

Embodied Carbon

Industry Task Force Recommendations

Proposals for Standardised Measurement Method

and

Recommendations for Zero Carbon Building Regulations
and Allowable Solutions

June 2014

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Section 1 - Executive Summary

1.1 Introduction

The Embodied Carbon Task Force comprises a group of practitioners, academics and developers who have an interest in ensuring that embodied carbon is integrated into normal good practice building design and development.

The objectives of the Task Force is to build industry-wide consensus on how embodied carbon should be measured and reported and to develop a methodology such that Embodied Carbon may be included as an Allowable Solution within the definition of Zero Carbon Building regulations for both Residential and Commercial Property.

Specifically the aim of The Task Force has been to deliver the following:-

- Agreement and proposals for minimum standards for measurement, reporting and verification
- Propose a methodology for Embodied Carbon being included as an Allowable Solutions
- Make recommendations to Government

This paper has been prepared by Guy Battle (The Sustainable Business Partnership) with additional editorial support from members of The Task Force and consultation with other industry bodies including:-

The Embodied Carbon Task Force

- | | |
|--|---|
| - The Sustainable Business Partnership | Guy Battle (Joint Chair and Editor) |
| - Sturgis Carbon Profiling | Simon Sturgis (Joint Chair) |
| - Arup | Kristian Steele, Andrea Charlson, Adrian Campbell |
| - Tishman Speyer | Philippa Gill |
| - AECOM | David Weight, Emily Woodhouse, Andrew Cripps |
| - Circular Ecology | Craig Jones |
| - Planet First | Steve Malkin, Sarah Gillett |
| - Atkins Global | Sean Lockie |
| - University of Cambridge | Alice Moncaster |
| - Skanska | David Mason |
| - Turley | Colin Morrison |

In putting this paper together we have also consulted with and would like to thank the following organisations.

- Association of Sustainable Building Products
- British Land
- Brighton and Hove County Council
- Derwent London
- Land Securities
- PE International
- ProLogis UK Ltd
- UKGBC
- Willmott Dixon
- WRAO

The Task Force is conducting further widespread consultation amongst key stakeholders including, RICS, CIBSE, ICE, RIBA, CPA, IStructE.

Note: - The content, analysis, opinions and policy recommendations contained in this publication do not necessarily reflect the views of the participating and consulted organisations.

The paper is divided into four sections

- Section 1 – Executive summary including recommendations to Government
- Section 2 – Supporting evidence, case studies and analysis
- Section 3 - Proposals for Standardised Measurement Method
- Section 4 - Conclusions, Recommendations and Next Steps

1.2 Overview

“Even before a building is occupied, between 30% - 70% of its lifetime carbon emissions have already been accounted forⁱ”

Why does Embodied Carbon matter?

- Even before a building is occupied, between 30% - 70% of its lifetime carbon emissions have already been accounted forⁱⁱ
- Embodied carbon (EC) makes up the largest proportion of the carbon emissions of a building through its lifetime. For some sectors such as industrial warehousing, it accounts for over 70% of lifetime emissions.
- Around 10% of UK emissions (c. 57MtCO₂e per year) are associated with the manufacture and transport of construction materials, and the construction processⁱⁱⁱ; if no change is made then this sector alone will be responsible for additional emissions of over 3100MtCO₂e^{iv} by 2050, equivalent to over 5.5 years of total UK emissions.¹

Opportunities for Carbon and Cost reductions

- Carbon saved during manufacturing and construction processes can be “banked” now and has a higher value than operational carbon saved in the future especially as the UK moves towards 80% grid decarbonisation.
- The measurement and management of EC has proven benefits as a proxy for capital investment reductions²
- Measurement of EC is likely to promote manufacturing innovation, job creation and of local sourcing.
- Research has shown that achieving embodied carbon reductions is cost effective than and will compliment initiatives already being taken to reduce operational carbon.³
- In July 2013, Construction 2025 reported its findings on the delivery of a more sustainable construction industry, supported by The Green Construction Board. Working together, Industry and Government have developed a clear and defined set of aspirations for UK construction. This document sets out a route map for the reduction of embodied carbon of 21% by 2022 and a 39% reduction by 2050.

The Drivers for Industry Action

Embodied Carbon reductions have a clear role to play in the decarbonisation of UK PLC and within the wider climate change debate. Aligning industry behind EC and larger resource efficiency measures is an essential part of the industry’s contribution to UK manufacturing, innovation and job creation.

The key issues that are seen to be blocking this adoption include:-

¹ See Low Carbon Construction Innovation & Growth Team by Paul Morrell

² Anglian Water has demonstrated between 30%-50% capital cost savings by tracking embodied carbon

³ . Many of the easier or cost neutral operational reductions have already been made, leaving embodied carbon as an untapped opportunity.

- Perception that embodied carbon is not a significant issue with respect to UK emissions and when compared to operational carbon
- Perception that embodied carbon is difficult to measure
- Perception that there is no agreed, standard methodology for measurement and that practitioners use multiple methodologies, leading to confusion
- Perception that there is no industry capacity or capability i.e. the industry is not ready

In response to this and given its national importance, an industry task force has been working with the express objective of harmonising measurement and reporting standards to ensure that in the first instance, EC may be taken forward as an Allowable Solution for 2016 (residential) and 2019 (commercial) and that EC may eventually form a part of the definition of Zero Carbon.

This White Paper forms the basis of our work to date and lays out our recommendations and a route map for the delivery of embodied carbon both as an Allowable Solution and eventually as a part of the definition of Zero Carbon Buildings.

1.3 Task Force Findings

In its work, The Task Force has consulted widely and found that the industry is well developed and that there is broad agreement on how EC should be measured. Key findings include:-

- 1. The Business Case - There is a clear business case for measuring and managing Embodied Carbon**
 - a. EC emissions are material to UK total emissions⁴
 - b. At present, abatement costs are lower⁵ than other 'in-use' solutions
 - c. EC reductions made now have a greater impact than operational emission made in the future as grid intensity reduced⁶
- 2. Agreed Standards – There is widespread agreement on best practice amongst industry practitioners**
 - a. All practitioners follow the basis of EN 15978 and EN 15804
 - b. These reflect international standards and therefore also ensure comparability across the world.
- 3. Industry capacity - There are many practitioners actively involved in measuring embodied carbon**
 - a. There is widespread interest in embodied carbon – a recent UKGBC Embodied Carbon Week⁷ attracted over 1000 attendees with over 24 events hosted as part of the week.
 - b. The industry is widely supported by guidance^v
 - c. There is general agreement on methodologies and measurement standards.
 - d. To date the task force considers that many 1000s of measurement projects have been carried out, with 200 projects already loaded into the WRAP Database^{vi} and over 500 buildings expected to be included by 2015.
 - e. Industry bodies are actively involved in the promotion of embodied carbon include RICS, RIBA, UKGBC, WRAP, BREEAM (see RICS guidance)⁸
- 4. Global awareness - There is growing global awareness globally of the importance of the EC**

⁴ Around 10% of UK emissions (c. 57MtCO₂e per year) are associated with the manufacture and transport of construction materials, and the construction process

⁵ This is principally due to the fact that the low hanging in-use measures are already addressed through Building Regulations

⁶ With In-Use measures there is always the risk that renewable solutions are not implemented for the lifetime of a building.

⁷ EC week has been the UKGBC's most successful awareness raising campaign to date.

⁸ RICS Professional Guidance, Global Methodology to Calculate Embodied Carbon 1st Edition 2014

- a. There is a danger that the UK will be left behind. Some Governments, such as The Netherlands, are promoting new legislation around embodied carbon in buildings^{vii}
 - b. Germany⁹ and the Netherlands already have nationwide materials databases
- 5. Planning – Many planners and local authorities are already aware of the issues**
- a. We have identified over 10 local authorities who are already requesting an assessment of EC or providing guidance as a part of the planning process
 - b. A number of Local Authorities are actively requesting measurement of EC as a part of planning submission requirements and some planners are beginning to accept embodied carbon reductions as a means of meeting local climate change targets.
- 6. Education and skills – Many universities and schools are already teaching ‘embodied carbon’.**
- a. Universities that have EC as an element of their curriculum include the universities of Bath, Reading, UCL and many others
 - b. A number of schools and colleges are looking at developing a curriculum around embodied carbon (a practical application of physics) including UTC Daventry and Banbury and Bicester College.
- 7. Market Failure – There is clear evidence that the lack of Government recognition of Embodied Carbon blocking industry innovation and will make meeting UK Carbon Reduction Targets more difficult to achieve**
- a. Present legislation ¹⁰and building regulations do not address embodied carbon.
 - b. The UK is in danger of missing emission targets by ignoring such a significant proportion of emissions
 - c. That recent interest and momentum within the development sector developer will falter without clear government support
- 8. Allowable Solutions – Embodied Carbon included as an Allowable Solution will provide significant benefits**
- a. Lower abatement costs
 - b. Easy to implement and measure
 - c. Easy to ‘police’ and ensure compliance
 - d. Immediate and short term reductions
- 9. National and Regional Economic Drivers – there is a clear economic case for including EC as an Allowable solution**
- a. Will promote and incentivise industry best practice and resource efficiency
 - b. Will promote innovation
 - c. Will promote the use of regional and national products
 - d. Provide a more cost effective and market driven mechanism for meeting UK carbon emission reduction targets

⁹ German Materials database was developed by PE International

¹⁰ For example CCL and CRC are having little impact on tackling emissions with respect to building products manufacture as most manufacturers are below thresholds or have negotiated a CCL opt-out

1.4 Task Force Proposals

In response to these findings The Task Force has developed a clear set of proposals for adoption by the industry as a whole in order to meet the concerns that Government presently holds:-

1. Minimum Reporting Requirements

Practitioners have agreed a standard minimum reporting framework for practitioners to follow. These are based upon recognised European Standards (CEN TC 350) on the “Sustainability assessment of construction works”, EN 15978:2011 and EN 15804:2012 which is widely accepted by industry bodies such as the Construction Products Association.

2. Buildings Database

Practitioners have agreed to use the WRAP buildings database as our standard reporting framework.

3. Materials Emission Factors

Practitioners have agreed that Material Emission Factors will be based on EN 15804 or equivalent (e.g. EN 16449 for timber) and that a UK database will be developed such that manufacturers and specifiers alike may assess product performance. It should be noted that such a database already exists in Germany.

4. Allowable Solutions

Industry has agreed to develop a staged approach to assessing Embodied Carbon reductions such that EC may be accepted as an Allowable Solutions. ¹¹

1.5 Proposed Road Map for Implementation

The task force has developed a road map for the delivery of these proposals as follows

- By April 2015
 - Practitioners to report against minimum requirements from June 2014
 - Test building analysis to assess software solutions – adapt models to meet +/-10% variation rate
 - Agree methodology and establish requirements for a UK wide materials database - seek TSB funding
 - Identify ‘Approved Measures’ for Allowable Solutions
 - Government releases a statement recognising the importance of embodied carbon and its intention to review its inclusion within the Zero Building carbon Regulations
- By April 2016
 - All practitioners to use agreed methodology and upload buildings database
 - Develop and promote materials data base
 - Finalise list of ‘Approved Measures’ to be included within Zero Carbon Building Regulations – seek assurance and establish methodology for manufacturer submissions
- 2016 - 2018
 - Gather sufficient evidence for planners and local authorities to request EC calculation to be carried out on all projects
 - EC calculation and reductions to be made mandatory of all public procurement following principles of the Social Value Act.

¹¹ The proposed methodology is laid out within this document and that phase 1a (Approved Measures) may be included within the 2016 Zero Carbon Regulations that that whole building analysis may be included for 2019.

- By 2019
 - Through review of all building data, establish building baselines (by typology) ready for integration into 2019 Zero Building carbon regulations

1.6 Recommendations to Government

The Task Force has made a number of key recommendations for consideration by Government as follows:-

Recommendation 1 – That Embodied Carbon should be included as an Allowable Solution within the Zero Carbon Building Regulations for both Homes and Commercial Development.

Recommendation 2 – That Government should support and fund the development of a UK wide materials database similar to those developed in Germany and The Netherlands.

Recommendation 3 – That Government should continue to support the development and upkeep of the WRAP Buildings Database

Recommendation 4 – That The Building Regulations should be developed to eventually include whole life carbon emissions.

Recommendation 5 – That in the light of The Social Value Act, Government should support further research on the benefits of managing and reducing embodied carbon.

1.7 Conclusions

Embodied Carbon within the construction industry is responsible for approximately 10% of UK annual carbon emissions and as such is a material factor within the UK Carbon Budgets.

Before a building is occupied, up to 70% of its lifetime emissions have been already accounted for and yet to date Building Regulations have not addresses this issue

Government has expressed concern with respect to measurement and complexity of accounting for embodied carbon. In response Industry is acting on these challenges and is increasing its capacity to measure and manage embodied carbon – this is being supported in the development of skills by schools, colleges and universities. A number of leading developers are also carrying out EC assessments on their projects and collaborated to host Embodied Carbon Week together with WRAP and the UK GBC.

This momentum will be further enhanced if Embodied Carbon is included within the suite of Allowable Solutions being developed by Government and The Zero Carbon Hub leading to significant national, regional and industry benefits including cost reductions, promotion of UK manufacturing, innovation and job creation as manufacturers align their products behind the new methodology.

*We are committed to delivering sustainable solutions for the built environment and we take a full lifecycle approach to carbon management including both operational and embodied carbon. For our buildings embodied carbon can represent up to 70% of lifetime CO2e emissions (based on a 30 year operational life) and therefore we believe it is essential to measure and reduce its impact. We roundly support the findings in this paper and would like to encourage Government to include embodied carbon as an allowable solution to incentivise its reduction and innovation around our supply chain - **Prologis UK Limited***

Section 2 – Background and Supporting Evidence

2.1 Introduction

2.1.1 Background

“The challenge and opportunity the transition to a low carbon economy presents the UK construction industry with terrific opportunities for growth. There are also opportunities through greater resource efficiency and from adaptation of our built environment to deal with climate change. These opportunities reach into every part of the construction supply chain and there is significant potential to exploit huge export markets.” - Construction 2025

[Construction 2025](#)^{viii} is a partnership between industry and Government to transform the construction industry. In July 2013 it reported its findings, supported by The Green Construction Board, for the delivery of a more sustainable construction industry. Working together, industry and Government have developed a clear and defined set of aspirations for UK construction.

“the construction industry has the most influence over the capital carbon impact of what it produces. In this area, less capital carbon^{ix} can equate directly to less capital cost. Together we can play a big role in promoting the benefits of investment in energy efficiency and low embodied carbon solutions and in developing products and services to sell into these diverse markets.”

In addition, the board has laid out specific objectives that it aspires to delivering by 2025 and which underpin the development of an embodied carbon reduction strategy.

- 21% reduction of capital carbon by 2022
- 29% reduction of capital carbon by 2027
- 39% reduction of capital carbon by 2050

2.1.2 Embodied Carbon Industry Task Force

The objectives of the Task Force is to build industry-wide consensus on how embodied carbon should be measured and reported and to develop a methodology such that Embodied Carbon may be included as an Allowable Solution within the definition of Zero Carbon Building regulations for both Residential and Commercial Property.

Specifically the aim of The Task Force has been to deliver the following:-

- Agreement and proposals for minimum standards for measurement, reporting and verification
- Agree methodology for Allowable Solutions
- Make recommendations to Government

2.2 What is embodied carbon and why is it important?

2.2.1 Overview

During its lifetime a development will ‘emit’ carbon through a number of separate phases. In principle these phases may be split into four broad phases categories. These are laid out and described within BS EN 15978:2011.

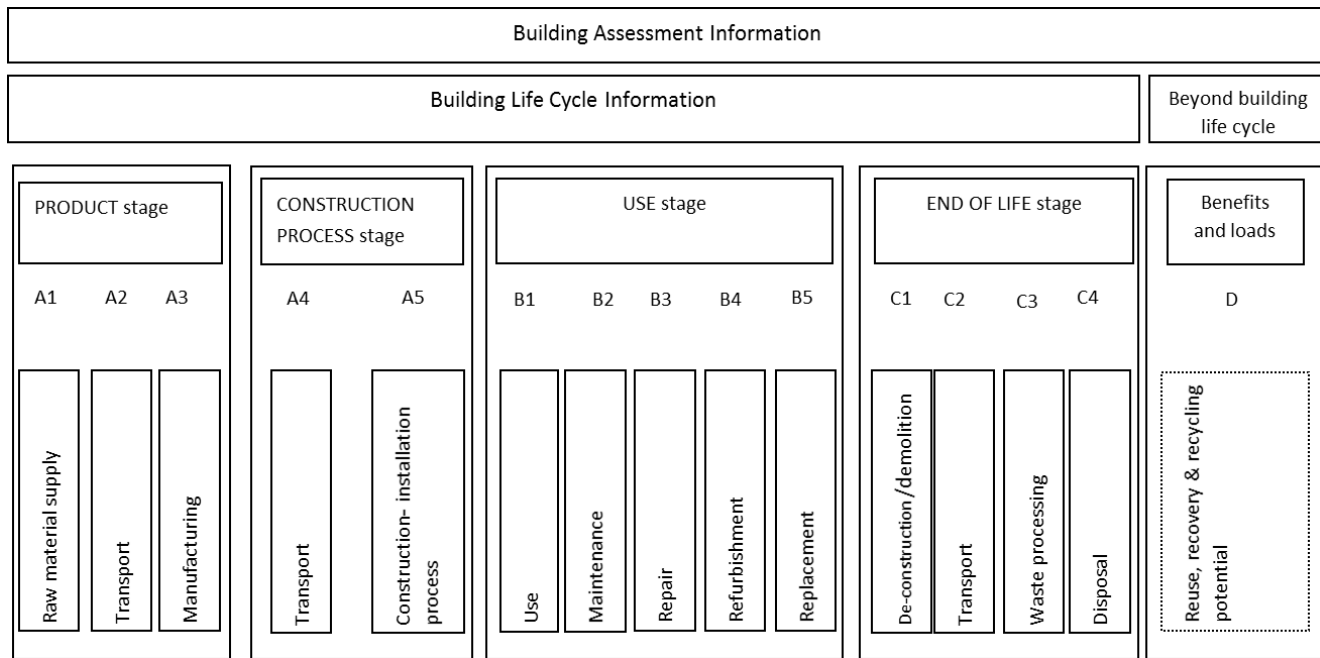


Figure 1 – Building Lifecycle Carbon Analysis based on BS EN 15978:2011 arising from CEN’s Technical Committee 350 (CEN/TC 350)

Although the current Building Regulations currently ignore the ‘embodied’ carbon for a typical office building, embodied carbon may form as much as 40% of lifetime emissions and in some building types for example distribution centres, embodied can be over 70% of emissions.

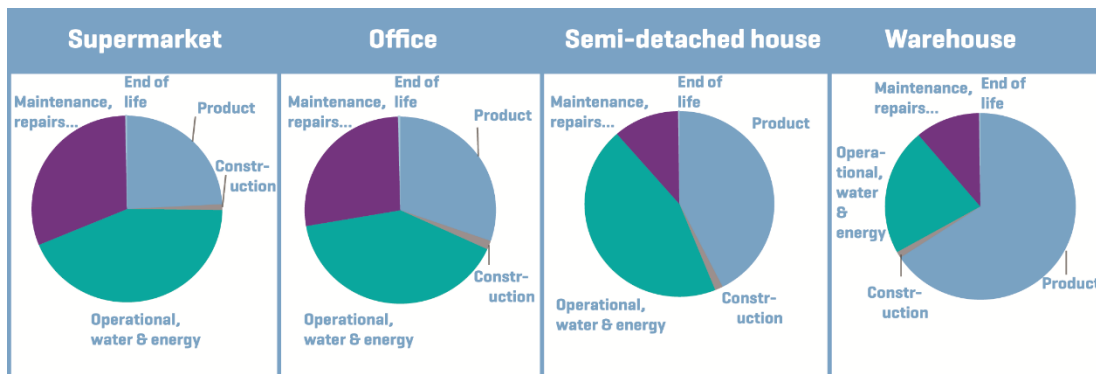


Figure 2 – Typical breakdown of embodied vs. operational carbon by building typology (RICS Professional Guidance, Global Methodology to Calculate Embodied Carbon 1st Edition)

As operational energy efficiency improves and the carbon intensity of the grid decreases, embodied energy will form an even greater percentage of the lifecycle total. It will become increasingly important to address EC and to understand how trade-offs between embodied energy and operational carbon can be considered in the cost effectiveness agenda.

2.2.2 Why now?

Over its lifetime, buildings are responsible for carbon emissions through a number of different phases

- Products - materials extraction, manufacture and transportation
- Construction – transportation and construction activities
- In Use – energy consumption, maintenance, repair, replacement and refurbishment
- End of life – demolition, transportation, waste processing and disposal

Figures 3 and 4 below, shows the carbon emissions over a building lifespan. It can be seen that embodied carbon emissions occur as a spike at the start of 'life' with major replacement cycles every 7-15 years. The overall emissions associated with materials manufacture is approximately 40%-50% (see figure 4). It is clear, however, that relative importance of embodied carbon will increase dramatically if either the building's life is shortened (typically to 30 years in London).

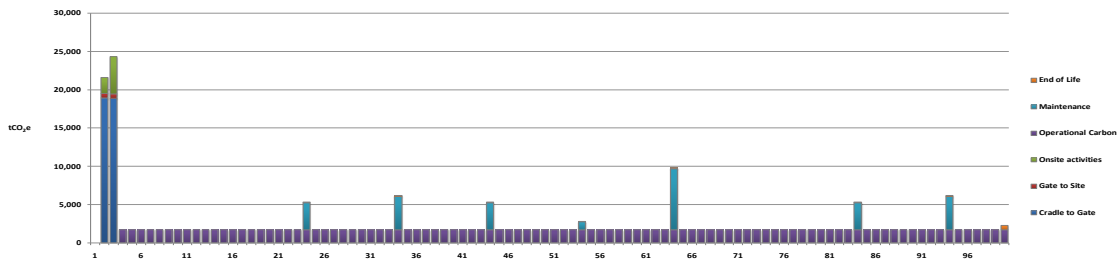


Figure 3 Building Lifetime Emissions (100 years)^x

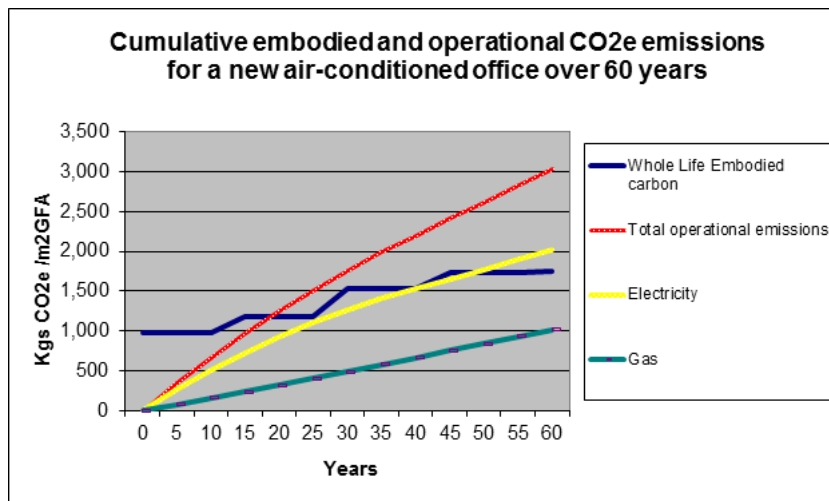


Figure 4 Cumulative building emissions over 60 years - AECOM^{xi}

Additional points to note are:-

- Large impact of construction materials during construction– over 40% of emissions are accounted for even before the building is occupied.¹²
- Impact throughout the life cycle of minor and major refurbishments
- Relatively low impact at end of life due to mainly inorganic materials use
- Relatively low impact of annual operational emissions compared to embodied emissions
- Emissions do not take the net impact of grid de-carbonisation into account, which will further decrease the net impact of operational emissions over time

2.2.3 Key benefits of measuring and managing embodied carbon

Typically embodied carbon is calculated based on building elements and materials and allows design teams to use carbon emissions as a proxy to optimise design and manage costs. Work carried out by

¹² See Figure 2 for detailed breakdowns

Anglian Water shows that by tracking embodied carbon they have been able to reduce the costs of their infrastructure projects by 30% - 50%.

Key benefits of measuring and managing embodied carbon:-

- i. Embodied carbon results from the expenditure of non-renewable fuels during manufacture, transport and construction. It follows that the reduction of EC will necessarily reduce the UK's energy consumption, supporting greater fuel independence and mitigating the price volatility of construction materials.
- ii. EC management promotes whole life cost thinking, leading to cost reductions and improved long term efficiency of our building stock
- iii. EC may be used as a proxy for cost management. By managing carbon emissions down, the use of energy intensive materials will be minimised.
- iv. The use of low embodied carbon materials will promote the specification of locally sourced solutions¹³ due to reduced transportation impacts. This will in turn support the local economy both within the regions and nationally.
- v. Innovation required to reduce the EC factors of materials will drive innovation and bring new skills to UK manufacturing
- vi. The management of EC promotes the reuse of materials and increased recycling leading to the reduction of waste and the move towards a 'circular economy'. This will in turn support the decoupling of the UK economy from carbon emissions
- vii. Promote fundamental change in supply side business models (materials/aluminium/systems and facades in particular) by promoting low carbon solutions
- viii. Improve the competitiveness of UK manufacturing sector within external markets
- ix. Build Industry knowledge around embodied carbon management allowing us to export this knowledge and sell UK expertise

London 2012 Olympic Stadium

Achieved a 38% reduction in embodied carbon through

- 100% recycled aggregates
- Cement substitutes
- Reuse of 'waste' steel from a local gas pipeline

ProLogis Distribution Centre, Daventry

10% reductions achieved through:-

- Innovative ground stabilisation programme
- On-site waste management programme
- Focus on travel and construction processes

2.3 Industry Capacity and Knowledge

2.3.1 Overview

The measurement of embodied carbon is not new and has evolved from the field of energy analysis, which was prominent in the 60's and 70's. The first detailed analysis of embodied energy being carried out by Davis Langdon Everest was circa 1985.

Since then a number of detailed databases of embodied carbon/energy have been developed and are now in widespread use for materials. These include 'Ecoinvent', which is typically used with the software 'SimaPro', and 'GaBi'.

¹³ This is one of the key objectives laid out in Construction 2025

In 2005 Dr Craig Jones, at the time a Research Officer at the University of Bath developed one of the first embodied carbon databases specifically covering building materials. Publications that have followed include

- BSRIA: Embodied carbon: The Inventory of Carbon & Energy
- Institution of Civil Engineers: Civil engineering standard method of measurement - CESMM3
- Hutchins: 'Black Book' – The cost and carbon guide
- Institution of Structural Engineers: Embodied energy and carbon
- RICS Professional Guidance, Global Methodology to Calculate Embodied Carbon 1st Edition

Measuring and reporting embodied carbon as a consultancy offering emerged over 10 years ago when the first practitioners started to actively measure and report embodied carbon as a part of the design process.

2.3.2 Practitioners and Industry Uptake

There are a growing number of practitioners providing consultancy services for embodied carbon and whole life carbon analysis. This was evidenced by the UKGB Embodied carbon week which saw an attendance of over 1000 people at their recent event Embodied carbon Week. Demand for services is being driven by a number of factors including recognition within BREEAM^{xii} as well as emerging requirements within the planning community. Leading practitioners include the following:

AECOM	ATKINS Global	ARUP
Best Foot Forward (Anthesis)	BRE	Circular Ecology
Sturgis Carbon Profiling	The Sustainable Business Partnership (formerly dcarbon8)	
PE International		

Many leading contractors have focussed on their part of the data management and now most organisations have processes in place to collect relevant data such as:-

Balfour Beatty	Buckingham Group	Gilliford Try
Kiers	Sir Robert McAlpine	Skanska
Wates	Wilmott Dixon	Winvic

In addition, a number of leading developers are supporting this transformation by through the appointment of consultants to provide specific advice around embodied carbon. Clients include:-

Anglian Water	British Land	Cross Rail	The Crown Estate
Derwent London	Development Securities	Gatwick Airport	Google
Grosvenor Estate	Kingfisher Plc.	Land Securities	Marks and Spencer
Marsh & McLennan	Network Rail	ProLogis	Sainsbury's
Thames Water	Tishman Speyer	WWF	

Prologis Corby.

Prologis UK Limited have for some time, voluntarily measured and mitigated 110% of the embodied carbon of any new building they construct in the UK. From a sustainability perspective this is one of the most significant commitments Prologis can make to reduce the total carbon emissions from their development activities.

The benefits of this approach was recognised by the planning system when consent was secured for a sustainable business park in Corby, North Northamptonshire. The Planning Applications case officers report stated;

As the demand for information from consultants has grown so suppliers and verifiers have begun to take the initiative on measuring their embodied carbon. This has been helped by the introduction of Environmental Product Declarations (“EPDs”) Examples include:-

Hanson	Gyproc	Interface Flooring	Kalzip
KONE Lifts	Cotto San Michele (clay tiles)	PU Europe	TATA Steel

Associations that have likewise developed solutions include

- Mineral Products Association (IBU EPD of UK cement)
- Brick Development Association

2.3.3 The Planning System

At present, the planning system is predominantly focused on operational energy/carbon use and therein, the Zero Carbon Buildings Policy. This is demonstrated through Paragraph 95 of the National Planning Policy Framework (NPPF) which states;

To support the move to a low carbon future, local planning authorities should:

- Plan for new development in locations and ways which reduce greenhouse gas emissions;
- Actively support energy efficiency improvements to existing buildings; and
- When setting any local requirements for a buildings sustainability, do so in a way consistent with the Government’s zero carbon buildings policy and adopt nationally described standards.

Because embodied carbon is not formally recognised by Government as part of the Zero Carbon policy it is often not present within local plans nor does it carry meaningful weight within the planning process or planning balance despite the planning system presenting the ideal vehicle to promote and recognise this issue.

One of the core planning principles of the NPPF is to require new development to mitigate and adapt to climate change. Section 2.0 of this report clearly demonstrates the significance of embodied carbon in terms of a buildings total carbon emissions and any efforts to measure and mitigate this would clearly be a positive climate change mitigation measure for the UK.

If embodied carbon is recognised by Government, preferably within the Allowable Solutions policy, then this would be fully supported by the existing NPPF.

Despite the above however, a number of forward thinking local authorities have taken the initiative to develop planning policies that request new development to consider embodied carbon as part of a total carbon reduction strategy. This reflects the small, but growing recognition that embodied carbon is an

important issue to tackle and, given that a local plan may be in place for 10 years or more, is a natural progression once the Zero Carbon buildings policy is in place to address regulated energy use.

Examples of local authorities that request embodied carbon to be considered as a part of planning are set out below;

Brighton and Hove County Council [Link](#) Huntingdonshire County Council – [Link](#)

London Borough of Wandsworth – [Link](#) Eastleigh County Council– [Link](#)

Dundee County Council– [Link](#) Leeds City Council- [Link](#)

There are a growing number of practical examples where embodied carbon has been recognised and promoted at a local level by an authority and an applicant

Brighton and Hove

Since 2005 B&H has had policy on the sustainability of materials proposed in planning applications. This expects the use of construction materials with low embodied energy; reduction of raw material inputs; and use of recyclable and/or recycled materials. This policy is being carried forward into the City Plan and will be further developed in further Planning Documents. This was introduced to address the

In response to Local Plan policy SU2 which expects the use of materials with 'low embodied energy', Brighton & Hove Local Planning Authority created and adopted a tool for estimating embodied carbon of building materials. Submission of a completed checklist is a validation requirement for all NEW BUILD RESIDENTIAL applications.

As part of the checklist a new feature incorporated an estimator for assessing embedded carbon of construction materials in residential and mixed use new build development. This is a free online tool which facilitates the planning applicant to estimate embedded carbon of building materials.

2.3.4 Environmental Impact Assessment – Revised EU Directive.

The European Union have recently adopted a revised Environmental Impact Assessment (EIA) directive which must be ratified into UK legislation by 2017. This directive gives far greater recognition to the issue of climate change and Greenhouse Gas (GHG) emissions, with the likely result being an assessment of a development's impact upon climate change within an EIA.

The Institute of Environmental Management and Assessment (IEMA) are the UK's leading authority and regulator of EIA best practice. As a result of the revised directive IEMA are currently developing new guidance for the assessment of climate change impact from new development during the EIA process. Fundamentally, this guidance suggests that potential impact can only be measured and assessed once the total GHG emissions (including embodied carbon) of a project has been calculated. Mitigation of impact will therefore be measured and assessed in terms of reduction in total GHG emissions.

If the revised EIA directive is implemented, much greater focus will be given to embodied carbon emissions as part of a total GHG assessment for those projects requiring an EIA. Given that an EIA is often a legal requirement as part of a planning application, this will inevitably raise the profile of this issue during the planning process.

With recognition from Government, the issue of embodied carbon could be promoted and recognised within the planning system in much the same way as the Building Research Establishment's Environmental Assessment Method (BREEAM). BREEAM is a voluntary standard but is a recognised metric of sustainable non-domestic buildings and has largely been adopted and accepted by the planning system. The Government have facilitated this by allowing local authorities to adopt 'national standards of sustainable design for non-domestic buildings' within their local plans. There is no reason therefore why the issue of embodied carbon could not be promoted in a similar manner.

2.3.5 Global uptake

Globally, the regulation and practice of measurement and reduction of embodied energy and carbon is growing rapidly. The UK is widely recognised as having been a leader in the field for a number of years, with the Bath ICE database in particular used across the world despite of its often-limited relevance for their region and industry. However, practices within Scandinavian and Northern European countries such as Germany and Austria may now be overtaking those in the UK, with widespread research programmes underway. In Australia, innovation credits for Lifecycle Impacts are already available as a part of the Green Star rating system and likely to be included as a firm credit in future updates, which has led to major developers making the EC measurement a standard feature of all of their projects.

In January 2013, The Netherlands became the first country to regulate for the measurement of greenhouse gases embodied in buildings: as of the 1st January 2013, a new environmental requirement in the Dutch Building Decree requires two new environmental indicators to be reported with respect to building materials being greenhouse emissions and depletion of resources (i.e. an LCA) for residential and office developments over 100m² according to the Environmental Assessment Method for buildings and civil engineering works. [Link](#)

Other countries have developed national databases of the environmental impacts of products and materials, including those used in construction. A list of several databases can be found in the references. [xiii](#)

Collections of manufacturers EPDs concentrating on construction products have also been developed - see for example www.environdec.com, www.bau-umwelt.de (Germany) and www.inies.fr (France), as well as the BRE Green Book in the UK

As well as the EU and International Standards which have been developed over the last few years, some countries have developed their own voluntary national standards and regulations. Examples are:

- Germany - VDI 4600 (2012) Cumulative energy demand: Terms, definitions, methods of calculation
- Switzerland - SIA 2032 (2010) Grey Energy of Buildings
- Britain - PAS 2050:2011 – Specification for the assessment of life cycle greenhouse gas emissions of goods and services, and PAS 2060:2010 - Specification for the demonstration of carbon neutrality
- USGBC - In LEED v4 (Building life-cycle impact reduction-Option 4) and LEED 2009 had a pilot credit, MRpc63 Whole building life cycle assessment.
- In DGNB (Germany), a building level LCA, incorporating the life cycle impacts from regulated energy use, is mandatory to provide the majority of the environmental credits.
- The Netherlands also has a national construction LCA database ^{xiv}(essential for the regulated LCA assessments)
- The German construction LCA database ^{xv}
- The Sustainable Energy Authority of Ireland has also carried out work on embodied carbon

At present, a major international project is currently underway to support the development of understanding in this area. **Annex 57: Evaluation of Embodied Energy & Embodied GHG Emissions for Buildings** is part of the International Energy Agency Energy “Conservation in Buildings” Programme, and includes participants from: Australia, Austria, Brazil, China, Czech Republic, Denmark, Finland, Germany, Japan, Korea, Portugal, Norway, Sweden, Switzerland, The Netherlands and the UK. Due to report in 2015, the Annex is writing advisory documents on methodology, tools, datasets and best practice case studies, in order to inform future regulations and practices.

2.3.6 Education

Teaching of embodied carbon calculations and considerations already forms a part of the core undergraduate curriculum at several UK Universities. Examples are the University of Bath, where the calculation of embodied carbon is incorporated into the undergraduate degree programmes for Architecture and Civil Engineering, and the University of Cambridge, where it forms part of a fourth year module for civil engineers.

2.3.7 Summary

Embodied Carbon as a practice has been developing since the 1980s and has gained significant traction within UK industry and globally. The UK, once leading in the practice is in danger of falling behind and certainly UK legislation is somewhat lagging other Governments, especially Germany and The Netherlands.

The industry is building capacity and is now looking for Government direction and support. Key opportunities include the following:-

1. Allow embodied carbon into Allowable Solutions given that this issue is very firmly embedded in current and emerging planning policy
2. Carry out embodied carbon assessments on all Government-financed projects
3. Incorporate the EIA directive into UK Legislation

2.4 Scope of present practice and key challenges arising

2.4.1 Measurement and Reporting

As the number of projects and practitioners has grown, different measurement and reporting strategies have emerged with respect to reporting boundaries, emission factors, and treatment of recycled content being some of the issues where the majority of differences exist.

However, in 2011 the Technical Committee CEN TC 350 provided guidance on measuring embodied carbon within construction materials with the publication of BS EN 15978 which has become the principle methodology followed by the majority of practitioners.

At present whilst most practitioners follow this standard, there is still scope for variation in reporting, which can make it difficult to compare the results of one building against another and has led to a number of challenges.

- *Reporting* – Although almost all organisations follow principles laid out within BS EN 15978, reports tend to describe different boundaries. In particular, most organisations report A1-3, some cover A1-5 but very few report on all stages. As a result reports are sometimes difficult to compare
- *Materials database and emission factors* – There are a number of materials databases that practitioners use. SimaPro and Gabi provide fundamental information about energy consumption and Bath ICE remains the only dedicated building materials database for the UK although this has not been updated since 2011. However, manufacturers are now aligning behind new EU guidance such as EN BS 15804.
- *Baselines* – Until recently, there has been no single database for buildings, although RICS has published guidance and has some information on previous building types. However, in April 2014 WRAP released its Buildings Database and this is now being widely considered as the industry standard.

2.4.2 Verification

There is no specific requirement for verification and some companies are presently carrying out verification of reports. PWC has assured one report for AECOM, the leading practitioner in this space is Planet First, which has developed the “Planet Mark” in collaboration with the Eden Project and represents the first certification solely focussed on verifying embodied carbon. The Planet Mark is a new, voluntary certification providing a third-party verified benchmark for buildings developed and administered by Planet First in partnership with the Eden Project. Certification is awarded to property developments on the basis of environmental and social performance and uses best practice methodologies such as ISAE 3000. To date Planet First ^{xvi}have certified over 2.5Mft².

2.4.3 Market uptake

Despite government targets and the obvious need for measuring and managing embodied carbon, and despite the fact that that in many cases the delivery of embodied carbon reductions is cost neutral, the demand for measurement and management is not yet widespread.

Key barriers to full market adoption include:-

- **Lack of regulation or government incentives** - Present market drivers such Part L and proposed Zero Carbon Building Regulations do not recognise the importance and opportunities of considering embodied carbon and are not supporting industry initiatives
- **Cost of analysis** – The cost of analysing the lifecycle carbon of a building is relatively low with typical fees being £5,000 - £50,000 representing less than 0.01% of build costs. However despite this low cost fee spend remains a barrier to uptake.
- **Comparability and Standardisation** – It is clear that there is a general perception amongst some clients that embodied carbon is complex and difficult to measure and that reports are not easily transferable

2.4.4 Summary

It is clear that if the UK is to meet its carbon commitments and the challenges of embodied carbon reduction as laid out by Construction 2025, then the industry needs to better manage the energy used in the materials production and construction. However, in order to do this a number of key challenges need to be addressed as follows:

- Practitioners need to agree and report against ‘minimum requirements’ to allow comparability.
- The business case for measuring and managing embodied carbon should be promoted not only amongst clients but also the supply chain
- A verification methodology should be developed
- Industry and government need to work together to put necessary incentives in place

Section 3 - Proposals for Standardised Measurement Method

The Industry Task Force have agreed to follow minimum standards ¹⁴as laid out below starting from June 2014.

3.1 Minimum Standards

3.1.1 Proposed Minimum Requirements

We have agreed that from June 2014 all practitioners will follow and report against the minimum requirements as laid out below.

These proposals are based on BS EN 15978:2011 and will deliver the following

- Robust measurement standards
- Comparability between reports from different consultants
- A basis for the delivery of Embodied Carbon as an Allowable Solution

a) Boundary

Stage	Sub Stage	Item	Commercial		Residential	
			Minimum	Optional	Minimum	Optional
Product Stage	A1	Raw Materials	X		X	
	A2	Transportation	X		X	
	A3	Manufacture	X		X	
Construction Process	A4	Transportation	X		X	
	A5	Construction and Installation	X		X	
Use Stage	B1	Use	N.A		N.A	
	B2	Maintenance		X		X
	B3	Repair		X		X
	B4	Replacement		X		X
End of Life	C1	Deconstruction and Demolition		X		X
	C2	Transportation		X		X
	C3	Waste processing		X		X
	C4	Disposal		X		X
Re-use	D1	Re-use		X		X

Figure 5 – Proposed Minimum Requirements - Reporting Boundary based on BS EN 15978:201

¹⁴ These are broadly based on 'RICS Professional Guidance, Global Methodology to Calculate Embodied Carbon 1st Edition' published 2014.

b) Scope of Reporting

Building Element	Sub element	Commercial		Residential	
		Minimum	Optional	Minimum	Optional
Sub structure	Foundations	X		X	
	Basement retaining walls and floors	X		X	
	Ground bearing slab	X		X	
Superstructure	Frame	X		X	
	Upper floors	X		X	
	Stairs and ramps	X		X	
	External walls and cladding	X		X	
	Windows and doors	X		X	
Fit out	Internal partitions (non-structural)		X	X (on plan only)	
	Raised floor		X		X
	Ceilings		X		X
Internal Finishes	Walls		X		X
	Carpets and other		X		X
	Ceilings		X		X
MEP Services	CAT A		X		X
	CAT B		X		X
External Areas	Roads and surfaces		X		X
	External services		X		X
	External drainage		X		X
External Landscaping	Earth works		X		X
	Planting		X		X
	Irrigation		X		X

Figure 6 - Proposed Minimum Requirements – Scope of Reporting

3.1.2 Materials Emission Factors

- i. We agreed that in the short term, Materials Emission Factors will be based on available data using Bath ICE and other established databases (e.g. SimaPro and GaBi) but that the industry will move toward using EN 15804 or equivalent (e.g. EN 16449 for timber) as the basis for all MEFs.
- ii. We also agreed that in the longer term, a UK database should be developed such that manufacturers and specifiers alike may assess product performance. It should be noted that such a database already exists in Germany.

Notes and Exclusions

- i. Recycled content – Key issues arise from recycled content especially with respect to steel use. We agreed to work with default standards at present.
- ii. Yields and production losses - Yield losses accrue in the manufacturing stages which follow material formation, being off-cuts and shavings. For some industries which use complex shapes,

yield losses may approach 50%. These will not be considered at present but it is recognised that this will be included within EN 15804.

3.1.3 Buildings Database

We have agreed that we will use the WRAP Buildings Database for submission of buildings and we agreed that we would upload all of our data available by 2015.

3.1.4 Proposed Verification Methodology

We have agreed that independent verification is a useful additional check but that it will be optional. Assurance may be 'Limited' or 'Reasonable' as is appropriate for the project except where it is used to establish an Allowable Solution in which case it should be 'Reasonable'. Assurance should be based on ISAE 3000 or similar.

3.2 Embodied Carbon as an Allowable Solution

3.2.1 Background and Justification

It is clear that unless action is taken to measure and reduce the embodied carbon associated with materials manufacture and building construction, the UK Government is unlikely to meet its own targets for reduction of greenhouse gas emissions.

There is a clear environmental and business case for measuring and managing embodied carbon, but current market mechanisms are failing to deliver change at the pace required to meet UK targets.

The Task Force believes that the inclusion of EC as an Allowable Solution would provide the industry with the necessary incentive to invest and drive change leading to some clear cross industry benefits.

There are two principle reasons for including EC as an Allowable Solution

1. Measuring and reducing EC will deliver real and absolute carbon savings immediately rather
2. Embodied Carbon reductions offer a cost effective means of reducing carbon emissions

In addition there are a number of other distinct benefits

- Provision of an incentive for materials and product innovation, reducing the UK's overall energy consumption and supporting greater energy independence
- Improvement in industry competitiveness
- Encouragement for product manufacturers who fall outside of the CRC and mandatory carbon regulations to measure and reduce carbon emissions, thus leading to increases in production and resource efficiencies unless checked
- Promotion of the use of low energy materials and those that sequester carbon over their lifetime
- Promotion of the uptake of renewables by manufacturers and logistics organisations in order to reduce their emissions
- Support for local and national sourcing
- Dissemination of best practice construction
- Promotion of whole life thinking and integrated waste management
- Development of UK PLC's skill set and competitiveness through industry alignment and ensuing job creation and up-skilling

3.2.2 How will EC as an Allowable solution be measured?

The Zero Carbon Hub is presently developing the methodology for calculation Allowable Solutions. The methodology is likely to be based on the following

- a) A prescribed and pre-calculated solution based on generic data similar to the methodology for ECO used by the Energy Sector with respect to insulation and other energy efficiency initiatives.

- b) A prescribed methodology that will allow new solutions to be developed over time based on robust and verifiable performance data

Our proposal will follow the same strategy but will be based on a pre-agreed list of prescribed solutions for key materials, with a means by which manufacturers may make proposals. Eventually, and only after sufficient case studies have been developed to establish a robust building baseline, the methodology should be applicable to 'whole building' analysis.

Phase 1a – Approved Measures - Materials

The Task Force proposes to develop a prescribed list of solutions that will be given a per unit rating kgCO₂e.

Stage	Activity	Example	Comments
Stage 1	Identify short list of key materials	e.g. Concrete, bricks, mortar, carpets	The list will be necessarily short and focussed to avoid lengthy negotiations with stakeholders
Stage 2	Agree baseline emissions factor for functional unit	e.g. Concrete (specific strength)	Based on business as usual (BAU)
Stage 3	Agree prescribed option	e.g. Incremental % cement substitute	Source solutions and best practice from industry
Stage 4	Calculate kg/m ³ saving	Allocate 'value'/m ³	Independent 3rd party analysis and verification

Figure 7 – Proposal for developing Approved Measures

Phase 1b – Innovation - Materials

We will develop a methodology based on the above that will allow manufacturers to submit proposals to be added as 'Approved Measures'. There will be a requirement for 'reasonable' assurance for any submissions and analysis will need to be based on an approved methodology.

Phase 2 – Whole Building Analysis

Baseline Measurement - Baselines will be developed using the WRAP database by building type. We expect that by 2016 over 1000 buildings will be within the database providing sufficient information to develop baseline by building typology

Simple Building Embodied Carbon Measurement Methodology (SBECM) – A simple analysis tool will need to be designed to allow the measurement of a Baseline using default material emission factors. We envisage that this will be developed using baseline data contained within the WRAP database.

Stage	Activity	Example	Comments
Stage 1	Develop baseline building emission factors / m ² or /m ³	Using WRAP database assess BAU emissions.	This will need to be based on WRAP database and be sector specific.
Stage 2	Develop simple analysis tool for setting baselines.	e.g. Based on a similar solution as SBEM used for 'in-use' measures	To be used by planners and building control officers
Stage 3	Agree submission requirements and award of AS	Submissions could be by material, building element or whole building analysis	Will require independent 3rd party verification
Stage 4	Independent body to monitor	Agree Verification methodology and approved verifiers	Set up independent body to monitor and police

Figure 8 – Proposals for including Whole Building Analysis as an Allowable Solution

3.2.3 Remaining Challenges and Gaps

Key issues that will need to be resolved to ensure EC may be used as an Allowable Solution include the following:-

- *Additionality* – Given the overall concept of AS, additionality related to product manufacture will follow the same justification.
- *Leakage* – How will the methodology take into account products made overseas when the benefit is not taken within the UK carbon boundary. Strategies that will be considered are as follows
 - Stage 1 – In first instance limit material solutions to main building components and materials (i.e. superstructure and roofing) where 100% UK sourcing may be assured.
 - Stage 2 – Allow material manufacturers to submit solutions where they have identified products made or assembled in the UK and energy boundary drawn accordingly
 - Stage 3 – Extend boundary to promote global best practice for all products made globally as long as verification is provided
- *Funding* will need to be found for the development of a Simple Building Embodied Carbon Measurement Methodology (SBECM).
- *Software comparison* – we have agreed to test analysis against a single set of source data with the aim of achieving a +/- 10% variation in results. This will be delivered by the end of 2014

Section 4 - Conclusions, Recommendations and Road Map

4.1 Minimum Reporting Standards

In response to these findings The Task Force has developed a clear set of proposals for adoption by the industry as a whole in order to meet the concerns that Government presently holds:-

Minimum Reporting Requirements

Practitioners have agreed a standard minimum reporting framework for practitioners to follow. These are based upon recognised European Standards (CEN TC 350) on the “Sustainability assessment of construction works”, EN 15978:2011 and EN 15804:2012 which is widely accepted by industry bodies such as the Construction Products Association.

Buildings Database

Practitioners have agreed to use the WRAP buildings database as our standard reporting framework.

Materials Emission Factors

Practitioners have agreed that Material Emission Factors will be based on EN 15804 or equivalent (e.g. EN 16449 for timber) and that a UK database will be developed such that manufacturers and specifiers alike may assess product performance. It should be noted that such a database already exists in Germany.

Allowable Solutions

Industry has agreed to develop a staged approach to assessing Embodied Carbon reductions such that EC may be accepted as an Allowable Solution.¹⁵

¹⁵ The proposed methodology is laid out within this document and that phase 1a (Approved Measures) may be included within the 2016 Zero Carbon Regulations that that whole building analysis may be included for 2019.

4.2 Proposed Road Map for Implementation

The task force has developed a road map for the delivery of these proposals as follows

By April 2015

- Practitioners to report against minimum requirements from June 2014
- Test building analysis to assess software solutions – adapt models to meet +/-10% variation rate
- Agree methodology and establish requirements for a UK wide materials database - seek TSB funding
- Identify 'Approved Measures' for Allowable Solutions
- Government releases a statement recognising the importance of embodied carbon and its intention to review its inclusion within the Zero Building carbon Regulations

By April 2016

- All practitioners to use agreed methodology and upload buildings database
- Develop and promote materials data base
- Finalise list of 'Approved Measures' to be included within Zero Carbon Building Regulations – seek assurance and establish methodology for manufacturer submissions

2016 - 2018

- Gather sufficient evidence for planners and local authorities to request EC calculation to be carried out on all projects
- EC calculation and reductions to be made mandatory of all public procurement following principles of the Social Value Act.

By 2019

- Through review of all building data, establish building baselines (by typology) ready for integration into 2019 Zero Building carbon regulations

4.3 Recommendations to Government

The Task Force has made a number of key recommendations for consideration by Government as follows:-

Recommendation 1 – That Embodied Carbon should be included as an Allowable Solution within the Zero Carbon Building Regulations for both Homes and Commercial Development.

Recommendation 2 – That Government should support and fund the development of a UK wide materials database similar to those developed in Germany and The Netherlands.

Recommendation 3 – That Government should continue to support the development and upkeep of the WRAP Buildings Database

Recommendation 4 – That The Building Regulations should be developed to eventually include whole life carbon emissions.

Recommendation 5 – That in the light of The Social Value Act, Government should support further research on the benefits of managing and reducing embodied carbon.

References

- ⁱ RICS Professional Guidance, Global Methodology to Calculate Embodied Carbon 1st Edition 2014
- ⁱⁱ RICS Professional Guidance, Global Methodology to Calculate Embodied Carbon 1st Edition 2014
- ⁱⁱⁱ Construction and Sustainable Development' Plain English, Constructing Excellence, Section 3 Page 2. 01/01/08
- ^{iv} Assumes annual 2% growth of construction industry
- ^v RICS Professional Guidance, Global Methodology to Calculate Embodied Carbon 1st Edition 2014; British Council for Offices Report 'Whole Life Carbon Footprint Measurement and Offices, 2012; British Council for Offices Guide 2014.
- ^{vi} WRAP Database was launched in April 2014 at the UKGBC Embodied Carbon Week
- ^{vii} Dutch Building Regulations require the submission of an Building LCA
- ^{viii} [Construction 2025 - https://www.gov.uk/government/publications/construction-2025-strategy](https://www.gov.uk/government/publications/construction-2025-strategy)
- ^{ix} Embodied Carbon is referred to as Capital Carbon within this document
- ^x Analysis by Deloitte based for an office building over 100 year lifetime – decarbonisation of the grid is not allowed for.
- ^{xi} Based on analysis by AECOM of a typical office building
- ^{xii} ENE 04 (4 + 1 exemplary), MAT 01 (5/6 + 1 innovation credit (including the EPD points uplift)), MAT 02 (1 credit), MAT 04 (1 credit). Note that BREEAM guidance note 8 now allows for a building LCA as an alternative route to obtain the innovation credit for MAT 01.
- ^{xiii} <http://www.ghgprotocol.org/Third-Party-Databases>, and <http://eplca.jrc.ec.europa.eu/ResourceDirectory/databaseList.vm>
- ^{xiv} <https://www.milieuDATABASE.nl/>.
- ^{xv} www.oekobau.dat
- ^{xvi} www.planetfirst.co.uk