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Carbon Neutral Buildings

Asset Assessment & Standards, Strategies & Implementation Options

Revision I1

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Contents

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1.0 Background

The case for decarbonisation is growing in scope, depth and impact. For years now, climate change has been high on global, national and local agendas. From early activist beginnings to current (more politicised) sustainability-oriented debates, making economies green(er) has come front and centre of efforts to adjust to new climate realities. The accelerating climb in temperatures, rapid changes in natural habitats and, not least, geopolitical risks are all informing public policies, existing or planned, to introduce radical changes into how climate change can be reversed. The span of such efforts varies, understandably, not so much across a well-defined continuum actor, governmental and non-governmental, argue and/or work on but is, indeed, greyish. Specifically, as more and more state and non-state actors contribute, positively or not, to climate change control positions – and, in response, policy-making processes and decisions – vary over a wide range of public and private matters of short-run and far-reaching consequences. For instance, whilst a global consensus has gradually emerged over an urgent need to act (now) on reducing carbon emissions, major (and much less so, if at all) economies differ, if not spar, over *means*, i.e., *least politically costly* and *most economically feasible*, to make carbon emissions reduction a reality. If anything, so much is at stake in shifting economies (and political orientation, if not stability) from one "fuelled" by (corporate-controlled and more centralised) fossil fuels to an economy "powered" by a cleaner, greener, more sustainable and, not least, decentralised energy (re)sources. To put matters into perspective, and in order not to drift away

from the present focus, central emphasis is laid on carbon-neutral buildings (CNBs) as one major component, among many, to decarbonise economies long fuelled by fossils.

Under current circumstances, standardisation of protocols, policies, and programmes is gaining more ground (in the UK and beyond) to achieve "carbon neutrality" in and around residential and commercial buildings. There is, a growing awareness amongst policymakers, at different decision-making levels, of an urgent need to act systematically on making buildings smarter in use and more substantial in lifestyle and economics. In a UK context, for instance, the government's department for Business, Energy & Industrial Strategy (BEIS) has rolled out an ambitious plan informed by the UK Prime Minister's Ten Point Plan for a Green Industrial Revolution (mentioned shortly) addresses a wide range of carbon emissions reduction issues across the UK home and business spectrum. [1] Of specific interest for current purposes is its objective to eliminate carbon emissions from domestic and commercial buildings by 2025.

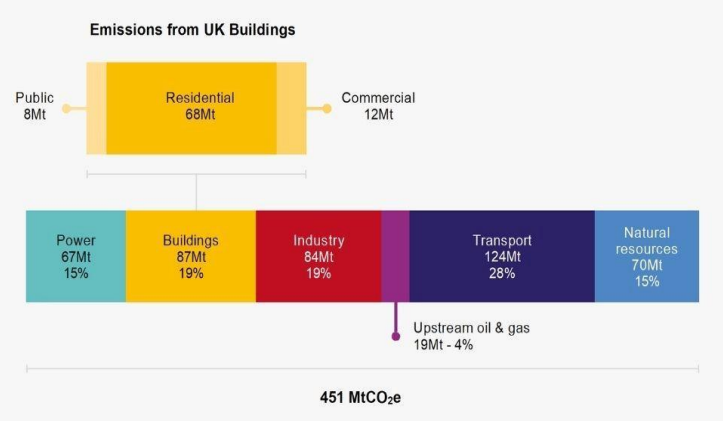

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Figure 1. Emissions from UK buildings in 2018. [2]

1. Department for Business, Energy & Industrial Strategy, "Energy White Paper: Powering Our Net Zero Future," https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future/energy-white-paper-powering-our-net-zero-future-accessible-html-version.
2. Ibid.

BEIS has introduced a number of programmes (e.g. Green Homes Grant Voucher Scheme, Public Sector Decarbonisation Scheme), enforce metrics (e.g. Energy Performance Certificates, EPCs) and standards (e.g. Future Homes Standard) to retrofit existing buildings to be more energy-efficient and also, perhaps, more importantly, to set (universal) standards for new buildings to be zero carbon ready. In addition, a wide range of initiatives, incentives and innovations, particularly in the electrification area, are in progress or planned and are aimed to make such a shift more affordable, particularly for *fuel poor* households which, according to one official definition, is "where a household has fuel costs that are above average and, were they to pay that amount, would be left with a residual income below the official poverty line." [3]

For commercial/industrial buildings, much appears to be needed to accelerate decarbonisation efforts. Specifically, whilst a wide official recognition is admitted of commercial/industrial activities to the UK economy, a holistic approach is yet to unfold by publishing an Industrial Decarbonisation Strategy in spring 2021 to hammer out more specific details about decarbonisation of the manufacturing industry. [4] Currently, the Carbon Capture and Storage (CCS) Infrastructure Fund, Net Zero Hydrogen Fund, UK Emissions Trading Scheme and Hydrogen Investor Map are not yet full-fledged mechanisms, in the wide, effective application. Then again, BEIS is only one, among so many, parties shaping the

current standardisation of protocols, policies, and programmes meant to retrofit and qualify existing and future domestic and commercial/industrial buildings to enter a new era of (genuinely) energy and carbon zero ready environments.

Consider (only for illustration purposes in the current section) private enterprises. For instance, White Arkitekter, a Sweden-based architecture house of extensive UK operations, is setting higher standards on the decarbonisation of buildings using an integrated and scalable approach. Specifically, a *carbon declaration* is made only after in-depth calculations of emissions produced in different construction phases and balanced out against construction economics, architecture aesthetics and sustainability. This is not, however, a whole new approach to decarbonisation nor, of course, to material sourcing and emission control and monitoring. Instead, White Arkitekter, among so many more actors in different sectors, is making possible a fuller, more measurable, and sustainable approach to achieve carbon neutrality in buildings. That is, accounting for a building's lifecycle from material sourcing to building repurposing or demolishing. White Arkitekter raises new bars for accounting for decarbonisation efforts beyond current official ones (much of which is still in progress). [6]

3. Department for Business, Energy & Industrial Strategy, "Energy White Paper: Powering Our Net Zero Future."
4. Ibid.
5. White Arkitekter, https://whitearkitekter.com/.
6. White Arkitekter, "Carbon Neutral Buildings – Creating Value Through Architecture," https://igsmag.com/market-trends/carbon-neutral-buildings-creating-value-through-architecture/.

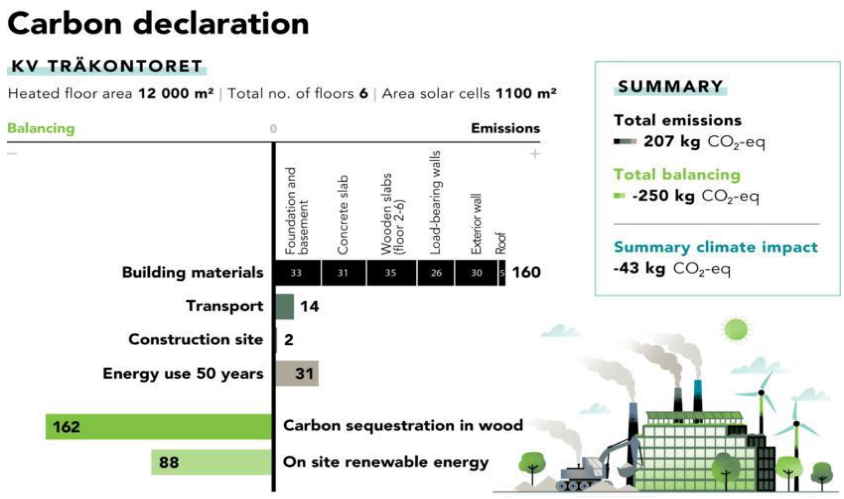

Figure 2. Sample carbon declaration used in White Arkitekter projects. [7]

Similarly, UK and non-UK professional organisations and associations are using or introducing metrics, or benchmarks, to measure and control building decarbonisation. For instance, the UK Green Building Council has developed a holistic *net-zero carbon buildings framework*, informed by two important concepts: ***net-zero carbon – construction*** and ***net-zero carbon – operational energy***. The framework offers guidance on strategies and metrics to eliminate carbon emissions during the construction phase and in operation. This approach admits, as discussed later, a need to account for net-zero whole life carbon [8] – in perhaps much a similar way to White Arkitekter.

7. Ibid.
8. UK Green Building Council, *Net Zero Carbon Buildings: A Framework Definition*, https://www.ukgbc.org/wp-content/uploads/2019/04/Net-Zero-Carbon-Buildings-A-framework-definition.pdf.
9. Ibid.

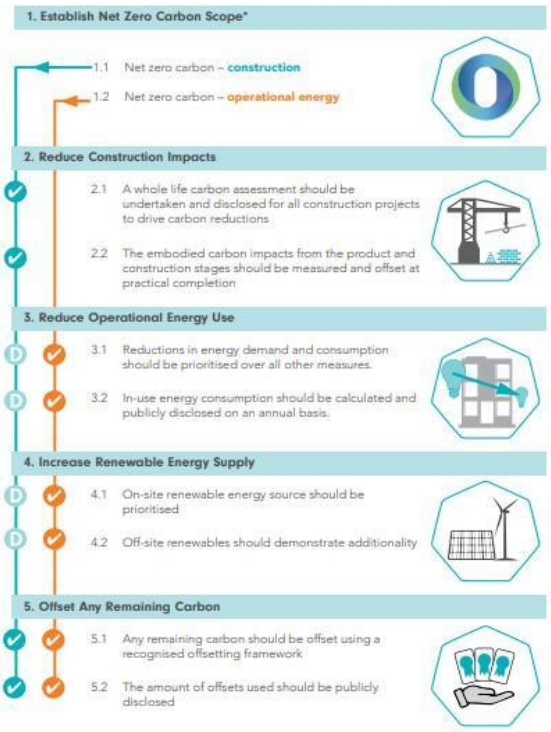

Figure 3. Steps to achieving a net zero carbon building in UK Green Building Council.

This mosaic of strategies, policies, metrics and standards to achieve net-zero carbon neutral buildings, or reduce carbon emissions to a minimum, shows a diversity of approaches to carbon neutrality. To put matters into perspective, more examples are provided from the different UK and non-UK organisations. This white paper aims to explore a wide range of standards already in use or planned by a variety of the UK and non-UK organisations to achieve net-zero carbon emissions in UK buildings against a wider background of a 'green revolution'.

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2.0 Asset Assessment & Standards (UK & International)

The BEIS white paper on energy management is perhaps a good start to showcase current mosaic standards for carbon-neutral buildings. As mentioned, BEIS provided a wide range of (mostly) government strategies, policies, programmes and initiatives to address climate change challenges by reducing carbon emissions across different sectors. The BEIS discusses, for instance, how a combination of electrification, digitisation, regulations and policies (particularly an ambitious UK Emissions Trading Scheme) are apt to reduce, if not eliminate, carbon emissions by the UK and international deadlines in 2030 and 2050. Moreover, special attention is paid to addressing carbon emissions from domestic and commercial/industrial buildings which, as shown in Figure 1 above, account for 19% of UK overall carbon emissions – the second largest. [10] That said, a notable lack of a *universal* and *detailed* plan, let alone *metrics*, re-explained to make carbon neutrality an everyday reality and practice. Instead, a diversity of (fragmented) efforts are mentioned and, as admitted, much still needs to be done to get "buy-in" from stakeholders, particularly in commercial/industrial sectors, to develop robust carbon declarations informed by detailed, and more importantly, traceable, measurable, and sustainable metrics for carbon emissions in buildings. Accounting not only for basic carbon emissions (as is currently proposed) during material sourcing and construction but phases also for a whole lifecycle of a given building, project or community from inception to end. Unsurprisingly, a plethora of decarbonisation standards, policies and metrics emerge to fill in such gap by a diversity of organisations. The following subsections showcase many standards, policies

and/or metrics developed by the select UK and non-UK organisations to set an acceptable benchmark for carbon-neutral buildings.

10. Department for Business, Energy & Industrial Strategy, "Energy white paper: Powering our net-zero future."

3.0 UK Green Building Council

The UK Green Building Council has developed, as noted above, a framework for net-zero carbon buildings. The steps to do so, in Figure 3 above, show a central focus on carbon emissions during construction and operation phases only. Indeed, the UK Green Building Council does emphasise a couple of concepts ("Net Zero Carbon – Construction" and "Net Zero Carbon – Operational Energy" – explained shortly) as a foundational for the proposed framework but also admits a need for "a further scope for net-zero whole life carbon." [11] The definition of boundaries, i.e., building areas a developer has an influence or direct control over, is, however, a matter of much debate and, as a consequence, has resulted in different practices and metrics being used by different entities. For the UK Green Building Council, such boundaries are defined as follows:

For Net Zero Carbon – Construction, the boundary is defined as all areas included in the whole life carbon assessment that have been reported and offset at practical completion. Where multiple buildings are being delivered, the aim should be to achieve net-zero carbon for the whole development.

11. UK Green Building Council, *Net Zero Carbon Buildings: A Framework Definition*.

For Net Zero Carbon – Operational Energy, the boundary (or energy scope) is defined as all areas under operational control or influence where a net-zero carbon balance has been achieved on an annual basis. The energy scope should be disclosed to allow comparability between buildings. [12]

So, what are Net Zero Carbon – Construction and Net-Zero Carbon – Operational Energy? According to the UK Green Building Council, **Net-Zero Carbon – Construction** is when the amount of carbon emissions associated with a building's product and construction stages up to practical completion is zero or negative, through the use of offsets or the net export of on-site renewable energy. [13]

Net-Zero Carbon – Operational Energy

This is when the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net-zero carbon building is highly energy-efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset. [14]

This leaves out boundaries, usually under Scope 3, which account for net-zero whole life carbon. To the UK Green Building Council's credit, however, more details are offered on scopes, approaches, scenarios and technical requirements. Technical requirements for Scopes 1&2 (i.e., Net Zero Carbon

– Construction and Net-Zero Carbon – Operational Energy) are, for current purposes, shown in insets below.

12. UK Green Building Council, *Net Zero Carbon Buildings: A Framework Definition*.
13. Ibid.
14. Ibid.

Technical Requirements for Net Zero Carbon – Construction [15]

A whole life carbon assessment should be undertaken to determine the building's carbon impact, in line with the RICS [Royal Institution of Chartered Surveyors] Professional Statement 'Whole life carbon assessment for the built environment'.

A building's product and construction stages are defined as modules A1 to A5 of EN 15978 ('embodied carbon to practical completion' as per Section 1 of the RICS Professional Statement).

The whole life carbon assessment and the related offsetting of carbon (either through net export of on-site renewable energy or the purchase of offsets) should be audited by a third party.

Technical Requirements for Net Zero Carbon – Operational Energy [16]

The building should report annual carbon impacts as a total (tCO2e) and in terms of intensity (kgCO2e/m2). The emissions factors used in calculations should be market-based or location-based.

Where the building's 'total annual net CO2e emissions' equal zero, and these calculations have been audited through a third party, the building can be considered net zero carbon for operational energy. The indicators reported against will quantify the extent to which off-site renewables and offsets are being used to achieve this outcome

15. UK Green Building Council, *Net Zero Carbon Buildings: A Framework Definition*.
16. Ibid.

Furthermore, the UK Green Building Council offers more detailed guidance on a much debatable metric of Net Zero Carbon – Operational Energy: *Embodied Carbon*. Then again, since what the UK Green Building Council offers is *only* guidance, constant emphasis is laid as to assessor's freedom to choose what best fits any given built environment to set out standards or calculation methodologies for embodied carbon, as shown in "example wording" samples below.

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Embodied Carbon: Assessment Standards & Calculation Methodology [17]

(Sample Wording)

Example 1

All assessments undertaken must have their methods conform with BS 15978:2011

Sustainability of construction works –

Assessment of environmental performance of Buildings.

Example 2

The methodology for calculation will be based on the RICS 2014 Methodology to Calculate

Embodied Carbon. Any deviations from this must be justified and agreed.

Example 3

The methodology for calculation will conform to BS 15978:2011 and will also use the RICS

Methodology to calculate embodied carbon. Data gathering shall conform to ISO 14025:2010

Environmental labels and declarations. Type III environmental declarations. Principles and

Procedures. An audit trail shall be presented.

17. UK Green Building Council, *Embodied Carbon: Developing a Client Brief*, https://www.ukgbc.org/sites/default/files/UK-GBC%20EC %20Developing%20Client%20Brief.pdf

4.0 Government Property Agency

As mentioned, a diversity of organisations contribute to current offerings on protocols, policies, standards and programmes for carbon-neutral buildings. The Government Property Agency (GPA – an executive agency of the Cabinet Office) offers, in a similar vein, a holistic guide, *Net-Zero and Sustainability: Design Guide – Net Zero Annex*, informed by detailed desktop research underpinned by empirical evidence and data to "identify the standards for Net Zero (NZ) and Sustainability for the Government Workplace Design Guide". Its ultimate aim: to "define the technical requirements and guidance to support the delivery of Net Zero carbon buildings" by practically applying such standards to "all Government Estates buildings." [18]

Government Property Agency Monitoring & Metering During Design Process [19]

- Implement a sustainability and efficiency energy management plan in line with ISO 50001 that includes provisions for carrying out a DEC assessment, reporting on the DEC assessment outcome on an annual basis and incentivise incremental performance improvement
- Implement a metering management scheme to ensure that meters are, and remain, calibrated throughout the operational life of the building
- Metering should also provide a breakdown of major energy uses in line with Soft Landings and TM39 requirements to provide accurate, useful information and should be designed in collaboration with building operators
- Install an automated metering system (AMR) with half-hourly data logging separate from the BMS with data storage and interoperability to access CSV data and interface with energy management systems
- The Building Management System (BMS) should be integrated between Cat A and Cat B and will enable 100% point commissioning

18. Government Property Agency, *Net-Zero and Sustainability: Design Guide – Net Zero Annex*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/925231/ Net_Zero_and_Sustainability_Annex_ August_2020_.pdf
19. Ibid

The scope of *Net-Zero and Sustainability* is, moreover, clearly focused on government buildings but, to GPA's credit, a more holistic approach is adopted by accounting for a whole life carbon assessment as opposed to the more limited scope used by the UK Green Building Council, for example. This guide, despite building on efforts made by different organisations, is particularly useful since the construction community can have at hand a more comprehensive guide on

standards and practices more common, or advanced, in construction requirements for carbon-neutral buildings. Therefore, instead of simply rehashing what is in GPA's guide, selective standards and practices are reproduced as shown in the inset above.

5.0 Royal Institution of Chartered Surveyors (RICS)

The principles, standards and guidance offered by RICS is the industry's most recognised and widely referenced. The RICS professional statement, *Whole Life Carbon Assessment for the Built Environment*, has been a result of an extensive "16-month Innovate UK co-funded project managed by Sturgis Carbon Profiling, with a working group comprising Arup, Atkins Faithful +"

Standard	Full title	Regional jurisdiction
EN 15978: 2011	Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method	European standard
EN 15804: 2012 + A1: 2013	Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products	European standard
PAS 2050: 2011	Specification for the assessment of the life cycle greenhouse gas emissions of goods and services	UK document
PAS 2080: 2016	Carbon management in infrastructure	UK document
ISO 21930: 2017	Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services	International standard
ISO/TS 14067: 2013	Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification	International standard
ISO 14025: 2006	Environmental labels and declarations – Type III environmental declarations – Principles and procedures	International standard
ISO 14040: 2006	Environmental management – Life cycle assessment – Principles and framework	International standard
ISO 14044: 2006	Environmental management – Life cycle assessment – Requirements and guidelines	International standard
EN 16449: 2014	Wood and wood-based products. Calculation of the biogenic carbon content of wood and conversion to carbon dioxide	European standard
EN 16485: 2014	Round and sawn timber. Environmental Product Declarations. Product category rules for wood and wood-based products for use in construction	European standard
EN 16757: 2017	Sustainability of construction works. Environmental product declarations. Product Category Rules for concrete and concrete elements	European standard

Figure 4. RICS: Key European and International Standards for Whole Life Carbon Assessment. [20]

20. Royal Institution of Chartered Surveyors, *Whole Life Carbon Assessment for the Built Environment,* https://www.rics.org/globalassets/rics-website/media/news/whole-life-carbon-assessment-for-the--built-environment-november-2017.pdf.

Gould Sustainable Business Partnership, Land Securities, Laing O'Rourke, Cambridge University, and RICS." [21] Understandably, any attempt to sum up all methodologies, standards and recommendations will fall short of giving such a comprehensive statement due acknowledgement. Instead, only selective technical standards are reproduced in Figure 4 above, as for GPA's guide, to give a general idea of primary standards and recommended practices.

21. Royal Institution of Chartered Surveyors, *Whole Life Carbon Assessment for the Built Environment.*

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6.0 Society of Building Science Educators & American Institution of Architects

Internationally, more efforts are emerging to address the climate change challenge by devising more universal and standardised principles to make carbon-neutral buildings a reality. The Carbon Neutral Design Project, a US-based collaborative project between the Society of Building Science Educators, the American Institute of Architects, and a private donor, is perhaps one of the most ambitious carbon neutrality offerings outside of the UK. [22] Still, a work-in-progress, The Carbon Neutral Design Project involves practically useful standards and protocols for carbon-neutral buildings. For current purposes, and to avoid clutter, quick reference is made to existing design protocols and standards as proposed by leading scholars and practising designers. For instance, Michael D. Utzinger, at the School of Architecture & Urban Planning, University of Wisconsin-Milwaukee, offers a 3-Level Carbon Neutral Design Metrics. [23] Similarly, Harvey Bryan and Maria Grimm, at the School of Architecture and Landscape Architecture, College of Design, Arizona State University develop a Carbon Emission Performance Standard based on a computer simulation model. [24]

22. Terri Meyer Boake, "The Carbon Neutral Design Project," http://www.tboake.com/carbon-aia/
23. Terri Meyer Boake, "Carbon Neutral Calculation Protocols: Carbon Neutral Design Metrics," http://www.tboake.com/carbon-aia/protocols1.html
24. Terri Meyer Boake, "Carbon Neutral Calculation Protocols: Creating a Building Carbon Emission Performance Standard," http://www.tboake.com/carbon-aia/protocols2.html

7.0 Strategies & Implementation Options

A great deal of effort is going into raising awareness of carbon emissions in UK buildings. As discussed in the examples above, organisations, informed by a complex mix of regulatory, design, protocol and standard options, offer strategies and implementation options which, overall, still fall short of universal application in the UK, not to mention internationally. The Committee on Climate Change (CCC) is an independent non-departmental public body. Unsurprisingly, it commissioned research on the costs and benefits of introducing stricter standards for new UK buildings. [27] It suggests three alternative policy *Options for Incorporating Embodied and Sequestered Carbon into the Building Standards Framework*. This useful roadmap is shown below.

Three Alternative Policy Options for Addressing Embodied and Sequestered Carbon in UK Buildings

Option 1 – Voluntary action & Government leads by example through procurement: This involves many parallel streams including promoting action to address lifecycle carbon in the construction sector (e.g. by setting non-binding sector targets and monitoring changes in the lifecycle carbon impact of new buildings over time) and requiring government-funded building projects to quantify and reduce this impact (e.g. by specifying the number of the relevant BREEAM and Home Quality Mark (HQM) credits to be achieved where assessments are already mandatory) alongside maximising sequestration. Voluntary action could also include lobbying for embodied and sequestered carbon assessment to become a mandatory issue in BREEAM and HQM.

Option 2 – Whole-life elemental carbon intensity targets: Elements, product types and material substitutions with the highest lifecycle carbon savings are identified, accounting for supply chain dependencies

(construction sector capacity, domestic capacity, the effect of materials source, etc.). Whole-life carbon intensity limits are set in building regulations for these elements, product types and materials, initially near levels met by incumbent options, along with a trajectory for progressive tightening of standards. The targets would need to consider the thermal performance of the building elements (including heat loss and thermal mass impact) to ensure that trade-offs between embodied and operational carbon are accounted for. A shift to Option 3 can be made if and when necessary to drive further savings.

Option 3 –Whole building lifecycle carbon intensity targets: A scheduled introduction of whole building lifecycle carbon intensity targets in building regulations could be considered. This will involve working with the construction sector and professionals to develop the corresponding regulatory tools and calculation method as well as capacity building for building control officers. Targets can be progressively tightened to drive increased carbon savings.

27. AECOM, *Options for Incorporating Embodied and Sequestered Carbon into the Building Standards Framework*, https://www.theccc.org.uk/wp-content/uploads/2019/07/Options-for-incorporating-embodied-and-sequestered-carbon-into-the-building-standards-framework-AECOM.pdf

8.0 Conclusion

There is, in balance, a growing need for more universal standards to decarbonise buildings in the UK and beyond. Given the current state of affairs, much attention is focused, understandably, on the most immediate carbon emission phases (namely, Scopes 1 &2: construction and operation, respectively). There has been, however, growing attention in literature and practice to expand standardisation efforts of decarbonisation practices in UK buildings beyond Scopes 1 & 2 such as to include Scope 3, including arguably a more extended quantification of carbon emissions over a building's/development's whole lifespan. [28] The policy options mentioned in the current white paper offer, perhaps, a more holistic approach to addressing a wide range of regulatory, design, standardisation, innovation and, not least, cost issues. The proper policy mix is, ultimately, what should inform any standardisation efforts. Indeed, unless primary and secondary stakeholders are properly engaged, willingly, achieving carbon neutrality could be only a fleeting dream. Therefore, such action is still needed, more so to make any standards scalable and flexible enough to accommodate ever-changing regulatory frameworks and, for that matter, changing perceptions among completely different constituencies on what counts as an extreme priority to decarbonise or not. This requires collaboration at local, national and international levels, as is emphasised by BEIS in *Energy White Paper: Powering Our Net Zero Future*. To do so, inter-organisational panels across different industry sectors, in and beyond the UK, are expected to integrate current approaches to decarbonisation frameworks, principles, guidelines, programmes and standards further to ensure

efforts are not wasted – just as current energy efficiencies in many domestic and commercial/industrial UK buildings still are.

28. Helen Carruthers and Tracy Casavant, "What is a 'Carbon Neutral' Building?" https://docplayer.net/38288381-What-is-a-carbon-neutral-building.htm

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