHRAE (2025) 2025 ASHRAE Handbook—Fundamentals.
[2]CIBSE (2016) CIBSE Guide B: Heating, Ventilating, Air Conditioning and Refrigeration.
[3]Rosenow et al(2026), Bridging the efficiency divide: open-source insights into UK heat pump performance gaps, Energy Build. 352.116785. https://doi.org/10.1016/j.enbuild.2025.116785.
[4]Roy et al (2009), Getting Warmer: a Field Trial of Heat Pumps, London. https://oro.open.ac.uk/31647/
[5] Lowe et al (2017), Final Report On Analysis Of Heat Pump Data From The Renewable Heat Premium Payment (RHPP) Scheme.

Integrating renewable energy without overloading the grid

Future standards should reward when buildings use renewables and how they respond To the grid.

Current UK NZCBS approach

Sets onsite generation targets and requires reporting of on-site use and exports.

Proposed Requirements

Renewable Energy Integration

Set a minimum for on-site self consumption or the renewable share of total building energy use .
Reward the use of thermal and electrical storage.

Grid Flexibility

Assess whether the building can respond to grid signals.
A metric can be the EU Smart Readiness Indicator (SRI).

Opportunity: Run heat pumps to charge thermal storage when renewables are available and the grid has capacity.

Takeaway Messages

A net zero carbon building, does not mean being net zero now, **but to prepare for being one.**

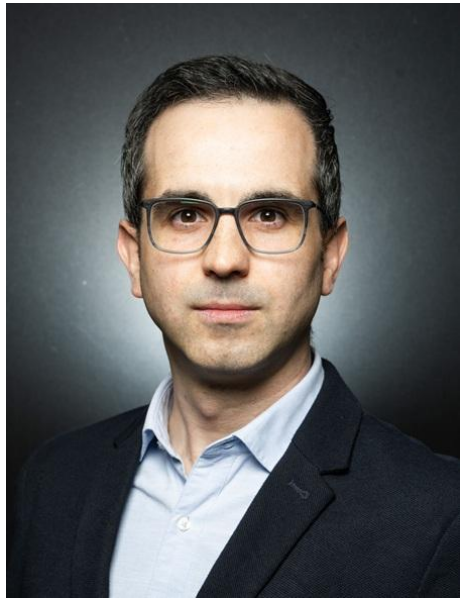
Ensuring that **building technologies** perform as expected **in practice** remains a critical challenge

Make net zero a whole-life responsibility: from material choices to efficient operation, adaptation and grid flexibility.

Panel Discussion

What next? And where do the Opportunities lie?

What next? And where do the Opportunities lie?



Prof Jesus Lizana

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Questions ☺