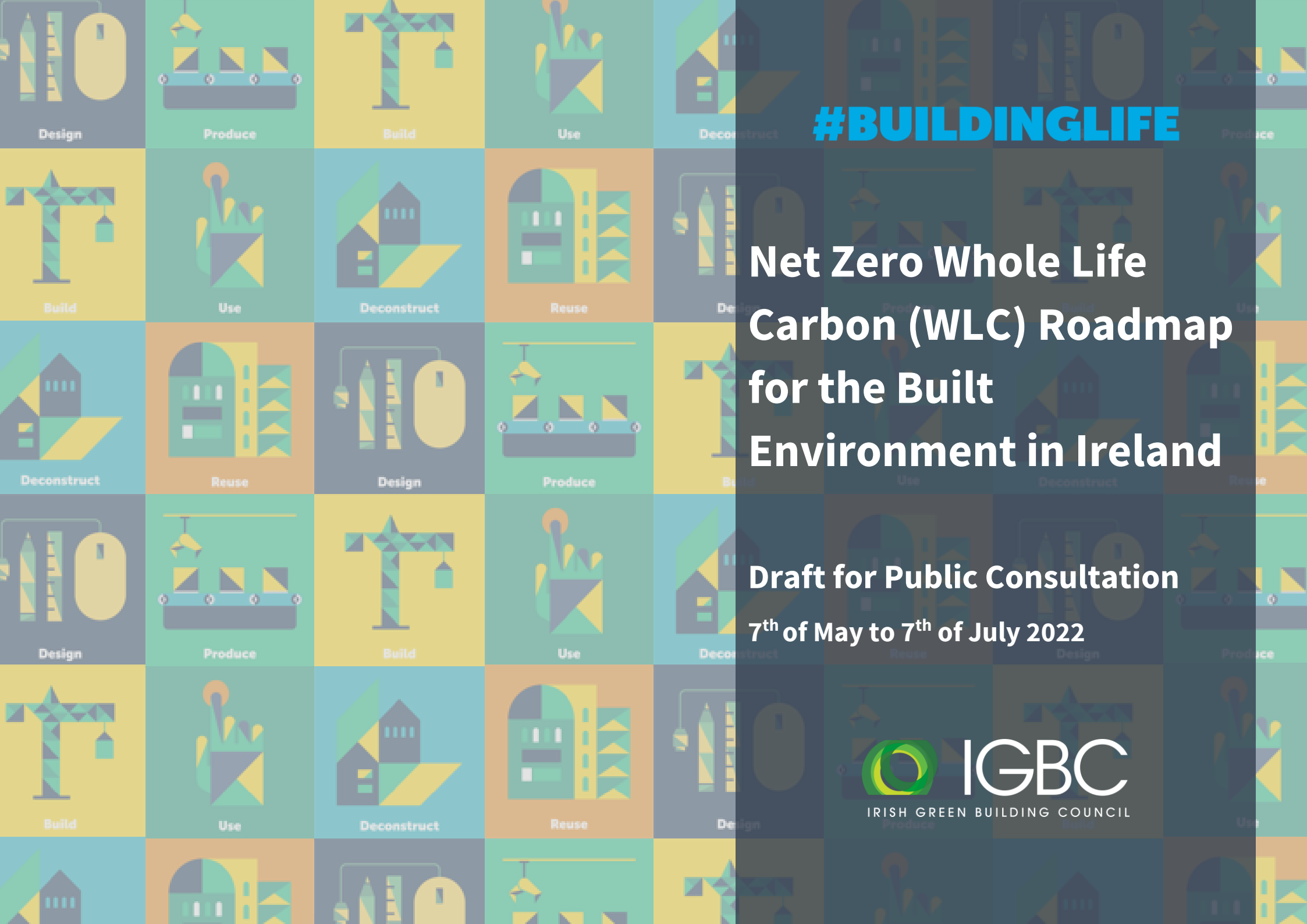

#BUILDINGLIFE

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

Draft for Public Consultation

7th of May to 7th of July 2022

IGBC
IRISH GREEN BUILDING COUNCIL

Acknowledgements

This report is part of the World Green Building Council (WGBC) #BuildingLife campaign in collaboration with other European Green Building Councils to develop ten national and one EU-wide Net Zero Whole Life Carbon Roadmaps.

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 300 members.

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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

The IGBC wishes to thank all the organisations who have attended workshops, reviewed documents, provided contributions, engagement, or feedback to assist in the development of the roadmap to date. They are listed on the following page.

Participation in the workshops/ review process does not necessarily constitute endorsement of the full content of this report.

Three expert advisory groups were also convened and met on several occasions in 2021 and 2022: The National Leadership Forum, The National Technical Committee, and the Carbon Modelling Steering Committee. The IGBC would like to thank them for their commitment, input, and feedback throughout the process.

This work is funded by the IKEA Foundation and the Laudes Foundation.

Thank you to our workshop participants:

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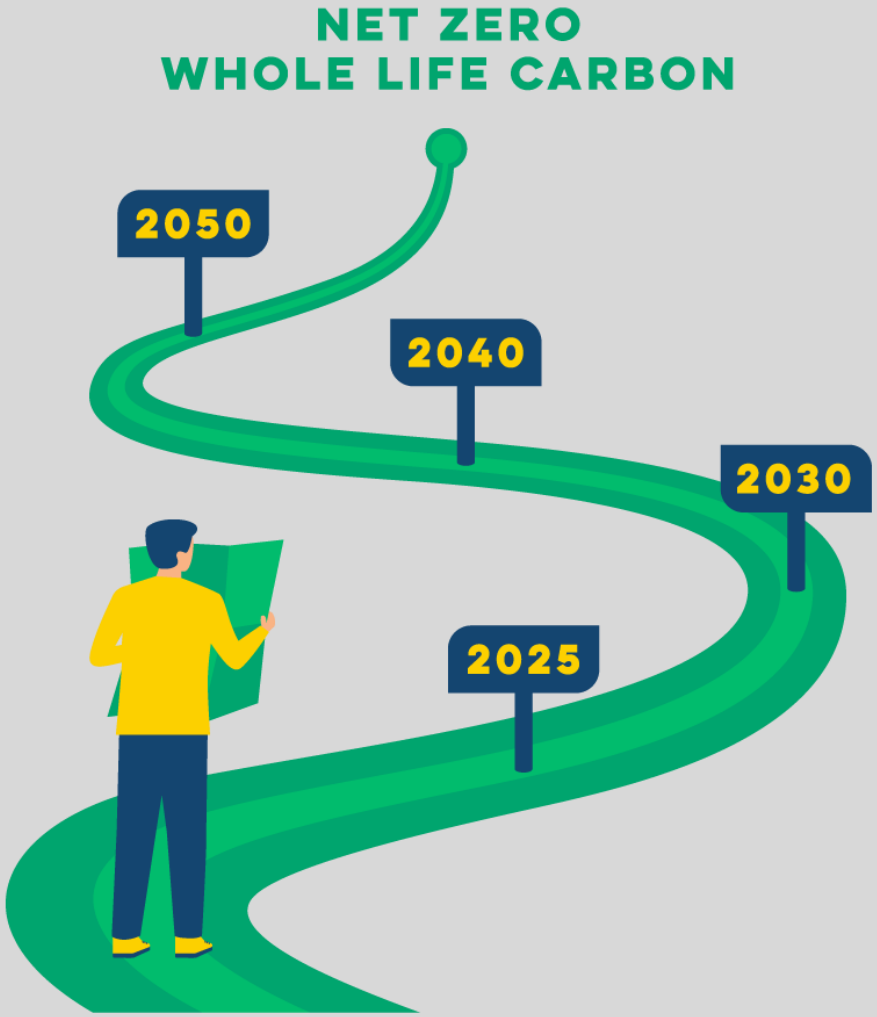

NET ZERO
WHOLE LIFE CARBON
2050
2040
2030
2025

Summary

The construction and built environment sectors account for **37% of Ireland's carbon emissions**, equalling agriculture [1].

Heating, cooling, and lighting our buildings account for 23% of our national emissions, with the remaining **14% being attributable to embodied carbon**. These emissions result from mining, quarrying, transporting, and manufacturing building materials, in addition to construction activities, the repair, renovation and final disposal of buildings [1].

Policies and regulation to date have mainly focused on reducing operational emissions, however, **without urgently addressing embodied carbon emissions, the construction and built environment sector will exceed its carbon budget** [1].

This report includes recommendations to address embodied emissions and decarbonise Ireland's built environment across its whole life cycle.

About the process

To produce these recommendations, the IGBC first developed a series of thematic briefing papers and invited key stakeholders to attend a series of workshops held between November 2021 and March 2022. Additional one-to-one interviews took place with experts in key subject areas. This extensive consultation process allowed the IGBC to develop an initial set of recommendations in March 2022. Workshops participants and other experts were subsequently invited to comment on these or suggest alternatives.

This document is open for public consultation until July, 7th 2022 (See the Have your Say section) and a final version of the roadmap will be released in September 2022. The IGBC encourage organisations to hold their own workshops on the recommendations to feed into the document.

Key Recommendations

This section presents IGBC's key recommendations to decarbonise Ireland's built environment across its whole life cycle. For further information on these recommendations see section 4.

- At the earliest opportunity, and no later than by 2025, the embodied and operational carbon impact of all proposed construction, renovation, and infrastructure according to the National Development Plan must be measured and its impact on the Climate action plan reported and evaluated.
- Mandate Whole Life Carbon (WLC) measurements at the earliest opportunity, and no later than by 2025 for all new build and major renovations (4.2.5).
- Introduce the first WLC budgets per square metre and per capita by 2027 for new build and major renovation and tighten them progressively to reach Net Zero carbon by 2035 (4.2.7).
- Reduce demand for new construction by prioritising reuse and preventing demolition of the existing stock through planning (4.1), regulation (4.2) and supporting mechanisms (4.3).
- Reduce future demand for new construction through design that supports adaptability, repair, and maintenance, in line with the indicators of the EU Framework for sustainable buildings, Level(s).
- Make energy renovation easier and more affordable to ensure all our buildings are net zero WLC by 2045. Key actions to support large-scale deep retrofit include technical (renovation advisor) and financial support (4.2 and 4.3), as well as the introduction of building renovation passports to support phased retrofit and projects aggregation to reduce costs.
- Harness the finance sector to accelerate the transition to Net Zero Whole Life Carbon through financial products and requirements. (4.3.11 – 4.3.22)
- Support greater use of reused and recycled materials, also in line with the Level(s) framework, to reduce embodied carbon emissions and waste. This requires introducing building material passports (4.7.18), supporting re-certification and the use of exchange platforms (4.7.19).
- Support the development of a biobased construction products industry in Ireland and its greater use in the country.
- It will require all stakeholders, across the industry to work together in collaboration and with great urgency if we are to address the need to decarbonise our built environment in a timely and effective way.

1. Introduction

The final version of the Roadmap for Net Zero Whole Life Carbon (WLC) in the Built Environment in Ireland will be released in September 2022. This **draft shall remain open for public comment and feedback until the 7th of July 2022**. Further details on how to get involved are available in the "Have your say" section and on www.igbc.ie.

The latest report of the Intergovernmental Panel on Climate Change (IPCC) highlights once again that immediate and deep emissions reductions across all sectors is needed to limit global warming to 1.5°C [2].

Since the signing of the Paris Agreement in 2015 Ireland and the European Union (EU) have significantly increased their climate ambitions.

In Ireland, the Climate Action & Low Carbon Development (Amendment) Act (2021) (The Climate Act) set a new legally binding target of a 51% reduction in national CO_2eq emissions by 2030 and an overall target of a climate neutral economy by 2050 [3]. The legislation introduced a raft of new measures, including a new Climate Action Plan and a National Long-term Climate Action strategy; the strategy consists of 5-yearly local authority mitigation plans, and economy wide 5-yearly sectoral carbon budgets to reduce emissions by an average of 7% per year, with further reductions required up to 2050 [4].

Based on the recommendations of the Climate Change Advisory Council (CCAC) [5], overall annual reduction targets of 4.3% (2021-2026) and 8.3% (2026-2030) were adopted by the Oireachtas in April 2022. The means of achieving these reductions will be via carbon budgets spread across seven sectors: residential, agriculture, electricity generation, heavy industry, transport, public services, and waste. Sectoral emission ceilings have yet to be adopted.

Together the individual budgets will represent an overall national emissions reduction of 51% when compared with 2018 emissions [6].

The built environment is both a carbon and resource intensive sector [1]. The objective of this roadmap is to support the decarbonisation of the sector across its whole life cycle. Whole Life Carbon emissions of buildings can be measured using the standard - EN15978 Sustainability of Construction Works Assessment of environmental performance of buildings [7]. It is a consumption-based method 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 aluminium are also included. Therefore, targets set for WLC reduction for buildings do not necessarily equate to national emissions reduction (which are production based) or vice versa. However, the WLC targets must align and enable national targets. Irrespective of national targets or sources of emissions, private or public organisations operating within the built environment and seeking to align their own targets with the Paris Agreement will need to measure their emissions on a consumption basis rather than a purely national production basis.

The EU Taxonomy for sustainable activities, and the proposed revisions of the Energy Efficiency and Energy Performance of Buildings Directives require or encourage measurement of Whole Life Carbon, hence taking a consumption-based approach.

Another factor to consider is the expected significant increase in construction activity over the next decade. The National Development Plan (NDP) proposes to increase construction, including a 50% increase in new housing developments up to 2030 and the deep energy renovation of 500,000 homes. In addition to this will be the accompanying construction of schools, healthcare, new roads, broadband, water, and rail infrastructure [8].

The overall reduction target of 51% across all sectors must be achieved despite a substantial increase in construction output. This means the overall embodied carbon intensity of new construction per m^2 will have to decrease in proportion to the increase in construction over the 2018 baseline year.

1.1. Aims & Objectives

In line with the project objectives, the roadmap for Ireland articulates the key policy routes and supporting actions needed to facilitate the decarbonisation of Ireland's built environment. It outlines a common vision for a decarbonised built environment, and the opportunities and challenges associated with achieving it.

The four key aims are:

1. Outline key recommendations on the integration of Whole Life Carbon impacts/issues into national policy and legislation.

2. 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.

3. Secure a cross sectoral Whole Life Carbon commitment and action on identified areas, to rapidly increase progress on this agenda.

4. Provide a blueprint that may be used by government and the construction sector to progress the integration of Whole Life Carbon in national policy and building practises in line with the direction of EU policy.

The roadmap is targeted at Irish policy makers and the construction industry, as well as parallel representative groups, product manufacturers, the education sector, financial institutions and investors, and civil society. It aims to provide stakeholders with a set of steps that will allow them to contribute to the decarbonisation of the built environment and to deliver on Ireland's climate targets.

At the EU level, the Irish roadmap, alongside the national roadmaps developed by other Green Building Councils, will support the work of officials in the Commission, Parliament, and Council.

2. Driving Change

Collaboration between business, government and civil society is critical to enable and accelerate transformative change within the construction and built environment sector. Achieving the Net Zero 2050 target is feasible, but will require awareness raising, education and innovation, as well as shifts in policy and regulation. These actions are interrelated, and iterative in nature.

2.1. Collaborate

The development of the roadmap was undertaken as part of a wider collaboration on delivering an EU-wide roadmap between the World Green Building Council (WGBC) Green Building Councils (GBCs) in Croatia, Finland, France, Germany, Ireland, Italy, the Netherlands, Poland, Spain, and the UK.

More information on the #BuildingLife project is available at

https://www.worldgbc.org/buildinglife.

In Ireland, the IGBC worked with researchers from the Building in A Climate Emergency (BIACE) Research Group at UCD who carried out extensive carbon modelling and scenario analysis for the built environment. The UCD report was jointly launched as a companion to this document and is available at www.igbc.ie.

The recommendations presented in this document were developed in cooperation with industry and key stakeholders. To date over a hundred people have participated in the process and communicated their input and feedback.

The IGBC is now seeking additional feedback on these recommendations. See the 'Have your say' section of this document for further information.

2.2. Communicate

The #BuildingLife communications campaign has been running for over a year in Ireland, in tandem with similar campaigns in other EU countries, with the goal of reaching a diverse range of stakeholders.

You can search social media for the hashtag **#BuildingLife** for more details, or read more on the IGBC website: https://www.igbc.ie/tag/building-life-blog/ and on our new dedicated **Whole Life Carbon webpage:** https://www.igbc.ie/lca/.

2.3. Educate

Since the #BuildingLife project started, IGBC has provided initial training on **Whole Life Carbon** to over 350 building professionals, and on **Environmental Product Declarations (EPD)** to over 150 people.

You can find out more about IGBC's Whole Life Carbon training and learning resources at https://www.igbc.ie/learning-hub/.

2.4. Innovate

In 2020 IGBC commissioned Cambridge Architectural Research to report on the carbon impacts of common, high volume materials such as cement, steel and brick, and develop average impact figures for their use based on the Irish context. These generic averages can be used in the absence of specific EPD data.

This year, IGBC has commissioned Dr. Craig Jones of Circular Ecology, developer of the ICE Database, to build on this report and develop additional datasets for materials, construction processes and default end of life scenarios for Ireland. The methodology closely follows that used by the Finnish government to develop their database of average carbon impacts. This work will lead to the launch of an online National Generic Database in 2022.

In November 2021, the Carbon Designer for Ireland Tool was launched. This is a free early design stage tool for estimating the carbon impact of buildings. The tool was funded by the EPA and LDA and developed by OneClickLCA.

The tool can be accessed at:

https://www.oneclicklca.com/carbon-designer-tool-ireland/

2.5. Advocate

Since the start of 2021, IGBC has made 30 submissions on policy including submissions on many Local Area Development Plans to advocate for decarbonisation of the built environment, and consideration of Whole Life Carbon.

#BuildingLife has recruited prominent voices across the EU to amplify this call for policies that address the full lifecycle impact of the built environment. Ireland now has 20 #BuildingLife Ambassadors (shown on the next page). These are all high-profile individuals, politicians, and business leaders who are willing to support the campaign by taking action to address the whole lifecycle impact of our sector.


#BUILDING LIFE
CAMPAIGN AMBASSADOR
Ali Grehan, Dublin City Council
Wayne Metcalfe, John Sisk and Son
John Maxwell, Lioncor
Claire Pomroy Hines
Susan McGarry, Ecocem Ireland
Cian O'Callaghan, T.D.
Frances Fitzgerald, MEP
Ciaran Cuffe, MEP
Jeff Colley, Passive House Plus
Sarah Ingle, ACEI
Eoin Ó Broin, T.D.
Eugene O'Shea, Walls Construction
Kathryn Meghen, RIAI
Ivana Bacik, T.D.
Rachael Meginley, CBRE
Pat Crean, Marlet Property Group
Francis Noel Duffy, T.D.
David Browne, RKD Architects
Oonagh Reid, Arup
Paul O'Neill, Cairn Homes

3. Vision for 2050

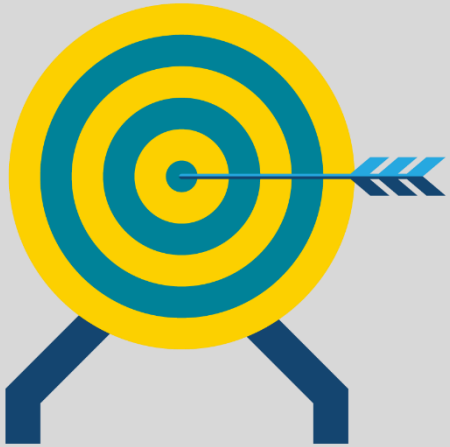
A totally decarbonised, circular, resource efficient built environment.

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 proposed Net Zero Whole Life Carbon roadmap for the Built Environment in Ireland is aligned with the WGBC 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 incremental targets were defined to reach Net Zero by 2050. The pathway includes several key milestones which were set down following consultation with the National Leadership Forum, National Technical Committee, Carbon Modelling Steering Group, and other key stakeholders. IGBC's vision aligns with government policy of achieving a 51% reduction in national CO_2eq emissions by 2030.

3.1. Net Zero WLC in Buildings: Definitions

The IGBC adopted the following definitions when developing this roadmap:

Net Zero Whole Life Carbon

A 'Net Zero Whole Life Carbon' building is a highly energy and resource efficient building where renewable energy sources and offsetting are utilised, such that the total Global Warming Potential for the whole building life cycle is less than or equal to zero.

'Net Zero Whole Life Carbon' is often referred to simply as 'Net Zero Carbon' or 'Carbon Neutral'.

Net Zero Operational Carbon

A 'Net Zero Operational Carbon' building is a highly energy efficient building where renewable energy sources are utilised for all energy use, such that the annual Global Warming Potential for operational energy use is less than or equal to zero.

The **Global Warming Potential** (GWP) of a greenhouse gas (GHG) is a characterisation factor to represent the climate change impact of that GHG relative to that of carbon dioxide.

- The overall GWP of a building should be calculated as per Indicator 1.2 of the EU Level(s) framework.
- GWP is quantified in $kgCO_2e/m^2/yr$ for a reference study period of 50 years.

Building life cycle stages are defined by EN15978:2011

- Modules A1 – A3 (PRODUCT stage) [Cradle]
- Modules A4 – A5 (CONSTRUCTION PROCESSES stage)
- Modules B1 – B7 (USE stage)
- Modules C1 – C4 (END OF LIFE stage) [Grave]
- Module D (Benefits and loads beyond the system boundary)

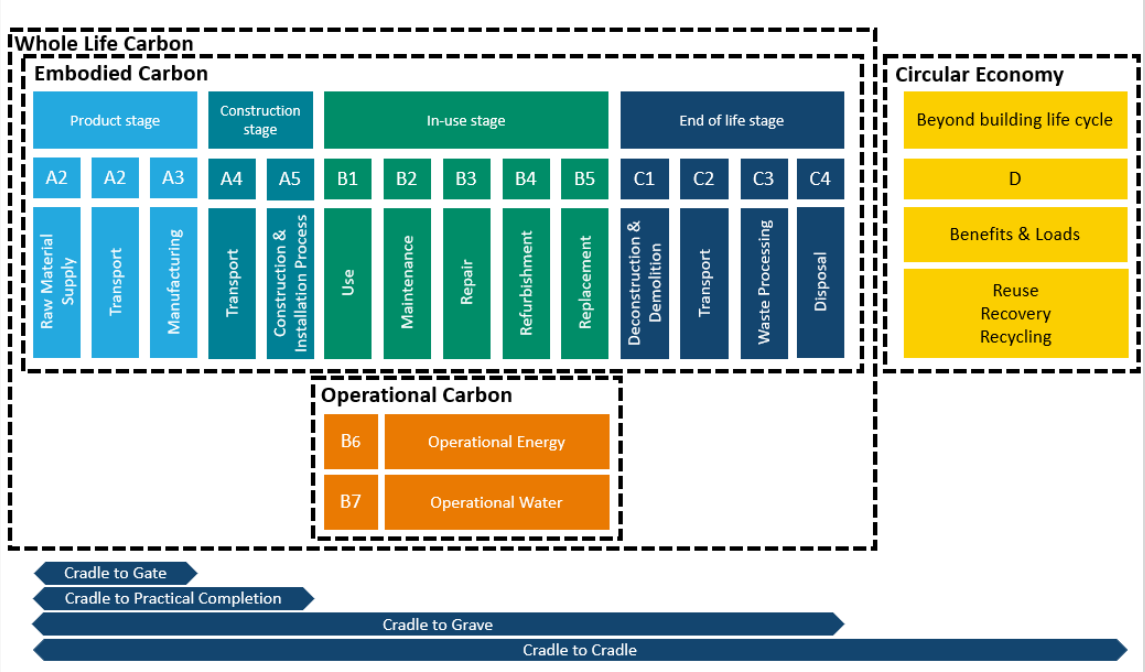


Figure 1: Building life cycle stages in EN15978:2011

'**Whole Life Carbon**' (WLC) is the total GWP associated with all life cycle stages of a building including both operational and embodied carbon.

- '**Operational Carbon**' is the GWP associated with operational energy and water use (modules B6 and B7) during the use stage of a building's life cycle.
- '**Embodied Carbon**' is the GWP associated with all construction materials and products over a building's whole life cycle; cradle to grave (modules A1-A5, B1-B5 and C1-C4).
- '**Upfront Embodied Carbon**' is the GWP associated with all construction materials and products up to building handover following construction; cradle to practical completion (modules A1-A5). Upfront Carbon excludes biogenic sequestration.

Renewable energy sources are those that are defined as such at national level. These may be any combination of on-site renewable generation. Off-site renewable energy generation is also acceptable if it demonstrates additionality.

- Additionality is the procurement of renewable energy for the building's use which results in new installed renewable energy capacity that would not have occurred otherwise.
- Direct emissions and any upstream emissions from renewable energy sources must be included as part of a WLC assessment.
- N.B. The requirement for all operational energy use to be met via renewable energy sources implies that a Net Zero carbon building does not utilise fossil fuels in any way.

Offsetting is when GHG emission reductions or removals achieved elsewhere are used to compensate, or "offset", the residual carbon of a building.

- **Residual carbon** is the remaining GHG emissions once both operational and embodied carbon have been reduced as far as possible.
- Offsetting should only be used after all efforts to reduce emissions have been exhausted and should be done following the Oxford Principles for Net Zero Aligned Carbon Offsetting.

All buildings must be **highly energy and resource efficient**. The built environment must be considered holistically to achieve a Net Zero carbon energy system and economy, and to minimise the use of offsetting which should not be viewed as a long-term solution. To achieve this, local targets have been developed to establish the energy and resource efficiency required by all buildings.

- The RIAI 2030 Climate Challenge has established voluntary local targets for operational energy use, water use, and embodied carbon in Ireland.
- Annex III of the proposed EPBD revision defines the 'very high energy performance' of a 'zero-emission building' in terms of local EUI targets.

N.B. Local targets may change over time as Net Zero carbon knowledge and strategies evolve.

3.2. Carbon Measurement -Ireland

National inventory of emissions

The EPA sectoral emissions inventory divides the nation's total GHG emissions into ten sectors [9]. 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 a significant proportion of emissions from manufacturing combustion, industrial processes, landfill waste and transport.

Furthermore, the EPA sectoral emissions inventory takes a production-based approach, as opposed to a consumption-based approach. This means that emissions associated with imported products used in construction in Ireland are not measured, whereas emissions associated with the production of cement for export are included.

Carbon accounting and appraisal of public investment projects

Under the Public Spending Code, a different methodology is used to evaluate the shadow price of Emissions Trading Scheme (ETS) and non-ETS emissions in the appraisal of public investment projects [10]. Emissions from carbon intensive materials manufacture are captured under the EU ETS data for large emitters [11]. Other EU member states, such as Finland and the Netherlands have taken a different approach and use a total carbon price for assessing construction projects based on impact irrespective of whether they are ETS or non-ETS related.

Whole Life Carbon assessment at building level

The most effective decarbonisation measure for new buildings in Ireland have been the changes to the Irish Building Regulations TGD Part L which have required reductions of 70% for residential [12] and 55-60% for non-residential since 2006 [13]. The regulations have driven change by setting limits on energy and fossil fuel use for heating in buildings.

In a significant advance the updated 2021 Climate Action Plan (CAP) [14] has now included actions to address Whole Life Carbon in the built environment (actions 134, 196, 198, 199 and 201). [15]. The previous 2019 CAP focused exclusively on reducing operational emissions, with actions to support retrofit and supply chain upskilling.

The proposed revisions of the Energy Efficiency Directive and Energy Performance of Buildings Directive encourage or require measurement of Whole Life Carbon for certain developments.

In the past year the EU taxonomy regulations criteria on Whole Life Carbon has already driven interest from development companies seeking investment finance. However, it is not currently being applied to the evaluation of most projects and therefore not affecting Ireland's overall contribution to rising global emissions.

This Roadmap aims to consider how Whole Life Carbon can be mainstreamed across policy and at building level in Ireland. It proposes a range of new policy measures, to address embodied carbon across all development, throughout the entire lifecycle, from supply through construction, operation, and disposal.

3.3. Carbon Modelling - Ireland

The Building in a Climate Emergency (BIACE) Research Lab at the UCD School of Architecture, Planning and Environmental Policy was commissioned to quantify for the first-time carbon emissions associated with the whole lifecycle of the building stock in Ireland. It was also tasked with modelling future emissions modelled on a variety of scenarios based on the National Development Plan (NDP) and other supporting documents.

The full carbon modelling report is available at www.igbc.ie.**Current levels of emissions**

The lab's initial results indicate that 23MtCO$_2$e per year are linked to the construction and operation of our built environment (BE). This equates to 37% of all national emissions, the same as agriculture.

This 37% is made up of **23% operational emissions** associated with the energy we use to heat, cool, and light our buildings and a further **14% embodied carbon emissions** from the production of construction materials, transport of materials, construction process, maintenance, repair and disposal of buildings and infrastructure.

The single largest contributor to BE emissions was found to be the operation of residential buildings, which account for 45% of the 23MtCO$_2$e.

Scenario modelling to 2030

How the construction and operation of the 400,000 new homes in the National Development Plan is executed will have a profound effect on both operational and embodied carbon in the state.

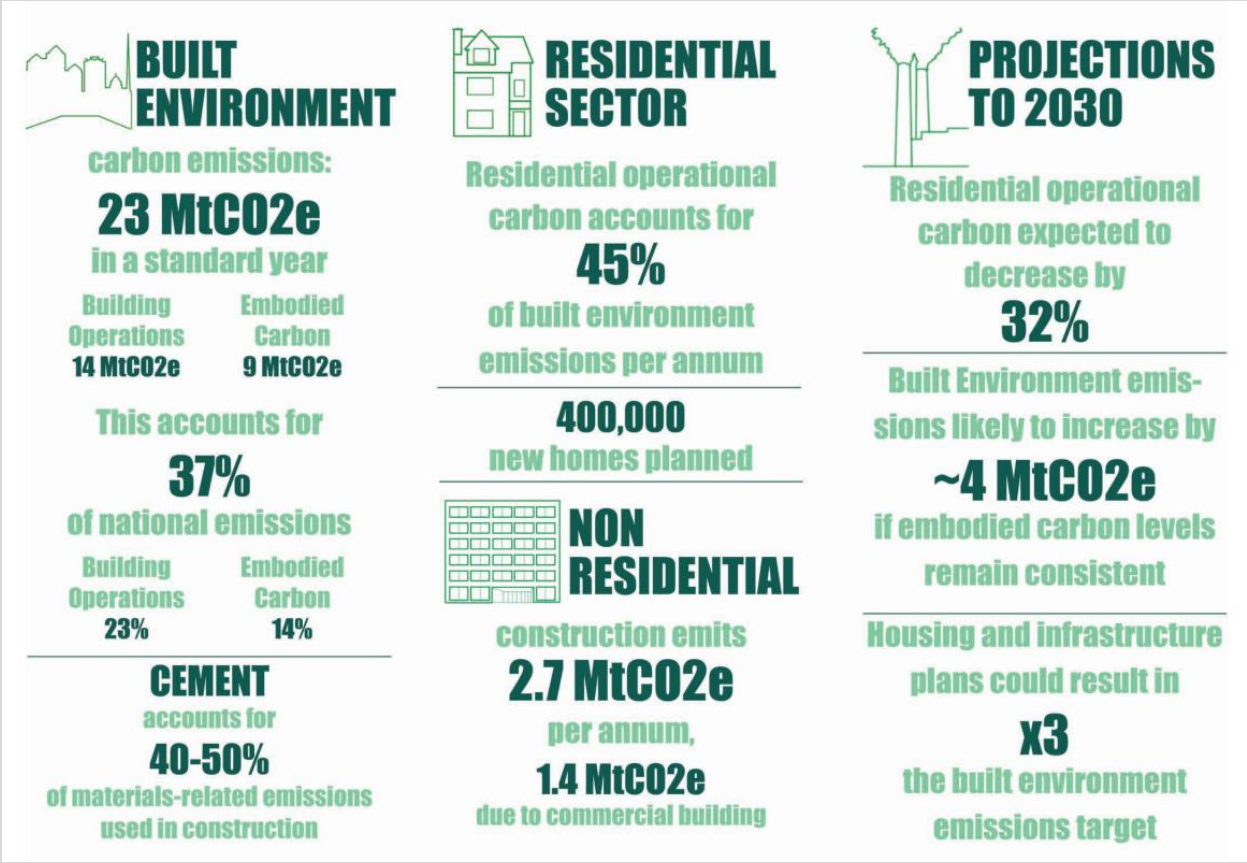


Figure 2: Carbon impact of the built environment [1]

The report includes projections to 2030 for a range of scenarios. Although these need to be further refined, the trends are reliable as they are based on recent and continuous trends and published national plans and policy for development and retrofit.

The national retrofit scheme and energy efficiency improvements in new build (NZEB standard), alongside a decarbonising grid, will **drive operational emissions down in the next decade**, **however, new construction outlined in the national development and housing plans will lead to a significant increase in embodied carbon, effectively negating the savings in operational emissions**.

At this early stage, three WLC scenarios were tested to scope their future impact on overall emissions from the built environment. All three assume all new housing energy will be supplied by electricity and that the carbon intensity of the grid will continue its downward trajectory, reaching around 150gmCO_2e/kWh by 2030.

The first considered a 'business as usual' scenario where the rate of construction and retrofit increase as planned but no efforts are made to address embodied carbon (EC). As

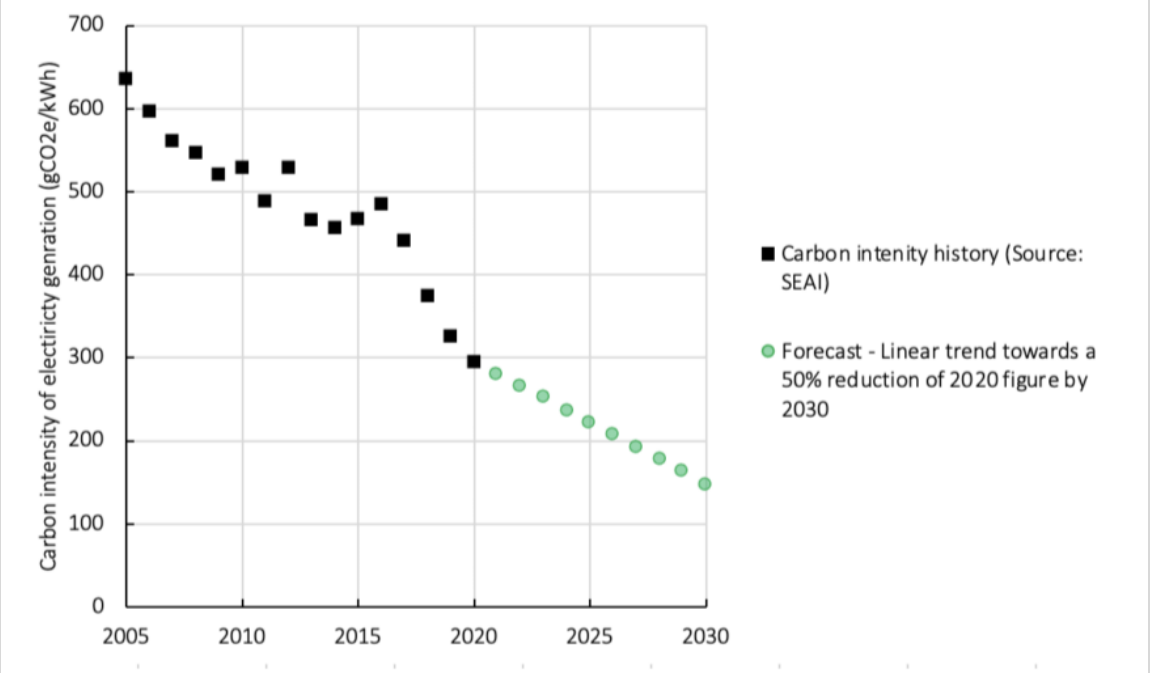


Figure 3: Historic and forecast carbon intensity of electricity to 2030 [1]

can be seen, the increase in the volume of building leads to an increase in EC. This increase completely negates any carbon savings from the decarbonising grid and in fact drives overall emissions up.

The second scenario considers the impact on emissions if all future builds were to meet the RIAI Climate Challenge of a 50% reduction in embodied carbon. Operational emissions decline but again these savings are negated by the EC involved in construction activity as envisaged in the NDP. Finally, the third scenario demonstrates the significant change to construction practices that is required alongside our decarbonised grid to reduce BE emissions by 51% from the 2018 level. This model proposes a combination of steps; the bringing back into use of 100,000 vacant buildings to reduce the need to build new and a reduction of 80% in EC. Only this third

scenario met the target of halving emission within the built environment. It is difficult to see how the third scenario would be possible. Whilst a reduction to 300,000 new homes may be possible through a combination of a shortfall in construction and using more vacant space, an order of magnitude cut in embodied carbon intensity per m^2 of 80% within 8 years is challenging. It will require ambitious zero carbon building methods, but additional savings such as cutting back on other projects or built area in the National Development Plan is likely to be required too.

Scenario modelling to 2050

Beyond 2030 certain assumptions are made to further decarbonise the built environment. It is assumed that there will be a reduction in the construction of new homes back to 2018 levels. Certain milestones are necessary including achieving 100% renewable electricity by 2040. By 2045 all homes are heated by either electricity or by green hydrogen with all fossil fuel boilers decommissioned. By 2050 embodied carbon is reduced to zero. Cement will have been fully decarbonised either by clinker replacement or with carbon capture storage which remains unlikely before 2040.

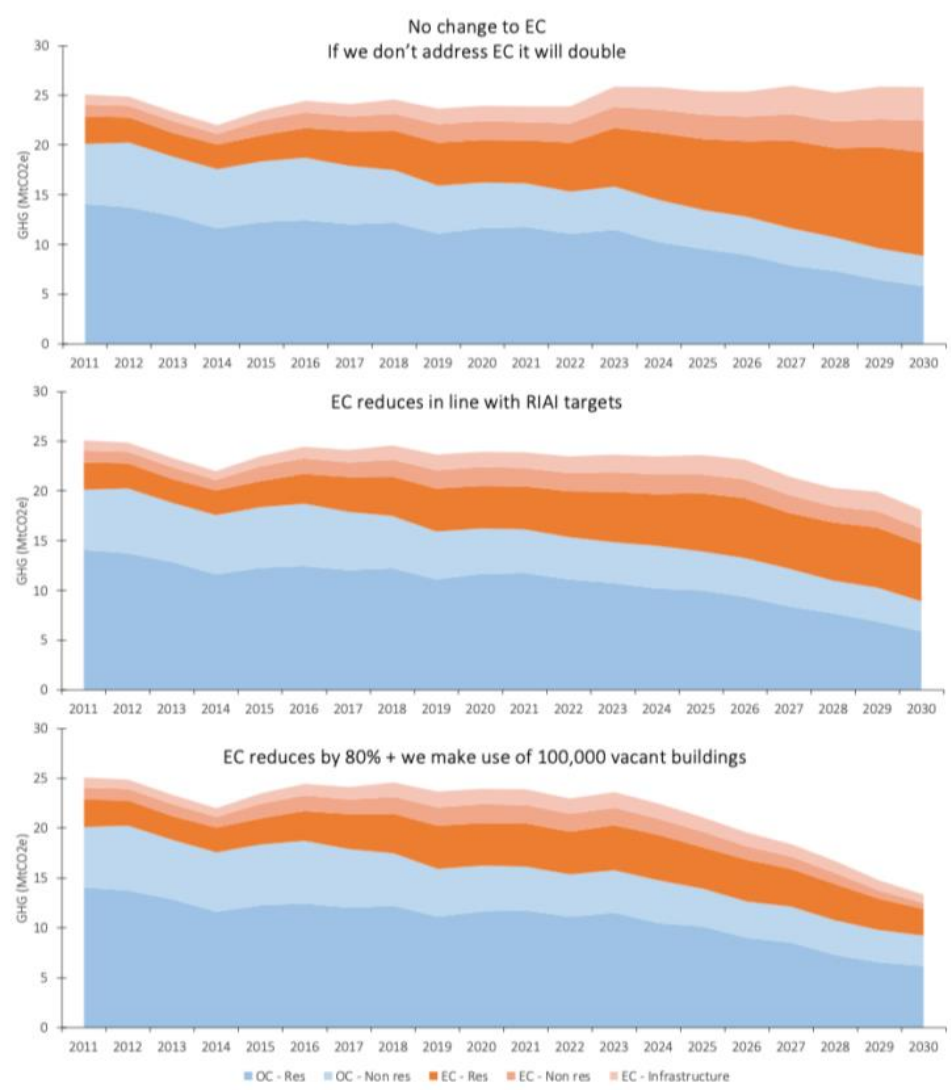
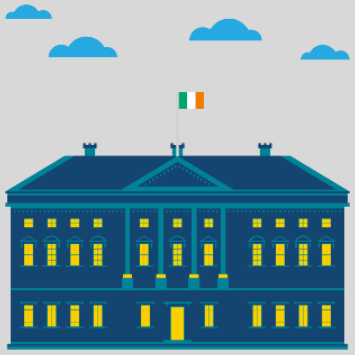


Figure 4: Projection to 2030 under the 3 presented scenarios [1]

4. Recommendations

This section presents recommendation for policy makers and key stakeholders to address Whole Life Carbon in the built environment. The recommendations are intended to enable Ireland to reach its 2050 Net Zero carbon target, assuming significant improvement of the carbon intensity of the electricity supply.

Decarbonisation assumptions and goals will need to be revised over the years. Continuous improvements will also be needed to keep up with best practices, product development or new technologies. The implementation of the roadmap and any updates should be done in a transparent, fair, and inclusive way.



4.1. Planning & Development

Background information

The 2021 Climate Action Plan has identified spatial planning as a key 'enabling framework' [14] in reducing built environment emissions and has the means to deliver necessary action on climate change, particularly at local level [16] [17]. Planning sits at the interface between how we live, how we adapt to climate impacts and how we mitigate against rising emissions [18]. While planning is not a silver bullet or catch-all solution, it does have the potential to trigger cascading action within the construction sector [19]. Taking a WLC approach may have a significant influence on a range of decisions that can shape the delivery of decarbonised development [20].

Although emerging, climate policy has not yet been given priority within local authorities in the same way as other mandates such as housing and budgeting remains dispersed [21] [22] [23]. Councils come under the control of the Department of Housing, Local Government and Heritage, but local planning policy is set by the Council Executive (planning team) and voted upon by elected Councillors. In addition, Councillors and officials agree on the Development Contributions Scheme, under Section 48, which sets down the criteria for revenue raising for specific infrastructure linked to planning permissions. The complexity of this delivery means that the new climate priorities require buy-in from many different stakeholders, which make it highly political [24]. In addition to allocation of resources, wide-scale upskilling of personnel and councillors would be required to communicate the benefits of low carbon development and develop the ability of local authorities to evaluate the carbon impacts of development proposals and planning applications.

While the NESC suggests that the Climate Action Plan should expedite a process *"that empowers front-line agencies and actors to explore, find, trial and cost new solutions tailored to specific contexts"* [25], the recent consultation on the Development Plan Guidelines states that Development Plans are not empowered to introduce "new or bespoke localised standards for construction of buildings that are governed by Building Regulations" [17, pp. 66,71]. Thus, in the future local authorities may be precluded from moving ahead with new measures to control embodied carbon within the realm of

planning. The six-year cycle for reviewing development plans also hinders timely action on decarbonisation.

There are, however, numerous international examples where WLC considerations are being integrated into planning policies and practices that could also offer potential solutions for Ireland to replicate or adapt. These include; setting embodied carbon targets for designated planning zones; utilising taxation, planning fees and levies as means to incentivise reuse of existing building (and disincentivise vacancy and dereliction); utilising carbon scoring in development land transactions with developers being required to declare the embodied carbon of their proposals within bids; limitations on parking; WLC calculations and circularity statements required as part of the planning application process; optimisation of building typologies, spatial layout and material use; incentivising good quality higher-density development.

Recommendations

4.1.1 Establish a strategic working group on WLC in planning policy by 2023.

4.1.2 Incorporate carbon accounting into National Planning Policy Frameworks to ensure net-zero is consistently included in all areas of national planning policy and develop guidelines for low carbon planning, including demolition.

4.1.3 Establish a regulatory pathway so that reporting on WLC is mandated as part of planning consent for new build by 2023.

4.1.4 Provide absolute clarity to local planning authorities that they can move faster than building regulations in mandating WLC assessment and setting ambitious limits on Whole Life Carbon for new development and major renovations.

4.1.5 Use the planning system to prioritise reuse of existing buildings and disincentivise demolition.
4.1.5.a Ensure the Derelict Sites Act 1990 is more strictly enforced.
4.1.5.b Introduce financial incentives to support reuse. This may include increasing levies on vacant properties and applying an additional planning levy (or increased rates) to new construction where major demolition is involved – See 4.3 for further details. Supporting measures to incentivise reuse are also needed and presented in 4.2 – Regulation & Policy. 4.1.5.c Re-introduce the planning exemption (previously SI 30 of 2018) to allow for commercial (not limited to pubs only) to residential conversions.

4.1.6 Where demolition is proposed, planning authorities should require pre-demolition audits, reuse assessments and WLC calculations.

4.1.7 Results of these 'urban metabolism' studies should inform an update of circularity requirements for planning.

4.1.8 To support greater adaptability of the building stock, reuse assessments and design for disassembly considerations should be required as part of the planning process for new build.

4.1.9 Planning levies should be linked to the carbon intensity of the proposed development.

4.1.10 For individual dwellings, reform the planning application fee so it is based on per m^2 as per non-residential to encourage more compact homes.

4.1.11 There is currently no comprehensive study on the impact on WLC emissions caused by different zoning decisions. Further research is needed to better understand the WLC impacts of zoning in development plans considering for example, ground conditions,

carbon sequestration, infrastructure and parking requirements, densities, height, and commuter patterns of users. Once this research is completed, this should be considered as part of zoning and planning permission decisions.

4.1.12 Minimum parking requirements to be reviewed in all development plans to reduce need for carbon intensive underground car parking structures in urban areas. Maximum carparking limits to be extended to wider urban areas. Use of onsite or nearby car sharing to be encouraged to allow substantial reductions in parking spaces.

4.1.13 Before 2025, information relating to climate change adaptation must become a requirement in all local authorities' planning statements.

4.1.14 To achieve their objectives, these actions must be supported by the digitalisation of the planning process.

4.1.15 Planning authorities will also require additional resources for inspections and enforcement – See 4.8.

4.2. Regulations & Policy

Background information

Up to 14% of CO_2e emissions in Ireland can be attributed to EC [26]. This percentage is higher than global average estimates of 11% and these are set to rise with an increase in construction [27]. However, current building regulations in Ireland only address operational energy during the useful stage of a building's lifecycle (equivalent to module B6 of EN15978). The 2019- and 2017-Part L Regulations (for Dwellings and Buildings other than Dwellings respectively) set requirements for new buildings to achieve Nearly Zero Energy Buildings (NZEB). There are no regulations concerning emissions from the manufacture of building materials or the construction of buildings. Unlike operational emissions, these emissions occur today so cannot be mitigated by a cleaner energy grid in the future.

The main driver for carbon related building regulation in Ireland to date has been the EU directives on energy, primarily the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED). Under the European Green Deal, the EU has agreed even more ambitious carbon reduction goals, with "Fit for 55" setting a target of a 55% greenhouse gas (GHG) emissions reduction by 2030 as a necessary intermediate step towards the long-term goal of Net Zero GHG emissions by 2050. In line with this new "Fit for 55" target key EU directives have or are currently being revised ("recast"). One of the aims of these revisions is to begin consistently integrating WLC requirements in the policy framework.

As part of the EU Green Deal, the Construction Products Regulation is also being reviewed to address the sustainability performance of construction products. In Ireland, the new National Circular Economy Action Plan (NCEAP) also mentions the possible introduction of recycled content requirements for certain construction products [28]. This will have a direct impact on WLC as the principles and actions required to mitigate these emissions are the same as those for advancing circularity; i.e. reuse, reduce, avoid over-specifications, consider local aspects and passive solutions, improve building resilience, flexibility and adaptability, extend the lifespan of buildings and components, and improve recyclability. [29]

A Science Based Target is any performance target related to GHG emissions that is in line with what the latest climate science deems necessary to meet the goals of the Paris Agreement; limiting global warming to well-below 2°C above pre-industrial levels and pursuing efforts to limit warming to 1.5°C. This is the basis for the EU's 'Fit for 55' targets and those of Ireland's Climate Action Plan 2021 which has set an emissions reduction target of 44-56% by 2030 for the construction industry.

Recommendations

4.2.1 Give responsibility of overseeing and coordinating climate action to one Department (e.g., the Department of An Taoiseach) to ensure a holistic and efficient approach to carbon emission reductions.

4.2.2 Set up a government task group to review embodied carbon, procurement, and circular economy policies, as well as building, planning, energy and transport regulations, and how they can better support the decarbonisation of the built environment across its lifecycle, taking into consideration developments at EU level.

Addressing Whole Life Carbon

4.2.3 In 2023, government to set out a clear implementation pathway with key dates for benchmarks and regulations for WLC assessment to provide certainty to industry.

4.2.4 At the earliest opportunity, and no later than by 2025, the embodied and operational carbon impact of all proposed construction, renovation, and infrastructure according to the National Development Plan must be measured and its impact on the Climate action plan reported.

4.2.5 Whole Life Carbon measurements should be mandated at the earliest opportunity, and no later than by 2025 for all new build and major renovation.

4.2.6 Validated data for WLC of buildings should directly inform sectoral emission ceilings.

4.2.7 The first Whole Life Carbon budgets per m^2 and per capita should be introduced for new build and major renovation by 2027 and tightened progressively to reach Net Zero carbon by 2035.

4.2.8 Regulation to address WLC in the built environment must be supported by suitable tools, data management and collection systems, as well as incentives for industry to reduce embodied carbon. Further information on tools is presented in greater detail in 4.3 and 4.7. These tools will be required to be in place in advance of the timeline set out above.

4.2.9 A national WLC assessment methodology aligned with the European Framework for sustainable buildings (Level(s)) and any future updates must be developed in the next two years.

4.2.10 WLC measurement must be supported by an independent, accredited Building Level WLC assessor and auditor scheme modelled on the ECO Platform EPD verification process to ensure the quality and repeatability of WLC assessments.

4.2.11 More EPDs are needed to improve the accuracy and quality of WLC assessments, as well as to increase transparency and competition between suppliers. Their development at the scale and quality required must be supported through high-quality guidance documents and financial support for smaller suppliers/ manufacturers (SMEs).

4.2.12 Any product manufacturer/supplier whose marketing communications contain environmental claims must produce an EPD as evidence of such claims.

4.2.13 Reusing existing buildings and bringing as much vacant property back into use in all villages, towns, and cities as possible, must be a priority. This requires a carrot-and-stick approach.
4.2.13a Stricter enforcement of the Derelict Sites Act 1990 should be considered, as well as how to use taxation to bring properties back into use – see 4.3.
4.2.13b Stricter regulation of demolition

practice should be considered. For instance, where demolition is proposed, pre-demolition audits and reuse assessments should be required.
4.2.13c All relevant policies, and fiscal incentives must be aligned to make adaptation and reuse of existing buildings easier and bring more vacant space back into use; the opportunity of setting-up a one-stop-shop for reuse should be explored, as well as how the impact of the vacant sites levy and Living City initiatives could be improved.

4.2.14 Introduce a requirement for new build and major renovation to demonstrate Net Zero carbon across their whole life cycle on completion by 2035.

Addressing operational carbon emissions

4.2.15 Introduce and clearly signpost a cut-off date of 2027 for sales of new gas and oil boilers. Assuming a typical 15-year boiler lifespan, the last remaining gas boilers are assumed to be decommissioned in 2042.

4.2.16 Address the performance gap, through;
4.2.16a A review of DEAP and NEAP methodologies for TGD Part L compliance and BER assessment to ensure that these accurately reflect systems design and current technology.

4.2.16b A reform of the BER to better take into account in-use energy performance.
4.2.16c Post-occupancy monitoring for all non-residential buildings, through tools such as the Display Energy Certificate (DEC) or independent operational energy use rating schemes.
4.2.16d Post-occupancy proof of compliance to be required from 2027 onward, this will be supported by the roll-out of smart meters.

4.2.17 Update the building regulations so that individual buildings must manage and limit their peak electricity demand, to reduce burden on the electricity grid infrastructure.

4.2.18 Enhance financial support for energy renovation – See 4.3.

4.2.19 Require better reporting on impact of renovation for all publicly funded projects, using reporting frameworks such as Build Upon – Energy Renovation Framework to track progress and measure impacts and benefits of renovation.

4.2.20 Introduce building renovation passports before 2025 to create a long-term renovation strategy for each building, support phased renovation and projects aggregation through better quality data – this in turn should reduce cost.

4.2.21 By 2023, publish a timeline for Minimum Energy Performance Standard (MEPS) where “A” rating, “zero emissions building” operational performance is achieved by all building stock by 2050. The first level of MEPS should come into effect in 2027, with second and third levels of MEPS coming into force by 2035 and 2042 respectively. From 2035 onward, MEPS should consider WLC.

4.2.22 By 2023, update the landlord and tenant (amendment) act 1980 to incorporate green clauses as a basic provision to raise energy efficiency and environmental awareness in the industry.

4.2.23 Develop quality assurance scheme for one-stop-shops to ensure independent advice and customer protection are provided, as well as appropriately assuring the quality of retrofit works delivered. Besides building renovation passports, this requires independent, trusted energy renovation advisors.

4.2.24 Develop and implement policies to facilitate and incentivise energy renovation upskilling of building professionals and construction workers, and to attract more

people to the industry. See 4.8 for further details.

4.2.25 Integrate WLC as a key consideration within the next national long-term renovation strategy and develop a comprehensive national circularity strategy for the reuse of material streams coming out of the retrofit programme, including glass, insulation, and timber.

Circularity and construction

4.2.26 By 2025, establish a legal framework for a Digital Building Logbook to capture better quality data on buildings and building materials, alongside Building Materials Passports to facilitate reuse and the transition to a circular economy.

4.2.27 Take actions to immediately facilitate and incentivise reuse of construction materials.
4.2.27a Facilitate decisions on certain C&D waste classes (as opposed to individual products and materials) such as windows, doors, or sanitary ware. One option may be to pre-qualify them so that they are immediately recognised as a 'by-product' or 'end-of-waste' product without having to carry out an article 27 or 28 application process for every item arising on every site.
4.2.27b Ensure the EPA have sufficient resources to process article 27 or 28 applications quickly and smoothly and the fee for doing so is not prohibitive.
4.2.27c Recognise and regulate a new type of waste or demolition contractor role (e.g., urban miner) that is authorised to collect, segregate, transport, and temporarily store by-products and end-of-waste products without affecting the non-waste status of those products even if they are collected alongside waste materials for recycling, landfill, or incineration.
4.2.27d Where design, construction, and demolition processes have been modified to support 'deconstruction' or 'disassembly', as opposed to demolition (for example, in line with EU Level(s) or ISO 20887) , then waste regulation will have to be updated to allow products to be considered as non-waste and reusable rather than considered 'production residue' (waste).

4.2.28 Support the development of recertification and remanufacturing schemes for reuse.

4.2.29 Encourage manufacturers to recertify products for reuse and place them back on the market.

4.2.30 Support the use of online materials exchange platforms to determine the potential market value and reuse destinations of construction products post-demolition.

4.2.31 By 2030, introduce a minimum requirement for reused or recycled products in new build and major renovation, and increase this percentage over time.

Construction materials

4.2.32 Biobased materials typically require lower CO_2e emissions to produce, and they sequester carbon. Ireland's climate is ideally suited for and has great potential to provide biobased construction materials from timber or rapidly renewable fibres such as hemp. Several actions are required to support the development of this industry.

4.2.32a Consider the performance requirements of TGD Part B to enable best practice timber construction above 10m.
4.2.32b Review NSAI certification process (agréments) to make it easier for new innovative materials, including biobased materials, to be placed on the Irish market without lowering standards. E.g., through proof of successful application in previous projects, through proof of compliance with relevant EN standards or hygrothermal

analysis such as IS EN 15026, or through enabling the certification process and working with the Construction Technology Centre to develop testing and materials assessment facilities.
4.2.32c Review and simplify the licensing process to plant and cut commercial forestry.
4.2.32d Explore the opportunity to build on the past successes of semi state companies such as Coillte and Bord Na Móna in developing large scale biobased production facilities for construction materials from nationally or privately owned forestry and agriculture.
4.2.32e Use public procurement to support the development of a biobased construction products industry – See 4.4.
4.2.32f Introduce support mechanisms to support the development of the industry – See 4.3.

4.2.33 Actions must be taken to decarbonise all construction materials, including carbon intensive materials such as concrete and steel.
4.2.33a Before 2025, set CO_2eq per kg limits on concrete mixes and strengthen them by 2035 to encourage innovation.
4.2.33b Support the deployment of hydrogen within industry to aid decarbonisation where high temperature processes are required, and work with industry to identify feasible options for Carbon Capture and Storage (CCS) and support its development to deal with hard to-abate emissions for which there are no alternative mitigation options.

Offsetting

4.2.34 Develop a national carbon offsetting scheme and guidance on the practice and rules of offsetting for construction. Offsetting must happen at the most local level to any development and must be phased out by 2045 – a so called sunset clause.

4.3. Finance & Tax

Background information

As owners of or lenders to real estate, institutional investors such as pension funds, insurance companies, sovereign wealth funds, large asset managers and Real Estate Investment Trusts, as well as banks (together "financial institutions") have a significant role in the decarbonisation of existing and future building stock globally (REITS) [30].

Financial institutions are increasingly focussed on financial risks relating to the building decarbonisation agenda as we transition to a low carbon, circular economy. Key drivers of this focus include pressure from shareholders, increasing evidence of the financial materiality of climate risk and opportunity in the real estate sector, market demand for green buildings, the push from policymakers, in particular the EU, to mobilise and steer capital towards greener economic activities, and the increasing focus of financial regulators on climate-related financial risk [30].

Financial policymakers also have an important role. Governments are seizing the opportunity to use financial institutions and the financial sector more broadly to support the delivery of these targets, through sustainable finance policy and regulation. Governments are also increasingly concerned about the potential impact of climate-related financial risks on the financial system, as well as on individual financial institutions. Sustainable finance policy measures introduced by the EU that will impact Irish financial institutions, include [30]:

- The EU Taxonomy – which outlines the key criteria to be met for an economic activity to be regarded as "green" or "social", with a view to tackling greenwashing.
- Requirements for standardised disclosures by asset managers in relation to the Environmental, Social and Governance (ESG) attributes of their fund products under the Sustainable Finance Disclosure Regulation (SFDR).
- Requirements for increased disclosures on climate risk and other ESG issues under the Corporate Sustainability Reporting Directive [30].

Financial regulators are similarly concerned with climate-related risks to financial stability at a global and national level, as well as risks to the individual financial institutions they regulate. Financial regulators have a leadership role to play in ensuring that mitigating climate risk is a strategic priority for the financial system, thereby reducing the effects of climate change on economies [30].

Insurance remains a barrier to all forms of non-conventional construction such as Modern Methods of Construction (MMC) and mass timber and solutions will have to be found for risk transfer to ensure that insurance is available and affordable. [31]

Events such as the pandemic and the war in Ukraine have affected supply chains and highlighted financial risks associated with fuel for the manufacture of construction products and the undertaking of construction works, as well as the rising cost of materials, and delays and shortages of fuel and materials.

Decarbonisation (and fuel poverty alleviation) will be impacted by the affordability of both ongoing energy consumption costs and construction and retrofitting costs, as well as the availability of affordable finance, grants, and financial incentives.

Recommendations

4.3.1 Targeted and effective government incentives are critical to decarbonise Ireland's built environment, but the scale of the challenge ahead means that private investment needs to be mobilised too.

Public funding – The role of grants and other financial incentives

4.3.2 Establish clear budget lines to support policy delivery on climate action and decarbonisation within local authorities and their planning departments.

4.3.3 The EU taxonomy outlines the key criteria to be met for an economic activity to be regarded as "green" or "social", with a view to tackling greenwashing. In simple terms, the more environmentally friendly a project is, the easier it should be to obtain funding at a lower interest rate.
4.3.3a From 2023, the public sector should demonstrate alignment with the Taxonomy for all investment in new build and major renovations.
4.3.3b This principle should gradually be extended to all public grants and tax incentives by 2026.

4.3.4 As early as possible, review existing retrofit grants and tax incentives to ensure they are fully aligned with regeneration objectives and overall carbon reduction goals, i.e., taking into account operational and embodied carbon, as well as transport related emissions. Policies that could be explored include better connecting retrofit grants and tax incentives to other schemes such as the Living City Initiative and reviewing the Help to Buy Scheme to ensure they encourage renovation and reuse of existing buildings.

4.3.5 Government should explore the opportunity of setting up a special purpose vehicle to buy up strategic vacant assets in town and city centres for conversion to social housing, community use or other social benefit.

4.3.6 Grants and tax incentives to support energy renovation of buildings must be maintained and improved.
4.3.6a Priority access to free energy upgrades must be given to means tested low-income households living in low BER homes at risk of energy poverty, regardless of home ownership status and not limited to homeowners receiving welfare payments.
4.3.6b Low/zero interest rates are critical for the "able to pay" market.
4.3.6c Homeowners do not all know what to do and where to start in relation to energy renovation. Independent high-quality advice is key, especially to support phased renovation and retrofit of traditionally built buildings. The current 23% VAT rate on professional services discourages building owners from getting professional advice. Consider VAT reduction on construction products and services for retrofits.

4.3.7 To decarbonise building energy use, financial incentives are needed for consumers to store and trade energy flexibly, as well as new pricing solutions such as flexible tariffs (e.g., based on the grid CO_2 intensity at time-of-use).

4.3.8 Use grants and the Accelerated Capital Allowance (ACA) scheme to encourage the use of the best performing heat pumps in the market (e.g., working with natural refrigerants with global warming potential below 5) to deliver higher climate benefits.

4.3.9 Directly support the development of a low carbon construction materials industry.
4.3.9a Provide financial incentives or directly fund production facilities for biobased construction materials such as (but not limited to), CLT, sheep's wool, hemp, straw, and mycelium.
4.3.9b Provide financial support to SMEs to develop EPDs, and to facilitate low carbon construction products safety testing and certification.
4.3.9c Incentivise industrial symbiosis rollout and scaling up. Industrial symbiosis is the association between industrial facilities or companies in which the waste or by-products of one become raw materials for another. Industrial symbiosis relevant to decarbonisation of buildings might include reuse of heat from data centres or refrigeration, or using waste streams from one industry (e.g., pharmacology or medical devices) as feedstock for other industries (e.g., cement/concrete).

4.3.10 Use tax incentives and grants to indirectly support the development of a low carbon construction materials industry.
4.3.10a Immediately review SEAI grants criteria for insulation materials to accept alternative methodologies as per TDG Part D to encourage best practice and a greater use of biobased construction materials.
4.3.10b Provide grants and tax incentives or VAT reductions for use of low carbon materials, including reused materials; extend the Accelerated Capital Allowance scheme to renovation products that have at least 50% lower than average GWP in their product category as demonstrated in their EPD.
4.3.10c Introduce an extensive design and capital grants system similar to the SEAI EXEED scheme for project developers engaged in innovative, measurable low carbon construction technologies.

The role of banks and financial investors

4.3.11 As retrofit finance providers, financial institutions should develop incentives and supports for owner occupiers to encourage retrofits; reduced interest rates on green loans and mortgage top-ups may help here as well as connection to retrofit service providers. They should also engage with owner occupiers at key moments, such as when purchasing a new home or property, expanding the family or retirement to raise awareness of grants and other public supports available.

4.3.12 As retrofit finance providers, financial institutions should make residential mortgages more accessible to applicants who wish to purchase commercial properties for conversion to residential as part of bringing vacant space back into use.

4.3.13 As retrofit finance providers, financial institutions should encourage landlords to develop a Net Zero pathway for each asset to achieve Net Zero operational emissions and ensure embodied carbon is minimised in retrofit and renovation works.

4.3.14 As lenders, financial institutions should incentivise the purchase of existing vacant buildings which support regeneration within existing towns cities and villages with discounted green finance based on in-use emissions performance and embodied carbon. Incremental discounts should be available over and above those based on BERs.

4.3.15 As part of retrofit project funding, lenders should require and verify that all property owners (excepting homeowners) evaluate and minimise embodied carbon in retrofit and renovation works through WLC assessment.

4.3.16 As building owners, financial institutions should set a science-based decarbonisation trajectory for each asset and also require this to be done for buildings they have lent against. This could be done through using the Carbon Risk Real Estate Monitor tool (CRREM), an EU-funded building-level tool to manage stranding risk and renovation strategy.

4.3.17 Financial institutions, whether as purchasers of newly constructed assets or as construction finance providers should include Net Zero operational energy performance and embodied carbon targets in financing/project development criteria and verify them through due diligence. These targets should be aligned with national and EU policy ambition as a minimum.

4.3.18 Financial institutions should introduce preferential discounted green mortgages for greener new homes based on additional criteria such as WLC, transport accessibility, land use and biodiversity and align with EU taxonomy.

4.3.19 Finance providers should engage with public finance providers (national and EU) on risk-sharing and credit guarantee mechanisms to reduce the financing cost for property owners on buildings that have low or Net Zero WLC.

4.3.20 Financial institutions should commence measuring and disclosing the operational carbon emissions and embodied carbon of all properties (owned and financed) through annual reporting.

4.3.21 Financial institutions should begin to report in line with the Task Force on Climate-related Financial Disclosures (TCFD) recommendations, in preparation for mandatory TCFD reporting requirements, and should consider how the analysis and approach influences future real estate portfolio strategies.

4.3.22 The Central Bank of Ireland (CBI) should introduce supervisory expectations with regards to climate risk management of real estate assets. It should state that it expects financial institutions to measure and disclose operational and embodied carbon emissions of all properties, reported in line with the TCFD. The CBI should also set a science-based decarbonisation trajectory for each asset using the Carbon Risk Real Estate Monitor (https://www.crrem.eu/).

Insuring "non-traditional" construction

4.3.23 Government, industry and insurers to develop workable solutions to difficulties insuring non-traditional construction which is currently acting as a barrier to innovation.

4.3.24 Explore the opportunity for developers to work together to create a 'captive insurer', whereby developers pool their premiums into one vehicle and essentially self-insure. The captive then goes to the re-insurance market. Because they are insuring each other, there is an incentive to keep standards up.

4.4. Public Procurement

Background information

Incorporating green criteria into public purchasing provides an opportunity for government to deliver concrete action on meeting environmental objectives and can provide support to national policy objectives [32]. Public procurement has a significant impact on the Irish economy and accounts for 10% to 12% of Ireland's GDP. In 2018 Irish construction and civil works contracts accounted for €5.3bn, with €655m spent on professional services (including architecture and civil engineering) [33].

Public procurement is often risk averse and can be slow to make changes without the correct knowledge and systems in place. This is especially true in the case of introducing new award and evaluation criteria based on carbon assessment [34]. Green Public Procurement (GPP) can also be perceived as costly to apply within tight budgets, difficult to verify, and open to legal challenge [35].

All public procurement procedures in Ireland must comply with the EU Treaty principles and fair competition rules. The revised EU Public Procurement Directive (2014) provides for societal goals, including environmental objectives, to be delivered via public procurement. In Ireland these have been transposed into law by means of Statutory Instruments.

The overarching Directive 2014/24/EU is transposed by means of S.I. No. 284 of 2016. It sets out the key rules regarding the awarding of public contracts and the arrangements for the application of life cycle costing within the procurement process. The Office for Government Procurement (OGP) states that the 'whole life cost' of contracts are considered primarily at the award and delivery stages, within the context of achieving value for money under the Public Spending Code [36, p. 3].

GPP is currently voluntary, both at EU and national level, however the application may become mandatory for certain sectors under the EU Green Deal [37]. Originally the 2012 National Action 'Green Tenders' plan set a target of 50% GPP in both the number and the value of public contracts to include environmental criteria [38]. The current EPA guidance (2021) [35] states that it shall apply to all publicly funded contracts from 2023 onwards. In this regard, the OGP is tasked with updating all procurement frameworks over the next 3 years.

Environmental criteria have been developed for ten priority sectors including the construction sector [35] [39]. The EU GPP criteria for building construction goes beyond the building itself and takes in architects experience, energy consumption, renewables, construction materials and products, waste, and water management [35, p. 32]. So far, the criteria have only been developed for the design, construction, and management of office buildings (based on criteria developed by the Joint Research Centre [40] [26]), but they may also be used for other publicly funded buildings.

Recommendations

Public bodies must lead by example when it comes to the decarbonisation of the built environment. Furthermore, public

procurement is a strategic instrument which can be used to support innovation and drive the market for more sustainable solutions, allowing for scale up and the development of entire supply chains.

4.4.1 Before 2023, develop high quality guidance documents for GPP, including guidance to underpin the application of WLC within public procurement for all building types.

4.4.2 Develop a GPP knowledge bank with examples of tools that can be used or piloted.

4.4.3 Before 2023, update OGP template and contract documents to lower the perceived risks associated with GPP and ensure all procurers are clear on the requirements.

4.4.4 As early as possible, review the shadow price of carbon in the public spending code in light of Ireland's enhanced climate ambition. Replace the shadow price of carbon by a carbon accounting approach, presenting carbon as a new currency, through the bill of quantities- which should become a bill of carbon, irrespective of ETS or non-ETS status.

4.4.5 As early as possible, review the Capital Works Management Framework (CWMF) so that environmental, decarbonisation and social objectives are included in the project appraisal parameters. Incorporate the evaluation of carbon within Pillar 3 of the CWMF.

4.4.6 In 2023, mandate the use of GPP for all publicly procured buildings and renovations – including social housing, and more specifically, the Level(s) macro-objectives, including WLC (*Level(s) indicator 1.2)*, Design for adaptability and renovation *(Level(s) 2.3)*, Design for deconstruction, reuse and recycling *(Level(s) 2.4)*, and Life Cycle Costing *(Level(s) 6.1)*.

4.4.7 By 2025, introduce the first per square metre and per capita carbon targets for different building types, and tighten them progressively so that all new public buildings are Net Zero carbon by 2028, and all major renovation by 2030.

4.4.8 Use GPP to support innovation and build capacity within industry to decarbonise Ireland's built environment. Implement a biobased first policy, create exemplar buildings with MMC and biobased materials. The future cost of disposal (at end-of-life stage) needs to be included as part of all procurements to incentivise reuse and a Whole Life Carbon approach to new build. Supporting the use of service schemes such as Lighting as a Service (LaaS) instead of procurement of physical goods shifts the onus to be as efficient as possible over the long term from the procurer to the provider. Encouraging the sharing of second-hand furniture and equipment through reuse platforms, such as WarpIt (https://www.getwarpit.com/) has the potential to cut costs and improve resource use. GPP may also be used to incentivise energy efficiency upskilling in the industry – See 4.8.

4.4.9 Identify all procurement stakeholders within the public sector and deliver a large-scale training programme in carbon accounting and Whole Life Carbon assessment – See 4.8.

4.5. Design

Background information

The consideration given to WLC can vary from project to project, but it is not typical practice in Ireland today as there are no regulatory requirements to do so. The use of green building certification schemes has increased considerably in the post-recession resurgence of the Irish construction sector, promoting sustainable design that goes beyond the operational energy use scope of the building regulations. Most notable being the Home Performance Index (IGBC) for residential buildings (10,000 homes registered), and LEED (USGBC) and BREEAM (BRE) for non-residential buildings.

The Royal Institute of the Architects of Ireland (RIAI) launched its 2030 Climate Challenge in October 2021 [41]. The challenge calls on architects and the wider construction industry to commit to four key targets:

- Reduce operational energy demand as much as possible, before offsetting
- Reduce embodied carbon by at least 40%, before offsetting
- Reduce potable water use by at least 40%
- Achieve core health and wellbeing targets.

The benchmarks and targets set in the RIAI Climate Challenge are aligned with those developed by The London Energy Transformation Initiative (LETI) in the absence of more specific data developed for Ireland and for operational energy are aimed at achieving actual performance in use rather than just design-based compliance.

LETI has published a Climate Emergency Design Guide which has already gained a lot of traction in Ireland and internationally [42].

As the Net Zero aspirations of businesses starts to create demand for net zero buildings, and as the market starts to respond to this demand, the terms there could be a risk of confusion.

To clarify for practitioners IGBC has set out a draft definition in section 3.1 and it is hoped to build on this working to align with international definitions and RIAI local targets.

EN 15978 sets out the methodology for calculating the environmental performance of buildings covering each stage of the life cycle. These stages mirror the stages set out for the construction product life cycle assessment standard EN 15804 [45]. To calculate the production stage modules A1 – A3 of EN 15978, the LCA practitioner needs a Bill of Quantities (BoQ) and information on the carbon impact of each of the materials in it, usually sourced from EPD data or using generic averages.

Together these two pieces of information can be used to calculate the total environmental impact of materials for the construction of the building. The construction phase modules A4 – A5 are calculated based on the distances the products are transported to site and from recording all on site energy use or if this is not available by using default values. For the use phase the outcomes from the energy simulation models should be used. [45].

Recommendations

Decarbonising our built environment across its whole life cycle will require significant changes in the way we design buildings.

4.5.1 A collaborative, integrated design process involving the building owner, occupant (where possible), various disciplines of the design team, contractor and facilities management team is needed to optimise design and actual performance outcomes.

4.5.2 The construction or renovation of more operationally efficient buildings often requires greater material inputs. Operational and embodied carbon must be optimised across the whole life cycle to avoid shifting emissions from the operational phase to the construction/renovation phases.

4.5.3 WLC assessment at early design stage is essential to identify and address carbon hotspots in the lifecycle. This may lead to rationalisation, elimination of unnecessary design variations, and substitution of high embodied carbon materials for maximum carbon reduction.

4.5.4 Design teams need to careful consider site conditions to minimise the need for foundations with high embodied carbon. This can be informed by 4.1.10.

4.5.5 Design teams can reduce cement in concrete by specifying the minimum needed for sufficiency and substituting wherever feasible. Possible low carbon curing technology solutions should be researched.

4.5.6 WLC assessment is also essential to identify lower carbon alternatives without impacting performance, for example large format honeycomb clay blocks offer both structural and thermal properties, off-site manufactured panels can be cut with greater precision to improve air tightness.

4.5.7 New build and renovation should be designed to optimise flexible space use to reduce future fitout requirements and associated carbon.

4.5.8 To ensure buildings and products remain in use for as long as possible, they must be:
4.5.8a Designed for adaptability and repurposing in future, as well as for
4.5.8b ease of maintenance, upgrade and access, and
4.5.8c ease of disassembly and reuse of elements.

4.5.9 Modern Methods of Construction (MMC) and Building Information Modelling (BIM) should be more widely used to support greater efficiency and reduction in material usage and waste.

4.5.10 New builds and major renovations must minimise operational energy use and address the performance gap by adopting a design for performance approach. Simulation software and detailed methodologies for accurately simulating operational energy use are widely available but underutilised.

4.5.11 To reduce the performance gap, the design team should also consult owners and where possible, users during the design stages to ascertain their requirements and provide them with appropriate information on how to use the building in the way it was designed to be used after handover.

4.5.12 Post Occupancy Evaluation (POE) is key in reducing the performance gap and tools such as the Soft Landings Framework should be integrated into the design process.

4.6. Construction & Supply Chains

Background information

To realise a decarbonised construction sector, tackling the supply chain of materials is key.

The best way to understand the environmental impacts of a material's production process and its future recycling potential is through its Environmental Product Declaration (EPD); an unbiased, third party verified lifecycle analysis of a product from cradle to grave.

Ireland produces a limited range of construction materials. These are generally materials with high bulk such as aggregates, cement, concrete products, gypsum products, petrochemical insulations, and some brick. Ireland is a net exporter of cement, primarily to the UK [46]. It is estimated that 80% of cement sales in Ireland are CEM II, and the average carbon intensity of cement production is 712kgCO2e/tonne [46]. A significant proportion of the emissions in its production come from the chemical reaction in the process that turns limestone to clinker, and not the use of fuels to reach the high temperatures needed [47]. This means there is a limit to what cleaner energy sources can achieve. The most common cement replacement materials – GGBS and fly ash are by-products of steel manufacturing in a blast furnace and coal burning respectively – both practices that need to be reduced, therefore other solutions for low carbon concrete must be developed.

The planned increase in construction and retrofit will require materials in considerable quantities, with up to 16 million cubic meters of insulation alone needed to retrofit 500,000 homes by 2030, and a further 9-10 million for new housing. Depending on the choice of insulation, the impact will be significant.

There is no steel, aluminium or glass production in Ireland. Most imports have traditionally come from the UK, although with Brexit now in place and shipping routes changing, it is difficult to predict if this will continue to be the case. The energy used in steel production accounts for 7 - 9% of global GHG emissions [48]. Around 23% of all aluminium used in the EU is in construction. Aluminium production from virgin bauxite requires around ten times the energy input for steel production, leading to a much greater GWP.

There are lower carbon alternative construction materials and solutions available today that can be implemented with little or no re-skilling required, for example insulation from waste streams, cellulose from paper or foam glass from recycled bottles.

Currently timber frame makes up only 24% of the Irish new housing market versus over 75% in Scotland, so there is huge potential for increasing the share of timber frame in our housing stock. New forms of construction such as engineered timber (CLT) allow construction up to 22 stories. Modern Methods of Construction (MMC), offsite construction, precision engineering in product design and manufacturing technologies can reduce the creation of C&D waste, and excess material usage. These technologies can be combined with rapidly renewable biobased materials, such as panelised strawbale construction, hemp and hempcrete.

Recommendations

4.6.1 Multiple stakeholders are involved across the full lifecycle of the built environment from planning, design, construction, to occupation/use, maintenance, repair and ultimately demolition. Each group has a role to play, and they must all work together to decarbonise our built environment.

4.6.2 All organisations working in the industry must develop decarbonisation strategies for their own activities. A first step in that process is to capture good quality data on current levels of emissions (scopes 1, 2, and 3) and to develop a roadmap to reduce them. Smaller organisations must be supported in the process – See 4.2 and 4.3.

4.6.3 All organisations involved in the industry must invest in upskilling to support this transition – See 4.8, and must enter into conversations with clients, suppliers, partners and other key stakeholders about actions required to decarbonise activities.

4.6.4 All 'Clients' should mandate the use of tools such as Carbon Designer for Ireland at early design stages to explore potential embodied carbon savings and carbon sequestration opportunities through different material approaches at the beginning of a project.

Institutional investors

This section should be read alongside "4.3 – The role of banks and financial investors".

4.6.5 All institutional investors should begin to disclose the operational energy and carbon performance of all held properties (at asset level) across their portfolios (funds) in annual reporting.

4.6.6 All institutional investors and lenders should set embodied carbon targets within project funding criteria (link with the EU taxonomy).

4.6.7 Irish property owners who have signed up to the Net-Zero Asset Owner Alliance should use their leadership position to advocate for all other institutional property owners nationally to do so too.

Construction product manufacturers and suppliers

4.6.8 Produce and disclose EPDs for all their materials, so that the rest of the value chain can make better informed choices.

4.6.9 Produce and implement carbon reduction action plans for products and operations. This involves optimising the production process (reducing materials and energy use, as well as waste), using renewable energy wherever possible, investing in research into alternative solutions (e.g., Carbon Capture and Storage) and offsetting any remaining carbon footprint. See 4.2 and 4.3 on support which must be made available to help SMEs to do so.

4.6.10 Develop a circularity roadmap and implement the principles of the circular economy; adopt new circular business models, support repair, reuse, and recyclability of products.

Developers

4.6.11 Include targets for embodied carbon and material reuse alongside operational energy intensity targets in project briefs.

4.6.12 Request a Design for Performance approach from design teams and contractors and seek to include contractual targets where possible.

4.6.13 Drive demand for EPDs by requiring that increasing percentages of products used in new projects have EPDs.

4.6.14 Develop the first carbon neutral projects and ensure they become the norm by 2035.

4.6.15 Require the design team to develop an overall circularity concept for projects; design for adaptability, disassembly and re-use and set a target for a percentage of reused and recycled products in designs.

Designers

4.6.16 Adopt the use of tools such as Carbon Designer for Ireland at early design stages to explore potential embodied carbon savings and carbon sequestration opportunities.

4.6.17 For WLC assessment of more detailed designs, adopt a consistent methodology in line with standard EN15978 and Level(s) indicator 1.2 to produce assessments that can be compared against one another and across the EU.

4.6.18 Advocate for maximum reuse of existing building structures.

4.6.19 Specify construction materials with EPDs and low embodied carbon to drive demand.

4.6.20 Reduce cement in concrete by specifying the minimum needed for sufficiency and substituting wherever feasible.

4.6.21 Advocate for embodied carbon targets on projects, design for performance, adaptability, and disassembly.

4.6.22 As organisations, set your own targets for different types of projects and challenge one another to reach them.

4.6.23 Disseminate knowledge about the carbon footprint of buildings to clients.

4.6.24 Share best practice and collaborate with the rest of the industry.

Contractors

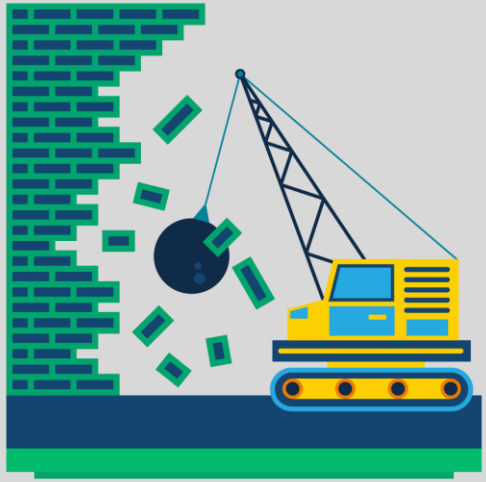
4.6.25 Measure the carbon footprint of the construction process for each project and create construction decarbonisation plans.

4.6.26 Use low carbon or renewable energy sources in the construction process where possible and develop a roadmap for transition to fossil free construction sites by 2035.

4.6.27 Develop new circular business models to reduce the carbon footprint of the construction process and reduce waste generation.

4.6.28 Require increasing percentages of reused products and products with EPDs in new projects to drive demand.

4.6.29 Introduce a new type of licenced contractors specialising in disassembly or create a resource retrieval contractor role (e.g., Urban Miner) with a focus on carrying out pre-demolition audits and identifying and handling materials and resources for reuse.



Facilities Managers

4.6.31 Monitor buildings' performance and carbon footprint on an ongoing basis.

4.6.32 Compare actual operational carbon emissions in use with targets set at design stage and optimise building management processes as necessary.

4.6.33 Support the development of digital building logbooks and oversee their implementation.

4.6.34 Provide Operation & Maintenance manuals to owners and users at handover. This should contain detailed information on carbon footprint of buildings (materials and technologies used), as well as information on how to maintain desired performance and reduce emissions.

4.6.35 Consider the full lifecycle of repair and replacement elements. Consider quality, longevity, re-use and recycle potential when selecting components.

4.6.36 Consider 'product as a service' for high energy or frequently replaced elements such as lighting, carpets, and furniture. This shifts the onus of efficiency from the customer to the provider and enables the repair and service economy.

4.7. Digital Technology

Background information

Technology alone is not a silver bullet but innovations in technology can help deliver decarbonisation in the built environment on many fronts. While carbon capture and storage technologies may play a bigger role in future, the focus of discussion here, particularly for the near-term goals of 2025 and 2030, will be on digital technologies especially those that are already in use, and could be scaled-up to quickly increase the rate of decarbonisation.

Renewable energy generation technologies continue to decarbonise the grid, necessitating additional technologies for grid expansion and stabilisation to balance consumption and production, and prevent surges and outages. This is particularly relevant as electricity demand from heat pump and EV uptake increases, and more renewable energy from micro-generation (e.g., Solar PV panels on homes) is brought onto the grid. Energy storage technologies will also be required to help maintain stability and consistency of supply and eliminate wastage. Energy can be stored in batteries (including in EVs), as thermal energy in hot water tanks, and in some cases in the thermal mass of the building fabric itself (e.g., in concrete floor slabs). However, there are global shortages of batteries (hardware), therefore it would be prudent to also harness software solutions to implement smarter strategies for when electricity is used and when renewables are available, using smart meters, energy data, and energy apps.

Smart meter apps can already be used to see when energy is being produced from on-site renewables. They could soon be used to switch appliances on and off or recharge them based on the price and availability of renewable energy on the grid, or to facilitate energy trading via blockchain technology on a community energy grid.

Virtual building information models (BIM) generally used at design stage, can utilise various software applications and plug-ins to calculate WLC. Increasingly sophisticated energy modelling software, satellite, and weather data can help predict the operational energy demands of buildings while data on construction materials and transport emissions, particularly in the form of (digital) EPDs can be utilised for calculating the embodied impacts.

Unfortunately, there is very often a gap between the energy performance predicted in design and what happens when a building is occupied. It is at this point that digital twins can be used to link real time data on building user behaviour from wearable technologies (like smart watch apps), motion detectors, and swipe access cards, with building management systems data from building equipment, and from occupied spaces through sensors to track temperature, humidity, light levels, and air quality (e.g., CO_2, carbon monoxide). This can trigger real-time mechanical carbon saving responses like opening vents, or switching off appliances, equipment, lighting, or heating and cooling systems. The UK recently published the Gemini Principles [49] for digital twins to help ensure that they are used in an open,

appropriate, non-intrusive, fair, and trustworthy manner.

Technology can also reduce the quantum of area required to be built; enabling greater use of space on university campuses and offices or supporting the use of car sharing for example, can both reduce the need for more floor area and the need for parking spaces.

Recommendations

Digital technologies have a key role to play in supporting our transition to a fully decarbonised built environment.

4.7.1 Advance the work of the Build Digital Project.

4.7.2 OPW (possibly in collaboration with CITA) should establish national BIM protocols for mandatory use for all publicly funded projects (e.g., Gemini Principles in UK). These should outline standardised open-source file types and provide product BIM files (inclusive of all EPD information) to support LCA and digital twin requirements.

4.7.3 OPW should set up a public sector digital twin pilot programme for different public building types, with priority on office buildings.

4.7.4 Progress towards 2030 and 2050 targets must be tracked on a regular basis. To make this process as transparent as possible, the launch of an online dashboard is suggested. For energy renovation, this could be based on the Build Upon Framework [50]. Making this data available at the local authority level would support greater citizen engagement.

Addressing embodied carbon

4.7.5 Develop and maintain a central database for embodied carbon, covering both asset and product level, to gather data across the industry, standardise inputs, and help set benchmarks and targets per sector.

4.7.5a The construction product database should include product specific EPDs, generic EPDs and defaults for construction products.

4.7.5b The building level database should focus on LCA data for new buildings. A single methodology should be used – see 4.2.9 – and the information should be publicly available as open data.

4.7.6 Develop an interactive construction material pyramid such as the Danish Materiale Pyramiden [51] to allow designers and all key stakeholders to quickly identify construction materials with lower embodied carbon.

Addressing operational carbon

4.7.7 A free open-source Dynamic Simulation Modelling (DSM) energy modelling software must be provided to or adopted by the industry, in addition to proprietary DSM software packages. This is key as DSM can more accurately model large complex non-domestic buildings and their systems, including part load operation and heat recovery. Level 3 & 4 modelling using iSBEMie, or any of its proprietary frontend packages, is not appropriate for large complex non-domestic buildings, but it is the only level of modelling available in Ireland for NEAP compliance modelling and non-domestic BER assessments. Free open-source DSM software packages such as EnergyPlus, or proprietary DSM software packages such as those from I.E.S. or Design Builder can create performance models that can estimate building energy use with more accuracy than the simplified iSBEMie software used for compliance modelling.

4.7.8 An appropriate energy modelling methodology, reporting framework, and Post Occupancy Evaluation (POE) criteria must be provided to or adopted by the industry. The Technical Memorandum 54 from the Chartered Institute of Building Services

Engineers (CIBSE) provides a detailed methodology for evaluating operational energy performance of buildings at the design stage. The NABERS energy rating scheme, now being adopted in the UK under the Design for Performance energy rating scheme, provides a framework for accurately estimating operational energy performance at design stage and verifying actual operational energy performance post occupancy. Upskilling of the industry is required to ensure these tools and methodologies deliver to their full potential – See 4.8.

4.7.9 POE of completed projects is invaluable and should become standard practice. A GDPR compliant national building stock database containing information on actual emissions and energy consumption of buildings should be developed by SEAI by 2025.

4.7.10 SEAI & Met Eireann should develop free open-source Test Reference Year (TRY) and Design Summer Year (DSY) weather data sets for multiple locations in Ireland.

4.7.11 SEAI & Met Eireann should develop free open-source climate change scenario weather data sets for multiple locations in Ireland.

4.7.12 Eirgrid should develop carbon metering protocols and tariffs that adjust carbon tax applied accordingly. To enable Building Management Systems (BMS) control for load shifting linked to grid CO_2 intensity rather than time of day, and optimisation of local energy storage for lowest carbon intensity.

4.7.13 Develop digital building logbooks and capture this information centrally to gather better quality data on buildings, support aggregation of retrofit projects (as linked with 4.7.14) and reuse of construction materials (as linked with 4.7.18).

4.7.14 Develop digital building renovation plans or 'passports' (BRPs) that inform retrofit pathways for existing buildings and are held within a central property database.

4.7.15 Develop an integrated retrofit one-stop-shop aggregation platform to capture data from BRPs to enable more cost-effective renovation at scale, and bulk purchase of materials and products.

Circularity and construction

New digital technologies are needed to support better use of existing buildings and reuse of construction materials.

4.7.16 OPW should develop an office scheduling protocol and portal to optimise public sector office space use.

4.7.17 Encourage the development of technologies which support sharing schemes, including for construction products and tools, such as libraries of things.

4.7.18 Develop building material passports to retain information on performance and ingredients to enable building products and materials to be reused in future (to align with the new requirements of the Eco Design Directive).

4.7.19 Further develop physical and virtual marketplaces for reuse of construction materials.

4.7.20 Create a database of Buildings As Material Banks (BAMB) of developments, including demolitions and refurbishments, creating a (geographical) map of resources suitable for reuse.

4.7.21 Urban metabolism (describing and analysing material flows using digital technologies such as GIS, BIM, databases of digital logbooks, materials passports and EPDs) is an important pillar in working towards a decarbonised built environment. Local Authorities to begin to develop Urban Metabolism (Buildings As Material Banks) mapping for all non-protected buildings by 2025.

4.8. Education & Awareness

Background information

Education, upskilling, training, and general raising of awareness of Net Zero WLC and how to achieve it, will be required across all professions, from procurement and finance, to design and construction. Recently, there has been increased impetus and recognition that education and training are viewed as fundamental to enabling the decarbonisation of society and the economy:

- In January 2022, the European Commission called for a systemic change in education and training to embed environmental sustainability to support he needs of the green transition [52].
- In Ireland, the 2020 report on future skills in the built environment [53] also acknowledged that education is considered crucial for delivery of skills for a low carbon economy.
- Education is listed as two of the nine priority areas for action under the 2020 built environment skills report [54]
- There is a commitment under the 2021 Climate Action Plan *Annex of Actions* [55] to delivery of a Green Further Education & Skills Development Plan.
- Ireland's Long Term Renovation Strategy's new Retrofit Taskforce is to examine, amongst other things, changes to existing apprenticeship and education programmes so that renovation targets can be achieved [56].
- Under Ireland's National Recovery and Resilience Plan (2021), €114m were allocated to develop SOLAS Green Skills Action Programme. This includes a focus on provision in Near Zero Energy Building and Retrofitting as well as the development of new modules in green skills. It is therefore clear that education will play a key role in enabling Ireland's climate transition.

It is acknowledged that the complexity and range of issues to be addressed under the climate policy banner poses challenges for educational delivery [57]. Furthermore, as the BE sector includes both direct construction occupations and inputs from the supply chain, and the professional services sector, the range of skills, knowledge, and competencies to be developed is vast and varied. All actors within the BE sector must undergo a deep cultural shift to grasp the new requirements of reducing carbon across the full lifecycle of buildings [58]. In addition, low carbon projects will require new understandings of collaborative approaches to design and execution [59] [53].

The public consultation on the next National Strategy on Education for Sustainable Development in Ireland [60] and the recent report from National Skills Council/Solas National Bulletin for 2021 [61] demonstrate that although there is emphasis on embedding sustainability across the curricula at all levels of education and training, there is a lack of focus on climate/decarbonisation skills, other than renewable energy and retrofitting.

In order to bring about transformation of the construction sector the whole supply chain, comprising a large number of occupations and people, must become carbon literate.

Recommendations

Raising awareness among the general public

4.8.1 Run a large-scale awareness raising campaign to ensure all citizens understand the benefits and importance of tackling WLC emissions and reusing buildings. The campaign should also address the perception that reused materials and timber frame buildings are of lower quality and may compromise safety.
4.8.1a Information on embodied carbon emissions could for instance be included in the BER and in the Building Renovation Passport.
4.8.1b To reach a wider audience, the campaign should be run in cooperation with banks, professional bodies, hardware stores and homeowner associations.
4.8.1c Simple information on WLC in the built environment, including case studies should be made available through an online platform.

4.8.2 Ensure primary, secondary and third level curriculum is infused with environmental education to increase carbon literacy. More specifically, WLC could be covered at secondary school level as part of STEM subjects, construction studies, geography, or home economics.

4.8.3 Make sure that the handover process forms an integral part of any national retrofit programme, and those homeowners and occupants receive clear and reliable information about the building, particularly for new, less familiar technologies.

Raising awareness across the supply chain

4.8.4 Raise awareness about the importance of addressing WLC in the industry. Campaigns must target investors, planners, developers, designers, procurers, product manufacturers/suppliers, contractors, and facility managers.

4.8.5 Professional bodies have a key role to play in running/supporting these awareness campaigns. They can for instance highlight exemplar projects, disseminate knowledge on best practices, or promote the concept of decarbonisation and circular economy through competitions (e.g., in architecture competitions).

4.8.6 Launch and maintain a resource sharing hub to disseminate information on tools and best practice to reduce the total carbon footprint, as well as exemplar projects (ideally located across the country). The hub could be hosted by the Construction Research Centre, professional bodies or the IGBC.

Attracting more people to the industry

Ireland has set highly ambitious new construction and renovation targets, but the industry does not currently have the capacity to deliver on these targets, nor to fully decarbonise. Offsite construction and innovation should increase productivity but retrofitting half a million homes by 2030 requires more qualified people.

4.8.7 Run targeted communication campaigns to inspire, recruit and upskill in energy renovation school leavers, those working in declining sectors and construction workers.

4.8.8 Industry to work with educational partners to promote built environment options within primary and post-primary curricula. Possible actions include using the STEM template to attract more young people to the industry, organising school visits and career guidance to ensure young people are aware of the diversity of work in the industry, working with girls' schools to ensure STEM subjects are available, and communicating

more about the key role of the industry in tackling climate change.

4.8.9 Incentivise and support construction companies to take on new apprentices.

4.8.10 To address labour shortages in the short term, explore ways to facilitate recruitment of energy renovation specialists from non-EEA countries. This may include better recognising construction qualifications and trainings undertaken outside of the Republic of Ireland (e.g., craft apprenticeships) or adding energy renovation specialists to the critical skills occupation list.

Making sure we have the right skills

To decarbonise Ireland's built environment across its whole life cycle, significant upskilling of the whole value chain is required.

4.8.11 A first step is to identify all key skills to decarbonise Ireland's built environment across its life cycle. Although many are profession specific, these will include energy efficiency, use of renewable energy for heat and power production, site suitability assessment, carbon budgeting, LCC, application of measurable circularity to construction, digital solutions for modern buildings, timber technique, MMC and POE, as well as soft skills (e.g., communication for retrofit advisors) and cross-sectoral cooperation. The construction and property development industry (including property valuers and estate agents) must also be aware of the needs and expectations of the financial sector in relation to WLC, including sustainable financial policy and financial regulatory developments that will drive financial institutions in coming years. This work should be supported by the National Centre of Excellence, the Construction Technology Centre, education providers and professional bodies.

4.8.12 Train the trainer programmes must be developed for educators, especially on WLC and circularity.

4.8.13 Additional guidance documents must be developed for building professionals; these include Guidance for adaptative reuse / designing for reuse; Guidance to clarify the intended use of NEAP and DEAP within the design process; and Guidance on what systems is most suitable for particular types of developments. E.g., MMC. The development of these guidance documents must be informed by research – See 4.9.

4.8.14 ETBs should develop and run training courses to gain key skills identify in 4.8.11 and support upskilling of construction workers.

4.8.15 All professional bodies should develop, run, and promote CPDs and micro-credentials for building professionals to ensure they can upskill in key areas identified in 4.8.11.

4.8.16 To facilitate upskilling, all education providers must ensure their training programmes are flexible, affordable, and widely available. In particular, they should be available online, in blended format or onsite. Tools such as the Build Up Skills Advisor App [62] and DASBE[1] are being developed to make it easier for building professionals and construction workers to identify training courses that suit their needs.

4.8.17 Initiatives are also needed to incentivise upskilling. Possible mechanisms include placing the Construction Industry Register of Ireland (CIRI) on a statutory footing and integrating minimum upskilling requirements in Whole Life Carbon and circularity. Professional bodies could also

[1] DASBE: https://dasbe.ie/

mandate that a certain percentage of CPDs focusing on these topics are completed annually. Alternatively, a “safe pass” for sustainability could be introduced for construction workers, or green public procurement could be used to incentivise upskilling.

4.8.18 Before 2025, review construction and built environment degrees, as well as apprenticeship to ensure all key skills identified (see 4.8.11) are fully covered.

4.8.19 Professional bodies must play a leading role in ensuring WLC and circularity are embedded into construction and built environment degrees. They should review accreditation of relevant degrees and training courses and make future accreditation conditional upon alignment to key sustainability skills identified.

4.8.20 Higher education providers must develop training courses to cover all key topics identified in 4.8.11.

4.8.21 Construction and built environment degrees, as well as apprenticeships must be reviewed on a regular basis to ensure curricula and mode of delivery keep pace with technology development and market needs.

4.8.22 To fully decarbonise our built environment, professionals working in other industries (indirectly related to construction) will need to upskill too. These include financial institutions, local authorities and elected representatives.

4.8.23 Awareness level training on WLC and circularity must be provided to key financial stakeholders, private and public investment professionals, estate agents and valuers. This cohort should also include financial policymakers (Dept of Finance) and the financial regulator (Central Bank of Ireland). The training should include a focus on the business case for financial institutions to adopt a WLC approach. To support this awareness raising, case studies of leading financial institutions that have adopted a WLC approach should be developed, with a focus on the drivers for them to do so and the financial impact.

4.8.24 Carbon literacy training programmes should be developed and delivered for local authorities and regional authorities’ staff. These should cover WLC requirement, LCA, low carbon construction and renovation, as well as policy tools and procurement of low carbon products and circular use of buildings and materials.

4.8.25 Awareness level training on climate policies, WLC, low carbon solutions and the circular economy should also be provided to local Councillors.

4.9. Further Research

Recommendations

A carbon-neutral built environment is a multidimensional, challenging goal that constantly needs new research data. Long-term quality data analytics are vital in dynamically informing the decarbonisation of our built environment. Although this should not lead to “analysis paralysis”, further research is needed to decarbonise our built environment.

Most of the recommendations presented in this section are based on the CSG Innovation & Digital Adoption Sub Group.

4.9.1 Ireland has one of the highest rates of abandoned, unused and underused housing in the world. A Review of the existing stock is urgently needed to decide what is needed in the future and for whom.

4.9.2 The review should be complemented by research on the reusability potential for different building typologies, to include a review of the adaptive reuse of different existing building typologies (e.g., office to residential) and requirements to allow future reuse of new built, as well as a review of reuse potential of building elements in existing buildings and requirements to increase potential in new built projects.

4.9.3 Similarly, detailed research into the existing vacant building stock is needed. In particular, research on barriers for local authorities to complete the vacancy register, research on potential for national database of vacant buildings, and research on potential of vacant buildings to be used for the NDP housing targets and benefits in terms of carbon savings.

4.9.4 Research to identify the optimal relationship between design, density, building height, land use and infrastructure to minimise WLC emissions.

4.9.5 Ireland’s National Retrofit Scheme does not currently consider the embodied carbon impact of retrofit. Further research on the WLC impact of deep and shallow retrofits on different building typologies in an Irish context is needed. This should inform research into opportunities to standardise retrofit of Ireland’s existing building stock, including the potential for off-site manufacturing of certain elements, the potential to standardise heat pumps, and the potential to use economy of scale to make retrofit cheaper.

4.9.6 A full scale study of the suitability, affordability and efficiency of heat pumps, district heating and solar PVs for different building typologies is also needed, taking a WLC approach. This could support the development of Guidance on when heat pumps are most appropriate.

4.9.7 Additional research is required on best practice guidance to developing digital twins for existing buildings.

4.9.8 Building data optimisation to minimise server requirements and reduce the digital carbon footprint of the future built environment utilising BIM, digital twins, and

smart or AI building controls should be investigated.

4.9.9 Likewise, a full scope research to scale up MMC in Ireland should be funded. The research should look at the LCA of traditional vs Off-site to create baseline database and demonstrate benefits of MMC. Off-site opportunities for retrofit should also be analysed, and pilot projects showcasing alternatives and benefits should be funded. These could be run by the Construction Technology Centre.

4.9.10 Further research is needed to address the performance gap, understand the impact of unregulated loads and how they could be reduced, as well as the impact of user behaviour on operational energy use.

More specifically, research is needed on how occupant behaviour and how building technologies can be optimised and synchronised for most efficient building energy use. I.e., alerts from BMS targeting key behavioural patterns affecting energy use.

4.9.11 To support the decarbonisation of the built environment, industry, valuers, and researchers must build evidence to demonstrate the business case for addressing operational emissions and embodied carbon. For instance, the correlation between WLC and building valuations, rental premiums, probability of default, stranded assets, and other climate-related financial risks must be further research.

4.9.12 Finally, research on decarbonising existing local material manufacturing and development of novel, local sustainable materials is needed. This should include research to understand and overcome potential barriers for low-carbon materials and research on how to accelerate the decarbonisation of cement.

5. Have your say

The IGBC would like to hear your feedback on this document and the proposed recommendations.

The public consultation period for submitting your feedback is open for two months from the 7th of May until the 7th of July 2022.

After this date we will analyse the results of the public consultation and integrate relevant feedback into the final roadmap document due for publication in September 2022.

If you wish to make a submission, please contact info@igbc.ie.

The IGBC would like to get your feedback on the following questions:

1. Do you agree in general with the roadmap?
2. What would it take for you to approve this roadmap?
3. Are there any specific recommendations that you disagree with? Or any key recommendations that are missing?
4. Do you believe that the proposed timelines are feasible?
5. Do you believe that the proposed recommendations and timelines will be sufficient to meet Ireland's decarbonisation targets?
6. What would you see as the major barriers to achieving our targets?
7. What would you see as the main drivers towards achieving our targets?
8. Do you have any comments on the modelling underlying assumptions? Read more about these in the companion report on the carbon modelling undertaken by UCD
9. Do you agree with the proposed definitions (3.1)?
10. Do you have anything else you would like to add?

List of Acronyms

ACA: Accelerated Capital Allowance

ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers

BAMB: Buildings As Material Banks

BER: Building Energy Rating

BIACE UCD: Building in a climate emergency research group, School of architecture, University College Dublin

BIM: Building Information Modelling

BMS: Building Management Systems

BREEAM: Building Research Establishment's Environmental Assessment Method

BRP: Building Renovation Passport

BoQ: Bill of Quantities

C&D: Construction and demolition

CAP: Climate Action Plan

CCAC: Climate Change Advisory Council

CIBSE: Chartered Institution of Building Services Engineers

CIRI: Construction Industry Register of Ireland

CLT: Cross-laminated Timber

CO2e: Carbon Dioxide equivalent

CRREM: Carbon Risk Real Estate Monitor tool

CSRD: Corporate Sustainability Reporting Directive

CWMF: Capital Works Management Framework

DEC: Display Energy Certificate

DECC: Department of the Environment, Climate, and Communications

DPER: Department of Public Expenditure and Reform

EED: Energy Efficiency Directive

EN: European Norm (European Standards)[2]

EPA: Environmental Protection Agency of Ireland

EPD: Environmental Product Declaration

EPBD: Energy Performance of Buildings Directive

ETBs: Educational Training Boards

ETS: Emissions Trading System[3]

GBC: Green Building Council

GDP: Gross Domestic Product

GGBS: Ground Granulated Blast-furnace Slag

GHG: Greenhouse Gases

GPP: Green Public Procurement

GWP: Global Warming Potential

HPI: Home Performance Index

IGBC: Irish Green Building Council

IPCC: Intergovernmental Panel on Climate Change

LCA: Life Cycle Assessment/Analysis

LCC: Life Cycle Costing

LEED: Leadership in Energy and Environmental Design

LETI: London Energy Transformation Initiative

MMC: Modern Methods of Construction

NABERS: National Australian Built Environment System[4]

NDP: National Development Plan

NESC: National Economic and Social Council

NZEB: Nearly Zero Energy Building

OGP: Office of Government Procurement

OPW: Office of Public Works

POE: Post Occupancy Evaluation

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

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

[4] More information on NABERS available here: https://www.nabers.gov.au/

RIAI: Royal Institute of Architects of Ireland

RIBA: Royal Institute of British Architects

SFDR: Sustainable Financial Disclosures Regulation

SME: Small and Medium Enterprise

STEM: Science, Technology, Engineering and Maths

TCFD: Task Force on Climate-related Financial Disclosures

TGD: Technical Guidance Document

WGBC: Word Green Building Council

WLC: Whole Life Carbon

Glossary of Terms

Absolute zero carbon: Eliminating all carbon emissions without the use of offsets [63].

Additionality: Additionality is the procurement of renewable energy for a building's use which results in new installed renewable energy capacity that would not have occurred otherwise. The principles of additionality apply when an organisation / consumer self-generates renewable energy from their own facilities or closes an electricity purchasing contract that contributes to the construction of new renewable energy facilities. Projects that comply with the principle of additionality result in real and verifiable emission reduction or emission avoidance for the organisation / consumer, as their direct effect is to increase renewable energy generation [64].

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 reuse 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 [27].

Built Environment: ranges from the scale of the individual building to neighbourhoods, communities, and cities with their associated infrastructure [65]. 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.

Carbon neutral: All carbon emissions are balanced with offsets based on carbon removals or avoided emissions [63].

Carbon neutral operation: The annual balance of emissions emitted by building operation and emissions avoided by generation of CO_2-free energy exported off site is zero or less than zero [66].

Carbon offsets: Emission reductions or removals achieved by one entity can be used to compensate (offset) emissions from another entity [64].

Carbon offset credit: A transferable instrument certified by government or independent certification bodies to represent an emission reduction of one metric tonne of CO2 or CO2e [64].

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 [67].

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 [68].

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" [3].

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 [69].

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. [27].

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 [70].

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 [27].

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) [63]. Their GWP is quantified in units of carbon dioxide equivalent. A kilogram of carbon dioxide therefore has a GWP of 1 kgCO2eq [27].

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.

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 [27].

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)) [71].

Major renovation: is renovation of a building where more than 25% of the surface of the building envelope undergoes renovation [72].

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 [3].

Net Zero carbon: All carbon emissions are reduced in line with the Paris Agreement 1.5°C trajectory, with residual emissions offset through carbon removals or avoided emissions [63].

Net Zero carbon building: A Net Zero carbon building is highly energy efficient with all remaining energy from onsite and/or offsite renewable sources [27].

Net Zero carbon – operational energy: A 'Net Zero Carbon – Operational Energy' asset is one where no fossil fuels are used, all energy use (Module B6) has been minimised, meets the local energy use target (e.g. kWh/m^2/a) and all energy use is generated on- or off- site using renewables that demonstrate additionality. Any residual direct or indirect emissions from energy generation and distribution are 'offset' [63].

Net Zero carbon – operational water: A 'Net Zero Carbon - Operational Water' asset is one where water use (Module B7) is minimized, meets local water targets (e.g., litres/person/year) and where those GHG emissions arising from water supply and wastewater treatment are 'offset' [63].

NZEB: Nearly Zero Energy Building (NZEB) is not a separate standard; it is a definition for the energy performance required, i.e., to comply with Part L a building must achieve or exceed NZEB performance.

Net Zero embodied carbon: A 'Net Zero Embodied Carbon' asset is one where the sum total of GHG emissions and removals over an asset's life cycle (Modules A1-A5, B1-B5 and C1-C4) are minimized, meets local carbon targets (e.g.kgCO2e/m2), and with additional 'offsets', equals zero [63].

Net Zero embodied carbon building (new or renovated) or infrastructure asset is highly resource efficient with upfront carbon minimised to the greatest extent possible and all remaining embodied carbon

reduced or, as a last resort, offset in order to achieve net zero across the lifecycle [27].

Net Zero in-use carbon: A 'Net Zero In-Use Carbon Asset' is one where on an annual basis the sum total of all asset related GHG emissions, both operational and embodied, (Modules B1-B7 (plus B8 and B9 for Infrastructure only)) are minimized, meets local carbon, energy and water targets, and with residual 'offsets', equals zero [63].

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 [73].

Net Zero upfront carbon: A 'Net Zero Upfront Carbon' asset is one where the sum total of GHG emissions, excluding 'carbon sequestration', from Modules A1-A5 is minimized, meets local carbon targets (e.g., kgCO2e/m2), and with additional 'offsets', equals zero [63].

Net Zero Whole Life Carbon: A 'Net Zero (Whole Life) Carbon' Asset is one where the sum total of all asset related GHG emissions, both operational and embodied, over an asset's life cycle (Modules A1-A5, B1-B7 (plus B8 and B9 for Infrastructure only), C1-C4) are minimized, meet local carbon, energy and water targets, and with residual 'offsets', equals zero [63].

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 [74].

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) [69].

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 [63].

Renewable Energy Guarantees of Origins (REGO): Each Renewable Energy Guarantees of Origins (REGO) certificate represent the 'energy attribute', i.e., the zero GHG emissions, associated with 1MWh of renewable energy generated [64].

Residual carbon/emissions: In the context of NZCB Framework Definition, the residual carbon relates to the remaining emissions once it has been reduced as far as possible in line with Steps 1 – 4 of the Framework Definition. These steps relate to reductions in Whole Life Carbon, improvements in energy efficiency and the procurement of renewable energy [64].

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 [75].

Whole Life Carbon (WLC): 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) [27].

Zero emissions building: Article 2, Proposed EPBD revision states that a 'zero-emission building' means a building with a very high energy performance, as determined in accordance with Annex I, where the very low amount of energy still required is fully covered by energy from renewable sources generated on-site, from a renewable energy community within the meaning of Directive (EU) 2018/2001 [amended RED] or from a district heating and cooling system, in accordance with the requirements set out in Annex III' [76]

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