Historic
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Whole life Carbon Guidance Note

Definitions and Considerations

This guidance is aimed at anyone wanting a general introduction to and understanding about what Whole Life Carbon means.
It explains why we should be considering Whole Life Carbon at an early stage of a construction project or when any works to existing buildings are being considered.

National Trust

Housing Executive

Any enquiries regarding this document should be sent to us at:

Department for Communities
Historic Environment Division
Ground Floor
9 Lanyon place
Belfast
BT1 3LP

or email: **hedcentraladmin@communities-ni.gov.uk**

General enquiries: **028 9082 3100**

This publication is also available to download from our website at
www.communities-ni.gov.uk/topics/historic-environment

Definitions

Whole Life Carbon:

Whole Life Carbon emissions are the sum total of all asset related GHG* emissions, both operational and embodied, over the life cycle of an asset including its disposal.

Upfront Carbon:

Upfront Carbon emissions are those GHG emissions associated with materials and construction processes up to practical completion (so product manufacture, transport and construction).

Embodied Carbon:

The Embodied Carbon emissions of an asset are the total GHG emissions and removals associated with materials and construction processes throughout the whole life cycle of an asset (Modules A1-A5, B1-B5, C1-C4, see diagram below).

Operational Carbon:

Operational Carbon is the GHG emissions arising from all energy consumed by an asset in use, over its life cycle and demolition phases.

Microsoft Word - 20210525.WLCN.LETI.Carbon Definitions Version 'A'.docx (asbp.org.uk)

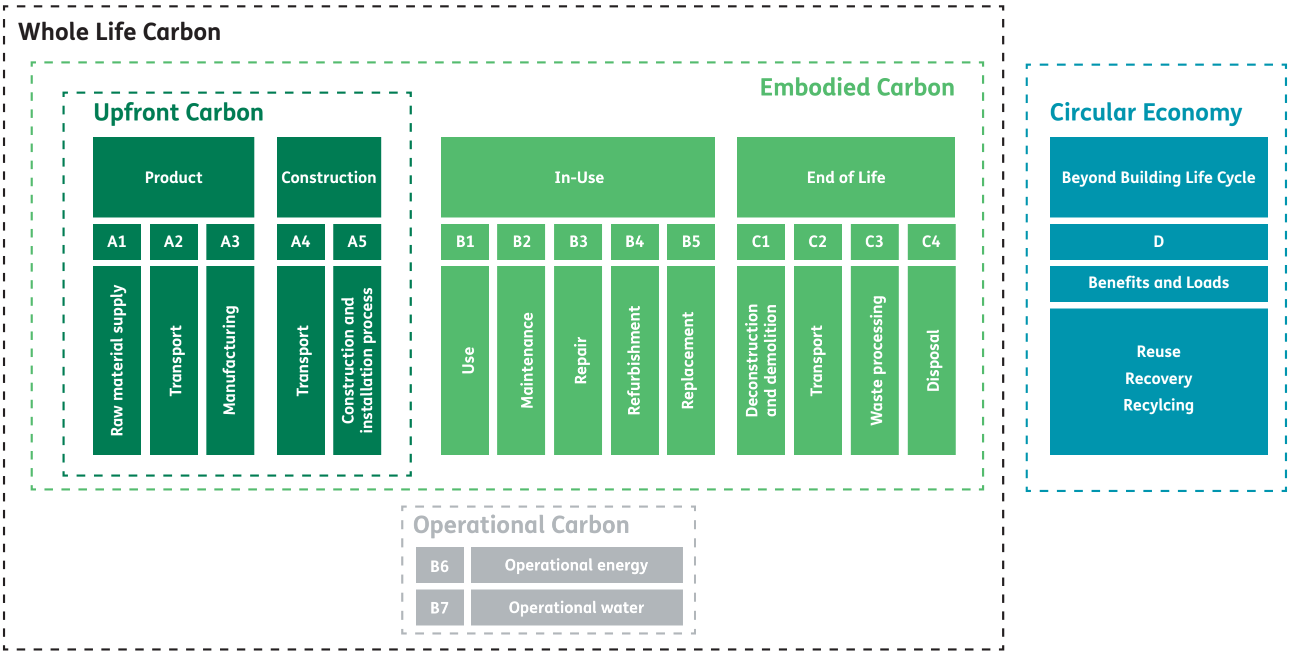


Diagram showing the different life cycle stages according to CEN/Tc350 and how they relate to Embodied Carbon

Circular Economy:

An economic system based on the re-use and regeneration of materials or products, a means of continuing production in a sustainable or environmentally friendly way. The Circular Economy Strategy for NI is currently being developed by DFE.
https://www.economy-ni.gov.uk/articles/circular-economy

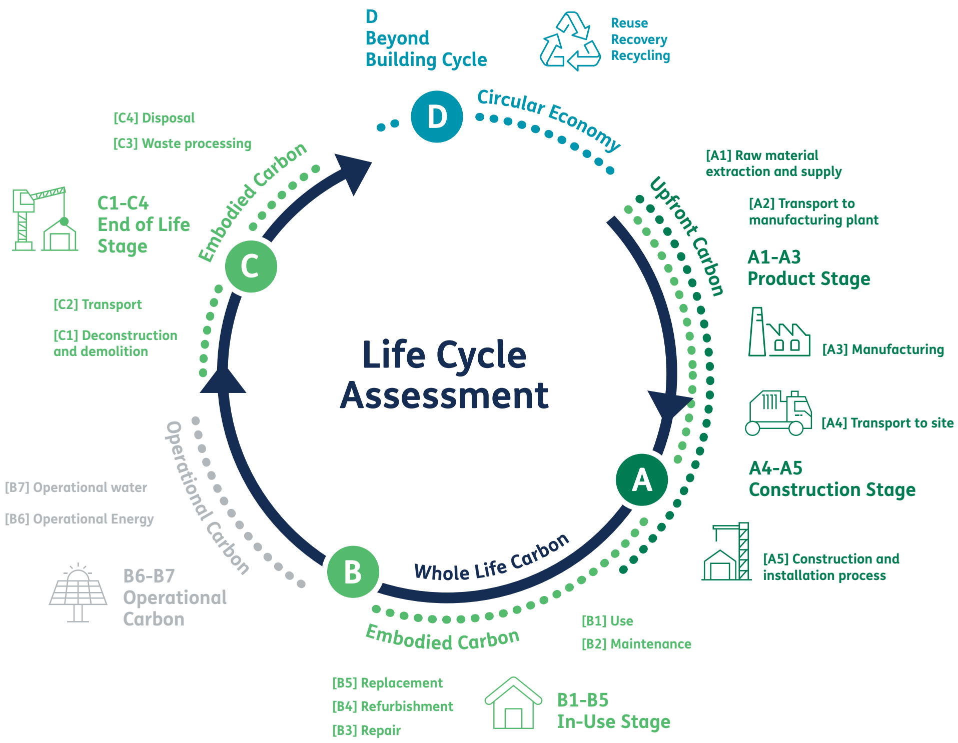
*GHG – Green House Gas

Scope of Whole Life Carbon Issues in Buildings

In 2018, the buildings and construction sector accounted for 39% of energy related carbon emissions. 11% of this was in the creation of building materials, whose embodied carbon contributed about 11% of all global carbon emissions (GlobalABC/IEA/UNEP, 2019) and, as a consequence of urbanization, practically all of it is caused by demand in cities.

Dramatic reduction of embodied carbon does not only entail a change for the construction sector itself, but also for the whole business environment surrounding the construction trade. It is not enough alone to reduce the carbon emissions associated with creation of the materials; dramatic reduction also requires changes to what we build and where, how requirements for projects are determined, as well as how projects are designed and delivered.

Embodied carbon can be up to 50-70% of the emissions of a building over its life cycle and is growing in importance due to the decarbonisation of the grid and the resulting reduction of Operational Carbon. Embodied Carbon savings should be made during the design and construction stage, to help reduce CO2 levels in the atmosphere. The Life Cycle Assessment below illustrates the relationship across the whole life of a building.



Embodied Carbon Relationships

The importance of Embodied Carbon

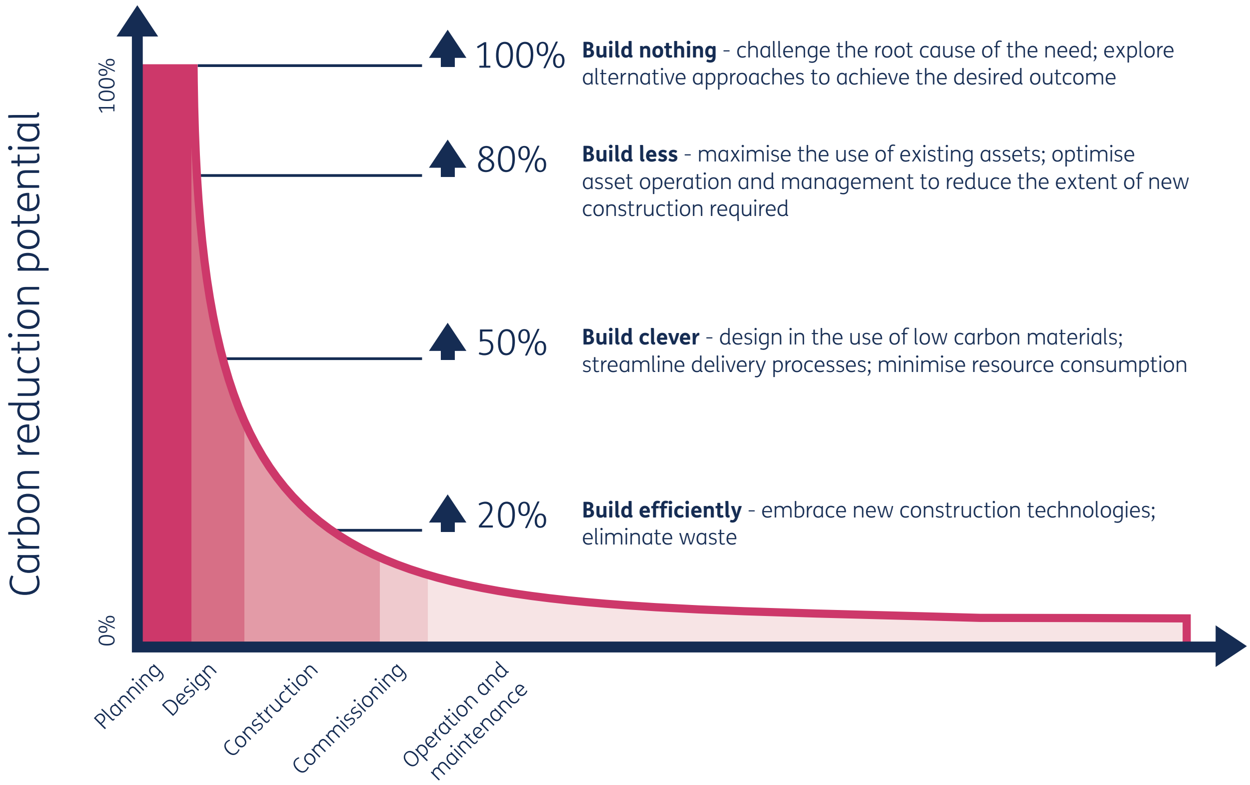
- BEIS's 2021 Carbon Emissions data shows that a kg of CO2 saved over the next 5 years has a greater environmental value than a kg saved in say 10 or more years' time.
- The Stern Review (2006) estimated that the cost of mitigating the harmful impacts of climate change would be 10 times the cost of acting now to reduce it.

The term 'net zero' is now commonly used and generally means that the building is highly energy-efficient with the operational energy use provided by renewable energy (preferably on-site but also off-site production), to achieve net zero carbon emissions annually in operation. Some also use 'zero energy' or 'energy neutral' or even 'energy positive' where a building produces more energy from onsite renewables than it consumes. More recently, Embodied Carbon is beginning to be considered in the context of a 'net zero carbon' building. For example, the World Green Building Council defines a 'net zero Embodied Carbon building' (new or renovated) as highly resource efficient with upfront carbon minimised to the greatest extent possible and all remaining carbon reduced or, as a last resort, offset in order to achieve net zero across the life cycle.

Reducing Embodied Carbon Options

There are various approaches to reducing Embodied Carbon dependent upon the stage of the project. Typically, those that will have the most effect will relate to very early decisions during the strategic planning stage. Existing buildings will generate a certain amount of carbon when being retrofitted, however they will already have 'spent' the majority of their upfront carbon at the operational phase. Because of this, they have an advantage over new build when considering future carbon emissions. Therefore, the re-use and continued use of existing buildings has an immediate advantage in terms of whole-life carbon expenditures. As the design, build, and lifespan of a building progresses, the opportunity to reduce impact also reduces, as shown below:

Embodied Carbon Reduction Curve



Tackle carbon early. Source: HM Treasury (2013) and Green Construction Board 2013 Diagram

Net Zero Carbon Design Principles

The RIBA (Royal Institute of British Architects) Journal 'Retrofit First' campaign summarises its own research and calls for evidence regarding the reduction of carbon in construction and how design and project management can facilitate future net zero targets, which points towards a retrofit strategy. Their published Net Zero operational carbon design principles and Net Zero embodied carbon design principles (Source – The RIBA Sustainable Outcomes Guide 2019)[1] are as follows;

Net Zero Embodied Carbon Design Principles:

- Prioritise building re-use
- Carry out whole life carbon analysis of all building elements
- Ethical and responsible sourcing of all materials
- Use low embodied carbon and healthy materials
- Minimise materials with high embodied energy impacts
- Target zero construction waste diverted to landfill
- Promote use of local natural materials
- Consider modular off-site construction systems
- Detailing to be long life and robust
- Design for disassembly and the circular economy
- Offset remaining carbon emissions through recognised scheme

Net Zero Operational Carbon Design Principles:

- Prioritise retrofit of existing buildings
- Prioritise fabric-first principles for building form and envelope
- Fine tune internal environment with efficient mechanical systems
- Provide responsive local controls
- Specify ultra-low energy appliances
- Specify ultra-low energy IT
- Prioritise maximum use of onsite renewables appropriate to context
- Demonstrate additionality of off-site renewables
- Offset remaining carbon through recognised scheme

1 **https://www.architecture.com/.../RIBASustainableOutcomesGuide2019pdf.pdf**

Policy Change

In the London plan, guidance has been published in March 22 on Whole Life Cycle Carbon Assessments. This guidance explains how to prepare a Whole Life-Cycle Carbon (WLC) assessment in line with Policy SI 2 F of the London Plan 2021 using the WLC assessment template. Policy SI 2F applies to planning applications which are referred to the Mayor. However, WLC assessments are also supported and encouraged on major applications that are not referable to the Mayor.

The first principle states:

1. Reuse and retrofit of existing built structures

Retaining existing built structures for reuse and retrofit, in part or as a whole, should be prioritised before considering substantial demolition, as this is typically the lowest-carbon option. Significant retention and reuse of structures also reduces construction costs and can contribute to a smoother planning process.

In summary, the construction industry is looking at how embodied carbon should be considered at pre-construction stage – potentially ‘saving’ upfront carbon expenditure before a project begins - right through to demolition and re-use of materials, creating a more sustainable cycle.

Effectively one of the biggest decisions on embodied carbon is made at the outset when comparing retrofit to new build. Policy decisions could influence and encourage the retention and retrofit of buildings, thus potentially having an influence on the reduction of future carbon. This may help in the reuse of existing vacant buildings and vacant upper floors above shops/commercial premises.

Building Regulations:

Building Regulations determine the minimum standards for all types of construction for both private and public buildings. These vary across the UK and in England changes were introduced to part L-Conservation of Fuel and Power in June 2022 as a step towards reducing carbon emissions.

The UK building industry has proposed a new 'Part Z' and Approved Document Z which outline one way in which embodied carbon could be introduced into UK regulation. Whilst this proposal has not yet been recognised by UK Government, they demonstrate the consideration of good practice in relation to Whole Life Carbon.

Bre TRUST- The Housing Stock of the United Kingdom- EUROSTAT, EU-SILC

In the UK, the framework for appraising the environmental impacts of the built environment is provided by **BS EN 15978: 2011: (Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method)**. It sets out the principles and calculation method for whole life assessment of the environmental impacts from built projects based on life-cycle assessment.

Underpinning **BS EN 15978 is the RICS Professional Statement: Whole Life Carbon assessment for the built environment (RICS PS).** The RICS PS serves as a guide to the practical implementation of the BS EN 15978 principles. It sets out technical details and calculation requirements. This is currently under review.

In IRL the revised **EU Energy Performance of Buildings Directive (EPBD)** will inform their Building Regulations once it is transposed into national legislation.

Prioritising Re-use and Retro-fit:

In the same way that the RIBA has recognised the need to prioritise the retro-fit and re-use of existing of buildings, an **'Understanding Carbon in the Historic Environment'** paper was produced by Historic England (2019) and a subsequent update **Understanding Carbon in the Historic Environment: Case Study Extension** was published in March 2020.

These documents provide evidence that retrofit of historic buildings is not only as good but generally better in terms of embodied carbon and whole-life carbon than new-build, after retrofitting for energy efficiency was carried out.

The 2019 study and the 2020 update paper compared the embodied and operational carbon emissions of three domestic refurbishments under three different levels of low-emissions intervention scenarios:

- 'Base-case' (do nothing);
- 'Refurbishment' (improve the performance of the existing building); and
- 'New-build' (demolish and rebuild the existing building to meet current building standards).

It estimated their financial attractiveness to homeowners/investors using the savings-to-investment ratio (SIR) metric. In addition, it estimated the policy attractiveness of each scenario using marginal abatement cost (MAC). Two reference study periods (RSPs) were assessed: 60 and 120 years. The reports should be read in conjunction with **'Understanding Carbon in the Historic Environment: Scoping Report'**. Some key findings from this work are described below:

i. The Base-case scenario has highest life cycle carbon emissions for both reference study periods (RSPs). In two of the three case studies Refurbishment is estimated to provide the highest cumulative carbon savings.

ii. In total, all three refurbishments saved 212 tonnes of carbon dioxide equivalents compared to the Base-cases over a 60 year RSP. In the case of the New-build scenario, this saving was 197 tCO_2e.

iii. For both the 60- and 120-year RSPs, the Refurbishment scenario outperformed the New-build option for two of the three case studies in terms of life cycle carbon emissions. One case study did not perform as well as the others due to the fact that the energy-efficient refurbishment measures employed were not as deep as those in the other case studies. Low emissions retrofits must therefore be carefully designed and implemented in order to outperform New-build alternatives.

iv. The Refurbishment scenario resulted in the lowest cumulative emissions for both 2030 and 2050 policy target years.

v. The Refurbishment scenario performed best in term of SIR ratio and MAC for all case studies under these study assumptions. It therefore offers the best value-for-money both to the homeowner/investor and the taxpayer. This is due to the fact that a deep energy-efficient refurbishment can achieve close to the same operational carbon emission reductions for significantly lower carbon and capital costs due to the re-use of the existing structure.

vi. Whilst this report and research was carried out by Historic England a Northern Ireland example Loanda Crescent is highlighted in the section under Housing.

Procurement:

Policy weighting could also be a consideration for procurement practices. It may be considered for the re-use and retro-fitting of existing buildings as a means of conserving embodied carbon. One way to reduce carbon could be through procurement methods, possibly one of the most impactful ways towards life cycle carbon reduction could be in the use of Carbon Limits for building materials.

This could allow for setting fixed maximum carbon limits for key construction materials such as concrete, steel, glass, gypsum board and insulation. This could also be extended to other projects and in all cases will require procurement teams to lead by example.

The circular economy involves sharing, leasing, reusing, repairing, refurbishing and recycling materials and products for as long as possible. Therefore, the life cycle of products is extended. This contributes to the reduction of carbon, minimising waste and maximising products and services.

Waste and Circularity:

These policies leverage a region's power to regulate permits and therefore attach requirements on waste handling to different types of projects. This requirement can be measured using **Design for Disassembly and Adaptability Criteria**. This policy ensures that in certain cases building elements and materials can be recovered and reused. **BAMB - Buildings As Material Banks (BAMB2020)** is a European Union Horizon 2020 funded initiative which is creating ways to increase the value of building materials; 'Dynamically and flexibly designed buildings can be incorporated into a circular economy – where materials in buildings sustain their value. That will lead to waste reduction and the use of fewer virgin resources.' (**www.BAMB2020.eu** 'What We Do')

Self-sufficiency/the carbon cost of transportation:

A geographical map of self-sufficiency or new policies could make NI/UK self-sufficient in the supply of construction materials. This could be considered future investment in carbon reduction. Much as calories are shown on food labels, transport and manufacture 'carbon costs' could be required for building materials and thus calculated for building projects. In the EU this is at an advanced stage and will be a requirement under the revised EPBD.

BAMB (see above) is piloting **BAMB Materials Passports** which aim to:

- Increase the value or keep the value of materials, products and components over time
- Create incentives for suppliers to produce healthy, sustainable and circular materials/building products
- Support materials choices in Reversible Building Design projects
- Make it easier for developers, managers and renovators to choose healthy, sustainable and circular building materials
- Facilitate reversed logistics and take back of products, materials and components

Quality of design:

Many buildings which are built now use concrete-based products, oil-based sealants and softwood timbers. These products are expected to have a lifetime of 25 – 50 years. Most pre 1919 buildings, if looked after well, will have a lifetime of several hundred years from then. This is due to the use of higher quality materials like stone, hand-made brick and pitch pine, traditional passive detailing and design/construction methods, which allow for the intake and expelling of moisture, and bespoke designs which account for location, regional conditions and orientation. If we consider that many insulation products have a comparatively short life, compressing or deteriorating after as little as twenty years, the question may be raised regarding what happens at that time. Many lightweight modern buildings will suffer when their insulation degrades, while the traditional building with its thermal mass and natural air leakage will be performing as well at that time as it does currently. We need to fully understand the energy/whole life cycle carbon cost over several generations, rather than as a short-term target, if we are to gain a full view of and make comparisons of 'whole life' carbon for different building types.

Financial:

A paper written by Lisa Sanfilippo and Pauline Ngan entitled Value Added: the economic, social and environmental benefits from creating incentives for the repair, maintenance, and use of historic buildings, further highlights in Appendix 3 the environmental advantages of new build versus refurbishment with regards to embodied carbon as well as social costs. Refer to link below;

Microsoft Word - 22 Feb VAT Brochure FINAL with credits LAYOUT.doc (ihbc.org.uk)

There needs to be a clear financial incentive to promote energy efficiency in existing buildings. This would encourage energy improvements to be made at the time of sale or change of tenancy, through tax incentives or stamp duty relief.

In **Historic England's 'Heritage Counts' Case Study extension paper (March 2020)**, the refurbishment scenario performed best in term of SIR (Savings to Investment Ratio) and MAC (Marginal Abatement Cost) for all case studies under these study assumptions. It offers the best value-for-money both to the homeowner/investor and the taxpayer. This is due to the fact that a deep energy-efficient refurbishment can achieve close to the same operational carbon emission reductions for significantly lower carbon and capital costs as a result of the reuse of the existing structure. This key finding requires a framework of policy, guidelines and illustration to demonstrate to the private investor that this is the case, and therefore demonstrate that this is a financially better option. Grants and case studies which demonstrate how replacing heating systems in existing buildings can reduce carbon expenditure and actual lifetime expenditure could therefore be made more widely available.

Design competitions which will use carbon as a key criterion and also allow consideration for achieving low operational carbon, making this an important competitive consideration. Currently there are third party accreditation schemes to promote sustainability and reduce carbon eg. BREEAM or House Quality Mark. These could be considered as part of the RIBA Carbon Design Principles Approach.

- **BREEAM** (BRE Environmental Assessment Method) and Home Quality Mark are the leading and most widely used environmental assessment method for buildings in the UK. Many publicly funded/ procured buildings are required to be BREEAM assessed and reach a minimum BREEAM rating. The health, wellbeing and societal 'added' benefits of community regeneration through investment in heritage can be brought out in policy using tools like BREAAM.

- **Home Quality Mark:** The Code for Sustainable Homes, which was a mandatory standard for new building housing until 2015, has largely been superseded by a voluntary standard from BRE, called Home Quality Mark. The Home Quality Mark provides impartial information from independent experts on a new home's quality and sustainability. It clearly indicates to householder's, high standards for running costs, health and wellbeing benefits, and environmental footprint associated with living in the home. In short, HQM helps everyone to fully understand the quality, performance and attributes of a new-build home.

Infrastructure

Infrastructure development typically covers a significant portion of all city construction, and infrastructure projects may use vast amounts of basic materials. In addition to covering built assets, this category also covers green areas such as parks. As most infrastructure projects are different from each other, they require project specific carbon considerations.

Public and Private Sector Education

Public and Private Sector Education like, infrastructure will require project specific carbon considerations and any new build project should involve an analysis of the carbon design principles at the earliest part of the decision-making process.

The new Erne campus for South West College is an example of a new build educational building which is recognised today as the world's biggest passive standard educational campus. This building has also achieved BREEAM 'Outstanding' certification.

The Erne Campus, the UKs first Passivhaus Premium

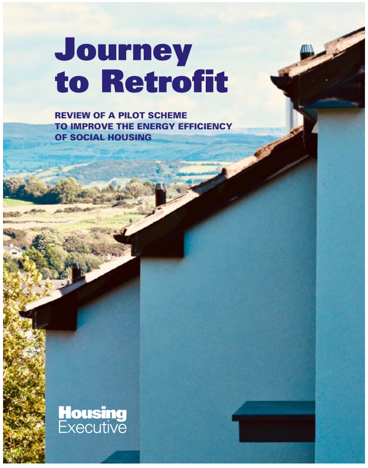
Photo courtesy of BMCK SWC

Housing

Retrofit – creating exemplar case studies:

Loanda Crescent, a recent NIHE pilot scheme, measured improvements in energy efficiency following retrofit of modern construction terraced dwellings.

The scheme was completed in 2018, followed by two years of post-occupancy evaluation. The purpose of the pilot was to understand the benefits and challenges of implementing various retrofit measures, which would then inform the strategy for future retrofit schemes on a much larger scale. The post project evaluation, 'Journey to Excellence' describes the process from its very early, ambitious beginnings, to the detailed and target-driven approach finally delivered. The five houses in Newry were chosen for their similarities in terms of location, orientation, size and layout, making them suitable for comparative purposes to demonstrate the impact of applying different packages of measures. The rendered blockwork cavity walls are also very typical of Housing Executive stock, meaning that the workable solutions developed through this scheme can be replicated easily. The measures implemented include external wall insulation, loft insulation, gas boilers, heating controls, new windows and doors, improved construction detailing to reduce thermal bridges at critical locations, an airtightness strategy, and innovative ventilation systems. The report details the lessons learned and recommendations to be applied to future retrofit projects with the aim of informing others who may be considering or are currently undertaking similar retrofit work.



Other examples of reducing embodied carbon are listed within **Wood knowledge Home Grown Homes** Project.

Other links to guidance / research

Whole Life Carbon Hub

Sustainability of the built environment (parliament.uk)

2021 Global Status Report for Buildings and Construction | UNEP - UN Environment Programme

EDGAR - The Emissions Database for Global Atmospheric Research (europa.eu)

whole-life-carbon-assessment-for-the--built-environment-november-2017.pdf (rics.org)

www.annex57.org

EBC_Annex_57_ST4_Case_Studies_Recommendations_Appendix.pdf (iea-ebc.org)

Embodied Carbon in Concrete: Problems of Mis-Messaging - News (buildingsandcities.org)

Chapter 32: Circularity in the built environment: a call for a paradigm shift in: Handbook of the Circular Economy (elgaronline.com)

Sustainability of the built environment (parliament.uk)

BakerandMoncaster-Paper39_ZEMCHMelbourne2018.pdf

Environmental Economics: Recommended Reading (env-econ.net)

Reading List for Ecological Economics | Vermont Reptile and Amphibian Atlas (vtherpatlas.org)

Targeting Zero: Whole Life and Embodied Carbon Strategies for Design Professionals: Embodied and Whole Life Carbon Explained

https://www.bre.co.uk/housing-standards-review

https://historicengland.org.uk/content/heritage-counts/pub/2020/heritage-and-the-economy-2020/

Whole Life-Cycle Carbon Assessments guidance | GLA (london.gov.uk)

‘Dramatically Reducing Embodied Carbon’ (837f9c_f9e27794727d44959e9bc96de91ccbf9.pdf (filesusr.com))

Options for incorporating embodied and sequestered carbon into the building standards framework

Duffy, A., Neguti, A., Engel Purcell, C. & Cox, P. (2019) Understanding Carbon in the Historic Environment: scoping study. London: Historic England

Historic England. (2020) There’s No Place like Old Homes. London: Historic England.

Röck, M. et al. (2019) ‘Embodied GHG Emissions of Buildings – The hidden challenge for effective climate change mitigation’ Applied Energy. 258, 114107.

Pender, R. (2021) ‘Making good decisions: avoiding alignment problems and maladaptation in retrofit and construction’ Journal of Architectural Conservation. 27:3, 151-175.

Pender, R. & Lemieux, D.J. (2020) ‘The Road Not Taken: building physics and returning to first principles in sustainable design’. Atmosphere, 11, 620.c

O’Hegarty, R., Wall, S. & Kinnane, O. (2022) Whole Life Carbon in Construction and the Built Environment Ireland. Available to download from: **https://www.igbc.ie/wp-content/uploads/2022/02/22-Whole-Life-Carbon-Built-Environment-Report.pdf**

Foster, G. (2020) ‘Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts.’ Resources, Conservation & Recycling. 2020: 152, 104507.

Baker, H., Moncaster, A., Remøy, H. & Wilkinson, S. (2021). Retention not demolition: how heritage thinking can inform carbon reduction. Journal of Architectural Conservation. 27:3, 176-194.

Berg, F. & Fuglseth, M. (2018) 'Life cycle assessment and historic buildings: energy-efficiency refurbishment versus new construction in Norway', Journal of Architectural Conservation. 24:2, 152-167.

Blundo, D.S. (2018) ‘Improving sustainable cultural heritage restoration work through life cycle assessment based model.’ Journal of Cultural Heritage. 32, 221-231.

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