Irish Green Building Council (IGBC)

Typical Building Materials, GWP Module Scenarios: Methodology Report

V1.1 (Draft for Consultation)

Date: October 2022

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1 Introduction

In 2021, the Irish Green Building Council (IGBC) commissioned a project to produce a generic dataset for the Global Warming Potential (GWP) impact indicator of common building materials in the Irish market. As a result, there is now generic data for the GWP indicator for cements, aggregates, steel, aluminium, brick, glass, gypsum products and Irish timber. IGBC now aims to add more materials and processes to the list, and broaden the dataset to include the A4, A5, B1, B4-5 and C1-4 modules based on the Environmental Product Declaration (EPD) Ireland specific Product Category Rules (PCRs) for EPDs in Ireland.

Circular Ecology has been commissioned to support IGBC in the further development of the above dataset in order to facilitate the creation of a single dataset for Life Cycle Assessments (LCAs) covering all key materials and processes for buildings in Ireland. This scope has been divided into two separate work packages:

Work Package 1 - Research the most commonly used building materials in the Irish Market, including the assessment and collation of all available GWP data to better inform embodied carbon calculations within product stages (A1-3).

Work Package 2 – Development of typical scenarios for embodied carbon data within transportation, construction, use and end-of-life stages (A4-5, B1, C1-4) to capture all significant impact stages and inform early design decisions.

This report is intended as an overview of the developed methodologies supporting the dataset issued for Work Package 2.

1.1 Goals & Objectives

The main objectives of the Work Package 2 assessment were to:

- Develop typical scenarios that capture all significant embodied carbon impact stages within the most used building materials in Ireland and inform early design decisions within the Irish building industry.
- Construct an overall picture of baseline embodied carbon models, by developing data on the GWP indicators for modules A4, A5, B1, B4-5 and C1-4.
- Be aware of the current developments in digitalisation and allow for the integration of these datasets using ILCD + EPD data format into the ecoPortal developed by ECO Platform.

The intended applications are to:

- Guide professionals on generic average impact data for common materials used in the Irish building industry for conducting LCAs at early design stages before any specific materials have been chosen.
- Guide professionals on generic average impact data for common processes (transport, construction etc.) with reference to the EPD Ireland reference PCR.
- Allow for more consistent building LCA results at early design stages by consistently using the same generic input data.

- Establish baseline models to inform national guidance for use in public procurement and as a basis for future regulations.
- Create a set of conservative default generic data which could be used in national procurement and building regulations where there is an absence of more specific data.

1.2 Method

The dataset has been developed from the existing methodologies and guidelines presented within the EPD Ireland PCR guidance document (EPD Ireland, 2021). Where the EPD Ireland PCR guidance document did not contain sufficient information, or the information was not deemed to be the most appropriate for the development of the embodied carbon dataset, further literature research has been undertaken and referenced within the relevant sections of this report.

The embodied carbon dataset has been further developed following the principles of EN 15804:2013 (BSI, 2014), "Sustainability of construction works, Environmental product declarations, Core rules for the product category of construction products", and RICS "Whole life carbon assessment for the built environment" (RICS, 2017) for cradle-to-grave (Modules A-C).

In any instance where wider resources have been utilised, or further assumptions have been made, have been highlighted and justified within the relevant module methodology statements outlined within this report.

2 Scope of Study

2.1 Modules Covered

This assessment provides the supporting methodologies used to evaluate the potential environmental impacts of the listed materials across the following modules according to EN 15804:

- Modules A1-3 – product, raw material, transport & manufacturing (cradle-to-gate)
- Module A4 – transport
- Module A5 – construction, installation & waste
- Module B1 – use
- Modules B4-5 – replacement & refurbishment
- Modules C1-4 – end-of-life stage -
    - C1, deconstruction, demolition
    - C2, transport to waste processing
    - C3, waste processing for reuse, recovery and/or recycling
    - C4, disposal

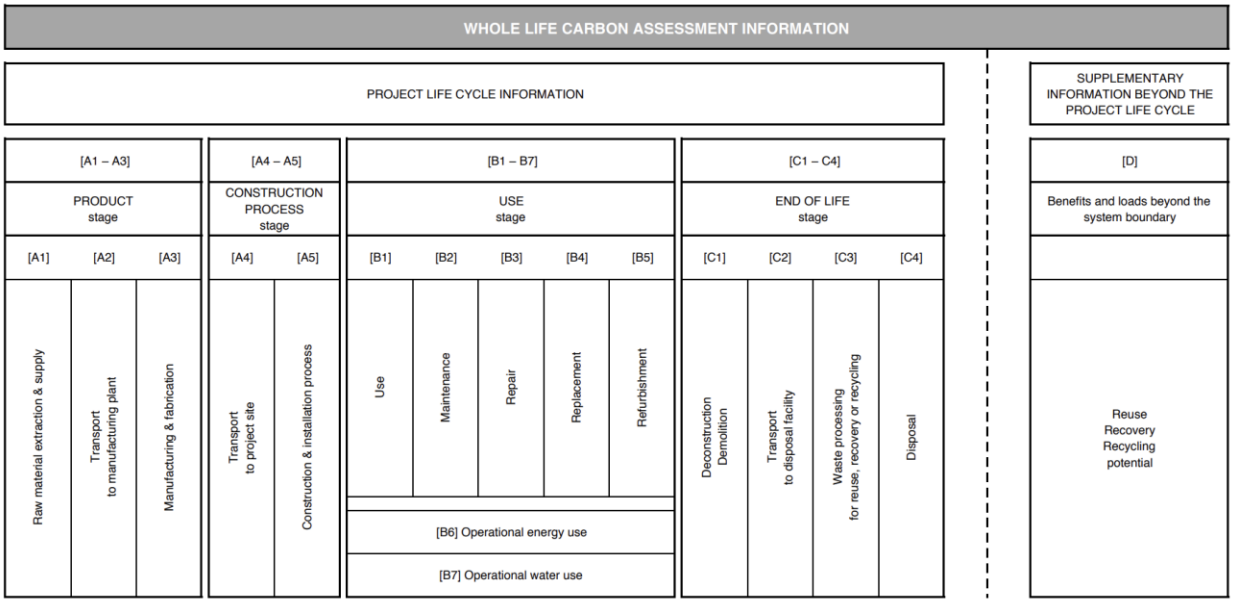

Figure 1: Lifecycle boundary modules (RICS, 2017)

The following modules are deemed out of scope of this assessment:

- Module B2 – Maintenance
- Module B3 – Repair
- Modules B6-7 – Operational Energy & Water Use
- Module D - Benefits and loads beyond the system boundary

2.2 Materials & Functional Units

The below table shows the materials that have been modelled along with their allocated Functional Unit (FU):

Table 1: List of modelled building materials, functional units, and FU characteristics

Material	Functional Unit (FU)	Reference Weight / FU (kg)	Biogenic Carbon Reported
Average Cement for Ireland	tonne	1,000	No
CEM I produced in Ireland	tonne	1,000	No
CEM II/A-V (<20% PFA)	tonne	1,000	No
CEM II/A-L (<20% Limestone)	tonne	1,000	No
CEM II/A-S (<20% GGBS)	tonne	1,000	No
CEM II A-D (<10% silica fume)	tonne	1,000	No
CEM II/B-S (<35% GGBS)	tonne	1,000	No
Average CEM II	tonne	1,000	No
CEM III/A (35-60% GGBS)	tonne	1,000	No
CEM III/B (66-80% GGBS)	tonne	1,000	No
Average Aggregate for Ireland	tonne	1,000	No
Average hot rolled steel coil used in Ireland	tonne	1,000	No
Average cold rolled coil used in Ireland	tonne	1,000	No
Average galvanised steel value used in Ireland	tonne	1,000	No
Average organic coated steel used in Ireland	tonne	1,000	No
Average steel section and steel rail value for Ireland	tonne	1,000	No
Average reinforcing steel used in Ireland	tonne	1,000	No
Average aluminium sheet used in Ireland	tonne	1,000	No
Average aluminium foil used in Ireland	tonne	1,000	No
Average aluminium extrusion used in Ireland	tonne	1,000	No
Average float or coated glass used in Ireland	tonne	1,000	No
Average facing brick imported from the UK (excl. transport)	tonne	1,000	No
Average Irish produced C16 timber	m^3	462	Yes
Average imported C16 timber (Swedish EPD)	m^3	455	Yes
Irish produced OSB	See Smartply EPD		Yes
Irish produced MDF	See Medite EPD		Yes
Imported MDF (737 kg per m3)	m^3	737	Yes
Average imported Chipboard Particleboard (640 kg per m3)	m^3	640	Yes
Average imported plywood	m^3	491	Yes
Expanded Polystyrene (EPS) Insulation	m^3	22.3	No
Polyisocyanurate (PIR) Insulation	m^3	30.4	No

Cellulose Insulation	m^3	40.0	Yes
Mineral wool Insulation	m^3	32.6	No
Sheepswool Insulation	m^3	10.5	Yes
Woodfibre Insulation	m^3	108	Yes
Hemp fibre Insulation	m^3	35.0	Yes
Concrete blocks	m^3	1,425	No
Hempcrete block	m^3	370	Yes
Straw	m^3	120	Yes
Concrete roof tiles	m^2	41.9	No
Hollowcore slabs	m^3	1,362	No
Slate	m^3	2,800	No
Stone	m^3	2,649	No
PVC (Double Glazed)	m^2	27.1	No
PVC (Triple Glazed)	m^2	33.6	No
Timber (Double Glazed)	m^2	38.0	Yes
Timber (Triple Glazed)	m^2	37.3	Yes
Aluminium (Double Glazed)	m^2	25.8	No
Aluminium (Triple Glazed)	m^2	31.0	No
Timber Alu (Double Glazed)	m^2	39.0	Yes
Timber Alu (Triple Glazed)	m^2	40.4	Yes
Cement fibre board	m^2	16.6	No
Plasterboard (gypsum)	m^2	9.5	No
Metal stud wall	m^2	2.6	No
Timber stud wall	m^2	8.6	Yes
Suspended ceiling (metal)	m^2	10.7	No
Suspended ceiling (other/timber)	m^2	19.0	Yes
Vinyl flooring	m^2	3.9	No
Ceramic tiles	m^2	19.1	No
Cork flooring	m^2	2.0	Yes
Permeable paving	m^3	2,350	No
Zinc sheeting	m^2	6.8	No
Recycled Copper sheeting	m^2	8.9	No
PVC Rainwater goods	kg	1.0	No
Damp proof membrane (DPM)	m^2	0.9	No
Vapour permeable sheet	m^2	0.2	No

Where biogenic carbon has been listed as reported for a material, this has been considered throughout the modelling of all modules outlined in the report.

2.3 System Boundary

2.3.1 Time Coverage

The methodologies outlined have been developed using the most recently published available datasets wherever possible, and it has been an objective that reference data should ideally be no more than five years old at the time of this report.

2.3.2 Technological Coverage

This study is intended to represent typical embodied carbon impacts for building materials to be used within the Irish building industry, and the datasets have been developed to typically cover average case technology scenarios where data is available or unless otherwise stated.

2.3.3 Geographical Coverage

This study is intended to represent embodied carbon impacts relevant to building construction in Ireland and so preference has been given to data which is representative of Ireland. However, the methodologies presented have considered datasets that reflect wider European or other universally recognised methodologies. It is also recognised that the listed building materials are manufactured both within Ireland and outside of Ireland (wider European, and North America) with appropriate assumptions made to cover any differences faced from the assumed material country of origin.

2.4 Exclusions and Cut-off Criteria

When modelling a carbon footprint, it is typical to exclude items considered to have a negligible contribution to results. To do this in a robust manner there must be confidence that the exclusion is fair and reasonable. Cut-off criteria are defined to achieve this, which allows items to be neglected if they meet the criteria. In this study exclusions could be made if they were expected to contribute a negligible impact on the overall embodied carbon model.

In this instance category B1 – Material Use has been excluded from the study as negligible following the recommendations from the Institution of Structural Engineers (IStructE) Guide on “How to calculate embodied carbon” (IStructE, 2020) - see section 3.4.

2.5 Selection of Impact Categories

The assessment covers carbon footprint (Global Warming Potential) indicators only.

3 Impact Methodologies of GWP Modules

3.1 Module A1-3 – Cradle-to-Gate

The GWP values for modules A1-3 have been developed for the listed building materials under a separate reporting scope. An initial assessment conducted by Cambridge Architectural Research (CAR) in 2021 produced A1-3 GWP values for a selection of the most widely used building materials in Ireland. Circular Ecology has since developed a complementary dataset of A1-3 GWP values for a wider selection of commonly used building materials.

The below table shows the A1-3 GWP, fossil values for the listed building materials, along with any reported carbon sequestration, and the source of the data included.

Table 2: Listed Building Materials' GWP values per FU

Building Material	Functional Unit (FU)	GWP, Foss. (kgCO2e / FU)	GWP, Seq. (kgCO2e / FU)
CAR A1-3 Dataset			
Average Cement for Ireland	tonne	*712*	-
CEM I produced in Ireland	tonne	*863*	-
CEM II/A-V (<20% PFA)	tonne	*728*	-
CEM II/A-L (<20% Limestone)	tonne	*696*	-
CEM II/A-S (<20% GGBS)	tonne	*724*	-
CEM II A-D (<10% silica fume)	tonne	*896*	-
CEM II/B-S (<35% GGBS)	tonne	*617*	-
Average CEM II	tonne	*674*	-
CEM III/A (35-60% GGBS)	tonne	*512*	-
CEM III/B (66-80% GGBS)	tonne	*371*	-
Average Aggregate for Ireland	tonne	*5*	-
Average hot rolled steel coil used in Ireland	tonne	*2,140*	-
Average cold rolled coil used in Ireland	tonne	*2,630*	-
Average galvanised steel value used in Ireland	tonne	*2,800*	-
Average organic coated steel used in Ireland	tonne	*2,830*	-
Average steel section and steel rail value for Ireland	tonne	*1,490*	-
Average reinforcing steel used in Ireland	tonne	*737*	-
Average aluminium sheet used in Ireland	tonne	*2,751*	-
average aluminium foil used in Ireland	tonne	*6,780*	-
Average aluminium extrusion used in Ireland	tonne	*4,855*	-
Average float or coated glass used in Ireland	tonne	*1,323*	-
Average facing brick imported from the UK (excl. transport)	tonne	*213*	-

Average Irish produced C16 timber	m^3	*104*	*-736*
Average imported C16 timber (Swedish EPD)	m^3	*29*	*-715*
Irish produced OSB	See Smartply EPD		
Irish produced MDF	See Medite EPD		
Imported MDF (737 kg per m^3)	m^3	*221*	*-803*
Average imported Chipboard Particleboard (640 kg per m^3)	m^3	*346*	*-962*
Average imported plywood	m^3	*137*	*-818*
Circular Ecology – Work Package 1, A1-3 Dataset			
Expanded Polystyrene (EPS) Insulation	m^3	106	-
Polyisocyanurate (PIR) Insulation	m^3	114	-
Cellulose Insulation	m^3	7.6	-53.5
Mineral wool Insulation	m^3	42.8	-
Sheepswool Insulation	m^3	13.4	-12.8
Woodfibre Insulation	m^3	90.9	-151
Hemp fibre insulation	m^3	21.8	-44.0
Concrete blocks	m^3	130	-
Hempcrete block	m^3	108	-172
Straw	m^3	72.2	-175
Concrete roof tiles	m^2	11.2	-
Hollowcore slabs	m^3	298	-
Slate	m^3	549	-
Stone	m^3	838	-
PVC (Double Glazed)	m^2	87.1	-
PVC (Triple Glazed)	m^2	125	-
Timber (Double Glazed)	m^2	TBC	TBC
Timber (Triple Glazed)	m^2	TBC	TBC
Aluminium (Double Glazed)	m^2	108	-
Aluminium (Triple Glazed)	m^2	128	-
Timber Alu (Double Glazed)	m^2	TBC	TBC
Timber Alu (Triple Glazed)	m^2	TBC	TBC
Cement fibre board	m^2	12.9	-
Plasterboard (gypsum)	m^2	2.5	-
Metal stud wall	m^2	6.3	-
Timber stud wall	m^2	2.3	-14.1
Suspended ceiling (metal)	m^2	26.7	-
Suspended ceiling (other/timber)	m^2	9.3	-8.2
Vinyl flooring	m^2	7.0	-
Ceramic tiles	m^2	10.3	-
Cork flooring	m^2	0.5	-3.3

Permeable paving	m^3	279	-
Zinc sheeting	m^2	16.8	-
Recycled Copper sheeting	m^2	7.5	-
PVC Rainwater goods	kg	2.6	-
Damp proof membrane (DPM)	m^2	3.0	-
Vapour permeable sheet	m^2	0.5	-

Please refer to the results of *"Work Package 1 IGBC - A1-3 GWP Data - v1.1 Draft for Consultation.xlsx"* for more information on the development of carbon impacts for modules A1-3.

3.2 Module A4 - Transport

Transport from the site of manufacture to site of use (module A4) requires the development of carbon intensity data based on a GWP per tonne.km basis, and so needs to consider the following calculation and parameters for the listed materials being modelled:

$$GWP_{A4} = Weight \times Distance \times Transport\ EF$$

Where the parameters are:

- *GWP_{A4} – embodied carbon of A4 – transport ($kgCO_2e$) per functional unit*
- *Weight – material weight (tonne) per reported functional unit*
- *Distance – distance travelled (km) between site of material manufacture and site of use*
- *Transport EF – relevant mode of transportation (e.g., road, sea freight) carbon emission factor ($kgCO_2e$ per tonne.km)*

The carbon impact associated with module A4 - transport has been modelled based on the functional unit weights (kg) shown in table 1.

Regarding the assumed distance travelled, the EPD Ireland PCR guidance document includes the following reference distances (one way) for materials manufactured in Ireland:

- Bulk materials: 100km
- Other materials, products, and elements: 200km

There are no defined distances stated within the EPD Ireland PCR guidance document for materials that are imported into Ireland. It is also challenging to define specific distances for each of the listed materials, as there are multiple material producers, and they are not typically manufactured and distributed from a single location. As a result, assumptions have been developed based on the expected transportation of goods from a generic global market via both road freight (manufacturer to nearest port, and from Irish port to site-of-use in Ireland (assumed 200km), and Sea freight (assumed Calais to Dublin (assumed 1,000km).

The table below shows an overview of the assumed distances travelled based on material type and origin of manufacturer:

Table 3: Assumed material transportation distance from manufacturer to site of use

Materials	Road distance, one-way (km)	Sea distance, one-way (km)
Bulk Material (Irish)	100	-
Other Materials (Irish)	200	-
Materials (Non-Irish)	200	1,000

The relevant transportation carbon emission factors have been taken from the IStructE guidance as are stated as follows:

Table 4: Emission factors for relevant modes of transportation

Mode of transportation	Transport (kgCO2e / tonne.km)	Source reference
Road	0.1065	HGV (all diesel) average laden, (IStructE, 2020)
Sea	0.0161	Average cargo/container ship, (IStructE, 2020)

The transport emission factors given by IStructE reference the UK Defra GHG conversion factors dataset (DEFRA, 2022), which is updated annually. Travelled distances are modelled as "one way" and the applied average laden emission factors account for an average laden vehicle balancing out any return leg journey.

3.3 Module A5 – Construction, Installation & Waste

3.3.1 Waste

The modelling of carbon impacts from waste in module A5 requires the development of a suitable dataset of typical waste rates (%) for the listed building materials. The defined waste rates can then be applied to the GWP (A1-3) values shown in table 2 of this report in order to establish the carbon impacts of waste from the use of a functional unit of each listed material:

$$GWP_{A5,waste} = \left(GWP_{(A1-3)} + GWP_{(A4)} + GWP_{(C2-4)}\right) \times Waste\ Factor$$

Where the parameters are:

- *$GWP_{A5,\ waste}$ – embodied carbon of A5 – waste ($kgCO_2e$) per functional unit*
- *$GWP_{(A1-3)}$ – cradle-to-gate embodied carbon of the listed building material ($kgCO_2e$ per FU)*
- *$GWP_{(A4)}$ – transport embodied carbon of the listed building material from manufacturer to site of use ($kgCO_2e$ per FU)*
- *$GWP_{(C2-4)}$ – end-of-life embodied carbon of the listed building material, including transportation from site ($kgCO_2e$ per FU)*
- *Waste Factor = (1 / (1 - Waste Rate%)) -1*
    - *Waste Rate (%) – the amount of the stated building material functional unit that is assumed to be wasted during the building construction / installation stage*

There are waste rates defined within the EPD Ireland PCR guidance document that cover the following building material categories:

- Pre-assembled products waste rate – 1%
- Prefabricated products waste rate – 5%
- In-Situ products waste rate – 8%
- Ancillary & finishing materials waste rate – 15%

Due to the broad nature of the above categorisations, it has been proposed to utilise a more robust dataset for waste rates in order to allocate more specific values to the listed building materials. The following established dataset has been considered for this purpose:

- WRAP – Net Waste Tool (WRAP, 2008)

The dataset with the WRAP Net Waste Tool contains both baseline and good practice waste rates for building materials. IStructE also publish a comparable table of waste rates based only on the baseline practice assumption waste rates as shown within the WRAP Net Waste Tool.

Table 5: Building Material Waste Rates

Building Material	Baseline Waste Rate (%)	Good Waste Rate (%)	Av. Waste Rate (%)	Data Source
Aggregates	-	-	0.50%	Custom
Aluminium Frames	1.00%	0.00%	0.50%	WRAP
Boarding	22.50%	5.00%	13.75%	WRAP
Bricks and Blocks	20.00%	10.00%	15.00%	WRAP
Doors, Windows, Glazing	-	-	1.00%	IStructE
Glass	5.00%	2.50%	3.75%	WRAP
Gypsum Products	5.00%	2.50%	3.75%	WRAP
In-Situ Concrete	5.00%	2.50%	3.75%	WRAP
Insulation	15.00%	5.00%	10.00%	WRAP
Non-Ferrous Metal	5.00%	2.50%	3.75%	WRAP
Plastic	5.00%	2.00%	3.50%	WRAP
Precast Concrete	1.00%	0.00%	0.50%	WRAP
Processed Timber	10.00%	5.00%	7.50%	WRAP
Steel Beam	1.00%	0.00%	0.50%	WRAP
Steel Braces	1.00%	0.00%	0.50%	WRAP
Steel Column	1.00%	1.00%	1.00%	WRAP
Steel Reinforcement	-	-	5.00%	IStructE
Stone	10.00%	5.00%	7.50%	WRAP

Structural Waterproofing	15.00%	5.00%	10.00%	WRAP
Structural and Roofing Frames	1.00%	0.00%	0.50%	WRAP
Tiled Soft Flooring	5.00%	2.00%	3.50%	WRAP
Tiles and Ceramics	8.00%	5.00%	6.50%	WRAP
Timber Frames	1.00%	0.00%	0.50%	WRAP
Wall and Floor Units	1.00%	0.00%	0.50%	WRAP

The average waste rates from the table above have been used when modelling the waste factor and calculating the embodied carbon associated with module A5 waste.

When considering aggregates, it is suggested to adopt a custom waste rate of 0.5% as it has been deemed that the WRAP stated figures of 10% baseline and 5% good rates are too high based on previous experience of the use of aggregates within a building project.

3.3.2 Construction & Installation

The modelling of embodied carbon impacts from building construction and installation activities at material level is challenging due to the lack of primary site activity data.

At building early-design stage, in the absence of any primary site activity data, RICS guidance recommends the use of an assumed rate of 1,400 kgCO2e per £100,000 construction cost for the whole building to cover emissions from site construction and installation activities.

However, a cost-based metric is not deemed to be the most appropriate solution for the IGBC, due to currency exchange rate volatility and significant expected cost increases across the construction industry.

In order to try and establish suitable values for construction and installation embodied carbon, further extraction of A5 construction/installation data has been undertaken from collected EPDs used to develop GWP A1-3 figures for Work Package 1.

Unfortunately, the data extracted from EPDs provided an inconsistent and unreliable view of A5 - Installation impacts, often with the impacts of A5 - Waste included within the overall figures with no ability to separate these out. As such it was not deemed possible to generate a reliable dataset for A5 – Installation based on actual data and so this impact has been stated as zero within the final provided dataset.

To assist with future development of this module's impact, Appendix B provides an overview of the extracted EPD data, including a range of GWP values (kgCO2e per kg) across different building material categories and a calculated average of each category, along with notes as to how accurate or reliable the data would be for use within A5 Construction & Installation. It should be noted not all EPDs disclosed information on A5 – Installation embodied carbon and so the reported values represent an average only of those EPDs which included A5 within its assessments.

Should it be possible to attain accurate and reliable figures for installation average GWP per kg values for each building material category in the future, the estimated embodied carbon impacts per functional unit could be established through the following formula:

$$GWP_{A5\ construction} = Weight \times Av.Building\ material\ factor$$

Where the parameters are:

- *$GWP_{A5\ construction}$ – embodied carbon of A5 – construction and installation activities ($kgCO_2e$) per functional unit*
- *Weight – material weight (kg) per reported functional unit*
- *Av. Building material factor – average GWP per kg of building material category construction and installation embodied carbon emissions taken from collected EPDs that have disclosed this information.*

3.4 Module B1 – Material Use

Referring to module B1 – Material Use, it has been deemed that the embodied carbon impacts can be excluded from the study as negligible following the recommendations from the IStructE Guide on "How to calculate embodied carbon" (IStructE, 2020) which states:

> *"Regarding structure, Module B1 (use) emissions are generally insignificant for structural materials.*
>
> *Concrete surfaces exposed to the atmosphere absorb CO2 during a built asset's life cycle through the carbonation process. This is estimated to account for up to 2.5% reabsorption of the CO2e emitted in the Product Stage (Modules A1–A3).*
>
> *Most concrete manufacturers include an allowance for this in their EPDs. If using manufacturers' EPDs to quantify carbonation, check the assumptions contained within the EPD to ensure they match the conditions of your project, e.g., check the study period and atmospheric exposure assumed."*

3.5 Module B4-5 – Replacement & Refurbishment

Modelling the embodied carbon of B4 – replacement relies on an understanding of the lifespan of the building and the materials used in its construction.

On discussion with IGBC, it has been agreed to use the European Union Level(s) indicator 1.2 user manual (Dodd, et al., 2021) to support the reference values within this module. The Level(s) guidance provides a list of expected lifespan values for typical building material categories based on the dataset outlined in RICS. The default Reference Study Period (RSP) mentioned by Level(s) to be used for building projects is 50 years (Dodd, et al., 2021).

For comparison, the Reference Study Period (RSP) stated by IStructE is 60 years (IStructE, 2020).

It is recommended by RICs that replacement emissions should be included from the following building element groups: Roofs, External Walls, Windows and External Doors, Finishes, Fittings Furnishings and Equipment, and Services (MEP). For all other main structural and substructural elements, the expected lifespan should be equal to that of the building, i.e., 50 years.

Table 6: Estimated building material / product lifespans (Dodd, et al., 2021)

Building Part	Building Elements / Component	Lifespan (years)
Structural	Load Bearing Structural Frame (frame, upper floors, external walls, balconies)	60
Superstructure	Non-load Bearing Elements (ground floor slab, internal walls, partition & doors)	30
Facade	External wall systems, cladding and shading devices	30
	Glazed external wall systems, cladding and shading devices	35
	Façade openings (including windows and external doors)	30
Roof	Roof (structure, weatherproofing)	30
Fittings & furnishings	Floor finishes, coverings	30
	Floor coatings	10
	Wall and ceiling finishes	20
	Wall and ceiling coatings	10
Landscaping	Paving and other hard surfacing	25
	Drainage Systems	30

It should be assumed that any materials in the above table should be modelled as 100% full replacements on a like for like basis as the original installed element. and should also include any sequestered carbon in both product (A1-3) and end-of-life (C1-4) stages.

Using the above references for material replacement cycles over a 50-year building lifespan, the below calculation can be used to establish the embodied carbon associated with any replacement of a functional unit of each listed material:

$$GWP_{B4} = \left(GWP_{(A1-3)} + GWP_{(A4)} + GWP_{(A5waste)} + GWP_{(C2-4)}\right) \times Replacement\ Factor$$

Where the parameters are:

- *GWP_{B4} – embodied carbon of B4 –replacement ($kgCO_2e$) per functional unit*
- *$GWP_{(A1-3)}$ – cradle-to-gate embodied carbon of the listed building material ($kgCO_2e$ per FU)*
- *$GWP_{(A4)}$ – transport embodied carbon of the listed building material from manufacturer to site of use ($kgCO_2e$ per FU)*
- *$GWP_{A5,\ waste}$ – embodied carbon of material waste during construction / installation ($kgCO_2e$ per FU)*
- *$GWP_{(C2-4)}$ – end-of-life embodied carbon of the listed building material, including transportation from site ($kgCO_2e$ per FU)*
- *Replacement Factor - number of expected replacement cycles of a building material within the lifespan of the building*

The replacement factor should be calculated using the estimated building lifespan (50 years) and the expected material lifespans in table 6 using the following formula:

$$Replacement\ Factor = \frac{Building\ Lifespan}{Material\ Lifespan} - 1$$

The above calculated replacement factor should be rounded up to the next full integer value if required.

In contrast, module B5 - refurbishment is defined as planned alteration or improvement works to enable the asset to cater for a desired future function identified and quantified at the outset of the building project. This generally means a change in the use of the building. As this would not typically be considered during early-design stage, this aspect is not included in the above values for this module.

3.6 Modules C1-4 – End-of-life

The embodied carbon associated with end-of-life is typically split in four sections (modules C1-4), which have subsequently been combined as much as possible into an overall value for the full end-of-life process for each listed building material, apart from C1 – Deconstruction, which has been modelled at building level due to a lack of other available data at material level.

3.6.1 C1 – Deconstruction

There is a lack of data available currently to illustrate the embodied carbon associated with building material / product deconstruction at material level during the early-design stage. This primary data would typically be provided by the contractor at a later stage. As such, it is recommended by RICS to model these emissions at building level at an average rate of 3.4 $kgCO_2e$ per m^2 GIA (Gross Internal Area). This value represents the rate from monitored demolition case studies in central London.

3.6.2 C2 – Transport to end-of-life

Transport of waste materials from the site of use to site of end-of-life treatment is modelled in the same way as the embodied carbon for module A4, using the following calculation and parameters for the listed materials being modelled:

$$GWP_{C2} = Weight \times Distance \times Transport\ EF$$

Where the parameters are:

- *GWP_{C2} – embodied carbon of C2 – end-of-life transport ($kgCO_2e$) per functional unit*
- *Weight – material weight (tonne) per reported functional unit*
- *Distance – distance travelled (km) between site of material use and end-of-life treatment*
- *Transport EF – relevant mode of transportation (e.g., road) carbon emission factor ($kgCO_2e$ per tonne.km)*

The table below shows an overview of the assumed distances travelled based on material type and end-of-life treatment scenarios:

Table 7: Assumed material transportation distance from site of use to end-of-life treatment

End-of-life Scenario	Distance – One-way (km)	Source reference
Waste materials to landfill	50	(EPD Ireland, 2021)
Waste materials to energy plant	250	(EPD Ireland, 2021)

Waste materials for recycling	50	(IStructE, 2020)
Waste materials for backfilling	0	(IStructE, 2020)

The actual distance used for each building material will be calculated as an average across the specific percentages of each end-of-life scenario for the material as shown in section 3.6.3 (C3-4 – Waste Processing and Disposal Scenarios).

The relevant transportation carbon emission factors have been taken from the IStructE guidance as are stated as follows:

Table 8: Emission factors for relevant modes of transportation for end-of-life

Mode of transportation	Transport (kgCO2e / tonne.km)	Source reference
Road	0.1065	HGV (all diesel) average laden, (IStructE, 2020)

The transport emission factors given by IStructE reference the UK Defra GHG conversion factors dataset (DEFRA, 2022), which is updated annually. Travelled distances are modelled as "one way" and the applied average laden emission factors account for an average laden vehicle balancing out any return leg journey.

3.6.3 C3-4 – Waste Processing and Disposal Scenarios

For the purpose of calculating the embodied carbon associated end-of-life waste processing and disposal scenarios, modules C3 and C4 have been grouped together.

Considering this, the below calculation can be used to establish the embodied carbon associated with the end-of-life processing and disposal scenarios of a functional unit of each listed material:

$$GWP_{C3-4} = \sum Weight \times (EoL\ Scenario_i \times Waste\ Management\ EF_i)$$

Where the parameters are:

- *GWP_{C3-4} – embodied carbon of C3-4 – Waste Processing and Disposal Scenarios ($kgCO_2e$) per functional unit*
- *Weight – material weight (kg) per reported functional unit*
- *EoL $Scenario_i$ – percentage of the material functional unit allocated to the stated end-of-life treatment scenario – recycling, energy recovery, disposal/landfill, backfilling*
- *Waste Management EF_i – embodied carbon emission factor ($kgCO_2e$) per functional unit for the stated end-of-life treatment scenario – recycling, energy recovery, disposal/landfill, backfilling*

The EPD Ireland PCR guidance document contains a table of default percentage values for construction and demolition waste scenarios, taken from the EPA Ireland Material Waste Statistics Report (2017). It was deemed appropriate to review this dataset and update the table to align to the latest figures reported by EPA Ireland, from the 2018 Material Waste Statistics Report, as shown in table 9 below.

Table 9: Percentage split of end-of-life treatment scenarios by material category (EPA (Ireland), 2021)

Material Category	Recycling (off-site)	Energy Recovery	Disposal (Landfill)	Reused (Reuse on site)
Metal	100%	0%	0%	0%
Segregated wood, glass, plastic	38%	54%	0%	8%
Concrete, brick, tile & gypsum	45%	0%	0%	55%
Bituminous mixtures	65%	0%	0%	35%
Mixed C&D waste	13%	2%	25%	60%
Soils, stones & dredging spoil	0%	0%	13%	87%
Waste treatment residues	0%	5%	85%	10%

When referring to reuse or "backfilling" this should be on the assumption that the material is reused on site for structural or engineering purposes otherwise in the place of a non-waste material. Energy recovery refers to the incineration of materials withing a waste-to-energy plant.

In alignment with the percentage allocation of materials to the relevant end-of-life treatment scenarios, appropriate waste management emission factors have been compiled from the DEFRA 2021 GHG emission factor dataset and are shown in table 10 below.

Table 10: End-of-life scenario emission factors by material category (DEFRA, 2022)

Material Category	Recycling (off-site) EF ($kgCO_2e$ / tonne)	Energy Recovery ($kgCO_2e$ / tonne)	Disposal (Landfill) ($kgCO_2e$ / tonne)	Backfilling (Reuse on site) ($kgCO_2e$ / tonne)
Metal	0.985	-	1.264	0.000
Wood	21.280	21.280	828.014	0.000
Glass	21.280	21.280	8.883	0.000
Insulation (synthetic)	0.985	21.280*	1.234	0.000
Insulation (non-synthetic)	0.985	21.280*	1.234	0.000
Concrete	0.985	-	1.234	0.000
Bricks and tiles	0.985	-	1.234	0.000
Plasterboard	21.280	21.280*	71.950	0.000
Average construction	0.985	21.280	467.008*	0.000
Plastics	21.280	21.280	8.883	0.000
Aggregates	0.985	-	1.234	0.000

The materials allocated for backfilling are assumed to require no further processing from their on-site state post-deconstruction, and therefore backfilling emission factors are set as zero.

As no factors are publish for energy recovery of insulation and plasterboard, proxy values have been input based on average construction factors published by Defra. Similarly, as no figures are published for landfill impacts of average construction, a proxy value has been included based on the landfill impacts of commercial and industrial waste as published by Defra.

Within the figures for C3-4 Waste Processing and Disposal Scenarios, the re-release of any relevant sequestered carbon within the listed building materials must also be accounted for. As there are several materials listed which claim an element of carbon sequestration within its product stage (A1-3), the same sequestered carbon must be addressed within the material's end-of-life dependent on the allocated waste management scenarios for that material (i.e., proportion of the material sent for recycling, energy recovery, landfill or re-used for backfilling).

According to EN15804 guidelines, the amount of carbon re-released at end-of-life should be equal to the biogenic carbon reported within modules A1-3, regardless of disposal method (BSI, 2014). In this instance the dataset therefore includes the release of any biogenic carbon stated in A1-3 within the material's C3-4 values.

4 Results of Carbon Impacts for Modules

A summary of the results for the embodied carbon impacts across all relevant modules can be found in Appendix A of this report.

The full set of results of the developed typical embodied carbon scenarios for modules A4-5, B1, B4-5, and C1-4, along with extended calculation methodologies by module, can be found in the accompanying "IGBC - GWP Module Scenarios_v1.0 - Draft for Consultation.xlsx" which outlines the proposed GWP data per material in kgCO2e per FU.

The set of results provided contain supporting assumptions which utilise annually published datasets (EPA waste report, Defra GHG emissions factors), and as such this dataset should consider the update of these supporting factors as new data is published.

Other supporting assumptions included, for example default material transport modes, distances, and waste rates, are intended for use as a baseline where more accurate supplier / contractor data is available. Where more accurate data is available, this should supersede the assumption made within this dataset.

5 Summary

In summary, the dataset has been developed to act as a generic and typical view of GWP within building construction in Ireland for the listed building materials across modules A4-5, B1, B4-5, and C1-4. The dataset contains a suitable representation of GWP values to allow for the early design stage lifecycle assessment of embodied carbon within the Irish building industry, but has excluded both A5-construction and installation, and B1 – material use modules due to a lack of reliable and accurate data at this time, although a secondary cost-based measurement methodology for A5 installation impacts has been provided. It is recommended to further build upon the dataset, methodologies and assumption across all modules as further guidance is published in the future.

6 Limitations

This study has been produced by independent consultants at Circular Ecology. The study should be considered valid for a period of 5 years from the date on the front of this report.

Limitations of the study include:

- The scope, boundaries and reference period defined within this assessment (e.g., the included modules and the defined list of building materials stated within the study).
- The exclusions defined within this assessment (see section 2.4).
- The availability of publicly disclosed EPDs and their inclusion/declaration of GWP impacts for the modules being assessed.
- The simplification of re-released biogenic carbon to equal the biogenic carbon estimated as stored within A1-3 modules (refer to package 1 dataset – A1-3 values).
- The lack of availability of geographically (Ireland) specific data within the assumption for certain modules, leading to the use of more generic (European, Global) datasets in their absence.

The above limitations of use and limitations of the current study should be acknowledged, and the results applied accordingly and where appropriate.

7 References

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Appendix A – Embodied Carbon Dataset (Modules A-C)

				Module GWP data ($kgCO_2e$)								
Product		**Unit**	**Weight (kg)**	**A1 - A3**	**A4 - Transport**	**A5 - Waste**	**A5 - Construction (Installation)**	**B1 -**	**B4 - B5 Replacement**	**C1 - EoL Deconstruction (Per m2 GIA)**	**C2-C4 - EoL**	**Total A-C**
Average Cement for Ireland	1	tonne	1,000	712	10.65	28.27	Excluded based on lack of reliable data. See A5 - Construction for further information and background.	NA - Insignificant for Structural Materials	0.00	3.40	2.84	753.76
CEM I produced in Ireland	1	tonne	1,000	863	10.65	34.15			0.00		2.84	910.64
CEM II/A-V (<20% PFA)	1	tonne	1,000	728	10.65	28.89			0.00		2.84	770.38
CEM II/A-L (<20% Limestone)	1	tonne	1,000	696	10.65	27.64			0.00		2.84	737.13
CEM II/A-S (<20% GGBS)	1	tonne	1,000	724	10.65	28.73			0.00		2.84	766.22
CEM II A-D (<10% silica fume)	1	tonne	1,000	896	10.65	35.43			0.00		2.84	944.92
CEM II/B-S (<35% GGBS)	1	tonne	1,000	617	10.65	24.56			0.00		2.84	655.05
Average CEM II	1	tonne	1,000	674	10.65	26.79			0.00		2.84	714.27
CEM III/A (35-60% GGBS)	1	tonne	1,000	512	10.65	20.47			0.00		2.84	545.96
CEM III/B (66-80% GGBS)	1	tonne	1,000	371	10.65	14.98			0.00		2.84	399.47
Average Aggregate for Ireland	1	tonne	1,000	5	10.65	0.08			0.00		0.82	16.55
Average hot rolled steel coil used in Ireland	1	tonne	1,000	2140	10.65	21.79			0.00		6.31	2,178.75
Average cold rolled coil used in Ireland	1	tonne	1,000	2630	10.65	26.74			0.00		6.31	2,673.70
Average galvanised steel value used in Ireland	1	tonne	1,000	2800	10.65	28.45			0.00		6.31	2,845.41
Average organic coated steel used in Ireland	1	tonne	1,000	2830	10.65	28.76			0.00		6.31	2,875.72
Average steel section and steel rail value for Ireland	1	tonne	1,000	1490	10.65	7.57			0.00		6.31	1,514.53
Average reinforcing steel used in Ireland	1	tonne	1,000	737	10.65	39.68			0.00		6.31	793.64
Average aluminium sheet used in Ireland	1	tonne	1,000	2751	10.65	13.91			2,781.87		6.31	5,563.74
average aluminium foil used in Ireland	1	tonne	1,000	6780	10.65	34.16			6,831.12		6.31	13,662.23
Average aluminium extrusion used in Ireland	1	tonne	1,000	4855	10.65	24.48			4,896.44		6.31	9,792.88

Average float or coated glass used in Ireland	1	tonne	1,000	1323	10.65	53.36			1,422.99		35.98	**2,845.98**
Average facing brick imported from the UK (excl transport)	1	tonne	1,000	213	10.65	39.97			0.00		2.84	**266.46**
Average Irish produced C16 timber	1	m^3	462		4.92	10.18			0.00		752.62	**135.72**
o Sequestration				-736								
o Fossil fuel emissions (A1-A3)				104								
o GWP A1-A3 incl sequestration				-632								
Average imported C16 timber (Swedish EPD)	1	m^3	455		4.85	4.07			0.00		731.37	**54.29**
o Sequestration				-715								
o Fossil fuel emissions (A1-A3)				29								
o GWP A1-A3 incl sequestration				-686								
Irish produced OSB	1	m3	630		6.71	56.73			412.60		1,053.89	**825.20**
o Sequestration				-1031.22								
o Fossil fuel emissions (A1-A3)				326.49								
o GWP A1-A3 incl sequestration				-704.73								
Irish produced MDF	1	m3	410		4.37	61.22			445.24		628.11	**890.48**
o Sequestration				-613.36								
o Fossil fuel emissions (A1-A3)				364.9								
o GWP A1-A3 incl sequestration				-248.46								
Imported MDF (737 kg per m3)	1	m^3	737		27.59	43.86			318.97		829.52	**637.94**
o Sequestration				-803								
o Fossil fuel emissions (A1-A3)				221								
o GWP A1-A3 incl sequestration				-582								
Average imported Chipboard Particleboard (640 kg per m3)	1	m^3	640		23.96	62.65			455.64		985.03	**911.28**
o Sequestration				-962								
o Fossil fuel emissions (A1-A3)				346								
o GWP A1-A3 incl sequestration				-616								

Average imported plywood	1	m^3	491		18.38	27.59			200.64		835.67	**401.27**
o Estimated sequestration				-818								
o Estimated fossil fuel emissions (A1-A3)				137								
o GWP A1-A3 incl sequestration				-681								
EPS	1	m^3	22.3	106	0.47	11.89			0.00		0.08	**118.91**
PIR	1	m^3	30.4	114	0.65	12.77			0.00		0.10	**127.67**
Cellulose	1	m^3	40.0		0.85	1.07			0.00		54.67	**10.69**
o Estimated sequestration				-53.5								
o Estimated fossil fuel emissions (A1-A3)				7.6								
o GWP A1-A3 incl sequestration				-45.9								
Mineral wool	1	m^3	32.6	42.8	1.22	4.90			0.00		0.11	**49.01**
Sheepswool	1	m^3	10.5		0.39	1.53			0.00		12.84	**15.34**
o Estimated sequestration				-12.8								
o Estimated fossil fuel emissions (A1-A3)				13.4								
o GWP A1-A3 incl sequestration				0.6								
Woodfibre	1	m^3	108		4.03	10.88			0.00		153.74	**108.84**
o Estimated sequestration				-151								
o Estimated fossil fuel emissions (A1-A3)				90.9								
o GWP A1-A3 incl sequestration				-59.8								
Hemp fibre insulation	1	m^3	35.0		1.31	2.68			0.00		44.99	**26.78**
o Estimated sequestration				-44.0								
o Estimated fossil fuel emissions (A1-A3)				21.8								
o GWP A1-A3 incl sequestration				-22.2								
Concrete blocks	1	m^3	1,425	130	53.35	33.07			0.00		4.05	**220.47**
Hempcrete block	1	m^3	370		13.85	21.75			145.02		172.80	**290.04**
o Estimated sequestration				-172								
o Estimated fossil fuel emissions (A1-A3)				108								

o GWP A1-A3 incl sequestration				-63.4								
Straw	1	m^3	120		4.49	13.56			90.38		175.42	**180.76**
o Estimated sequestration				-175								
o Estimated fossil fuel emissions (A1-A3)				72.2								
o GWP A1-A3 incl sequestration				-103								
Concrete roof tiles	1	m^2	41.9	11.2	0.45	0.82			12.56		0.12	**25.13**
Hollowcore slabs	1	m^3	1,362	298	51.01	1.77					3.87	**354.74**
Slate	1	m^3	2,800	549	104.83	53.66					7.95	**715.42**
Stone	1	m^3	2,649	838	99.18	76.60					7.52	**1,021.36**
PVC (Double)	1	m^2	27.1	87.1	0.58	0.89			89.32		0.77	**178.63**
PVC (Triple)	1	m^2	33.6	125	0.72	1.28			128.08		0.95	**256.16**
Timber (Double)	1	m^2	38.0		1.42	0.68			67.62		20.77	**135.25**
o Estimated sequestration				-19.7								
o Estimated fossil fuel emissions (A1-A3)				64.5								
o GWP A1-A3 incl sequestration				44.8								
Timber (Triple)	1	m^2	37.3		0.79	0.92			91.63		17.91	**183.26**
o Estimated sequestration				-16.9								
o Estimated fossil fuel emissions (A1-A3)				88.9								
o GWP A1-A3 incl sequestration				72.0								
Aluminium (Double)	1	m^2	25.8	108	0.55	1.13			112.92		3.09	**255.83**
Aluminium (Triple)	1	m^2	31.0	128	0.66	1.34			133.65		3.71	**267.31**
Timber Alu (Double)	1	m^2	39.0		0.83	1.37			137.00		21.80	**274.00**
o Estimated sequestration				-17.1								
o Estimated fossil fuel emissions (A1-A3)				130								
o GWP A1-A3 incl sequestration				113								

Timber Alu (Triple)	1	m^2	40.4		0.86	1.31			130.82		23.22	**261.64**
o Estimated sequestration				-18.4								
o Estimated fossil fuel emissions (A1-A3)				124								
o GWP A1-A3 incl sequestration				105								
Cement fibre board	1	m^2	16.6	12.9	0.18	2.14			15.56		0.39	**31.12**
Plasterboard (gypsum)	1	m^2	9.5	2.5	0.10	0.11			2.98		0.22	**5.96**
Metal stud wall	1	m^2	2.6	6.3	0.03	0.03			6.33		0.02	**12.66**
Timber stud wall	1	m^2	8.6		0.09	0.01			2.67		14.36	**5.34**
o Estimated sequestration				-14.1								
o Estimated fossil fuel emissions (A1-A3)				2.3								
o GWP A1-A3 incl sequestration				-11.8								
Suspended ceiling (metal)	1	m^2	10.7	26.7	0.40	0.14			27.31		0.07	**54.61**
Suspended ceiling (other/timber)	1	m^2	19.0		0.71	0.05			10.71		8.91	**21.41**
o Estimated sequestration				-8.2								
o Estimated fossil fuel emissions (A1-A3)				9.3								
o GWP A1-A3 incl sequestration				1.0								
Vinyl flooring	1	m^2	3.9	7.0	0.15	0.26			7.50		0.14	**14.99**
Ceramic tiles	1	m^2	19.1	10.3	0.72	0.77			11.81		0.05	**23.63**
Cork flooring	1	m^2	2.0		0.07	0.02			0.64		3.28	**1.28**
o Estimated sequestration				-3.3								
o Estimated fossil fuel emissions (A1-A3)				0.5								
o GWP A1-A3 incl sequestration				-2.7								
Permeable paving	1	m^3	2,350	279	25.03	1.56			311.95		6.67	**623.89**
Zinc sheeting	1	m^2	6.8	16.8	0.26	0.67			17.76		0.04	**35.53**
Recycled Copper sheeting	1	m^2	8.9	7.5	0.33	0.31			8.21		0.06	**16.41**

PVC Rainwater goods	1	1 kg installed pipeline	1.0	2.6	0.04	0.10			2.75		0.04	**5.50**
DPM	1	m^2	0.9	3.0	0.03	0.34			3.45		0.11	**6.89**
Vapour permeable sheet	1	m^2	0.2	0.5	0.01	0.06			0.64		0.02	**1.28**

Appendix B – A5 Construction & Installation data extracted from EPDs

Product Reference	Product Name	A5 Value	Unit	Conversions made	Notes (Green = suitable, Orange = mixed with waste data, Red = waste data only)
Insulation					
EPS 15	EUMEPS – Expanded Polystyrene (EPS) Foam Insulation	0.03040	per kg	Divided GWP total figure (unit per m3) by the density to obtain GWP per kg	The amount of installation waste varies and is not declared in this EPD. For the calculation of the environmental impact of EPS including a certain amount of installation waste the values for the production stage (A1-A3) and end-of-life (C3, C4 and D) must be multiplied with the amount of waste (e.g., 2% installation waste, factor 1.02).
PIR 1	Kingspan - Therma TP10, TF 70, Therma Duct, TW50, TW55	0.09335	per kg	Density is 31 volume is 0.066 and so mass is 2.046. 0.191/2.046 = GWP per kg	Installation wastage rate - 2% of product
PIR 2	Xtratherm avg	0.22525	per kg	Density is 32 volume is 0.025 and so mass is 0.8kg. 0.196/0.8 = GWP per kg	No additional info on build-up of A5 data
PIR 6	Xtratherm Insulation CT/PIR	0.22300	per kg	Density is 30 volume is 0.100 and so mass is 3kg. 0.669/3 is GWP per kg	No additional info on build-up of A5 data
Cellulose 1	European Cellulose Insulation Association (ECIA) - Loose fill cellulose insulation	0.01820	per kg	No conversion	The loose fill cellulose insulation is applied into the construction by a machine. Therefore, the energy consumption of the blowing or spraying machine is considered.
Cellulose 2	Ecocel - Cellulose Fibre Insulation	0.00798	per kg	Density is 37 volume is 0.300 and so mass is 11.1kg. 0.0886/11.1 is GWP per kg	This module covers the pumping of the insulation into cavities in the construction. Pumping is powered by on-site electricity.
Mineral Wool Insulation 1	Saint-Gobain, ISOVER - ISOCONFORT 35 140mm	0.08429	per kg	Density is 20 volume is 0.140 and so mass is 2.80. 0.236/2.8 is GWP per kg	Includes only 5% wastage in figure - no installation energy
Mineral Wool Insulation 3	ROCKWOOL - Stone Wool Thermal Insulation	0.03719	per kg	Density is 22 volume is 0.044 and so mass is 0.968. 0.036/0.968 is GWP per kg	no additional info
Woodfibre insulation 4	STEICOflex flexible wood fibre cavity insulation	0.24600	per kg	GWP value divided by the density to get GWP per kg	The information in Module A5 exclusively refers to the disposal of packaging materials.
Woodfibre insulation 5	Hunton Wood Fibre Insulation Board	0.01429	per kg	Density is 50 volume is 0.038 and so mass is 14kg. 0.2/14 is GWP per kg	Includes both installation energy and 2% waste rate

Mineral Wool Insulation 4	Knauf Insulation - CLT Thermal	1.40857	per kg	density is 70 volume is 0.100 and so mass is 0.7kg. 0.986/0.7 is GWP per kg	Installation wastage rate - 2% of product
					Range = 0.00798 – 0.246, Average = 0.21714
Windows and Doors					
PVC (double glazed) 1	Munster Joinery - Passiv PVC Double Glazed Window	0.00178	per kg	weight per m2 is 27.3	No energy is allocated to this process, as it is largely manual work. Material allocated to the installation process is oil-based bedding mastic. On average 80ml is used per window.
PVC (double glazed) 2	Munster Joinery - HP uPVC double glazed window	0.00678	per kg	weight per m2 is 23.6	Installation of the window in the building uses 80ml of oil-based bedding mastic Reference: market for bitumen seal, polymer EP4 flame retardant | Global
PVC (double glazed) 3	Munster Joinery - Passiv uPVC double glazed window	0.05861	per kg	weight per m2 is 27.3	Installation of the window in the building uses 80ml of oil-based bedding mastic Reference: market for bitumen seal, polymer EP4 flame retardant | Global
PVC (double glazed) 4	EPPA - PVC-U plastic windows	0.06490	per kg	weight per m2 is 30.2	All processes relating related to the installation of the window in the building are considered in module A5.
PVC (triple glazed) 2	Munster Joinery - HP uPVC triple glazed window	0.00140	per kg	weight per m2 is 34.874	No energy is allocated to this process, as it is largely manual work. Material allocated to the installation process is oil-based bedding mastic. On average 80ml is used per window.
PVC (triple glazed) 3	Munster Joinery - Passiv uPVC triple glazed window	0.00515	per kg	weight per m2 is 31.097	Installation of the window in the building uses 80ml of oil-based bedding mastic Reference: market for bitumen seal, polymer EP4 flame retardant | Global
Timber (triple glazed) 1	Munster Joinery - Triple glazed windows (Hardwood)	0.00416	per kg	weight per m2 is 38.5	Installation of the window in the building uses 80ml of oil-based bedding mastic Reference: market for bitumen seal, polymer EP4 flame retardant | Global
Timber (triple glazed) 2	Munster Joinery - Triple glazed windows (Softwood)	0.00452	per kg	weight per m2 is 35.4	Installation of the window in the building uses 80ml of oil-based bedding mastic Reference: market for bitumen seal, polymer EP4 flame retardant | Global
Timber (triple glazed) 6	Elitfönster Original Trä - EFK	0.07880	per kg	weight per m2 is 34.9	When installing and uninstalling the window no environmental aspects in addition to using of electrical machines is assumed according to installation instructions from Elitfönster.
Timber (triple glazed) 7	Elitfönster Original Trä - EFH	0.07143	per kg	weight per m2 is 37.8	When installing and uninstalling the window no environmental aspects in addition to using of electrical machines is assumed according to installation instructions from Elitfönster.
Timber (triple glazed) 8	Elitfönster Original Trä - EFS	0.07392	per kg	weight per m2 is 37.2	When installing and uninstalling the window no environmental aspects in addition to using of electrical machines is assumed according to installation instructions from Elitfönster.
Aluminium (double glazed) 1	AMS - XT66 Performance Plus Casement DG 1.23m x 1.48m	0.09464	per kg	weight per m2 is 28	The A5 stage, installation on site assumes 1% installation losses, as per default values in the Product Category Rules (PCR) for EPD Ireland

Aluminium (double glazed) 2	AMS - XT66 Performance Plus Casement DG 1.48m x 2.18m	0.21471	per kg	weight per m2 is 13.6	The A5 stage, installation on site assumes 1% installation losses, as per default values in the Product Category Rules (PCR) for EPD Ireland
Aluminium (triple glazed) 1	AMS - XT66 Performance Plus Casement TG 1.23m x 1.48m	0.08249	per kg	weight per m2 is 35.4	The A5 stage, installation on site assumes 1% installation losses, as per default values in the Product Category Rules (PCR) for EPD Ireland
Aluminium (triple glazed) 2	AMS - XT66 Performance Plus Casement TG 1.48m x 2.18m	0.21508	per kg	weight per m2 is 17.9	The A5 stage, installation on site assumes 1% installation losses, as per default values in the Product Category Rules (PCR) for EPD Ireland
Timber Alu (double glazed) 1	Munster Joinery - Passiv AluClad	0.00516	per kg	weight per m2 is 31	Installation of the window in the building uses 80ml of oil-based bedding mastic Reference: market for bitumen seal, polymer EP4 flame retardant | Global
Timber Alu (triple glazed) 2	Munster Joinery - Passiv AluClad	0.00423	per kg	weight per m2 is 37.8	Installation of the window in the building uses 80ml of oil-based bedding mastic Reference: market for bitumen seal, polymer EP4 flame retardant | Global
					Range = 0.00140 – 0.21508, Average = 0.05810
Walls and Flooring					
Vinyl flooring 1	Amtico Spacia Luxury Vinyl Floor Tiles	0.27765	per kg	Weight per m2 is 3.4	Includes installation energy, cleaning, and a 5% waste rate
Vinyl flooring 2	ERFMI - Homogeneous polyvinyl chloride floor coverings	0.31212	per kg	Weight per m2 is 3.3	Module A5 includes the production of offcuts (6% waste rate) and adhesive for the installation of the floor covering, and incineration of offcuts and packaging material.
Vinyl flooring 3	BOLON - Woven vinyl flooring delivered as rolls	0.37241	per kg	Weight per m2 is 2.9	10% of the product is lost during installation
Vinyl flooring 4	BOLON - Woven vinyl flooring delivered as tiles	0.27000	per kg	Weight per m2 is 4.0	10% of the product is lost during installation
Vinyl flooring 5	RFCI - Vinyl Tile	0.19831	per kg	Weight per m2 is 5.9	Installation of this product primarily involves hand tools for measuring and cutting floor materials. Approximately 4.5% of the total material is assumed to be trimmed and discarded as waste. Hand trowels are used to spread appropriate adhesive (300g per sqm) which adheres flooring to subfloor.
Ceramic tiles 1	Kaleseramik - Ceramic Floor Tiles	0.06879	per kg	Weight per m2 is 17.3	Includes the adhesive mortar usage in the construction site in addition to packaging waste transportation and disposal processing. For 1 m2 ceramic tile installation; 3.3 kg mortar and 0.8 L water usage assumed. A 3% (in mass) wastage is assumed during the installation.
Ceramic tiles 2	Confindustria Ceramica - Italian Ceramic Tiles	0.14070	per kg	Weight per m2 is 19.9	Module A5 considers all tile installation steps (like adhesives consumption) also packaging waste processing (recycling, incineration, disposal). During this phase, a ceramic material loss of 6,5% has been considered.

Ceramic tiles 3	Mosa - Ceramic Floor Tiles	0.05421	per kg	Weight per m2 is 19.0	Module A5 concerns the installation of a Mosa floor tile. 5% waste rate also included. In accordance with the PCR, various choices can be made for the installation, namely: bonding or laying by means of a cement mortar or grout. The second option from PCR-EN17160: 2019, table 11, p. 41 has been used for this study. This results in the use of 3.3 kg of cement and 0.8 litres of water per square meter.
Ceramic tiles 4	Spanish Ceramic Tile Manufacturers' Association (ASCER) - Spanish ceramic tiles	0.02562	per kg	Weight per m2 is 20.3	Data show that, in a real scenario, the ceramic tiles need to be installed with fast-setting mortars. Waste from packaging waste is handled separately depending on the geographic location of the installation site.
Cork flooring 1	ERFMI - Cork Floor Tiles	0.41000	per kg	Weight per m2 is 2	Module A5 includes the production of offcuts (4.5% waste rate) and adhesive for the installation of the floor covering, and incineration of offcuts and packaging material.
Plasterboard 1	Gyproc Fireline - 12.5mm	0.01009	per kg	Weight per m2 is 10.6	All installation materials and their waste processing (10% waste rate) are included.
Plasterboard 2	Gyproc Wallboard - 12.5mm	0.02434	per kg	Weight per m2 is 8.3	All installation materials and their waste processing (5% waste rate) are included.
Metal stud wall 1	British Gypsum - Gypframe metal	0.04423	per kg	Weight per m2 is 2.6	All installation materials and their waste processing (5% waste rate) are included.
Metal stud wall 2	Steel Formed Sections - Cold-rolled steel profiles for framing and partition systems	0.03262	per kg	Weight per m2 is 2.6	Transport and recycling of installation losses
Total					**Range = 0.01009 – 0.41, Average = 0.16008**
Blocks and Tiles					
Permeable paving 1	Tobermore paving products - Hydropave, Manhattan	0.00046	per kg	Weight per m2 is 2350	In the construction installation process, the following assumptions apply: • No ancillary materials are used (i.e., zero) • No energy or other resources are used (i.e., zero) • Losses of 5% of the product occur on-site during the installation processes. • The lost material is re-used on site as incidental construction infill, and not transported off site.
Permeable paving 2	Tobermore Products - Fusion, Sienna	0.00037	per kg	Weight per m2 is 2350	In the construction installation process, the following assumptions apply: • No ancillary materials are used (i.e., zero) • No energy or other resources are used (i.e., zero) • Losses of 5% of the product occur on-site during the installation processes. • The lost material is re-used on site as incidental construction infill, and not transported off site.
Permeable paving 3	Tobermore Products - Sienna Sets, Sienna Duo	0.00093	per kg	Weight per m2 is 2350	In the construction installation process, the following assumptions apply: • No ancillary materials are used (i.e., zero) • No energy or other resources are used (i.e., zero) • Losses of 5% of the product occur on-site during the installation processes. • The lost material is re-used on site as incidental construction infill, and not transported off site.

Permeable paving 4	Tobermore Products - Artro, Hydropave Pedestra, Marker Block, Shannon, Toberloc	0.00037	per kg	Weight per m2 is 2350	In the construction installation process, the following assumptions apply: • No ancillary materials are used (i.e., zero) • No energy or other resources are used (i.e., zero) • Losses of 5% of the product occur on-site during the installation processes. • The lost material is re-used on site as incidental construction infill, and not transported off site.
Concrete Block 1	Concrete Block Association (CBA) - UK Manufactured Precast Concrete Blocks	0.00002	per kg	Weight per m3 is 1425	3% waste rate included
Hempcrete Block 1	ISOHEMP - Hemp Concrete Blocks (PAL36 – Bloc de béton chanvre)	0.02203	per kg	Weight per m3 is 340	The installation of hemp concrete blocks in the building is done using adhesive mortar, applied in strips 90 mm wide on a thickness of 3 mm, and which integrates with the blocks. At the construction site, materials for packing blocks and bags of adhesive mortar are released. The installation of the blocks leads to 5% material losses which are taken into account
Concrete Roof Tile 6	Sneldex Aerlox Concrete Roof Tiles	0.04193	per kg	Weight per m2 is 41.5	The installation of the product including manufacture, transportation and end-of-life of ancillary materials and any energy or water use required for installation or operation of the construction site are taken into account. The end-of-life of packaging material up to the end-of-waste state or disposal of final residues is also included
Slate 1	Cupa Pizarras - Cupa Heavy 3 Roof Slate	0.00009	per kg	Weight per m3 is 2800	This scenario includes the collection of the material in the distributor until it is installed on the roof, as well as the installation of the slate on the roof. 5% waste rate also included
Slate 2	Cupa Pizarras - Cupa 12 Roof Slate	0.00005	per kg	Weight per m3 is 2800	This scenario includes the collection of the material in the distributor until it is installed on the roof, as well as the installation of the slate on the roof. 5% waste rate also included
Stone 1	Natural Stone from Silkarstone - 30mm	0.00707	per kg	Weight per m3 is 2700	No energy during installation, adhesives, mortar, water use, and steel backing structure included.
Ceramic tiles 1	Kaleseramik - Ceramic Floor Tiles	0.05595	per kg	weight per m2 17.3	For 1 m2 ceramic tile installation; 3.3 kg mortar and 0.8 L water usage assumed. A 3% (in mass) wastage is assumed during the installation
Ceramic tiles 2	Confindustria Ceramica - Italian Ceramic Tiles	0.14070	per kg	weight per m2 19.9	Module A5 considers all tile installation steps (like adhesives consumption) also packaging waste processing (recycling, incineration, disposal). During this phase, a ceramic material loss of 6,5% has been considered.
Ceramic tiles 3	Mosa - Ceramic Floor Tiles	0.05421	per kg	weight per m2 19	Module A5 concerns the installation of a Mosa floor tile. 5% waste rate also included. In accordance with the PCR, various choices can be made for the installation, namely: bonding or laying by means of a cement mortar or grout. The second option from PCR-EN17160: 2019, table 11, p. 41 has been used for this study. This results in the use of 3.3 kg of cement and 0.8 litres of water per square meter.
Ceramic tiles 4	Spanish Ceramic Tile Manufacturers' Association (ASCER) - Spanish ceramic tiles	0.02562	per kg	weight per m2 20.3	Data show that, in a real scenario, the ceramic tiles need to be installed with fast-setting mortars. Waste from packaging waste is handled separately depending on the geographic location of the installation site.
					Range = 0.00002 – 0.14070, Average = 0.02499
Metals					

Suspended ceiling (metal) 6	Lindner Group - Metal ceiling systems made of steel	0.00368	per kg	weight per m2 is 10.4	During installation in the building, no other materials are considered; Module A5 comprises the environmental loads for disposal of packaging.