

Net Zero Whole Life Carbon Roadmap for the Built Environment in Ireland

Preliminary
recommendations:
Vision for 2050

November 2021



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The Irish Green Building Council (IGBC) is one of over 70 Green Building Councils around the world. IGBC was founded in 2011, and now has over 250 members.

IGBC aims to:

- Provide a source of leadership for sustainability and quality in the built environment
- Promote and assist in the provision of credible metrics for measuring progress towards the end goal of sustainability
- Provide a source of resources to companies transitioning their activities towards more sustainable practices
- Be central to alignment of the policies of organisations seeking to achieve sustainability in the built environment

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List of Acronyms

CAP: Climate Action Plan

DEC: Display Energy Certificate

EED: Energy Efficiency Directive

EN: European Norm (European Standards)¹

EPBD: Energy Performance of Buildings Directive

ETS: Emissions Trading System ²

GHG: Greenhouse Gases

GWP: Global Warming Potential

HPI: Home Performance Index

IGBC: Irish Green Building Council

LCA: Life Cycle Assessment/Analysis

LCC: Life Cycle Costing

LETI: London Energy Transformation Initiative

NABERS: National Australian Built Environment System ³

NDP: National Development Plan

TGD: Technical Guidance Document

WGBC: Word Green Building Council

WLC: Whole Life Carbon

1. More information on European Standards available here: https://europa.eu/youreurope/business/product-requirements/standards/standards-in-europe/index_en.htm

2. More information on the EU ETS available here: https://ec.europa.eu/clima/policies/ets_en

3. More information on NABERS available here: <https://www.nabers.gov.au/>



Introduction

Introduction

Globally the built environment accounted for nearly 40% of overall emissions in 2019 [1] [2] of which 29% were from operational emissions and 11% from embodied emissions. In Ireland, for the baseline year of 2018 used in the roadmap, this is estimated at 35% of all national emissions, including 15.7 MtCO₂eq operational emissions and 6.9 MtCO₂eq embodied carbon [3]

An initial baseline for carbon emissions from the Irish construction and built environment sector has been developed by UCD for IGBC to establish the gap between the current trajectory and the required route to decarbonisation by 2030 and 2050. This modelling work will inform the roadmap. The modelling allows for a degree of uncertainty due to quantities of materials imported and materials manufactured in Ireland that are exported.

This report aims to set out an initial vision for the roadmap for the decarbonisation of the building and construction sector in Ireland.

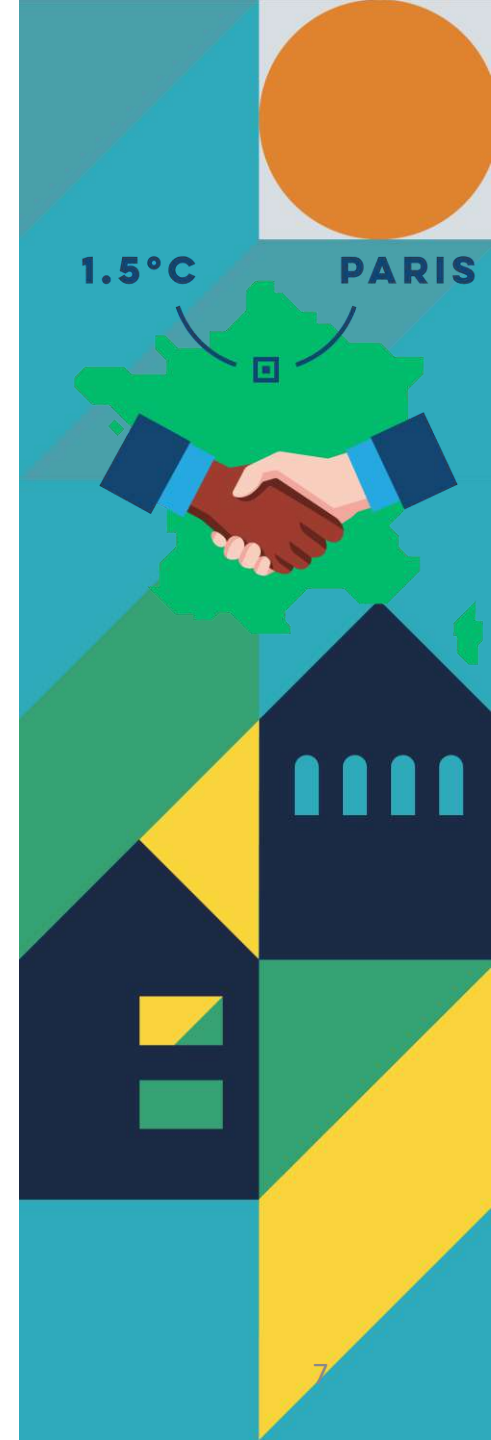
It sets out a list of broad recommendations for further detail exploration. And is hence a first step in the development of a roadmap presenting actions and policies that will enable Ireland to set 'whole life carbon' (WLC) targets for the national building stock - moving beyond just operational carbon.

The content of this document has been developed based on discussions with the National Leadership Forum⁴ and other key stakeholders between March and October 2021.

The development of the national roadmap is part of a joint effort by 10 European Green Building Councils, through the BuildingLife project which aims to support and accelerate the ambitions of the EU Green Deal by setting 1.5 °C compatible targets for Europe's building sector.

At European level, an EU Policy Whole Life Carbon Roadmap will be developed. Key EU legislation such as the Energy Efficiency Directive (EED) the Energy Performance of Building Directive (EPBD), and the Construction Products Regulations (CPR) are currently under review. Guided by the EU Strategy for a Sustainable Built Environment [4] (encompassing all European Green Deal measures) this will be the first of many crucial years for European buildings and climate policy. It is hoped that the project will help inform the revision of relevant directives and ensure that the buildings and construction sector is making its sectoral contribution to delivery of the EU climate goals.

4. IGBC has convened three steering groups as part of the process of developing the roadmap, a National Leadership Forum, a National Technical Committee, and a group of [BuildingLife Ambassadors](#).





Aims & Objectives

Aims & Objectives of the Roadmap

In line with the project objectives, the roadmap for Ireland will “clearly articulate the key policy routes and supporting actions needed to facilitate the decarbonisation of Ireland’s built environment” [5]. It will outline a common vision for a decarbonised built environment, and the opportunities and challenges associated with achieving this vision.

To this end it will:

- Outline key policy recommendations and inform policy reviews on the integration of Whole Life Carbon impacts/issues into national policy and legislation.
- Develop, in collaboration with key stakeholders, a comprehensive set of actions, timelines, roles and recommendations to ensure that the building and construction sector has the knowledge and capacity to deliver on these policy ambitions.
- Secure a cross sectoral whole life carbon commitment and action on areas identified, to rapidly increase progress on this agenda.
- Provide a blueprint that may be used by government and the construction sector, to progress the integration of Whole Life Carbon roadmap in national policy, in line with the direction of EU policy, and supporting wider development of a Europe wide Whole Life Carbon roadmap, as announced under the EU Renovation Wave [6].

The roadmap is targeted at Irish policy makers and the construction industry, as well as other parallel representative groups, professionals, developers, product manufacturers, the education sector, financial institutions and investors and civil society. It aims to provide stakeholders with a set of steps so that they can contribute to the decarbonisation of the built environment and to deliver on the targets set by the Irish government for 2050. At the EU level, the Irish roadmap will also support the work of officials in the Commission, Parliament and Council [7].

NET ZERO WHOLE LIFE CARBON





Vision

2050 Vision

Totally decarbonised, circular, resource efficient built environment.

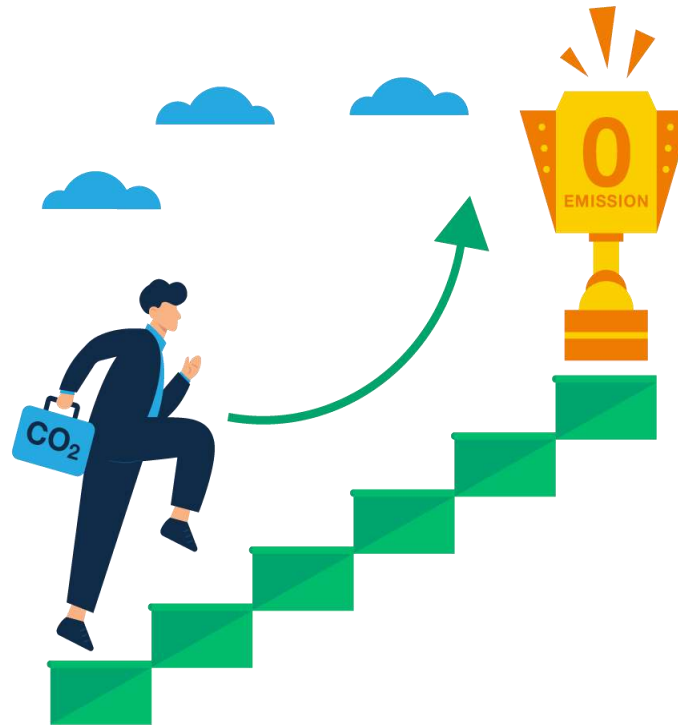
This means that by 2050:

- Decarbonisation: New developments, infrastructure, and renovations will have net zero embodied carbon, and all buildings, including existing buildings, must be net zero operational carbon.
- Resources and Circularity: A built environment that supports restoration of resources and natural systems within a thriving circular economy.

The goal of the Irish roadmap is aligned with the WGBE target of net zero operational and embodied carbon emissions across the whole building life. This requires taking a Whole Life Carbon approach from the outset for new developments, alteration, and renovation projects, with the aim of reaching net zero operational and embodied carbon emissions across the whole building life.

A series of targets will be defined to reach the high-level vision of net zero incrementally between now and 2050. The pathway will include several key milestones which will be set down following consultation with the National Leadership Forum, and other key stakeholders.

IGBC's vision is to have an interim goal by 2030 which aligns with government policy of achieving a 51% reduction in national CO₂eq emissions by 2030 and is within or near the range of other targets set by organizations such as RIBA (40-60% reduction by 2030) [8], RIAI (50% reduction on embodied carbon by 2030) [9], Architecture 30 (60%) [10].





Background

Background and alignment with national climate targets

From 2021 stringent new Government climate policies will be in place to reduce emissions. Under the Climate Action & Low Carbon Development (Amendment) Act (2021) (The Climate Act), a new legally binding target of a 51% reduction in national CO₂eq emissions by 2030 and an overall target of a climate neutral economy by 2050, has been established [11]. The legislation introduces a raft of new measures, including a new Climate Action Plan and National Long-term Climate Action strategy; 5-yearly local authority mitigation and adaptation plans, economy wide 5-yearly sectoral Carbon Budgets to reduce emissions by an average of 7% per year with further reductions required up to 2050 [12].

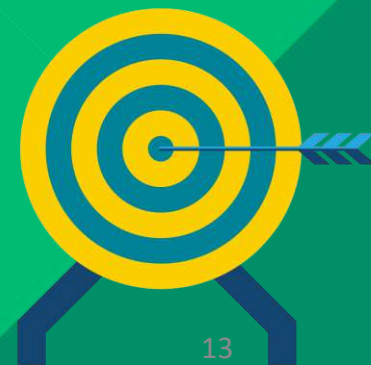
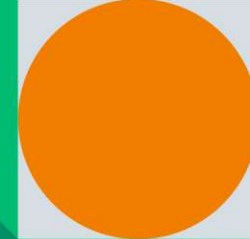
The recently released Carbon Budget Technical Report by the Climate Change Advisory Council (CCAC) [13] indicates new annual reductions of 4.3% (2021-2026); 8.3% (2026-2030) and 3.5% (2031-2035). The sectoral reduction allocations, to be recommended by the CCAC, which are to be based on a burden sharing basis, have not yet been made public. The sectors are Residential, Agriculture, Electricity Generation, Heavy Industry, Transport, Public services, and Waste.

Together the individual budgets should add up to an overall national emissions reduction target of 51% on 2018 emissions.

The built environment sector will be required to respond to the measures that will give effect to these legal obligations, and this roadmap will assist the sector in playing its part.

Whole life carbon emissions of buildings can be measured using the standard - EN15978 Sustainability of Construction Works Assessment of environmental performance of buildings [14]. It is a consumption-based method⁵ that draws on data from seven sectors of the EPA inventory: Residential, Electricity Generation, Heavy Industry, Transport, Public services, F gases and Waste. The impact of carbon intensive materials manufactured outside of the State such as glass, steel and aluminum are also included. Therefore, targets set for WLC reduction for buildings do not necessarily equate to national emissions reduction or vice versa. However, the WLC targets must align and enable national targets.

5. Consumption based emissions are all the emissions resulting from construction irrespective of where they arise either in Ireland or imported from the other countries where products are manufactured, whereas production-based emissions are emissions occurring in Ireland only



Background and alignment with national climate targets

Another factor to consider is the expected significant increase in construction activities over the next decade. The National Development Plan (NDP) proposes to increase construction, including a 50% increase in new housing construction up to 2030, the deep energy renovation of 500,000 homes in addition to construction of schools, healthcare, new roads, broadband, water and rail infrastructure [15].

The overall high level reduction target of 51% across all sectors must be achieved despite a substantial increase in construction output. This means that the overall embodied carbon intensity of new construction per m² will have to decrease in proportion to the increase in construction over the 2018 baseline year.





Measurement

How carbon is measured in Ireland

Ireland's EPA sectoral emissions inventory focusses on emissions arising from the agriculture, transport, residential, commercial, non-energy intensive industry, and waste sectors [16]. It does not provide a single sectoral category for the Built Environment (BE). Emissions attributable to the BE are found under a range of headings including space and water heating across residential, commercial and public buildings, and also a significant proportion of emissions from manufacturing combustion, industrial processes, landfill waste and transport.

Emissions from carbon intensive materials manufacture are captured under the EU Emissions Trading Scheme (ETS) data for large emitters [17]. For this reason, these emissions are not currently accounted for in the process of shadow pricing for the appraisal of public investment projects by the Department of Public Expenditure and Reform. According to DPER, inclusion would be considered 'double counting' however Governments such as Netherlands do not make this distinction⁶ [18].

The 2019 Climate Action Plan (CAP) [19] considers carbon from a purely operational energy perspective. For example, it proposes reducing the carbon intensity of cement (Action 34) by substitution of fuel, but not the greater carbon

emissions resulting from the chemical process of converting limestone to clinker. All current built environment measures within the 2019 CAP relate to energy efficiency: retrofit, grant support, supply chain upskilling, rating, and building certification.

The most effective decarbonisation measure for new buildings in Ireland have been the changes to the Irish Building Regulations TGD Part L [20] which have required reductions of 70% for residential and 55-60% for non-residential since 2006. The regulations have driven change by setting limits on energy and fossil fuel use for heating in buildings.

However embodied carbon remains overlooked when it comes to the evaluation of individual construction projects; and in terms of Ireland's overall contribution to rising global emissions.

This Roadmap aims to consider this by examining how Whole Life Carbon can be mainstreamed across policy and at building level. It will propose a range of new policy measures and propose carbon limits at the building level, to constrain embodied carbon across all development, throughout the entire lifecycle, from supply through construction, operation and disposal.

6. CO2e emissions from inputs/materials purchased from organisations/facilities/installations with the EU ETS sector should not be included in the quantification of emissions for a project scenario as this would be double counting





Modelling

Baseline modelling of carbon emissions in the Irish built environment

According to the EPA total GHG emissions in Ireland were 60.9MtCO₂eq in 2018 [21]. In order to understand what proportion of this is related to the built environment, IGBC commissioned the UCD Building in a Climate Emergency Research Group to model the carbon emissions associated with the construction, buildings, and infrastructure sectors. The methodology used is on a consumption (production plus imports, minus exports), rather than a production only basis

Their final report, due at the end of 2021, will set out the emissions associated with all aspects of construction, including renovation, with reference to the National Development Plan and the Climate Action Plan. Initial findings are presented in draft below.

The team at UCD is currently working to produce a more comprehensive and robust data set. The initial findings presented below and in more detail in the Appendix remain subject to revision.

Initial Findings

The initial report looks at the current situation in order to establish a baseline and offers initial modelling of actions required to reach the legally binding target of a 51% reduction from 2018 levels of GHG emissions by 2030. Initial findings suggest that today the BE accounts for around 22MtCO₂eq per year. A 51% reduction by 2030 would mean a BE total carbon budget of 11MtCO₂eq for 2030. As Ireland's new Carbon Budget framework evolves, the modelling work for the roadmap will respond to any changes as they occur (e.g., sectoral budgets).

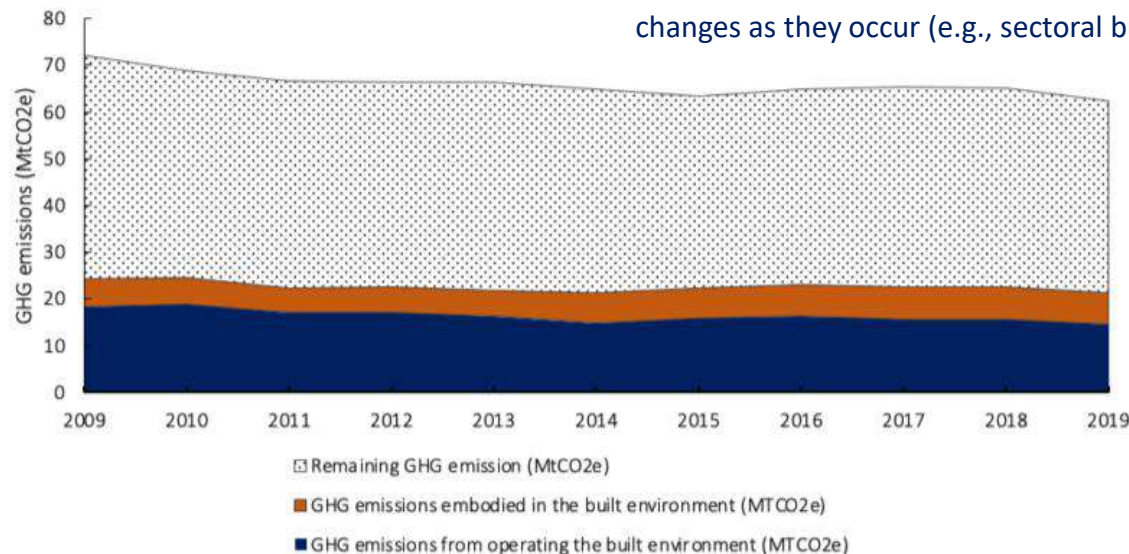


Figure 1: National GHG emissions and those associated with the operation and construction of the built environment [3]

Baseline modelling of carbon emissions in the Irish built environment

Key Findings

To date, key findings based on data from the national carbon inventory (EPA), national energy balance database (SEAI) and other data from the CSO are as follows:

- The construction and operation of the Irish built environment accounts for around 22MtCO₂eq in a standard year, equal to around 35% of all emissions in the EPA inventory.

- This breaks down into 15.7MtCO₂eq (24%) in operational carbon and 6.9MtCO₂eq (11%) in embodied carbon.
- GHG emissions associated with the operation of the residential sector account for the largest share of buildings related emissions.
- Works outlined in the National Development Plan will increase total embodied carbon by around 10% each year.

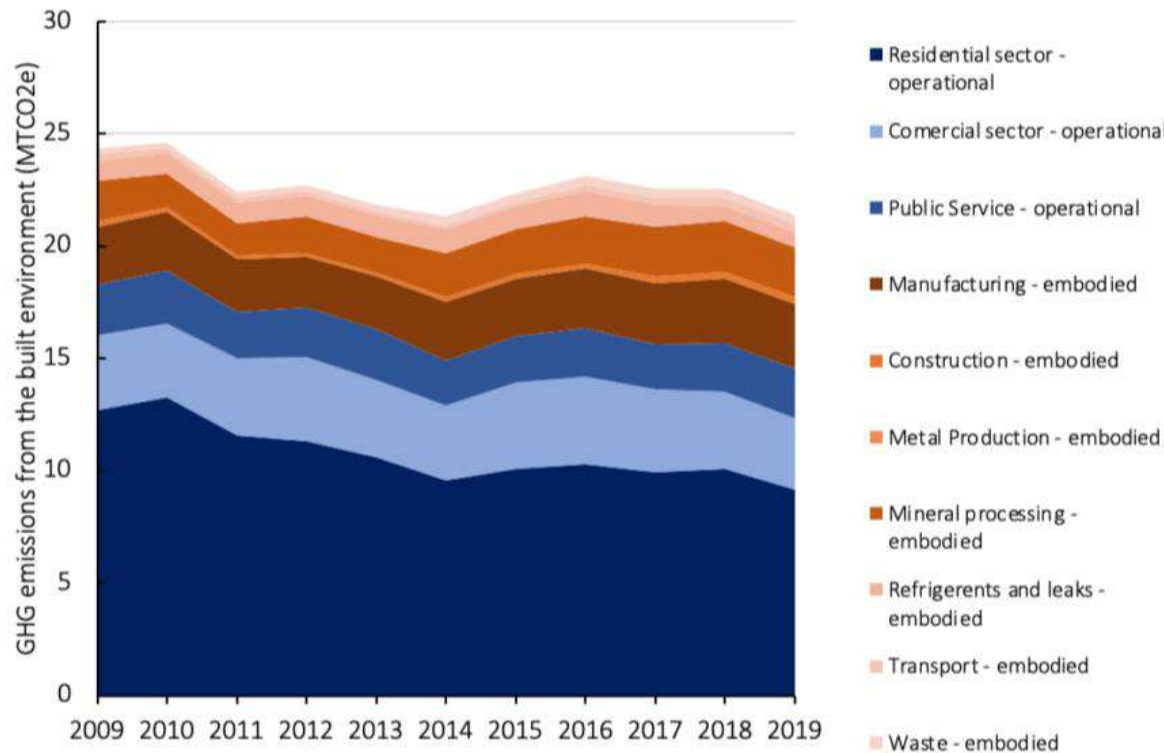
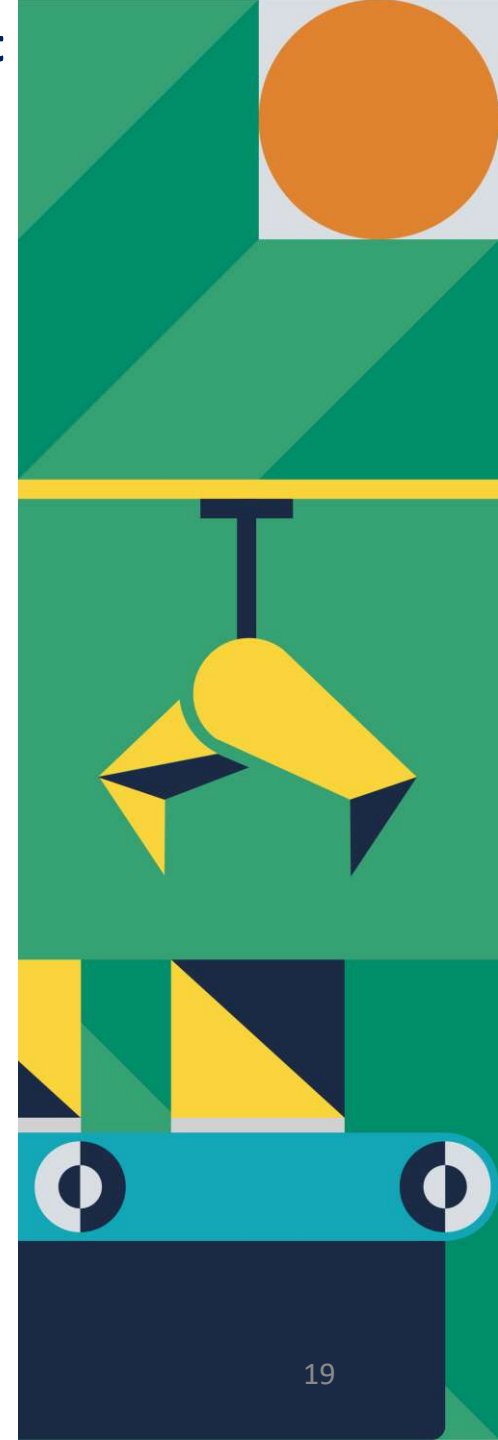


Figure 2:GHG emissions subcategories for embodied and operational carbon [3]



Baseline modelling of carbon emissions in the Irish built environment

Key Findings: Residential Sector

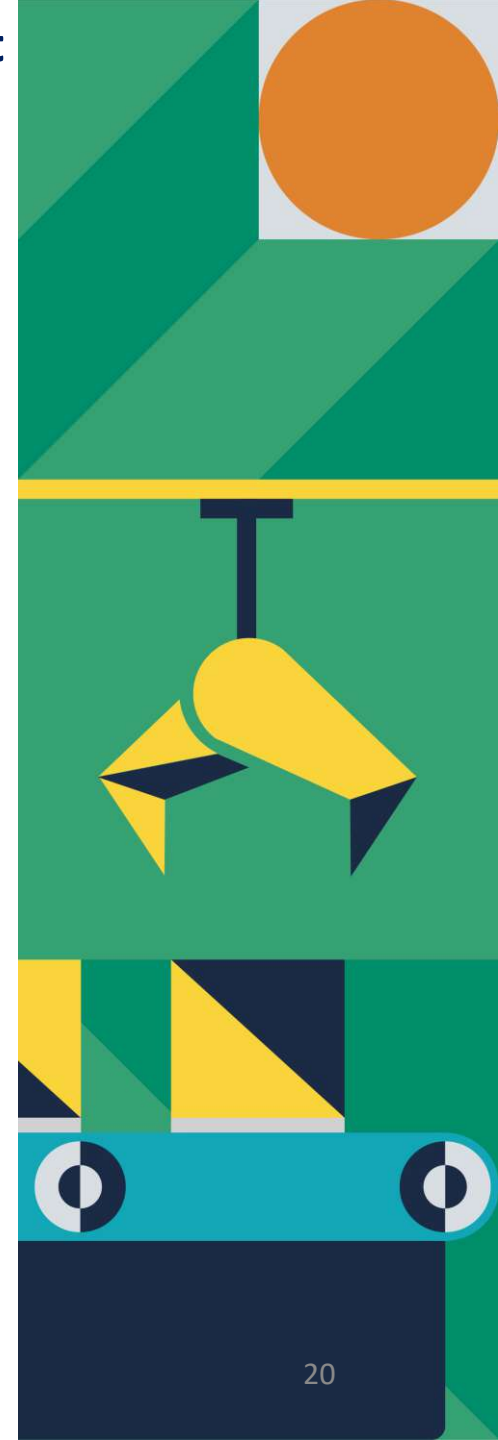
In the residential sector the key findings are as follows:

- The residential sector is the largest emitter in terms of both embodied and operational carbon.
- At 10.3MtCO₂eq in 2018, the operation of the residential sector is responsible for 45% of all BE emissions. This is the largest single contributor overall.
- As a result of more newbuild and renovation, embodied carbon is expected to treble during the decade, to reach 3.7MtCO₂eq per year.
- More than half of the housing stock is expected to be B rated or better by 2030. As a result, operational carbon is expected to fall by around 30% by 2030.
- Reduction in operational carbon through renovation will increase the relative levels of embodied carbon emissions.

Key Findings: Non-Residential Sector

Initial findings for the non-residential sector indicate:

- Operational emissions in non-residential account for 5.6MtCO₂eq
- Embodied emissions from non-residential construction are relatively high at 2.7MtCO₂eq per year.
- Owing to greater use of electricity and lower use of fossil fuels than the residential sector, operational carbon is expected to fall by around 50% by 2030.



Baseline modelling of carbon emissions in the Irish built environment

Key Findings: Infrastructure Sector

In the infrastructure sector, initial attempts to quantify the embodied carbon of the NDP reveal the following significant key points:

- Based on infrastructure projects as described in the NDP, embodied emissions are predicted to be around 2.8MtCO₂eq per year across infrastructure projects.
- The most significant contribution may come from road building, with the 850km of new road projects in the NDP predicted to have an embodied carbon cost of 0.74MtCO₂eq per year.
- Installation of wind and solar energy expansion projects to decarbonise electricity will have an embodied carbon cost of around 3.9MtCO₂eq to 2030.

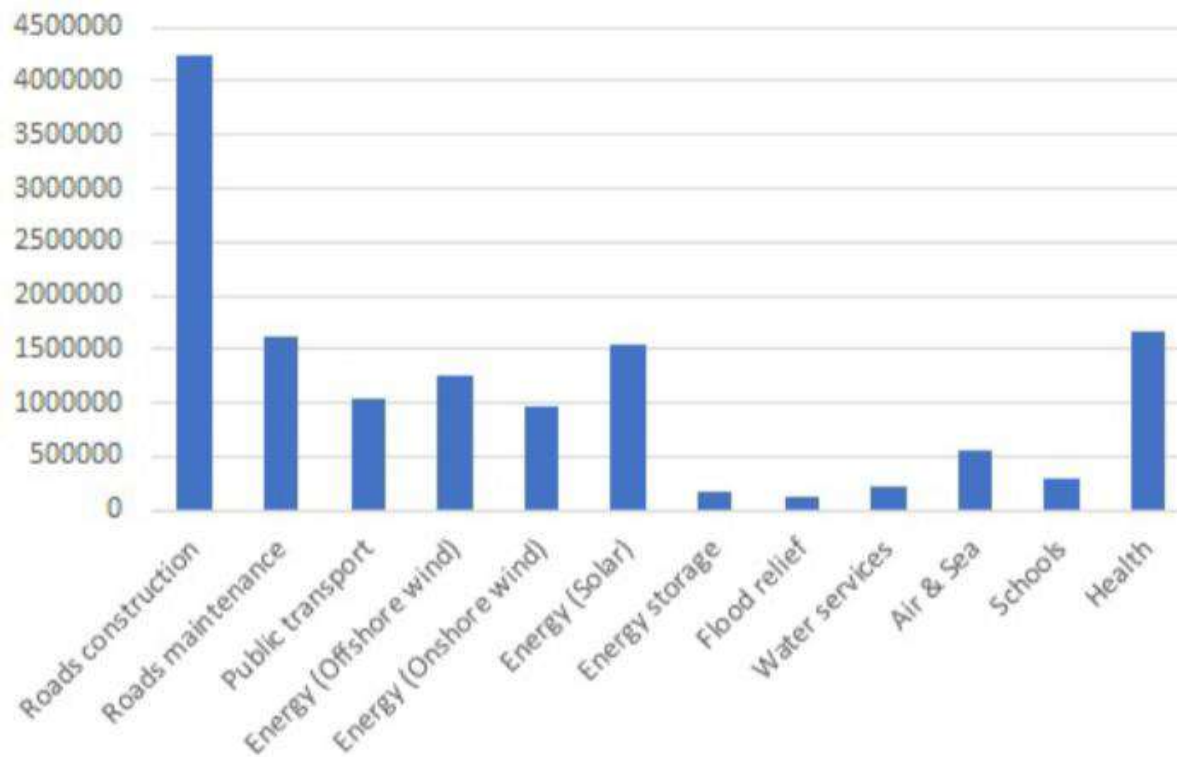


Figure 3: Initial estimates of GHG emissions (in MtCO₂e) of project categories within the NDP using a mostly bottom-up approach [3]



Methodology

Boundaries & Benchmarks

The modelling in the roadmap will apply to all stages of the building life cycle as set out in EN 15978:2011 Sustainability of Construction Works - Assessment of Environmental Performance of Buildings- Calculation Method (See Figure 4 below). with reference to EU Level(s) indicator 1.2 Lifecycle GWP which provides an outline of the scope to consider in the assessment.

Benchmarks

In order to understand and report on how the sector is performing a set of benchmarks will be useful

but because there has never been a requirement to measure embodied carbon in Ireland, no official benchmarks exist today.

The most referenced benchmarks in the region are those developed by the London Energy Transformation Initiative (LETI) in 2020 which have been adopted by the RIBA in the UK and now by the RIAI in Ireland. Carbon measurement consultancy OneClickLCA have also developed a set of European benchmarks based on data provided by their users.

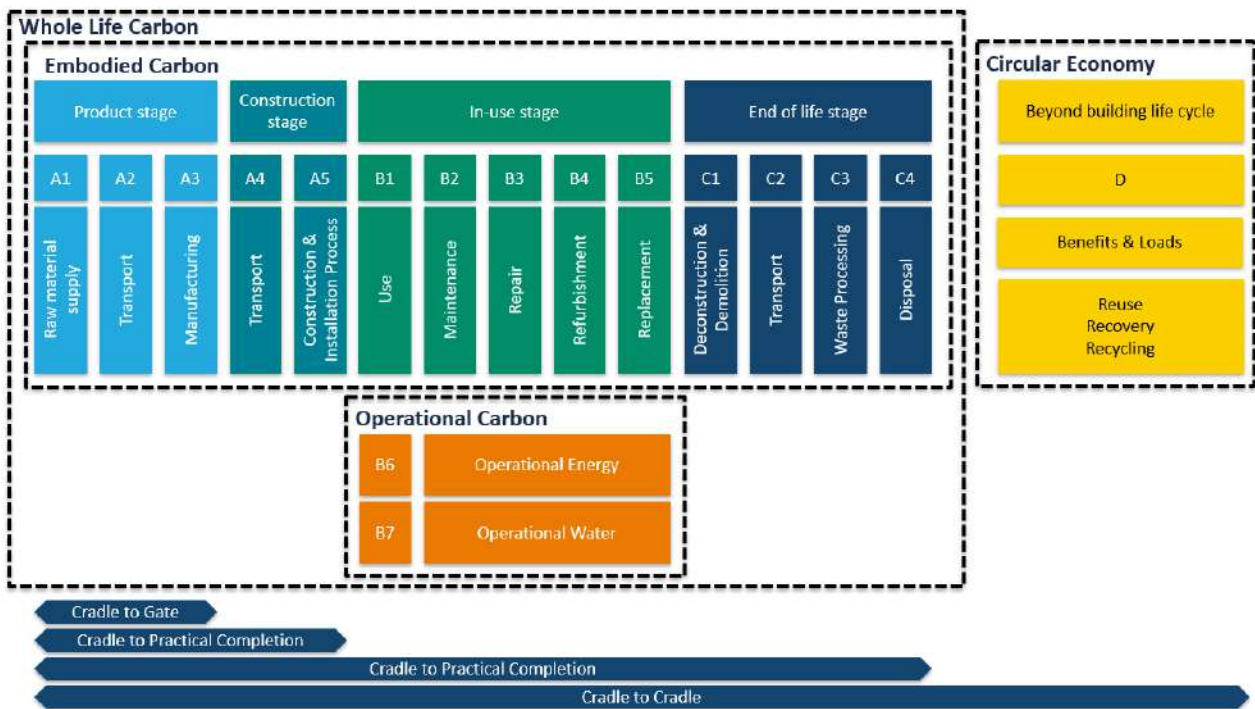


Figure 4: Carbon types, stages, modules and system boundaries of EN15978





Recommendations

Recommendations

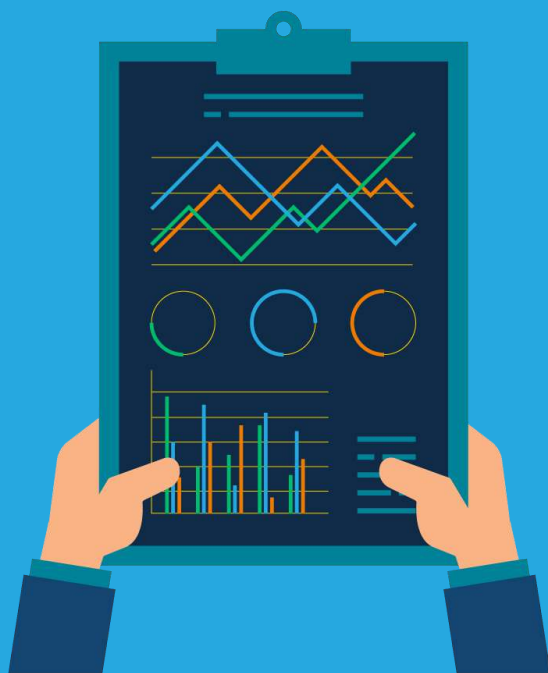
As part of the development of the roadmap, recommendations for various stakeholders and sectors will be made. The following are initial recommendations based on engagement over the past six months with key stakeholders, including the National Leadership Forum, BuildingLife Ambassadors and National Technical Committee. Actions are grouped under key thematic themes. These will be reviewed and developed through detailed thematic workshops over the coming six months.

To meet the national 51% absolute reduction required by 2030, the built environment will have to play its part. Deep reductions in carbon intensity per square meter will be required, however the expected increase in construction and renovation activity means that this may not be enough. Optimisation of the building stock will also be required.

This will require actions from across the sector including Government, local authorities, building owners, construction product manufacturers, construction professionals, planners, educators, contractors, financiers, investors and developers. The recommendations do not at this stage state who should implement, or how these recommendations should be achieved, as that is the aim of the next stage of the process.

Governance, Data, and Reporting

- Provide consumption-based emissions data on the impact of buildings, renovation and infrastructure to complement the EPA carbon inventories and provide a more comprehensive view of the GHG emissions for which the country is directly responsible.
- Carry out comprehensive detailed carbon modelling of National Development Plan including all proposed construction, new housing, renovation and infrastructure and reconcile with the 5-year Climate Budgets to reach the targets of 51% reduction by 2030.
- Require better reporting on impact of renovation for all funded projects, using reporting frameworks such as Build Upon² multi-level framework to measure impacts and benefits of renovation.





Regulation and Policy

- Set out a clear implementation pathway with key dates for benchmarks and regulations for WLC assessment to provide certainty to industry.
- Review DEAP and NEAP methodologies for Part L compliance and BER assessment to ensure that these reflect optimal design and current technology.
- Require post occupancy monitoring with Display Energy Certificate (DEC) or NABERS type performance-based assessment for non-residential properties.
- Introduce Building Renovation Passports and logbooks to create a long-term strategy for each building.
- Introduce Minimum Energy Performance regulations for rental of homes and commercial buildings where feasible, with incremental pathway to net zero by 2050⁷.
- Address peak demand to reduce burden on grid infrastructure in all buildings.
- Introduce specific requirements for data centres to limit their impact on electricity and water infrastructure.
- Integrate WLC as a key consideration within the national long-term renovation strategy.
- Streamline application of building regulations, through information, education and further guidance and align all relevant policies, and fiscal incentives to make adaptation and reuse of existing buildings easier, bringing more vacant space back into use.
- Ensure application of building regulations facilitates innovation and use of low carbon technologies and products and reuse of existing materials in a safe manner.
- Ensure optimisation of built space based on real need, avoiding emissions associated with unnecessary built space and unnecessary demolition.

7. See IGBC's work on this topic at <https://www.igbc.ie/wp-content/uploads/2019/06/IGBC-SEAI-Report-Final.pdf>



Procurement

- Alongside WLC assessment to EN 15978, use Level(s) indicators 2.3 (Adaptability) and 2.4 (Deconstruction) to promote circularity in public procurement.
- Review shadow pricing to ensure that the full environmental impact of construction projects is costed within procurement.
- Integrate innovative procurement approaches to help encourage and develop a low carbon product sector, services, and supply chain.
- Ensure tenders allocate time and fees for design teams to undertake integrated design team working, iterative whole life carbon measurement to EN15978, and innovation from early concept stage.

Planning

- Provide planning policy guidance for local authorities on the application of WLC to planning practice and development plans, including, policies on demolition.
- Ensure WLC Assessment is used as part of the evaluation at planning approval stage for all development with level of assessment appropriate to scale.
- Introduce the concept of circularity statements for larger developments at planning stage as per the City of London⁸
- Carry out research to understand better WLC impacts of zoning in development plans considering for example, ground conditions, infrastructure requirements, materials, form factor, density, height, and car parking provision requirements.

Education & Skills



- Integrate low carbon design and construction skills into all relevant construction undergraduate programmes, including architecture, engineering, construction, and surveying.
- All existing construction professionals to have access to CPD and micro credential courses/modules to skill up in WLC measurement and circularity.
- All procurers skilled up in procurement of low carbon construction and renovation including in procurement of low carbon products and circular use of buildings and materials.
- Ensure awareness level training on whole life carbon and circularity provided to key financial, private and public investment professionals, estate agents, valuers and policy makers.
- State training bodies to extend specialist craft worker training to all construction workers to eliminate performance gaps between design and construction.
- Establish a register of qualified renovation advisors for homeowners and SMEs based on the recommendations and work of the National Renovation Upskilling Committee⁹

9. Read more at Developing a Register of Building Professionals & Construction Workers who have upskilled in Energy Renovation - Irish Green Building Council (igbc.ie): <https://www.igbc.ie/resources/developing-a-register-of-building-professionals-construction-workers-who-have-upskilled-in-energy-renovation/>



Construction & Supply Chains

- Transition the supply chain from an over reliance on imported products and carbon intense native manufacturing to a thriving Irish low carbon construction product sector.
- Rapidly reduce the CO2 emissions associated with the cement production process by maximising clinker replacement and investigating alternative technologies.
- Rationalise use of cement and concrete by designing out redundant strength and volumes in building design.
- Develop a largescale biobased construction products industry drawing on the forestry and agriculture sector. Build on existing or past successes of semi state companies such as Coillte and Bord Na Mona, in developing vertically integrated manufacturing from nationally or privately owned natural resources.
- Develop new forms of offsite modern methods of construction (MMC) reducing waste and using native low carbon construction products from bio based and circular sources.
- All construction manufacturers expected to develop a roadmap for circularity and zero carbon for their product setting out incremental targets in line with roadmap.
- Further research is required allowing City and Local Authorities to lead in the undertaking of urban metabolism analysis to facilitate the development of the construction circular economy.
- Facilitate innovative, remanufactured and reused products to come within certification such as Agrément offering assurance of compliance with building Part D.



Finance

- Green finance and mortgages to support and incentivise renovation of existing buildings and homes in town centres ahead of new build.
- Link green finance to EU taxonomy to drive transition to whole life zero carbon buildings and integration of circularity.
- Provide easy to access affordable finance packages and grants for all homeowners to renovate their homes, ensuring income is never a barrier.
- Private and public finance to fund research, development and scaling of low carbon technologies/products to enable a rapid transition for the existing Irish manufacturing sector.
- Remove current financial barriers such as refusal of building insurance, for new innovative low carbon construction technologies. Base risk on scientific evidence only.

Design, innovation, and collaboration

- Transformation of the current building design approach to one based on planetary limits, in line with the New European Bauhaus¹⁰ beautiful and sustainable.
- Make sure integrated design team working is always used, to ensure that building design is informed at the right time by the right expert.
- All Designers work with research bodies and manufacturing industry to enable innovation, including new circular design concepts, low carbon products and technologies, and business models such as 'product as a service' to scale.
- Achieving Net Zero in the building sector is not a competition but a shared goal. All of industry to share knowledge in a spirit of open collaboration.

Building and Product Data

- Develop a comprehensive national freely available database of generic construction products for early design stage modelling as available for use in regulation as in Netherlands and France.
- Construction product manufacturers to provide Environmental Product Declarations (EPDs) for the main construction products to enable more accurate modelling of building whole life carbon.
- Create a database of verified building level WLC results and operational data from which benchmarks for different Irish building typologies can be developed and used for setting baselines.
- Develop the use of material passports retaining information on performance and ingredients to enable building products and materials to be reused in the future.

10. New European Bauhaus: https://europa.eu/new-european-bauhaus/about/about-initiative_en





Glossary



Glossary of terms and definitions

Building Life Cycle: A building's lifecycle can be broken down into sixteen modules across three stages as defined in EN15978. A further stage, stage D, includes the potential re-use and recycling benefits of the building's components after the useful life of the building. The definition of the specific life cycle stages of a building is defined in EN 15978. The life cycle stages include A1-3 production, A4-5 transport and construction, B1-7 use, and C1-4 end of life [22].

Built Environment: ranges from the scale of the individual building to neighbourhoods, communities, and cities with their associated infrastructure [23].

Built Environment sectoral emissions are all emissions directly related to the BE. With reference to the EPA Emissions Inventory this would include: all space and water heating of residential and commercial/public buildings; a share of manufacturing combustion and industrial processes emissions for cement manufactured and consumed in Ireland, a share of landfill waste and a share of transport emissions. Outside of the EPA inventory the BE is also directly responsible for imported embodied carbon and carbon related to on-site construction activity.

Circular Economy: is an economic model, and the policies and practices which give effect to that model, in which resources are kept in use for as long as possible, the maximum value is extracted from those resources whilst in use, and products and materials are recovered and regenerated at the end of life [24].

Circularity is an essential part of a wider transformation of industry towards climate-neutrality and long-term competitiveness. It can deliver substantial material savings throughout value chains and production processes, generate extra value and unlock economic opportunities [25].

Climate Neutral economy: a national objective of the Irish government under the Climate Action and Low Carbon Development (Amendment) Act (2021) is defined as ““a sustainable economy and society where greenhouse gas emissions are balanced or exceeded by the removal of greenhouse gases” [11].

Decarbonisation: is the means of reducing carbon dioxide (and other greenhouse gas) emissions into the atmosphere. Climate neutrality is the goal of the decarbonisation process, i.e., to achieve zero net greenhouse gas emissions (net zero carbon footprint) by the target date [26].

Embodied carbon: covers the entire carbon emissions associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure. Embodied carbon therefore include the following modules (or lifecycle stages of a building) under EN 15978: material extraction (module A1), transport to manufacturer (module A2), manufacturing (module A3), transport to site (module A4), construction (module A5), use phase emissions (module B1, e.g. refrigerant leakage but excluding operational carbon), maintenance (module B2), repair (module B3), replacement (module B4), refurbishment (module B5), deconstruction (module C1), transport to end of life facilities (module C2), processing (module C3), disposal (module C4). Benefits beyond the system boundary (modules D1 – D4) should also be reported separately to modules A-C. [22].

EN 15978: This European Standard specifies the calculation method, based on Life Cycle Assessment (LCA) and other quantified environmental information, to assess the environmental performance of a building, and gives the means for the reporting and communication of the outcome of the assessment.

The standard is applicable to new and existing buildings and refurbishment projects [27].

End of life carbon: The carbon emissions associated with deconstruction/demolition (C1), transport from site (C2), waste processing (C3) and disposal (C4) modules of a building or infrastructure's lifecycle which occur after its use [22].

Greenhouse Gases (GHG) often referred to as Carbon emissions. In the context of the scope of the built environment only the following GHGs with Global Warming Potentials (GWP) are considered: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF₆) [28]. Their GWP is quantified in units of carbon dioxide equivalent. A kilogram of carbon dioxide therefore has a GWP of 1 kgCO₂eq [22].

Level(s): Launched in October 2020, Level(s) is a framework of sustainability indicators that are common to all buildings. The key idea is that if all member states focus on these same indicators we can use them to learn, set benchmarks and develop standards. The framework offers comprehensive manuals for the understanding and reporting of each indicator. Level(s) was developed as a detailed reporting framework to improve the sustainability of buildings from the life cycle perspective, including the transition towards a circular economy. It encourages life cycle thinking and supports users all the way from design stage through to operation and occupation of a building.



Glossary of terms and definitions

Life Cycle Assessment (LCA) LCA is defined as a systematic set of procedures for compiling and examining the inputs of materials and energy into a process, and the outputs in terms of the associated environmental impacts directly attributable to the process. It defines the scope or system boundary of the process and assigns environmental impact factors to all energy and materials within that scope, which in turn becomes the inventory for measurement. ISO 14040-44 provides a general overview of the principles, framework, and requirements; The detailed procedure for applying LCA methodology in the built environment is described in EN 15978 (ISO 14040: 2006 [22].

Life Cycle Cost (LCC): Life-cycle costing takes into account cost or cash flows, i.e., relevant costs (and income and externalities if included in the agreed scope) arising from acquisition through operation to disposal of buildings and constructed assets (ISO 15686-5:2017(en)) [29].

Major renovation is renovation of a building where more than 25% of the surface of the building envelope undergoes renovation [30].

NABERS: NABERS is a sustainability rating for the built environment. Like the efficiency star ratings that you get on your fridge or washing machine, NABERS provides a rating from one to six stars for buildings efficiency across: Energy, Water, Waste, and Indoor environment. This helps building owners to understand their building's performance versus other similar buildings, providing a benchmark for progress.

National climate objective: to reduce the extent of further global warming by no later than 2050, the transition to a climate resilient, biodiversity rich, environmentally sustainable and climate neutral economy [11].

Net zero embodied carbon building (new or renovated) or infrastructure asset is highly resource efficient with operational carbon minimised to the greatest extent possible and embodied carbon minimised and, as a last resort, offset in order to achieve net zero across the lifecycle - using only approved/verified offset scheme [22].

Net zero resources and circularity: A built environment ensuring the safe, responsible, and sustainable manufacturing and use of building materials, creating positive cycles through new business models and practices that avoid resource depletion and pollution, and the regeneration of natural systems that promote social and economic benefits [31].

New development: the carrying out of any works on, in, over or under land or the making of any material change in the use of any structures or other land [32].

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Offset Where a certain quantity of carbon emissions is deemed too difficult or even impossible to mitigate directly within the building life cycle, the equivalent amount of emissions may be mitigated elsewhere, either by purchasing certified carbon credits or by investing in carbon sequestration projects (e.g., reforestation) [26].

Operational carbon 'Operational Carbon – Energy' (Module B6) are the GHG emissions arising from all energy consumed by an asset in-use, during the operational stage of its life cycle [28].

Shadow pricing is a means of placing a value on a non-market good. Carbon emissions are monetised according to the 'shadow price of carbon' differentiated between domestic and large industry emissions. In Ireland the shadow price for industrial emissions captured within the Emissions Trading Scheme (EU-ETS) is based on market projections for the price of carbon traded within the EU-ETS up to 2025 and based on the EU Reference Values thereafter. For domestic emissions outside the ETS emissions (non-ETS) the shadow price is based on the estimated cost to Ireland of removing emissions from the atmosphere [18, p. 5] Details of the differentiated price are presented in the Public Spending Code [33].

Whole life carbon is simply the sum of the embodied and operational carbon. It includes all the major and immediate sources of a building's carbon footprint. It is based on lifecycle stages as defined in EN 15978, (i.e., modules A1 to C4, with module D reported separately) [22].

11. As a last resort, offset residual embodied carbon emissions either within the project or organisational boundary (check sectoral roadmaps for appropriate mitigation options) or through verified offset schemes. Approved offset scheme to be determined by local GBC or relevant industry body [22]



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