Supporting the Development of Quality Data

Availability, quality and use of construction product LCA data Ireland, Italy and Croatia

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1. Introduction

The LIFE Level(s) Project (2019-22) aims to promote sustainability through greater awareness and use of EU indicators to address the life cycle performance of buildings. The project is led by the Green Building Councils of Ireland, Italy, Croatia and Spain, and is co-funded by the European Commission.

Work package B2 (2020-21) focuses on improving the quality and correct use of data in EU member states where building level Life Cycle Assessment (LCA) is not yet mainstream, particularly the four project partner countries of Ireland, Italy, Croatia and Spain. Cambridge Architectural Research (CAR) were commissioned in September 2020 to complete the objectives of this work package for Ireland, Italy and Croatia. A separate team from EcoMetro is delivering the work package for Spain. This report includes only the work completed by CAR.

1.1 Report objectives

The objectives of this report are to:

- Identify data sets for ten commonly encountered high impact construction materials, identified in the tender as class 1 Materials: namely Cement, CEM I, II & III, Aggregates, Steel, Aluminium, Glass, Brick and Timber. This data is to be country-specific where available, and generic where country-specific data is not available.
- Identify the key factors which vary the impact categories for each material in order to effectively create a calculation tool for each material and provide a roadmap for fitting generic data more closely to national data.
- Identify additional materials of interest specific to the country, which might include specialised or novel materials which are used in the country (defined herein as class 2) or locally produced low impact materials (class 3). For these materials, to suggest sources for data, and specify the quality of the data based on defined rules; and to identify relevant factors in national production.
- Propose a data quality assessment method and uncertainty surcharge for data from different sources, with awareness of not penalising small and innovative national manufacturers.
- Review existing databases and identify their key structures and functionality as a starting point for the development of national databases within the participating countries

1.2 Structure of report

Following this introduction, a brief description of the methods used in this project is given in chapter 2. This report is then split into two main sections.

Section A reviews and analyses the existing data for construction products, focusing principally on the ten key ‘class 1’ materials and on the three countries. This section includes chapters 3-7. Chapter 3 provides an extensive review of multiple sources of information, including European EPD and EPD tools, then country-specific sources covering in turn Ireland, Italy and Croatia. The country specific sections also include lists of particular novel or locally produced materials.

Chapter 4 provides the results of the analysis of EPD for the ten identified ‘class 1’ materials. Chapters 5 to 7 describe in detail the analysis of country-specific data for each of the ‘class 1’ materials for Ireland, explaining how each is derived, and recommending specific values for each. A summary table for data recommended for use within the specific country is provided as the first section of each of these chapters.

Section B develops the requirements for developing a national database. Chapter 8 reviews existing database platforms and existing and forthcoming data exchange formats, as well as product classification systems and approaches to digitisation. Chapter 9 considers how the issue of variation in LCA data is and should be approached within databases, including an analysis of the data produced for chapter 4 and a discussion on the use of safety margins in existing databases and tools. The final chapter 10 concludes the report with brief recommendations for the data, format, structure and design of the database. The recommendations are based on the detailed work throughout this report.

1.3 Authors and acknowledgements

This report was written by Alice Moncaster, Jane Anderson and Helen Mulligan, on behalf of Cambridge Architectural Research, and for a client body led by Pat Barry of the Irish Green Building Council. Substantial input and additional data analysis was provided by Julia Barnard of Julia Barnard Consulting.

2. Methods

2.1. Introduction

The following methods have been used to develop the data for chapters 3 to 7 of this report:

- Qualitative interviews with key stakeholders within each country to identify specific features of the regulatory environment and of the construction product markets.
- Identification, review and detailed quantitative analysis of existing generic and product specific materials data, through review of EPD programmes and manufacturers' sites, identification and analysis of local, EU and international EPD.

These are described in more detail in the following two sections.

For chapters 8 to 10 detailed reviews were undertaken – these are described in section 2.4.

2.2. Qualitative data

In order to gather additional contextual information for each of the countries participating in the Life Levels project, qualitative research was undertaken. This included both ongoing discussions with the Green Building Council representatives for each country, and more formalised semi-structured expert interviews with a number of industry stakeholders. The purpose was to identify specific features for: national rules/regulations; the significant construction product markets in the country; which materials/products are produced locally and which are imported from where; any additional sources of data and relevant local factors; and any specialised or novel materials.

The expert interviews were held between November 2020 and March 2021, with stakeholders identified by the Green Building Council representatives for each country. Appendix 1 gives details of the GBC representatives and the stakeholders who participated in the interviews for each country. The interviews were based on an interview template developed by the CAR team which is attached as Appendix 2. Interviews were held through an online platform and were recorded where participants gave their consent. Notes were transcribed following each interview and double-checked with recordings, where available, to clear up ambiguities and misinterpretations where possible. In some cases the respondents sent text responses to the proforma questions. Several stakeholders also provided links to further online information.

2.3. Data identification and analysis

For each of the identified class 1 material types a spreadsheet dataset comprising EPD metadata and LCA results for selected impact categories (varies by material) and modules (primarily A1-A3, some C3, C4) was created.

For Cement, CEM I, II & III, and aggregates, the data used is that reported in Anderson & Moncaster (2020) which can be downloaded from https://journal-buildingscities.org/articles/10.5334/bc.59/. The data source set is accessible at https://doi.org/10.21954/ou.rd.12200873.v1.

For the other class 1 materials published, verified EPD available globally in December 2020 were downloaded. Numbers included are as follows (number of EPD in brackets): Steel (252), Aluminium (66), Glass (74), Brick (44), Timber (72).

Key metadata, and selected LCA results were identified. Metadata included representativity and quality of data identified, and covered place of manufacture, applicable market area where stated, EPD type (manufacturer specific, industry average, etc.), EPD reference number, product type group, product names, material content and other specific factors (e.g., recycled content - some differences depending on material), declared or functional unit, and masses for non-mass units

(where stated). To allow for future data additions and updates, metadata also included filenames and declared modules applicable to the EPD.

For a large number of the EPD documents, Google Translate was employed to gather data from a range of other languages.

Several of the spreadsheet datasets were plotted as stacked bar charts, via pivot tables/charts in excel – this allows the user to click and few buttons to switch the comparison between different product groups, and to show an overall summary. The data is shown either having been transformed into "per tonne", or where appropriate using the most consistent unit for that type (e.g., m3 or m2). The stacked graphs show Global Warming Potential (GWP) for modules A1-A3. Where the A1, A2, and A3 modules were stated separately these are kept separate so that the division of these impacts is clear. Where other impact categories were also included, graphs have been created to compare data of the same units.

In addition, to allow trends to be analysed, scatter graphs were produced for some datasets where both GWP and energy impact categories were available, showing for example:

- Primary energy renewable total (PERT)
- Primary energy non-renewable total (PENRT
- Renewable secondary fuels (RSF)
- Non-renewable secondary fuels (NRSF)
- recycled content
- a combination of fields

Some composite, or specific functional unit types have been excluded.

For each country (Ireland, Italy, Croatia), the national production, imports and export statistics for the key products were investigated. Where relevant, this was broken down to relevant sub-categories based on HS commodity codes. An example is given for timber below.

Table 1 Example of timber sub-categories

HS Code	Description
4403	Wood in the rough, whether or not stripped of bark or sapwood, or roughly squared
440711	Wood; coniferous species, of pine (Pinus spp.), sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness exceeding 6mm
441860	Wood; posts and beams

The consumption mix for these products (production – exports + imports) was also investigated. For imports the main source countries and relevant EPD were identified.

Where there were no average EPD, information on national production of the key products was sought, including information on the energy intensity, CO2 intensity, fuel mix, technology mix, recycled content etc. This information can be used with the data from EPD globally for each product, to derive datasets for the products, together with uncertainty information.

2.4. Reviews

For chapter 8, a detailed review of global existing databases for generic and product-specific LCA data for construction materials was undertaken, along with the current and forthcoming EU and international standards for the development of data and databases.

A similar review collated and compared published approaches to uncertainty, and variations in construction products and tools, in order to recommend a suitable approach to be followed by the proposed national database.

SECTION A: DATA

3. Sources of information: general and country-specific

3.1. Introduction

This section lists the sources of information, including EPD programmes, which produce and publish EPD for European construction products, with specific focus on sources for Ireland, Croatia and Italy.

First the following section lists the international generic EPD programmes and the range of European products they cover, and then lists some of the tools which are available to produce EPD for common products/materials with minor variations, at lower cost than an individual EPD. Note that some of these tools may require membership of or affiliation to the owning organisation.

See Anderson (2020) at https://asbp.org.uk/briefing-paper/epd-where-to-find for further details of where EPD can be found.

The next sections provide country-specific data sources for Ireland, Croatia and Italy, followed by additional information from the stakeholder interviews. It should be noted that the data available for the three countries is very varied. That for Ireland and Italy includes sources of data for most of the class 1 materials. That for Ireland also includes relevant UK-specific generic programmes and product ranges, since historically, Ireland imports a significant proportion of these construction products from the UK[1]. The section on Italy includes information about the fuel sources. There is very limited country-specific data for Croatia, beyond the stakeholder interview summary.

3.2. European Sector EPD programmes

The table below lists the EPD programmes which provide sector EPD for European-produced generic materials and products.

Table 2 EPD programmes for European construction materials and products

EPD Programme	European Industry Average EPD
International EPD programme	**European General Galvanizers Association** (**EGGA)** – 1 EPD for hot dip galvanising of steel products **European Waterproofing Association** – 2 EPD for bitumen roof sheets and underlay
IBU EPD Programme	**European Federation of Concrete Admixtures Associations (EFCA)** – 6 EPD for concrete admixtures **European Extruded Polystyrene Insulation Board Association (EXIBA)**- 1 EPD for extruded polystyrene (XPS) with halogen free blowing agent) **European Manufacturers of Expanded Polystyrene (EUMEPS)** – 7 EPD for expanded polystyrene insulation products **European PVC Window Profiles and Related Building Products Association (EPPA)** – 2 EPD for double and triple glazed PVC windows **European Resilient Flooring Manufacturers (ERFMI)** – 10 EPD for PVC (5), LVT (2), Rubber, Linoleum and Cork resilient flooring products

[1] This is based on historical trends for imports and exports and may change following Brexit.

EPD Programme	European Industry Average EPD
	Gemeinschaft umweltfreundlicher Teppichboden e.V. (GuT) – 30 EPD for carpet tiles **ICDLI – Laminate Association** – 2 EPD for high pressure laminates **IGI - The Global Wallcoverings Association** – 5 EPD for wall coverings **PPA-Europe - European Association for Panels and Profiles** – 2 EPD for steel sandwich panels, 2 EPD for profiled metal sheet **PU Europe** – 1 EPD for PU spray insulation
RT EPD Programme (FI)	**European Cellulose Insulation Association (ECIA)** – 1 EPD for loose fill cellulose insulation
Inies EPD Programme (FR)	**European Copper Institute** – 3 EPD for copper pipe and 1 EPD for copper sheet **European Cellulose Insulation Association (ECIA)** – 3 EPD for cellulose insulation
Own Programme	Cembureau – 3 EPD for European average cements Eurima – 3 EPD for mineral wool insulation European Lime Association – LCI* for quick lime and for hydrated lime Eurogypsum – unverified LCA for plasterboard Plastics Europe – LCI* or EPD for up to 70 plastic products and intermediate products The European Plastic Pipe and Fittings Association (TEPPFA) – 21 unverified EPD for plastic pipe products

3.3. EPD tools for construction materials

The table below provides information on pre-verified EPD tools which can be used to reduce the cost of EPD production. These are tools which are commercially available to any company.

Table 3 Commercially available pre-verified EPD tools

Tool	Materials (Class 1 materials in bold)	Linked EPD programme
BRE Lina (ecoinvent)	Any materials	BRE EPD Programme (UK)
One Click LCA pre-verified EPD tools (current)	**Cementitious Products (concretes)**: ready-mix concrete, pre-cast concrete, concrete products and cementitious mortars and screeds.	RT EPD (Finland) International EPD Programme (Sweden)
	Primary Steel and **Aluminium** and all Metal-Based Products.	
	Wood & Plant Fibre based Products: wood, wood-based boards and elements, including composites.	
	Asphalt, **Aggregates** & Stone products.	
	Bitumen Membranes.	
	Paints, Coatings, Sealants and Adhesives.	
	Plumbing Products.	
	Plastic-based Products and Systems	RT EPD (Finland)

Tool	Materials (Class 1 materials in bold)	Linked EPD programme
One Click LCA pre-verified EPD tools (future)	Ceramic and Clay-based Products	International EPD Programme (Sweden)
	Gypsum, Limestone and Porcelain-based Products	
Climate Earth EPD tool for Concrete (ecoinvent)	Concrete	ASTM (USA)

There are also pre-verified tools which are only open to members of trade associations, customers of particular manufacturer or only used by a particular manufacturer. Some examples are listed below, but it has not been possible to list all of them.

Table 4 Limited access pre-verified EPD tools

Tool	Materials (Class 1 materials in bold)	Linked EPD programme
GCCA concrete EPD tool (ecoinvent)	**Cement**, concrete, mortars, **aggregates** – for GCCA membership organisations and their members	International EPD
BASF concrete EPD tool (GaBi	Concrete – for customers of BASF.	IBU (Germany)
European Aluminium EPD tool (GaBi)	**Aluminium** products – for members of European Aluminium	European Aluminium EPD programme
CARES EPD tool (GaBi)	Steel – for customers of CARES Certification	BRE EPD Programme (UK)
EasyEPD (ecoinvent)	Timber – for members of the German sawmill and timber industry association (DeSH)	IBU (Germany)

It is also possible in the IBU EPD programme to provide Template or Model EPD. This uses LCA data from the industry to provide "worst case" EPD for products which meet given criteria to ensure that they do not have worse performance than that provided by the Template EPD. Details of Template EPD schemes are provided below.

Table 5 Template EPD schemes

Tool	Materials (Class 1 materials in bold)	Linked EPD programme
FEICA Model EPD (Template EPD) (GaBi)	Adhesives, sealants – for members of FEICA	IBU (Germany)
IFT Rosenheim Model EPD (Template EPD) (GaBi)	**Glass**, insulated glass units, doors, windows, roller shutters, **steel facades**, electric drives, electric control units	IBU (Germany)

3.4. Country specific information: Ireland

Main data sources

EPD Ireland: https://www.igbc.ie/epd-search/ currently lists most of the EPD found through this project's searches covering Irish production. It also lists many products produced elsewhere but sold in Ireland.

We note the following EPD for products produced in Ireland which are not currently included on the EPD Ireland site:

- Roadstone Thermal Liteblock: https://www.environdec.com/library/epd2442
- Gyproc Wallboard (expired): https://www.environdec.com/library/epd582
- Gyproc Fireline (expired): https://www.environdec.com/library/epd583
- Gyproc plaster (expired): https://www.environdec.com/library/epd584

Table 6 Class 1 product data sources for Ireland

Class 1 product type	Available Data for Ireland
1 CEM I cement (clinker 95-100%)	Cement Manufacturers Ireland are working on an EPD for Irish CEM I Cembureau EPD – European Average CEM I EPD available Dataset for Irish CEM I to be provided.
2 CEM II cement (CEM II/A – 6-20% fly ash/GGBS/limestone, 6-10% silica fume; CEM II/B – 21-35% fly ash/GGBS)	Not commonly made or used in Ireland. Cembureau EPD – European Average CEM II EPD available Dataset for Irish CEM II to be provided.
3 CEM III cement (CEM III/A GGBS 35-65%, CEM III/B 66-80%)	Irish EPD for Ecocem GGBS Cement Manufacturers Ireland are working on an EPD for Irish CEM III Cembureau EPD – European Average CEM III EPD available
4 Average Cement	Cement imports are mainly from the UK. UK average Cement EPD available (IBU) Dataset for Average Irish Cement to be provided.
5 Aggregates	1 Irish EPD for recycled aggregate (IMS Greenstone) No Average Irish, UK or European EPD. Specific EPD for UK aggregates from Aggregate Industries (BRE) and Tarmac (BRE). Review of global EPD shows small variation in impact for aggregates. Dataset for Average Irish aggregate to be provided.
6 Steel	No primary (BF/BOF) or secondary steel (EAF) production in Ireland. One manufacturer uses imported cold rolled steel. No Average UK or European EPD. • Worldsteel provides LCI data for steel products in various regions including Europe. • BauforumStahl provides an EPD for structural steel covering several companies and - 12 sites (DE, FR, LX, PO, ES, RO) UK is the main import market for steel, most steel comes from Europe. **Hot rolled coil** (33% of Irish steel imports).

	71% comes from the UK, 16% from Germany, 7% from outside of Europe. World Steel Data for Europe appropriate. **Cold Rolled coil** (5% of Irish steel imports) 94% comes from the UK, 1% from outside Europe. World Steel Data for Europe appropriate. **Galvanised steel** (less than 1% of Irish steel imports) 89% from the UK. World Steel Data for Europe appropriate. Coated steel products – including cladding, roofing, flooring *Tata Steel EPD* for UK products based on cold rolled coated steel *Euroclad Group EPD* for UK cladding products *CA Group EPD* for UK cladding products World Steel Data for Europe appropriate. **Structural Steel Section** (41% of Irish steel imports) 56% from the UK, 25% from Spain. 16% from outside Europe (7% from Turkey). Rail 75%, Various EPD available for UK produced steel (Liberty Steel/Rotherham, British Steel, Celsa Steel). EPD for Spanish Steel sections from Global EPD. Also specific Spanish EPD at Global EPD. World Steel Data for Europe appropriate. Hollow Steel Tube EPD available for UK/Dutch produced steel (Tata Steel) Reinforcing Steel: 36% from the UK, 37% from Portugal, 24% from Spain. Less than 1% from outside Europe Specific EPD available for UK produced rebar (*Celsa Steel*), Specific EPD for Portuguese rebar at BRE EPD. Generic EPD for Spanish rebar and Spanish ribbed rod, also specific Spanish EPD at Global EPD and BRE EPD. World Steel Data for Europe appropriate.
7 Aluminium	Ireland is a major producer of alumina for Europe, but it is all exported and then reimported as aluminium. Most imports from Germany, UK, France, Italy, US. Extrusion – no European generic EPD Sheet – no European generic EPD World Aluminium produces LCI and LCIA data for primary and recycled aluminium – data is global and for Europe World Aluminium data to be used to produce datasets

	Euric gives post consumer recycled content for EU at 14%. (https://bit.ly/2ZjxdM3) Other aluminium products available through EAA EPD programme.
8 Glass	Float Glass No float glass manufacture in Ireland. Main imports float glass from UK (50%) and China (25%) Saint Gobain and AGC EPD (not UK) Pilkington NSG (UK manufacturer – claims 1.1 kg CO2e/kg glass globally but no EPD). No Chinese glass EPD Generic Dataset to be produced
	Windows: Timber windows – 66% from Denmark and then UK (16%) PVC windows - 62.5% from UK Munster Joinery Passiv PVC double glazed and triple glazed window EPD (EPD Ireland) *EPPA generic EPD* for PVC windows from BRE EPD Programme. Reynaers aluminium doors, windows and curtain walling EPD available through EPD Ireland. Other aluminium window product EPD available through EAA EPD programme.
9 Brick	1 clay brick manufacturer in Ireland (8 million bricks/year with natural gas) 3 concrete brick manufacturers in Ireland (4 million bricks/year) Imports almost entirely from the UK according to Comtrade, also lots of re-exports back to UK. 75 million bricks used per annum total *UK Average Brick EPD* covers all UK brick production Irish brick dataset to be produced
10 Timber	**Structural Timber** - Annually around 1,065 thousand cubic metres of sawn timber is produced in the Republic (half construction timber, mainly C16), of which 50% is used in local construction, about 50% exported. About 315 thousand cubic metres sawn timber is also imported, predominantly from Sweden (C24).See paper by Knaggs and O'Driscoll (2018)/ UK kiln dried timber EPD Swedish kiln dried timber EPD Irish kiln dried C16 timber dataset to be produced
	Wood panel products overall OSB&MDF Production 808,000 m3, export 691,000 m3, WP products import 295,000 m3 Medite MDF and Smartply OSB EPD (EPD Ireland)
	Chipboard/Particleboard – imported UK (30%) SPAIN 26%, Portugal 25%

	Financiera Maderera EPD for Spanish and Portuguese Particleboard UK consumed chipboard LCA dataset available from woodforgood database
	Plywood – imported UK (35%), china (25%), brazil (12.5%) Malaysia 5% UK consumed plywood LCA dataset available from woodforgood database

Table 7 Class 2 (specialised or novel) and class 3 (locally produced low impact) data sources for Ireland

Class 2 or 3 product type	Available Data for Ireland
Precast Concrete products	Hollowcore slabs – Mannok (was Quinn) EPD Precast Cladding – Techcrete EPD Lightweight Blocks – CRH Roadstone EPD for Liteblock Aircrete – Mannok Aircrete block EPD Paving products - Kilsaran EPD Concrete rooftiles - Mannok EPD Fibre cement slates – Tegral EPD Concrete Bricks – No EPD
Screeds, Mortars etc	Cemfloor EPD by McGraths Masonry mortar - Kilsaran EPD
Insulation products:	PIR Insulation: Xtratherm PIR insulation EPD (EPD Ireland) Mannok PIR insulation EPD (EPD Ireland)
	Expanded Polystyrene (EPS) Insulation: KORE EPS insulation EPD (EPD Ireland) Mannok EPS insulation EPD (EPD Ireland)
	Ecocel cellulose insulation EPD (EPD Ireland)
Gypsum based products	Gyproc Gyptone (through EPD Ireland) Aquaroc (through EPD Ireland) Gyproc Wallboard (expired): https://www.environdec.com/library/epd582 Gyproc Fireline (expired): https://www.environdec.com/library/epd583 Gyproc plaster (expired): https://www.environdec.com/library/epd584
Paint	Graphenstone natural paint EPD (through EPD Ireland)
Construction materials common to Ireland:	Render; Natural stone;

	Insulation (Kingspan – PIR, Phenolic, VIP, EPS, XPS); Lime, for pointing/repointing/lime render (No specific information provided)

Table 8 EPD programmes for generic UK products, for application in Ireland

EPD Programme	UK Industry Average EPD
BRE EPD Verification Programme (UK)	**Brick Development Association** – EPD for average UK produced brick **Wood for Good** – EPD for UK grown and produced kiln dried sawn timber
IBU EPD Programme (DE) (5 EPD)	**British Precast** – 1 EPD for precast concrete pipe, 1 EPD for Hollowcoare flooring, 1 EPD for a T-beam **British Precast - Concrete Block Association** – 1 EPD for precast concrete block, 1 EPD for autoclaved aerated concrete block **British Precast – Interpave** – 1 EPD for precast paving **British Precast - Architectural and Structural** – 1 EPD for a concrete ground beam, 1 EPD for architectural cladding, 1 EPD for brick-faced cladding **British Ready-Mixed Concrete Association (BMRCA)** – 1 EPD for ready mix concrete

For updated data, please check https://asbp.org.uk/online-briefing-paper/epd-uk-products

Table 9 EPD programmes for generic UK products, for application in Ireland

EPD Programme with link	EPD from UK Manufacturers
BRE EPD Verification Programme (UK))	**Addagrip Terraco** – 1 EPD for resin bound surfacing **Aggregate Industries** – 3 EPD for aggregates **Altro** – 15 EPD for flooring products **Amtico** - 11 EPD for flooring products **Building Innovation** – 3 EPD for insulation Brett Martin Daylight Systems -3 EPD for rooflights **Celsa Steel** - 2 EPD, for steel rod and bar, and for steel section **Crown Paints** - 6 EPD for paint **Ecotherm** – 5 EPD for insulation **Etex** – 1 EPD for GTEC plasterboard **Falcon Panel Products** - 1 EPD for Resysta profile **Hambleside Danelaw** - 3 EPD for rooflights **Hanson UK** – 13 EPD for ready mix concrete Kingspan Insulation – 4 EPD for insulation **Kingspan** – 6 EPD for insulated panels **Knauf** - 4 EPD for stone wool insulation products **Midland Lead** – 1 EPD for cast lead sheet

EPD Programme with link	EPD from UK Manufacturers
	MW Insulation – 1 EPD for Supaphen phenolic insulation **Pasquill Saint Gobain** – 1 EPD for a timber roof truss **Polyfoam XPS** - 2 EPD for XPS insulation **PPG Architectural Coatings** – 12 EPD for Johnstone's paints **Pyroguard** - 1 EPD for safety glass **Saint Gobain PAM UK** – 4 EPD for municipal street products **SAS International** - 49 EPD for suspended ceiling systems **Sika** - 16 EPD for coatings and finishes Speciality Steel UK Limited/Rotherham Steel and Bar – 1 EPD for reinforcing steel from scrap **Tarmac** – 1 EPD for aggregate, 2 EPD for asphalt, 3 EPD for ready mix concrete **Texfelt** - 1 EPD for underlay **Xtratherm** – 1 EPD for PIR insulation, 1 EPD for phenolic insulation
International EPD programme	**AM Technology** – 1 EPD for Airlite paint **British Gypsum Saint Gobain** – 7 EPD for Gyproc plasterboards, 7 EPD for Thistle plasters, 3 EPD for Glasroc products, 1 EPD for Gypframe metal framing for plasterboard **Burmatex** – 20 EPD for carpet tiles **Clayworks** – 1 EPD for clay plaster **Hyten** – 1 EPD for steel reinforcement **Interfloor** – 1 EPD for acoustic insulation **Isaac Grainger and Son** – 1 EPD for raised access flooring **James Jones & Sons** – 1 EPD for JJI Joists **Kingspan Access Floors** - 11 EPD for raised access flooring **Knauf** – 2 EPD for glass wool insulation products **Norbord Europe** – 2 EPD for MDF and OSB **Optima Products Ltd** – 2 EPD for aluminium glazed doors and partitions **Protec International** - 3 EPD for Protec sheets **Shaw Contract** – 1 EPD for Ecoworx flooring **Squiggle Glass** – 1 EPD for magnetic glass panels **Vastern** – 1 EPD for 3 thermally treated timber products
IBU EPD Programme **(DE)**	**Armstrong World Industries** – 29 EPD for ceiling products **Assa Abloy UK** - 1 EPD for a Union cylinder lock **Milliken Industrials** - 6 EPD for carpet tiles
MRPI EPD Programme **(NE)**	**AkzoNobel Decorative Paints** – 32 EPD for Dulux paints **AkzoNobel International Paint** – 2 EPD for International intumescent paints
EPD Norge **(NO)**	**Accys Technologies PLC** – 1 EPD for Accoya timber decking

EPD Programme with link	EPD from UK Manufacturers
	Jotun Paints UK – 3 EPD for Steelmaster intumescent paint
Company Verified EPD programmes – Tata Steel EPD Programme	**British Steel** – 1 EPD for a steel product **Tata Steel** – 14 EPD for steel products **CA Group** – 1 EPD for steel cladding **Euroclad Group** – 2 EPD for insulated wall panel system

For updated data, please check https://asbp.org.uk/online-briefing-paper/epd-uk-products

Additional information

Political and industry context in Ireland

In 2019 the Irish Government published the Climate Action Plan setting out actions to be taken towards net zero by 2050, with an interim target by 2030. The Government publishes quarterly updates on progress.

The Plan notes that enterprise (industry) is responsible for 13.4% of emissions, which is less in percentage terms than the EU average, but similar to the EU per person average of industry emissions of 1.7MTCO2e. Manufacturing combustion is responsible for the majority of these emissions, with the mineral industry (mainly cement production) having the second major impact. These two emissions are closely linked to the economic environment, dropping by a third during the recent recession but having risen again to pre-recession levels since then. It is assumed that these emissions don't include imported materials.

The construction sector is not mentioned as a specific industry or sector in the Plan. The sections on buildings and the built environment focus mainly on energy use in buildings. However the Plan encourages specific changes which will affect the construction materials sector including:

- Increased use of timber in construction from local forestry
- reduction in waste production, including from construction
- a focus on retrofit of existing homes, schools and public buildings
- expanding the use of alternative fuels in cement manufacture

The Executive Summary includes under 'Enterprise and services' (p12):

'Embed energy efficiency, replacement of fossil fuels, careful management of materials and waste, and carbon abatement across all enterprises and public service bodies'

However it also states (p10) that only 'the lowest savings are from segments of the Enterprise sector. The aim is to pursue the pathway with the least burdens and the greatest opportunities.'

Ireland has also passed the Low Carbon Development Bill, which in law requires 7% annual reductions, and carbon neutrality by 2050 with an interim focus on 2030. Decarbonisation ranges and budgets are also stated, with 5 year budgets and individual sectoral ranges.

The Environmental Protection Agency (EPA) in Ireland currently requires all significant manufacturing facilities to hold an Industrial Emissions/Integrated Pollution Control (IE/IPC) licence, and to report fossil fuel use and greenhouse gas emissions. These are open access (though some information may be redacted) and therefore should provide a useful source to identify for example the type, and potentially the amount of fuel used in the manufacture of materials and the waste produced. However in practice it was difficult to find specific data for individual companies researched, and there is no collated database which provides information across a specific material or sector. The database is searchable by the name of the company rather than by more general serach terms.

The Construction Industry Federation (https://cif.ie/about/) is the industry representative body.

Ireland is currently in a changing and uncertain period. Before Brexit, trade in construction materials with Northern Ireland in particular, and with Great Britain, was extensive, but this seems likely to change.

Brick

Around 75million bricks are used each year in Ireland of which around 8 million clay bricks are produced in Ireland. About 4 million of the bricks used are concrete, manufactured by Roadstone, and Atcheson and Glover. The rest are imported currently mainly from the UK but also Europe.

EPD certification is currently under way. Positive changes so far towards reducing emissions and waste include changes to the clay and voids allowing slightly lighter bricks, and changes to packaging. Palletless packaging has lost 25,000 pallets and instead using packaged brick bales, which has reduced wastage. Materials are recycled on site.

Drivers for reduction come from the parent company and from regulations from UK mainland and Europe. Other drivers for innovation include the cost of transport, pallet prices, and the low sulphur surcharge on shipping fuels.

The current fuel used is natural gas, but there is a five year business plan to look at alternative fuels.

Timber

Coillte is the main fibre supplier, and supplies the timber industry in the Republic of Ireland and Northern Ireland with pulp wood, small sawlogs and large sawlogs. Coillte also produces engineered wood panel products through the brands ‘Medite’ (MDF) and ‘Smartply’ (OSB).

For the determination of carbon values for timber products, specifiers typically use generic data from the ICE database, but there is an appetite by the forest products sector for developing specific values, and Medite and Smartply products already have EPDs.

Species grown commercially for structural timber grading in Ireland are currently almost entirely Sitka spruce. Approximately 95% is graded as C16; there is the technical potential for producing the higher grade C24 timber, but this must be balanced against the expected sawn board yield and the economics of production. Machine settings have recently been developed for Douglas fir and larch within the WoodProps programme at NUIG, so these species can now be machine graded, producing higher yields for strength classes like C24.

Annually around 1,065 thousand cubic metres of sawn timber is produced in the Republic, of which approximately 50% is used in construction pallet and packaging and fencing applications , and about 50% exported, mostly to the UK. About 315 thousand cubic metres sawn timber is also imported, predominantly from Sweden and central Europe. About 3.3 million cubic metres of logs are produced. A paper by Knaggs and O’Driscoll (2018) supports these figures.

Of about 22,000 (housing) units built in 2019, about 5,000 were timber framed (with masonry outer leaf).

There is some cross-border trade with both logs and sawn timber being traded between the two jurisdictions.

Table 10 Major timber sawmills in Ireland

Size	Sawmill name	Location	Website
Large	Balcas Ltd	Enniskillen, Co. Fermanagh	www.balcas.com
Large	ECC Timber Products Ltd./Earraí Coillte Chonnacht Teoranta	Corr Na Móna, Co. Galway	www.ecc.ie
Large	Glennon Brothers Ltd.	Longford, Co. Longford Fermoy, Co. Cork	www.glennonbrothers.ie

Large	GP Wood Ltd.	Enniskeane, Co. Cork Lissarda, Co. Cork	www.gpwoopd.ie
Large	Murray Timber Group (MTG)	Ballygar, Co. Galway Ballon, Co. Carlow	www.mtg.ie
Medium	Coolrain Sawmills Ltd.	Coolrain, Co. Laois	www.gardendeckingfencing.ie
Medium	Laois Sawmills Ltd.	Portlaoise, Co. Laois	www.laoissawmills.com
Medium	Woodfab Timber Ltd.	Aughrim, Co. Wicklow	www.woodfabtimber.ie

Transport Infrastructure sector

In 2018, Transport Infrastructure Ireland (TII) developed its own country-specific carbon assessment calculation tool to ensure compliance with the EIA Directive. The devised tool is used for assessing both “embodied” and “operational carbon” and is required for all future national road and light rail projects.

The features and benefits of the tool are as follows:

- It is primarily used by designers as part of activities leading up to the design and statutory procedures for new road and light rail projects and is aligned to integrate with the existing planning and design cycle
- Its outputs allow TII and scheme designers to compare and evaluate the lifecycle carbon impacts of multiple design options
- It facilitates carbon assessment at the planning, construction, operational and maintenance phases as well as decommissioning and disposal.

The tool is designed with flexibility and longevity in mind; for example, to allow TII to update the emission factors, as and when more country-specific data becomes available. For example, material-specific data (e.g. from Environmental Product Declarations) and Ireland-specific energy or transport emissions can be added to the tool as part of any update.

As well as measuring the carbon impact of schemes, the tool considers and record carbon savings. This is intended to be used to track savings that can be successfully implemented in the design to demonstrate climate change mitigation.

To-date, the tool has successfully been piloted on a number of TII road projects. The immediate objective is to further enhance the tools functionalities so that it becomes a fully embedded part of the procurement and design process.

The tool is, therefore, currently undergoing further upgrades. The tool’s further development will enhance its alignment with the EPA Green Procurement Guidance for the Public Sector 2014, in the way that it facilitates the identification and selection of solutions that have a reduced impact on the environment throughout their life-cycle, as compared to alternative products/solutions. The tasks, currently underway, include:

- TII is enhancing the tool to facilitate the transition to a circular economy and its sustainability policies. This will further facilitate TII’s commitment to incorporate sustainability principles into the development and operation of the national road and light rail network.
- A benchmarking exercise that will examine typical carbon emission associated with road and light rail projects. This information can then be used to set targets for Carbon savings in particular projects.
- A review and upgrade of the most recent carbon emission factors (this is expected to be an ongoing requirement as further emission factors are published in Ireland).

• A review of how the maintenance programs and cycles can be more accurately reflected in the tool.

These upgrades will be completed by the second quarter of this year and Version 3 of the tool will be delivered.

3.5. Country specific information: Italy

Main data sources in Italy

The Italian LCA network, section Buildings and Construction (http://www.reteitalianalca.it/gruppi-di-lavoro/edilizia-e-climatizzazione/obiettivi-specifici) deals with issue related to the LCA in building and construction sector.

Sources include: EPDItaly, Rete Italiana LCA, Universities, Accredia, FIVRA members, AITEC (category association of Italian cement), some manufacturers of raw materials and/or building products (eg. MAPEI, San Marco, Saint Gobain, and other companies such as Italcementi, Buzzi Unicem, Kerakoll, Knauf, Mapei, Fassa Bortolo.

https://www.epditaly.it/view-view-epd/

https://ibu-epd.com/en/published-epds/

In the last few years several product-specific EPD studies have been made. In Italy almost all key products have a reference association that collects and publishes statistics on its sector.

Other sources giving data for production and trade are:

http://epp.eurostat.ec.europa.eu/newxtweb/

http://dati.istat.it

ENEA provides data on energy intensity per sector: https://www.enea.it/it/seguici/pubblicazioni/pdf-volumi/rea2000-dati.pdf

ISPRA provides data on CO2 emissions per sector: https://www.isprambiente.gov.it/files2018/pubblicazioni/rapporti/Rapporto_295_2018.pdf

Construction specific information is at: https://www.isprambiente.gov.it/it/pubblicazioni/ and https://www.istat.it/it/industria-e-costruzioni

Table 11 Class 1 product data sources for Italy

Class 1 product type	Available Data for Italy
1 CEM I	AITEC have produced sector EPD for CEM I in the EPD Italia Programme. Federbeton: statistics on sustainability of cement. Documents of interest: Rapporto di sostenibilità (Sustainability reports) where emissions, consumed and recovered energy and so on are quantified. AITEC: import/export of cement. Documents of interest: Notizie statistiche (Statistics) that reports data on import/export of cement. Federbeton https://www.federbeton.it/ AITEC https://www.aitecweb.com/Pubblicazioni. https://www.cemnet.com/global-cement-report/country/italy AICAP : http://www.associazioneaicap.com/

2 CEM II cement	AITEC have produced sector EPD for CEM I in the EPD Italia Programme.
3 CEM III cement	AITEC have produced sector EPD for CEM I in the EPD Italia Programme.
4 Average Cement	Unknown
5 Aggregates	Unknown
6 Steel	Federacciai: statistics on steel production. The data refers to the world of steel in Italy; few statistics are available on steel in building and construction sectors. Federacciai http://federacciai.it/ https://www.promozioneacciaio.it/cms/it1-home.asp There are some EPD for Italian produced steel.
7 Aluminium	Assomet: statistics on the production, import/export and other information. http://www.assomet.it/.
8 Glass	Assovetro: the association has recently published the first sustainability report. Assovetro https://www.assovetro.it/
9 Brick	Andil: the association provides statistics on the Italian market in bricks. http://www.andil.it/servizi/centro-studi.html There are some EPD for Italian produced brick.
10 Timber	Federlegno-Asssolegno: the association gathers all producers of wood products. Specific sections are dedicated to wood in building sector such as, structural wood, wooden houses and so on. An Institute of CNR, IVALSA now IBE, deals with research on the wood chain. They could provide useful information. Federlegno-Asssolegno https://www.federlegnoarredo.it/it/associazioni/assolegno https://www.lignius.it/ https://www.promolegno.com/tecnologie There are some EPD for Italian produced timber products.

Table 12 Class 2 (specialised or novel) and class 3 (locally produced low impact) product data sources for Italy

Class 2 or 3 product type	Available Data for Italy
Ceramic tile products	CONFINDUSTRIA CERAMICA: http://www.confindustriaceramica.it/site/home.html Note from CC: 'It is important to consider that the ceramic tiles sector is characterized by heterogenic products with a wide variability of thickness (0.3-30mm) and shapes. Therefore, it is not representative to draft a product benchmark as the technical and mechanical characteristics and environment performance have a wide range. This also applies to bricks and roof tiles.' Industry wide EPD for Italian ceramic tiles, plus publicly available EPDs done by individual companies for the brick, roof tile and ceramic tile sectors,

	mainly available in the libraries of Program Operators EPD Italy and IBU http://www.confindustriaceramica.it/site/home/articolo8548.html Up to date environmental data for ceramic tiles can be found at the following links: https://ambiente.regione.emilia-romagna.it/it/sviluppo-sostenibile/approfondimenti/documentazione/documentazione-aia http://www.confindustriaceramica.it/site/home/aree-e-servizi/ambiente/articolo9015.html The ceramic tile industry worldwide publishes on the UL SPOT library for the US market: https://spot.ul.com/main-app/products/detail/5ae3516b55b0e812b4f0e6dd?page_type=Products%20Catalog
Insulation products:	AIPE is the association of EPS in Italy. It provides data in the impact of EPS in building sector, durability, etc. AIPE https://www.aipe.biz/mondo-eps/edilizia/edilizia/ FIVRA is the association of mineral wool. Some information is available on their website. FIVRA http://www.fivra.it/ ANIT is the association of insulation material. ANIT https://www.anit.it/ A 2013 report gives a snapshot of the situation in Italy: https://www.anit.it/wp-content/uploads/2016/08/2014_02_18-Rapporto_Anit2013_febbraio_2014.pdf There are some EPD for Italian produced insulation products.
Gypsum based products	Assogesso: the association of gypsum is the mirror of the European association Eurogypsum. In the website, some information about the life cycle of gypsum and gypsum plasterboard are provided but no specific quantitative data. Assogesso http://www.assogesso.it/ There are some EPD for Italian produced gypsum products.
Other materials (no specific information provided)	Finishes (plasters, paints and varnishes) Insulation materials including atural insulants (cellulose, sheep wool, cork, etc.) Specific solutions for green systems (green roofs, green façades, living wall, etc.): ○ growing media ○ drainage/accumulation layers ○ integrated hydroponics systems Membranes (bituminous, pvc, epdm, etc.) Stone materials (granite, marble, slate, etc.)

Specialised or novel materials (no specific information provided)	Innovative high-performance materials (for example based on the integration of nanotechnology) Innovative solutions integrating photovoltaic cells PCM Aerogel
Other trade associations	UNCSAAL association of metallic curtain walls and windows http://www.unicmi.it/uncsaal_srl.html FEDERCHIMICA: https://www.federchimica.it/

Additional Italian EPD for specific products

This is provided in Appendix 3.

National fuel mix and primary energy factors (PEF) for electricity for Italy

GSE publishes the national fuel mix every year (https://www.gse.it/servizi-per-te/fonti-rinnovabili/fuel-mix/documenti).

The following table provides a summary of primary energy factors in Italy, compared with those provided by EN ISO 52000 and other member States (MS).

Table 13 Primary energy factors in Italy

Source	Carriers								
	Fossil fuels			Biofuels			Electricity	DH/DC	RES
	Solid	Liquid	Gas	Solid	Liquid	Gas	-	-	-
EN 52000 (non ren)	1.1	1.1	1.1	0.2	0.5	0.5	2.3	1.3	0.0
EN 52000 (tot)	1.1	1.1	1.1	1.2	1.5	1.5	2.5	1.3	1.0
MSs	1.0 ÷ 1.46	1.0 ÷ 1.23	1.0 ÷ 1.36	0.01 ÷ 1.1	0.01 ÷ 1.1	0.01 ÷ 1.26	1.5 ÷ 3.45	0.15 ÷ 1.5	-
Italy (non ren)	1.1	1.05 ÷ 1.07	1.05	0.2	0.4	0.4	1.95	0.5 ÷ 1.5	0
Italy (tot)	1.1	1.05 ÷ 1.07	1.05	1.0	1.0	1.0	2.42	0.5 ÷ 1.5	1.0

Official energy statistics are available on the Bilancio Energetico Nazional, and the emissions on the European Registry:

https://dgsaie.mise.gov.it/ben.php

https://dgsaie.mise.gov.it/ben.php

https://ec.europa.eu/clima/policies/ets/registry_en#tab-0-1

Additional information

Context

The construction market in Italy is characterized by small or micro enterprises. This feature needs to be considered when/if the construction phase is analysed. Transportation is an important variable. In setting the framework of the Italian LCI database, ITC-CNR defined average distances

by dividing Italy in three macro-regions and choosing the most appropriate transport. Most construction products are made in Italy. All the 10 key products are produced in Italy. However, much of the supply chain is frequently non-Italian.

Italy has a great tradition in the production of cement and bricks - plants are found throughout Italy. Production of glass for buildings is around 1 Mtonnes. Production of timber products is widespread in Italy and especially localized in northern and central regions. Gypsum and gypsum plasterboards are produced in Italy, as is steel and aluminium. Italian and international factories produced insulation materials in Italy, but the main production site of multinational companies are outside national boundaries. For example, most mineral wool products are made abroad; in Italy there are only two production plants. There are some imports, such as in the ceramic tile sector, as given in the Confidustria Ceramica annual statistic report.

Construction types

In order to specify new thermal and energy parameters for energy-efficient buildings in Italy, ENEA has defined a series of reference buildings based on statistics for the Italian building stock and selected samples.

Up to 1991 office buildings were mainly built with concrete, and brick masonry. Buildings constructed before 1920 were in load-bearing masonry; reinforced concrete bearing structures became widespread after 1960. After 1970, precast concrete frames and aluminium windows began to be widely used for office buildings. Up to 1970 most windows were timber framed. After that date the percentage of building with glass curtain walls increased, but these were never as common as the other typology. Starting from the 70s, but especially after 1991 construction projects paid attention to energy issues, using insulation materials in the building envelope.

Ref: Office (F. Margiotta, G. Puglisi (2014) RSE. Caratterizzazione del parco edilizio nazionale Determinazione dell'edificio tipo per uso ufficio.)

Commercial buildings are mainly built with a reinforced concrete bearing structure and multi-layered insulated concrete walls. Roofs and basements are precast concrete slabs. Glazing systems consist of aluminium frame double glazing windows or glazing curtain walls.

Ref: Retail, mall, etc. (A. Bellazzi, I. Meroni (2009) RSE. Definizione degli indici e dei livelli di fabbisogno dei vari centri di consumo energetico degli edifici e valutazione dei consumi nell'edilizia esistente e benchmark mediante codici semplificati)

Most Italian schools are built with concrete and brick masonry. Buildings built before 1920 were in load-bearing masonry. Reinforced concrete bearing structures became widespread after 1960. Up to 1970 most windows were timber framed. After 1970, precast concrete frames and aluminium windows began to be widely used for large school buildings. In recent years, timber has also been used for schools. Starting from the 70s but especially after 1991, construction projects paid attention to energy issues, using insulation materials in the building envelope.

Ref: Schools (S. P. Corgnati, E. Fabrizio, F. Ariaudo, L. Rollino (2010). Edifici tipo, indici di benchmark di consumo per tipologie di edificio, ad uso scolastico (medie superiori e istituti tecnici) applicabilità di tecnologie innovative nei diversi climi italiani).

More than half of residential building were built before 1970, in load-bearing masonry. After 1980, buildings with concrete load bearing and brick masonry became the norm. The typical glazing system for all time periods is timber framed windows.

Ref: Residential buildings (V. Corrado, I. Ballarini, S. Corgnati (2012). National scientific report on the Tabula Activities in Italy)

Further data sources

Additional construction materials data sources for Italy are provided in Appendix 3.

3.6. Country specific information: Croatia

Main data sources

There are very few examples of country-specific LCA data in Croatia. One such is the EPD for the innovative Eco-sandwich panel developed at the University of Zagreb.

Some companies in the survey have EPDs for their products which have been developed for other markets, including Holcim – Czech Republic and Austria, and Mapei - Italy

The only more comprehensive database that was mentioned by Croatian stakeholders was GaBi, with the suggestion that it could be adapted from German to Croatian conditions.

The Croatian Ministry of Environment and Energy produce a National Inventory Report each year providing details of greenhouse gas emissions for different sectors and, their make-up.

Additional information

Context

Participants felt strongly that Croatia was lagging other countries in the adoption of LCA. The main reason cited for this was lack of customer demand, intertwined with lack of regulatory requirement for such calculations. Within the construction profession, there is little familiarity with LCA beyond discussion of the concept. However, several LCA tools were referenced by participants: SimaPro, GaBi and in-house cradle-to-cradle calculations. Besides these, other tools to assess building performance in terms of cost and/or sustainability were mentioned, notably BREEAM and LEED (German version - DBMG); Pipelife; and PPP Centre's LCC tool. For particular products, the German DIN standards and Blue Angel mark were mentioned as an examples of technical performance and quality assurance.

Energy mix: in Croatia, there is increasing use of electricity generation from renewables (current figure given as 43%), and is now accepted as the norm for M&E. Renewables mostly hydro but with growing amounts of solar and wind – particularly for island locations

However, the point was also made that the Austrian or German primary energy mix would be more relevant for the many materials that are imported from those countries.

EU regulations for emissions are a possible source for thermal data. Holcim uses 60% thermal energy from coal and coke; and 40% from waste sources including tyres, emulsifiers, refuse-derived fuel and oil waste.

Market

The public sector has the predominant role as a developer: '60-70% investment from public financing – probably more since tourism investment dried up in 2020 because of Coronavirus'.

A further driver is 'commercial real estate, with multi-national players who want a standard across development in different countries. EU initiatives are bringing change, increasing energy efficiency in projects co-financed by European funds. An example is renovation of multi -family housing – this increased the awareness of the general public about sustainability. This could be transferred to awareness of materials properties, then LCA.'

Building materials

The Croatian building materials industry is closely linked to that of neighbouring countries. Holcim – one of three cement producers – reports that it exports 30% of its production in Croatia to Slovenia, Italy and Bosnia-Herzegovina. Simultaneously, 20% of the country's cement needs are met by imports.

Most construction uses traditional materials. Stakeholders report that there is some national production of bricks, clay tiles, different concrete products, wall panels, flooring. Two suppliers make pre-stressed elements, mostly for industrial buildings. There is good quality timber that is mainly exported. Steel possibly still produced in 1 plant (at Sisak), but not aluminium. Glass bottles are produced, maybe some glass elements in Zagreb.

Larger commercial projects, often developed by multinational companies, import a wide variety of more high-tech materials. New plants have recently been established to expand production of materials such as of insulation, and there is prototype production of some innovations such as the University of Zagreb's Eco-sandwich and Eco-tech products.

Additional Croatian EPD for specific products

Additional construction materials data sources for Croatia are provided in Appendix 4.

3.7. Classification of data availability for Ireland, Italy and Croatia

Table 14 Proposed Classification system for data availability

Production for country	EPD Data for country
1 No production in the country 2 Production in the country, but significant imports (over 25%) 3 Production in the country, some imports (<25%) 4 Production in the country, minimal imports	A No EPD B Only national sector EPD/data C Only European Sector EPD/data D Only global EPD/data E National or European sector EPD and some specific EPD for the country F EPD for <25% market G EPD for <50% of market H EPD for < 80% of market I EPD for >80% of market

Table 15 Classification for Products by Country

	Croatia	**Ireland**	**Italy**
Cement	4C	4C	3 E national
Aggregates	4A	4A	4F
Concrete – readymix	4A	4A	4 F
Concrete - precast	3A	4F/G	4 F
Steel	2A	1A	3F
Primary Aluminium	1A	1A (but alumina produced and exported)	1 C/D (but revamped plant due to restart production in 2021)
Glass	1A	1A	3 F
Brick	2A	2A	4F
Timber	3A	2G	2F

4. Generic data for class 1 products

4.1. Introduction

This section identifies and summarises existing EPD data for the set of ten class 1 common and high impact materials. This data is not specific to individual countries but can be used to develop generic data sets where necessary.

The following subsection gives results of the collated and analysed EPD for the class 1 products.

4.2. Average cement, CEM I, CEM II, and CEM III

Anderson and Moncaster's 2020 paper provided an indication of the range of GWP for different types of cement (Figure 1), and the influence of energy use clinker content on this (Figure 2). Figure 3 shows the variation in GWP caused by different clinker contents for all types of cement.

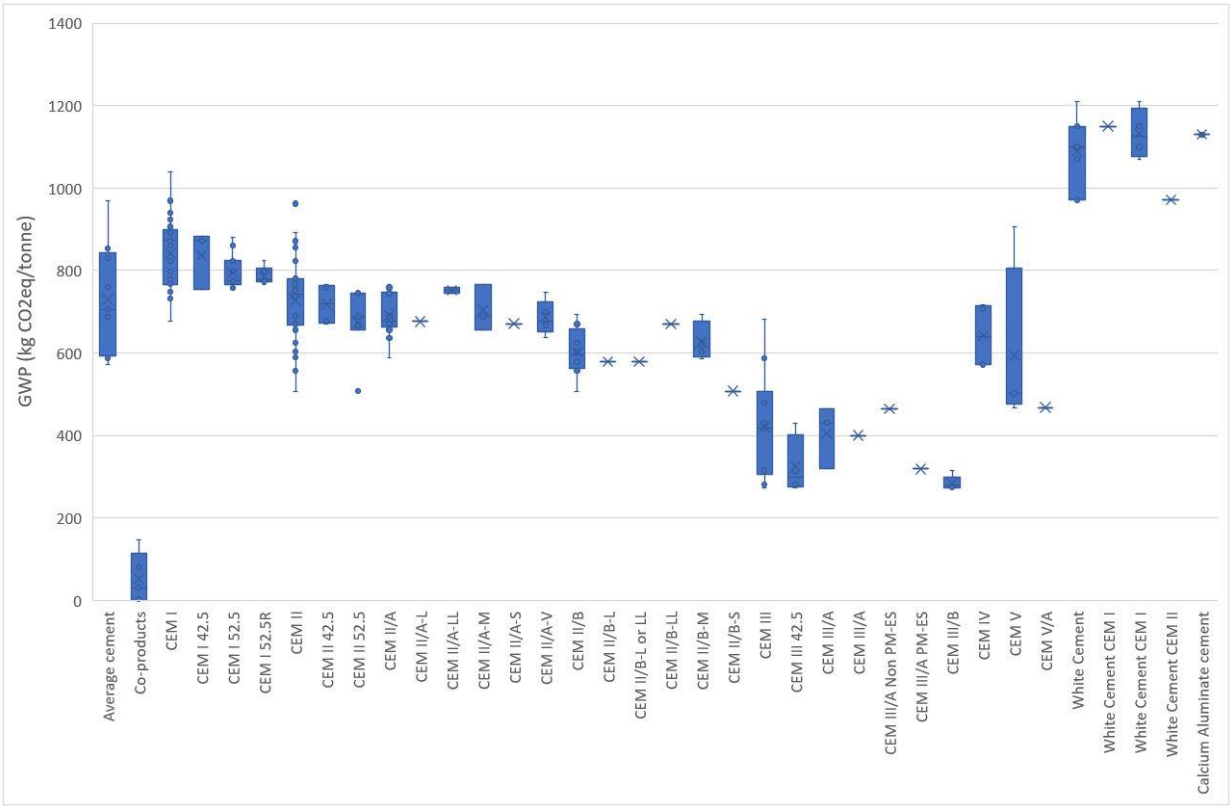


Figure 1 Variation in GWP (A1-A3) for different cements (Anderson and Moncaster, 2020)

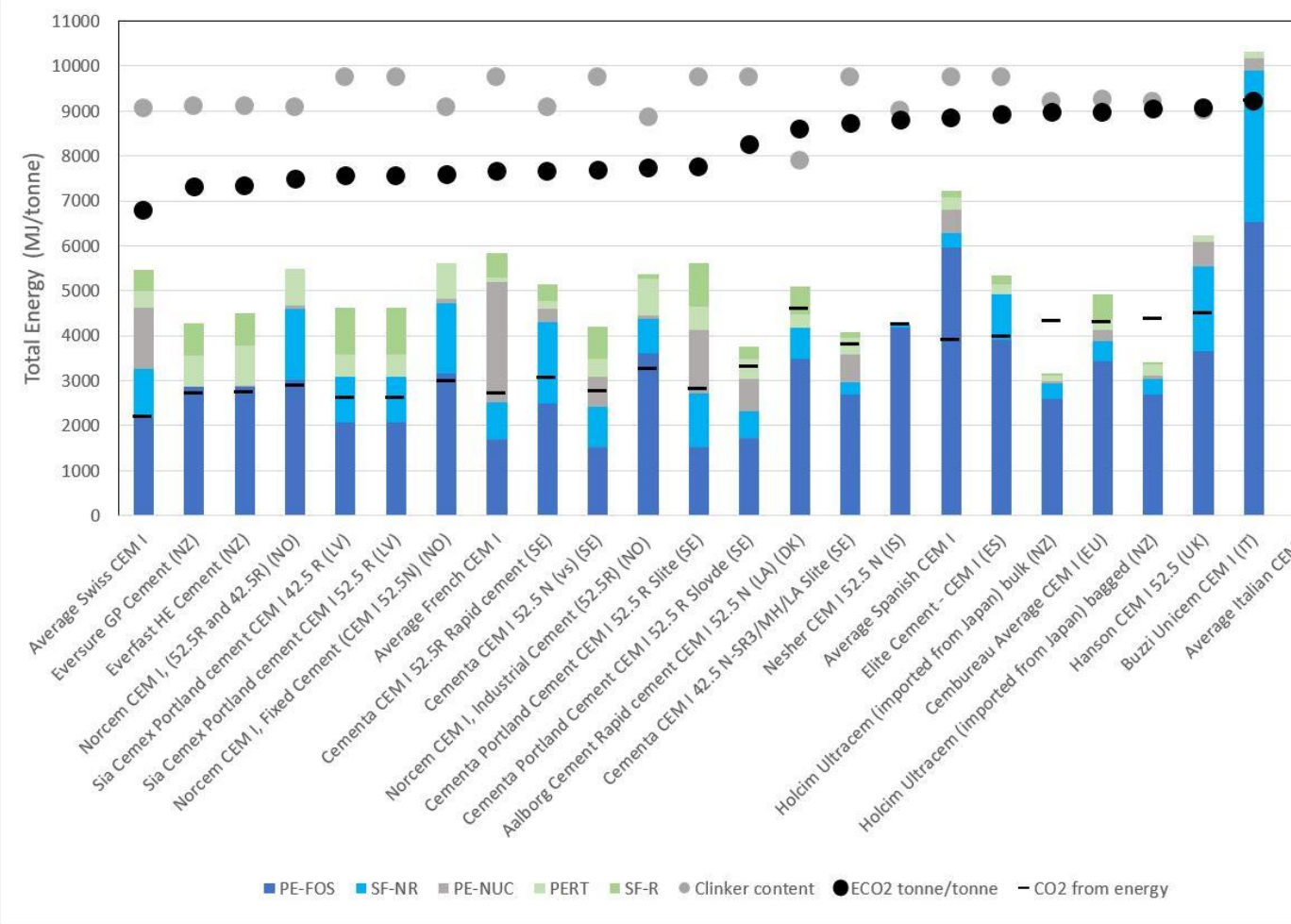


Figure 2 GWP, Energy Use and Clinker content for CEM I cements (Anderson and Moncaster, 2020)

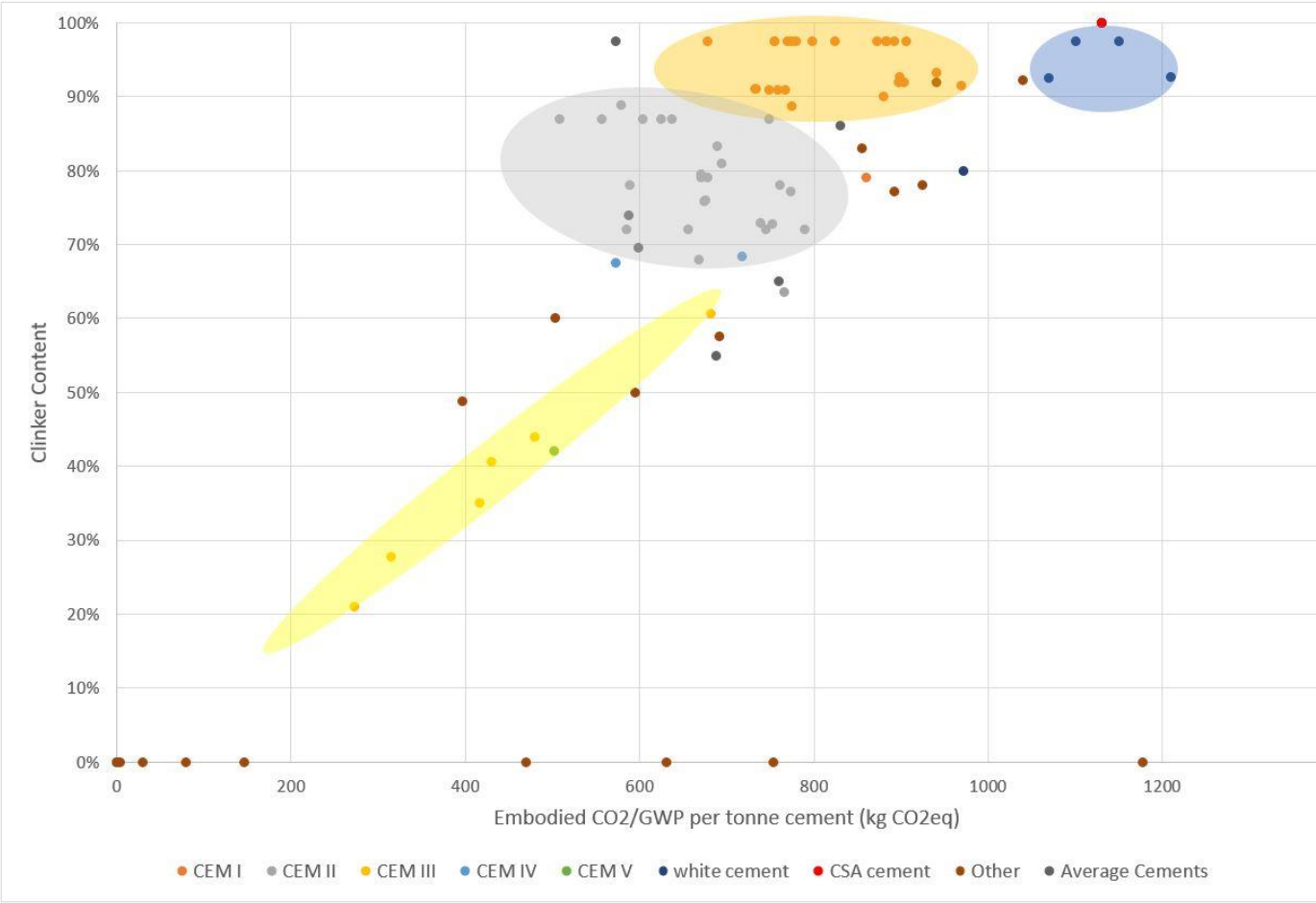


Figure 3 Clinker content v GWP (A1-A3) for different cements (Anderson and Moncaster, 2020)

4.3. Aggregates

Anderson and Moncaster (2020) also provided data for aggregates by type as reproduced here.

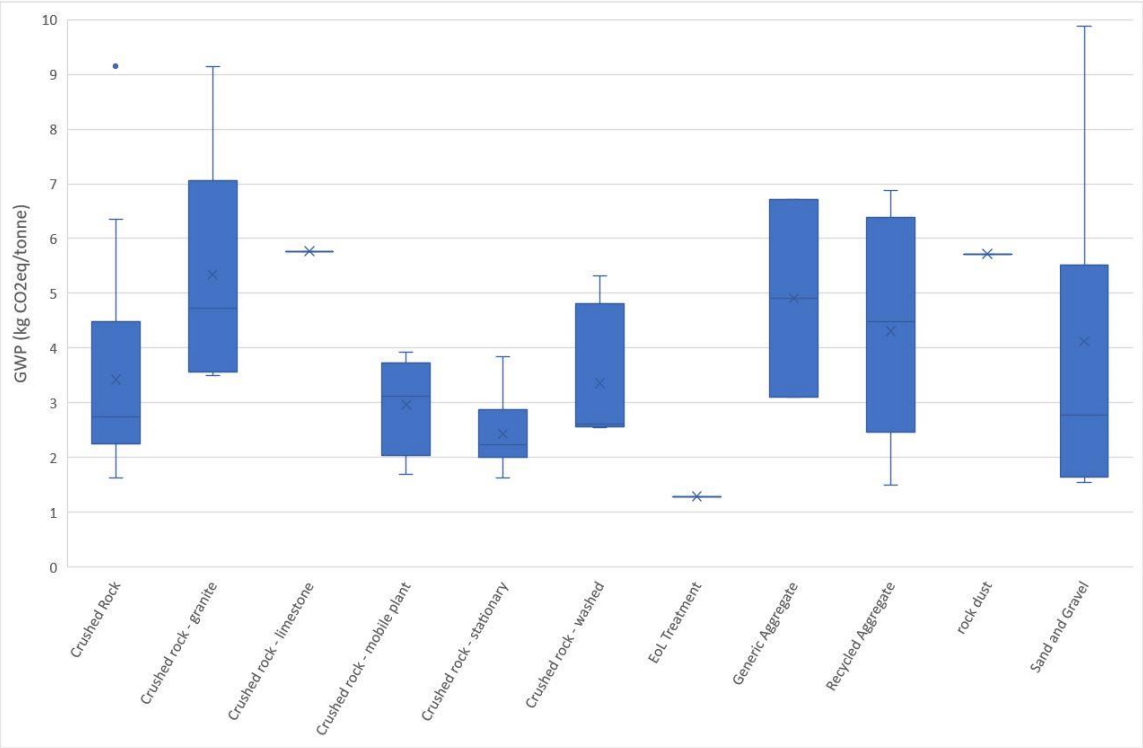


Figure 4 GWP of Normal Aggregate by type (Anderson and Moncaster, 2020)

4.4. Steel

Figure 5 shows that there is a strong correlation between the GWP impact of steel and the amount of non-renewable energy used. It can also be seen that steels with high recycled content tend to have lower impacts than those with low recycled contents - this is more clearly shown in Figure 6.

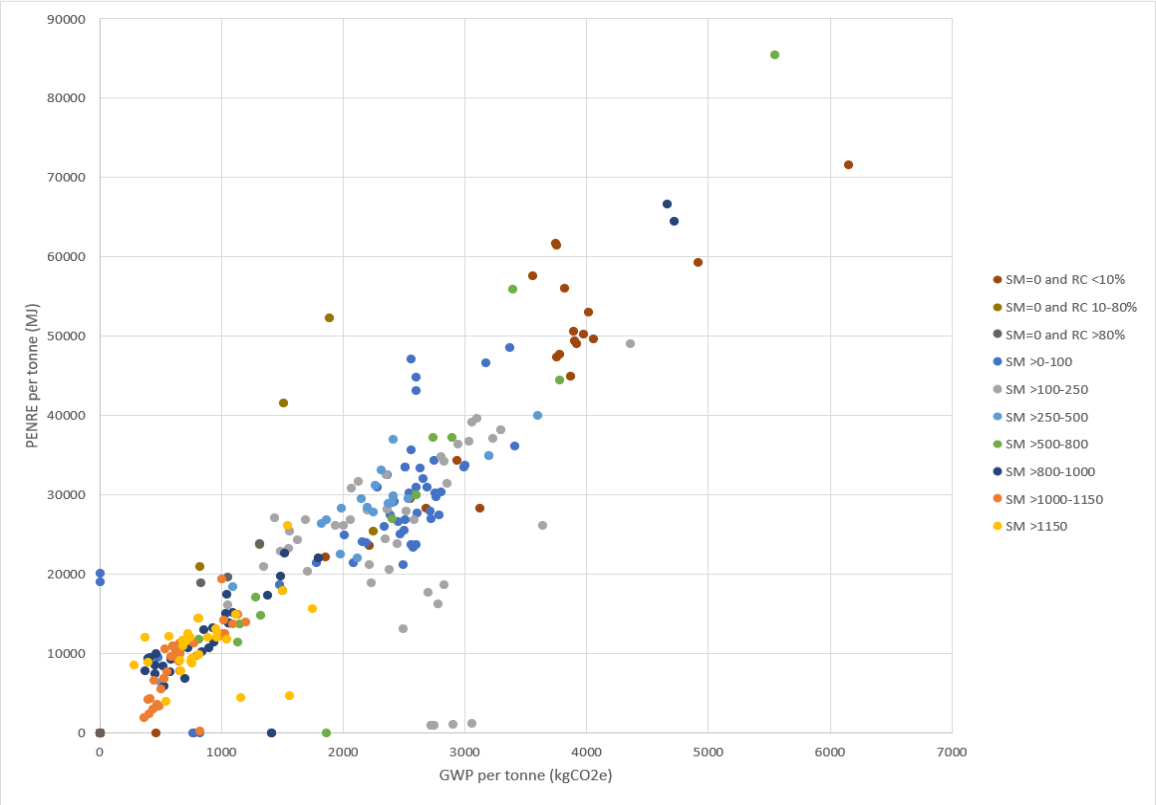


Figure 5 PENRE energy consumption v GWP for steels by recycled content or use of secondary material

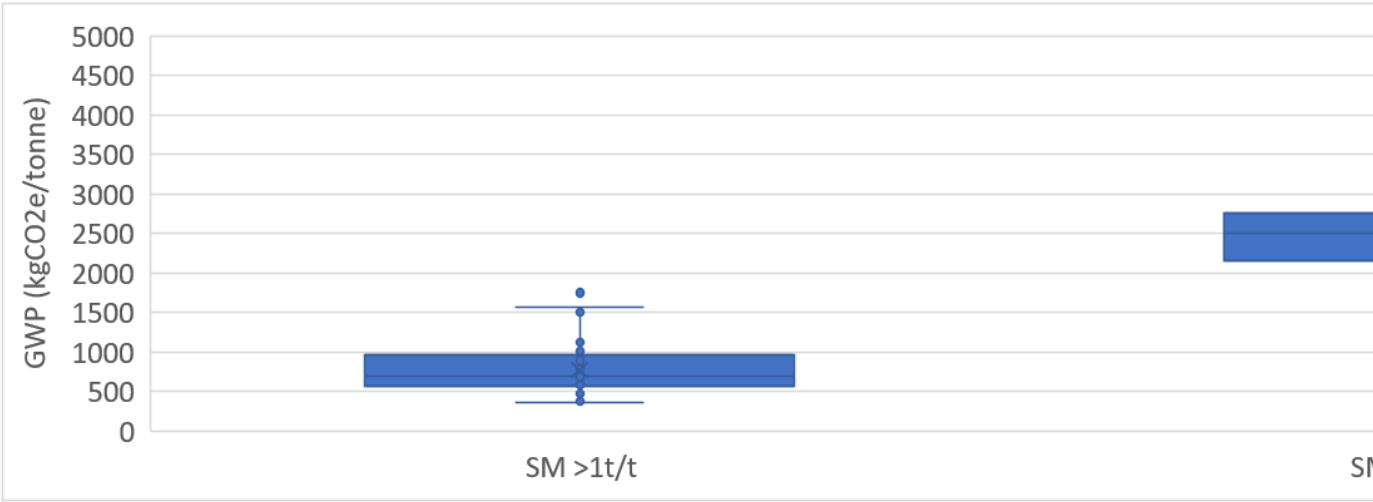


Figure 6 GWP (A1-A3) for steel EPD grouped by reported use of secondary material

4.5. Aluminium

Figure 7 shows that there is a clear correlation between the GWP for aluminium and the use of non-renewable primary energy. There is not so much obvious link between the use of high recycled content and impact, as many virgin aluminium products use high proportions of renewable energy, although all the products with high GWP have small proportions of recycled content.

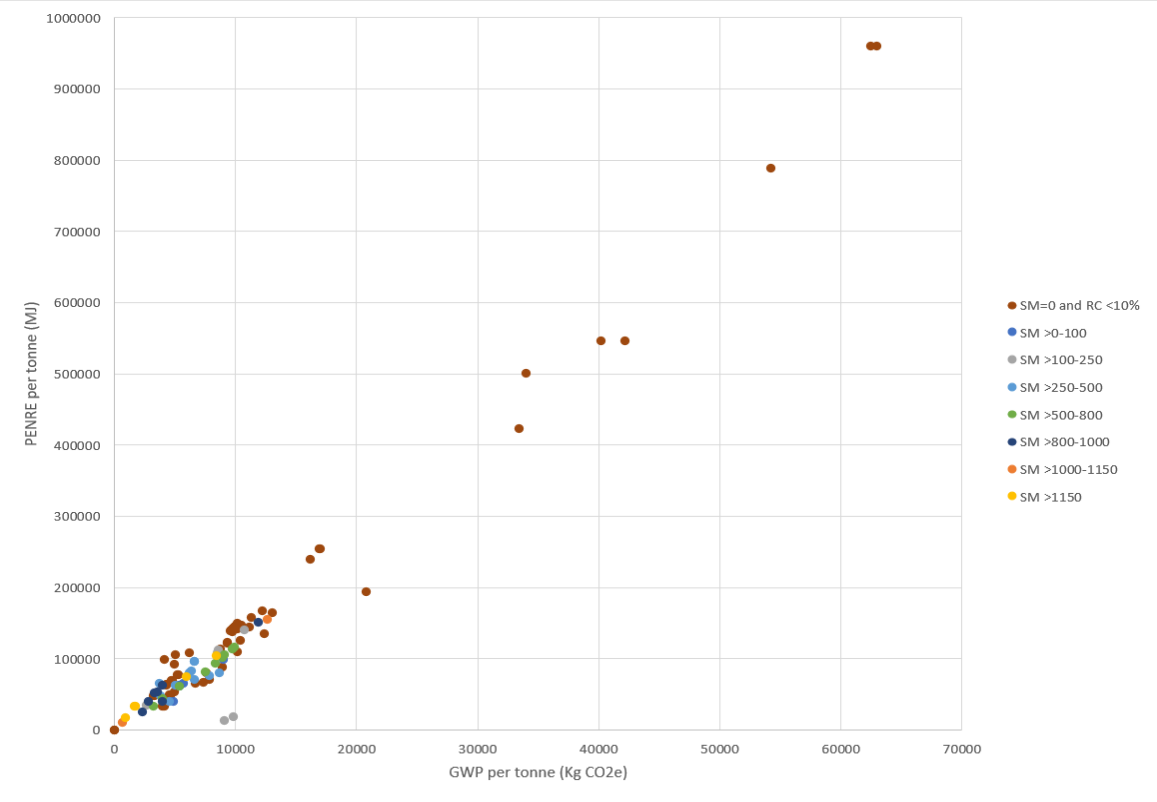


Figure 7 Use of non-renewable primary energy v GWP (A1-A3) for aluminium, grouped by use of secondary material

4.6. Glass: showing GWP v PENRE per tonne for different product types

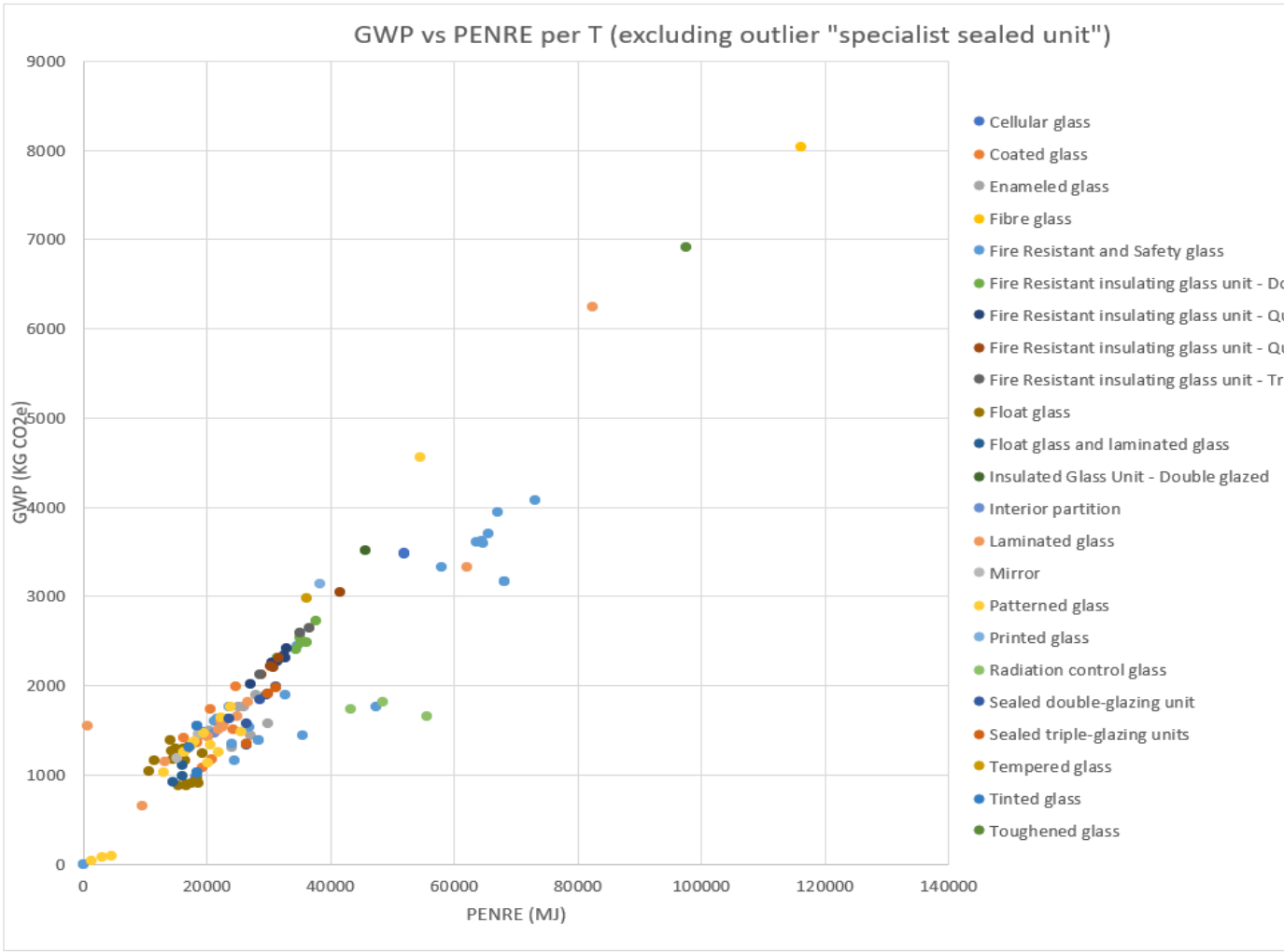


Figure 8 GWP (A1-A3) v. non-renewable primary energy v for glass products

4.7. Brick: showing GWP v PENRT+NRSF per tonne by product type

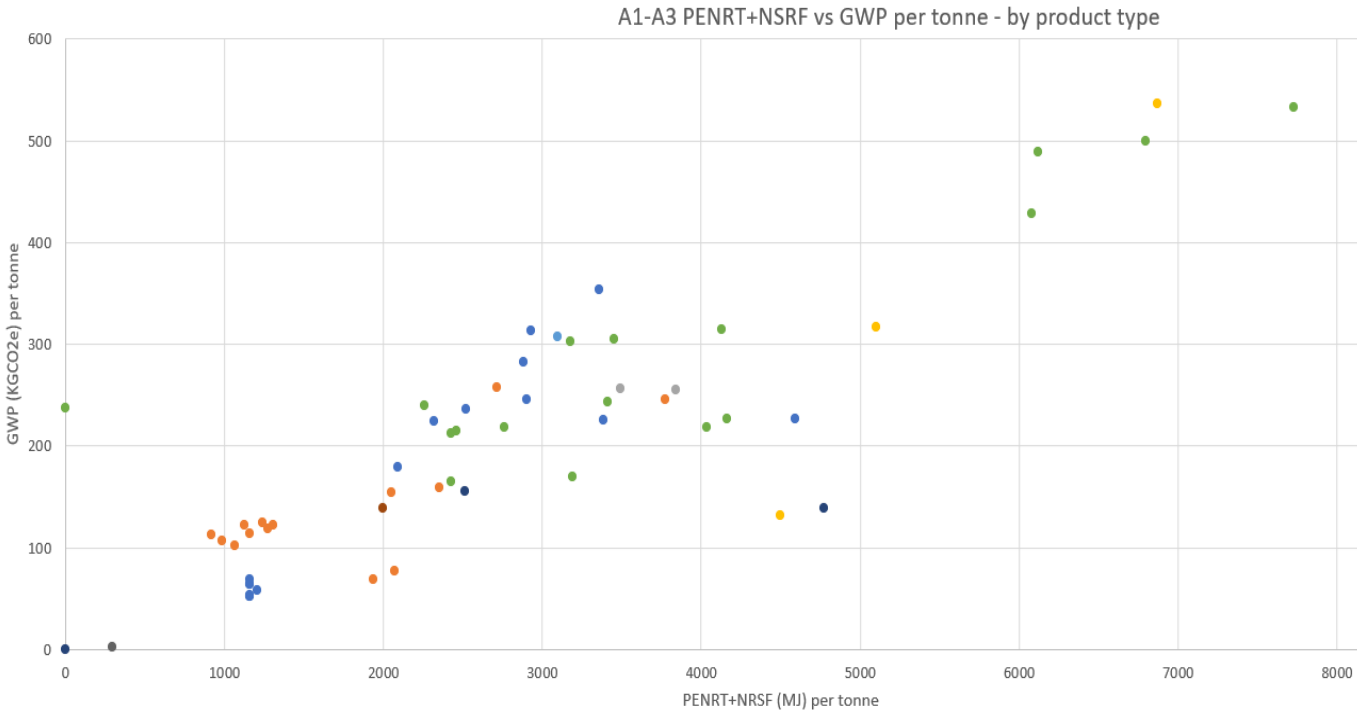


Figure 9 GWP v PENRT+NRSF per tonne for brick products

4.8. Solid Timber: showing GWP v PENRE+NRSF per m3

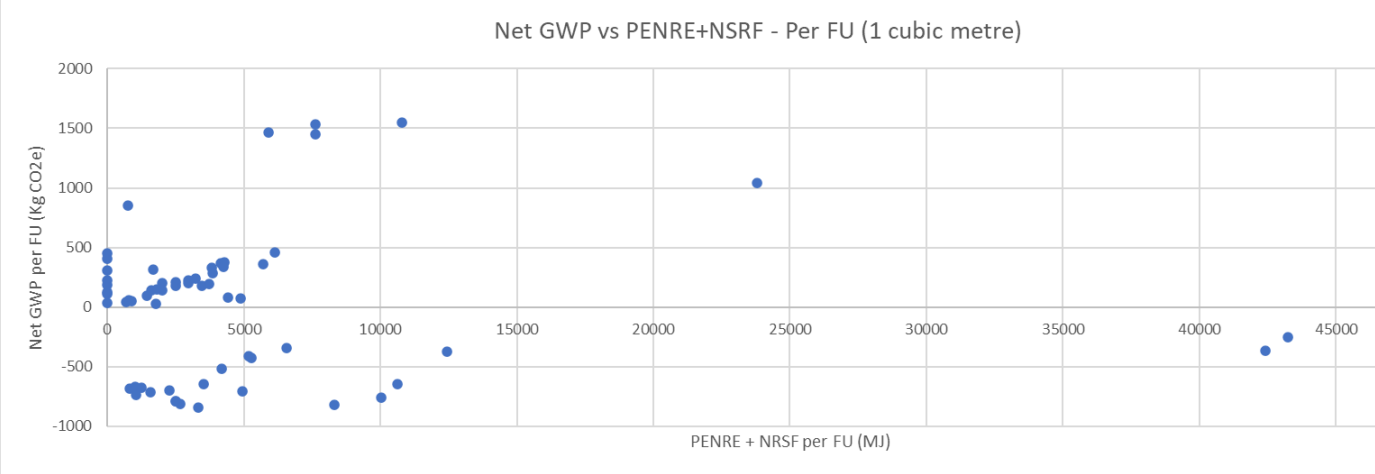


Figure 10 GWP v PENRT+NRSF per m3 for solid timber

4.9. Timber panel products: showing GWP v PENRE+NRSF per m2

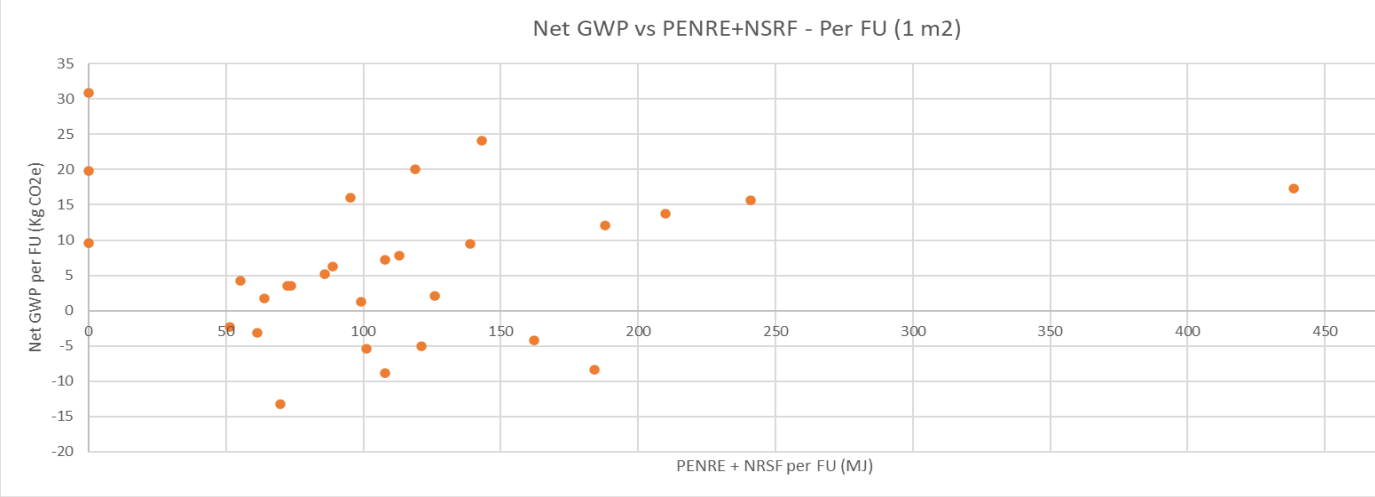


Figure 11 GWP v PENRT+NRSF per m2 for timber panel products

5. Derivation and results of data for class 1 products in Ireland

5.1 Summary of Embodied Carbon A1-A3 (GWP) Class 1 products: Ireland

Table 16 Embodied carbon GWP (A1-3) for class 1 products for Ireland

	Product	GWP A1-A3 (embodied carbon)
1	Average Cement for Ireland	712 kgCO2e/tonne
2	CEM I produced in Ireland	863 kgCO2e/tonne.
3	CEM II/A-V (<20% PFA)	728 kgCO2e/tonne
	CEM II/A-L (<20% Limestone)	696 kgCO2e/tonne
	CEM II/A-S (<20% GGBS)	724 kgCO2e/tonne
	CEM II A-D (<10% silica fume)	896 kgCO2e/tonne
	CEM II/B-S (<35% GGBS)	617 kgCO2e/tonne
	Average CEM II	674 kgCO2e/tonne
4	CEM III/A (35-60% GGBS)	512 kgCO2e/tonne
	CEM III/B (66-80% GGBS)	371 kgCO2e/tonne
5	Average Aggregate for Ireland	5 kgCO2e/tonne
6	Average hot rolled steel coil used in Ireland	2140 kgCO2e/tonne
	Average cold rolled coil used in Ireland	2630 kgCO2e/tonne
	Average galvanised steel value used in Ireland	2800 kgCO2e/tonne
	Average organic coated steel used in Ireland	2830 kgCO2e/tonne
	Average steel section and steel rail value for Ireland	1490 kgCO2e/tonne
	Average reinforcing steel used in Ireland	737 kgCO2e/tonne
7	Average aluminium sheet used in Ireland	2751 kgCO2e/tonne
	average aluminium foil used in Ireland	6780 kgCO2e/tonne
	Average aluminium extrusion used in Ireland	4855 kgCO2e/tonne
8	Average float or coated glass used in Ireland	1323 kgCO2e/tonne
9	Average facing brick imported from the UK (excl transport)	213 kgCO2e/tonne
10	Average Irish C16 timber ○ Sequestration ○ Fossil fuel emissions (A1-A3) ○ GWP A1-A3 incl sequestration	 736 kgCO2e/ m^3 104 kgCO2e/ m^3 632 kgCO2e/m^3
	Irish produced OSB	See Smartply EPD in EPD Ireland
	Irish produced MDF	See Medite EPD in EPD Ireland
	Imported MDF (737 kg/m3) ○ Sequestration ○ Fossil fuel emissions (A1-A3) ○ GWP A1-A3 incl sequestration	 -803 kgCO2/m3 221 kgCO2e/m3 -582 kgCO2e/m^3
	Average imported Chipboard Particleboard (640 kg/m3) ○ Sequestration ○ Fossil fuel emissions (A1-A3) ○ GWP A1-A3 incl sequestration	 -962 kgCO2e/m^3 346 kgCO2e/m^3 -616 kgCO2e/m^3
	Average imported plywood	

	○ Estimated sequestration ○ Estimated fossil fuel emissions (A1-A3) ○ GWP A1-A3 incl sequestration	-818 kgCO2e/m^3 137 kgCO2e/m^3 -681 kgCO2e/m^3

5.2 Average Cement, CEM I, CEM II, CEM III: Ireland

Average cement

- Ireland is a net exporter of cement (95% to the UK) (source: Comtrade for 2019).
- CEM II cement accounts for 80% of cement sales in Ireland (source: CMI 2014, Building a sustainable future for Ireland).

On the basis that

- 20% of cement sold in Ireland is CEM I (as above)
- 80% of cement sold in Ireland is CEM II, and this is made up of CEM II/A-V (30%), CEM II/A-L (30%) and CEM II/A-S (20%), the following value is estimated:

The GWP of the **average Cement for Ireland**: 712 kgCO2e/tonne

CEM I Cement (clinker 95-100%): Ireland

- No EPD for cement manufactured in Ireland.
- Ireland is a net exporter of Cement (95% to the UK) (source: Comtrade, 2019 (https://comtrade.un.org/data/)).
- 34% of fossil fuels have been replaced in cement manufacture (source: CMI 2016, Cement and concrete factsheet).
- Solid Recovered Fuel is the most common alternative fuel used in Ireland (source: CMI 2015, Ireland's cement industry and alternative fuels).
- No data found on renewable content of recovered fuels for cement in Ireland.
- The weighted average of thermal energy to produce 1 tonne clinker in Ireland is 3,538 MJ (95% of the European average). (CMI 2014, Building a sustainable future for Ireland).
- The average electricity demand for cement in Europe is 115 kWh/tonne (source https://gccassociation.org/gnr/EU28/GNR-Indicator_33AGW-EU28.html).
- With the average electricity carbon intensity in the EU of 285 kgCO2/kWh, 115 kWh would have GHG emissions of 32 kg CO2e. For Ireland, 115 kWh electricity would have GHG emissions of 40.6 kg CO2e as the carbon intensity is 353 gCO2/kWh (source: https://www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity-6#tab-googlechartid_go).

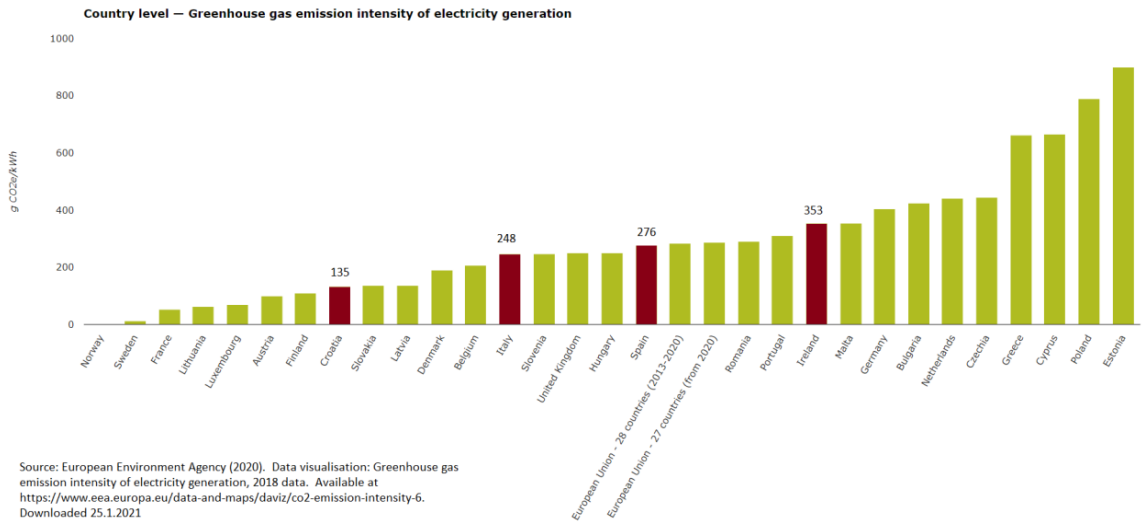


Figure 12 Greenhouse gas emission intensity of electricity generation by country

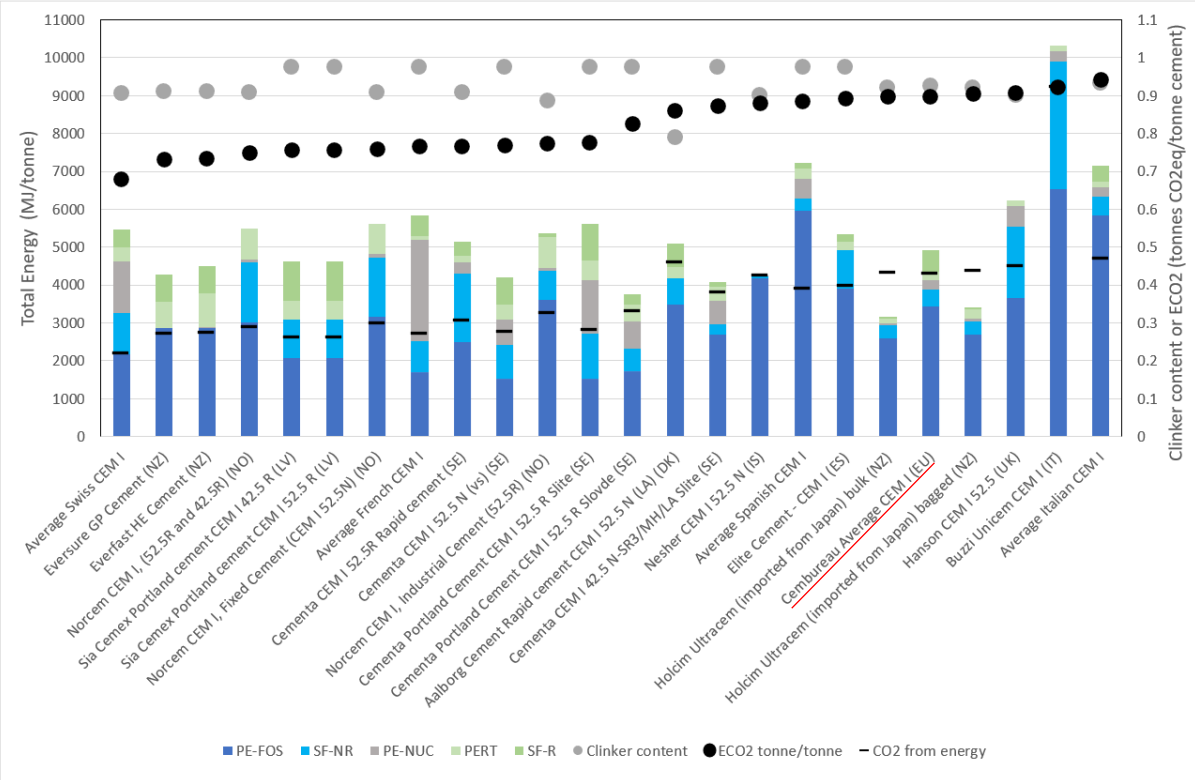


Figure 13 Energy requirement and GWP emissions for CEM I cements (source Anderson & Moncaster, 2020)

The Cembureau EPD (2015) for CEM I (underlined in red) shows a total energy demand of 4212 MJ/tonne.

Taking 95% of the Cembureau GWP per tonne excluding 32 kgCO2e electricity emissions (as the thermal energy requirement is 95% of the Cembureau average), and adding the GWP of 40.6 kgCO2e from Irish electricity, we estimate that:

The GWP of the average CEM I cement in Ireland is 863 kgCO2e/tonne.

CEM II cement: Ireland

- No EPD for cement manufactured in Ireland.
- Ireland is a net exporter of cement (95% to the UK) (source: Comtrade for 2019).
- CEM II cement accounts for 80% of cement sales in Ireland (source: CMI 2014, Building a sustainable future for Ireland).
- CEM II commonly uses limestone and fly ash in Ireland (Source: CMI 2014, Building a sustainable future for Ireland).

The impact of fly ash, GGBS and silica fume depends on the approach to allocation from the production processes creating these co-products. The PCR for cement, EN 16908, quotes the Guidance document to EN 15804, CEN/TR 16970, that allocation rules are used to understand the impact connected to low value co-products used as inputs. It also gives the relative value of PFA, blastfurnace slag and silica fume relative to their main co-products as <1% . The latest Cembureau EPD have used economic allocation to assign impact to byproducts on this basis.

- A review of academic papers conducted by the authors found Habert, G. and Ouellet-Plamondon, C. (2016[2]) give a value for fly ash (PFA) allocated on this basis (1% of coal fired electricity) as 190 kg CO2e/tonne.
- A review of academic papers conducted by the authors shows the GWP impact of ground limestone varies from 8 to 75 kgCO2e/tonne, with an average of 30 kgCO2e/tonne.
- The impact of silica fume is given as 1200 kgCO2e/tonne in the one study found by the authors using economic allocation[3].
- A review of academic papers conducted by the authors found the impact of GGBS varies from 130-195 kgCO2e/tonne when economically allocated with an average of 161 kgCO2e/tonne.

Assuming the maximum use of cement replacement based on the classification of cements under EN 197-1, the economically allocated impacts for cementitious by-products above and using the CEM I data (as above) for the remainder, the following values are estimated:

The GWP of the average CEM II/A-V (<20% PFA) in Ireland: 728 kgCO2e/tonne

The GWP of the average CEM II/A-L (<20% Limestone) in Ireland: 696 kgCO2e/tonne

The GWP of the average CEM II/A-S (<20% GGBS) in Ireland: 724 kgCO2e/tonne

The GWP of the average CEM II A-D (<10% silica fume) in Ireland: 896 kgCO2e/tonne

The GWP of the average CEM II/B-S (<35% GGBS) in Ireland: 617 kgCO2e/tonne

Assuming CEM II is made up of 37.5% CEM II/A-V, 37.5% CEM II/A-L and 25% CEM II/A-S:

The GWP of the average CEM II in Ireland: 674 kgCO2e/tonne

CEM III cement: Ireland

Assuming that GGBS content is 50% for CEM III/A and 70% for CEM III/B, the economically allocated impacts for GGBS given above, and using the CEM I data (above) for the remainder, we estimate the following:

The GWP of the average CEM III/A (35-60% GGBS) in Ireland: 512 kgCO2e/tonne

The GWP of the average CEM III/B (66-80% GGBS) in Ireland: 371 kgCO2e/tonne

5.3 Aggregates: Ireland

- Irish EPD for recycled aggregate from construction and demolition waste (IMS Greenstone)
- No average or specific Irish, average UK or average European EPD found.
- The average embodied carbon for generic aggregate found in Anderson and Moncaster (2020) is 5 kgCO2e/tonne (see figure below).

[2] Habert, G. and Ouellet-Plamondon, C. (2016). "Recent update on the environmental impact of geopolymers", RILEM Technical.

[3] G. Habert, J.B. d'Espinose de Lacaillerie, N. Roussel, An environmental evaluation of geopolymer based concrete production: reviewing current research trends, Journal of Cleaner Production, Volume 19, Issue 11, 2011, Pages 1229-1238, ISSN 0959-6526,

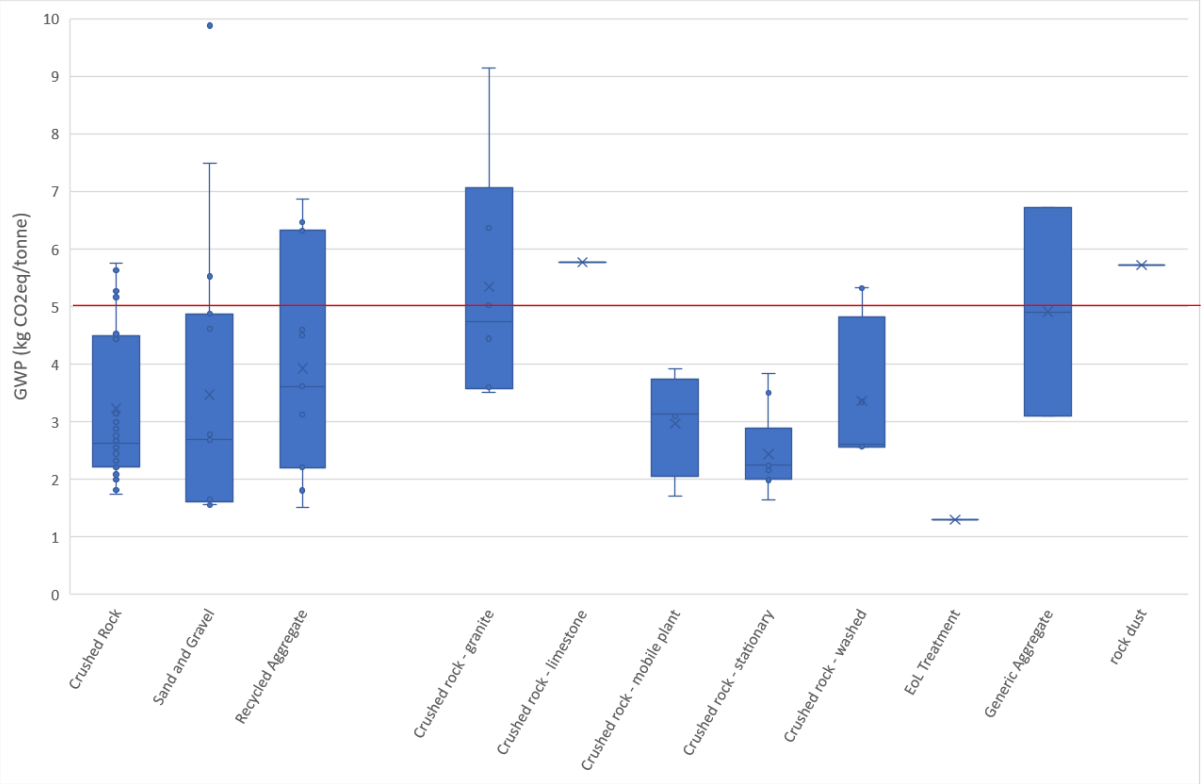


Figure 14 GWP for aggregate EPD from Anderson & Moncaster, 2020 showing the proposed value for Aggregate in Ireland

Therefore we estimate:

The GWP of the **average aggregate for Ireland**: 5 kgCO2e/tonne

5.4 Steel: Ireland

- No primary (BF/BOF) or secondary steel (EAF) production in Ireland
- No sector average EPD for any UK or Europe steel products
- WorldSteel provides LCI data for average steel products in various regions including Europe
- UK is the main import market for steel, most steel comes from Europe (source Comtrade)

Hot rolled coil

(33% of Irish steel imports) (Hot rolled steel sheet with an anti-slip surface and a diamond or teardrop pattern is typically used in construction for stairs and industrial floors)

- 71% comes from the UK, 16% from Germany, 7% from outside of Europe.
- World Steel value for European Hot rolled coil (12% recycled content) 2140 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average hot rolled steel coil** used in Ireland: 2140 kgCO2e/tonne

Cold Rolled coil

(Finished cold rolled steel applications in construction include various kinds of sections roofing applications, profiled sheets, wall elements, etc.)

- 5% of Irish steel imports
- 54% comes from the UK, 1% from outside Europe.
- World Steel value for European finished cold rolled coil (5% recycled content) 2630 kgCO2e/tonne

World Steel value for European finished cold rolled coil (5% recycled content) 2630 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average cold rolled steel coil** used in Ireland: 2630 kgCO2e/tonne

Galvanised steel

(Hot dip galvanised steel and electrogalvanized applications include building applications (e.g. wall elements, roofing applications), lighting fixtures, drums and various kinds of sections applications, profiled sheets, etc).

- Less than 1% of Irish steel imports
- 89% comes from the UK
- Relevant UK EPD:
  - Tata RoofDek 2718 kgCO2e/tonne
  - Tata ComFlor 2721-3053 kgCO2e/tonne.
- World Steel value for European hot dip galvanised steel (6% recycled content) 2560 kgCO2e/tonne
- World Steel value for European electro-galvanised steel (12% recycled content) 2450 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average galvanised steel** used in Ireland: 2800 kgCO2e/tonne

Organic coated steel sheet

(Organic Coated Steel use in construction includes roof, wall and ceiling claddings, lighting, radiators etc)

- Relevant UK EPD:
  - Tata Colorcoat® 2690 kgCO2e/tonne
  - Tata Colorcoat HPSS200 Ultra® 2800 kgCO2e/tonne
  - Tata Colorcoat Prisma® 2830 kgCO2e/tonne
- World Steel value for organic coated steel (6% recycled content) 2630 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average organic coated steel** used in Ireland: 2830 kgCO2e/tonne

Structural Steel Section

- Steel section: 41% of Irish steel imports
- Steel section: 56% from the UK, 25% from Spain; 6% from Luxembourg, 4% from Germany, 7% from Turkey.
- Steel rail: <1% of Irish steel imports
- Steel rail: 75% from UK, 9% from Spain, 9% from NL, 5% Germany, 1% Turkey.
- UK EPD:

  - British Steel section and rail: 2450 kgCO2e/tonne
  - Celsa Steel section: 683 kgCO2e/tonne
- Spanish Sector EPD:
  - Spanish Average Steel section: 567 kgCO2e/tonne
- Other relevant EPD:
  - BauforumStahl members (DE, FR, LX, PO, ES, RO) average steel section: 1320 kgCO2e/tonne
- World Steel value for European section (73% recycled content) 1490 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average steel section and steel rail** for Ireland: 1490 kgCO2e/tonne.

Reinforcing steel, rebar

- 19% of Irish steel imports
- 37% from Portugal, 36% from the UK, 24% from Spain. Less than 1% from outside Europe
- UK imports of rebar mainly from Portugal, Germany, Spain and the Czech Republic.
- Portuguese specific rebar EPD:
  - Maia Portugal 438 kgCO2e/tonne
  - Seixal Portugal 655 kgCO2e/tonne
- UK specific EPD available for:
  - Celsa UK 647 kgCO2e/tonne
  - Liberty Steel UK 1180 kgCO2e/tonne
- Spanish sector average EPD:
  - Average Spanish rebar 545 kgCO2e/tonne
  - Average Spanish rebar 598 kgCO2e/tonne ribbed
- World Steel value for rebar (44% recycled content) 2290 kgCO2e/tonne
- Most relevant datasets for rebar are EAF (95+% recycled content).

Therefore we estimate:

The GWP of the **average reinforcing steel** used in Ireland: 737 kgCO2e/tonne

5.5 Aluminium: Ireland

- Ireland is a major producer of alumina (intermediate material for aluminium production) but it is all exported.
- No aluminium production in Ireland
- Most imports from Germany, UK, France, Italy, United States.
- No sector average EPD for Europe.
- World Aluminium produces LCI and LCIA data for primary aluminium – data is available for Europe
  - World aluminium primary aluminium ingot (European production and processing) 7000 kgCO2e/tonne
- European Aluminium produces LCI and LCIA data for recycling aluminium – data is available for Europe
  - European Aluminium remelted aluminium ingot (European production – “new scrap” pre-consumer scrap) 367 kgCO2e/tonne
  - European Aluminium recycled aluminium ingot (European production – “old scrap” post-consumer scrap) 507 kgCO2e/tonne
- European Aluminium produces LCI and LCIA data for secondary processing (sheet, foil and extrusion) – data is available for Europe
  - Aluminium sheet rolling: ingot + 568 kgCO2e/tonne
  - Additional impact for foil : ingot + 1100 kgCO2e/tonne

- Additional impact for extrusion: ingot + 759 kgCO2e/tonne

- Passarini et al (2018)[4] gives post consumer (old scrap) recycled content for EU at 12% and states that pre-consumer (new scrap) is over 70% of all recycled content. We therefore assume that any recycled content is 25% post consumer scrap and 75% pre-consumer scrap carrying both primary and pre-consumer scrap recycling impacts.
- We assume the average aluminium ingot used for sheet rolling is 27% primary, 73% recycled content (source WRAP, Opportunities to use recycled materials in building, 2004).
- We assume the average aluminium ingot used for foil is 80% primary, 20% recycled content (source WRAP, Opportunities to use recycled materials in building, 2004).
- We assume the average aluminium ingot used for extrusion is 56% primary, 44% recycled content (source WRAP, Opportunities to use recycled materials in building, 2004).

Therefore we estimate:

The GWP of the average **aluminium sheet** used in Ireland: 2751 kgCO2e/tonne
The GWP of the average **aluminium foil** used in Ireland: 6780 kgCO2e/tonne
The GWP of the average **aluminium extrusion** used in Ireland: 4856 kgCO2e/tonne

5.6 Glass: Ireland

- No float glass manufacture in Ireland.
- Main imports float glass from UK (50%) and China (25%)
- No EPD data for UK or Chinese glass
- No sector EPD or studies for Europe or global glass production
- A review of 30 EPD for float and coated glass (mainly European) conducted by the authors found the average to be 1323 kgCO2e/tonne.

Therefore we estimate:

The GWP for the average **float or coated glass** used in Ireland: 1323 kgCO2e/tonne

5.7 Facing Brick: Ireland

- One clay brick manufacturer in Ireland (8 million bricks/year with 80000 GJ natural gas
- Assume Irish clay brick = 2.3 kg each
- Assume process emissions (carbon content of clay) based on UK – given as 11 kgCO2e/150 kg brick (source: BDA 2016 Brick Sustainability Report).
- Assume 120% of Irish electricity use based on UK brick industry (≈20% of 728 kWh/tonne (source: BDA 2016 Brick Sustainability Report))
- On this basis, Irish clay brick: approx 400 kgCO2e/tonne. However please note that an EPD is currently being produced and should be used to replace this estimate. Therefore for now we recommend using the GWP for the average UK brick

- Imports almost entirely from the UK (source: Comtrade 2019)
- UK average clay brick EPD: 213 kgCO2e/tonne

[4] Passarini, F., Ciacci L., Nuss P. and Manfredi S., Material Flow Analysis of Aluminium, Copper, and Iron in the EU-28, EUR 29220 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-85744-7, doi:10.2760/1079, JRC111643

Therefore we estimate:

The GWP for the average **facing brick imported from UK (excl transport)**: 213 kgCO2e/tonne

5.8 Timber: Ireland

Structural Timber

- Annually around 1,065 thousand cubic metres of sawn timber is produced in the Republic (half construction timber, mainly C16) (Source Knaggs and O'Driscoll (2018)[5]
- 50% is used in local construction, about 50% exported. (Source Knaggs and O'Driscoll (2018)
- About 315 thousand cubic metres sawn timber is also imported, predominantly from Sweden (C24). (Source Knaggs and O'Driscoll (2018)
- Energy data or 2016 for Irish Sawmills provided to the project team by Des O'Toole at Coillte
- Types of energy uses sourced from publicly available Irish EPA data (http://www.epa.ie/terminalfour/ippc/index.jsp). This suggests 75% of the direct fuels used Irish saw mills are renewable (mainly wood).
- Irish electricity demand for sawmills based on UK at ≈1000 MJ/m^3.
- 75% of sawmill energy in Irish Sawmills comes from biomass (sawdust and waste wood). This compares to about 60% in the UK and 90% for Swedish timber.
- Assume Irish Timber (C16 Spruce) has a density of 462 kg/m3 @ 15% moisture content. (source Harte et al, 2014)[6]
- On this basis, Irish Timber (462 kg/m3@15% mc):
    - Sequestration 736 kgCO2e/m^3
    - Fossil fuel emissions: 104 kgCO2e/m^3 (A1-A3)
    - GWP A1-A3 -632 kgCO2e/m^3
- EPD for **Swedish Timber** (455 kg/m3@16% moisture content).
    - Sequestration: 715 kgCO2e/m^3
    - Fossil Emission: 28.7 kgCO2/m^3

On this basis, we estimate:

The average GWP (A1-A3) for Irish produced C16 timber is -632 kg CO2e/m^3 including sequestration The average GWP (A1-A3) for Irish produced C16 timber is 104 kg CO2e/m^3 excluding sequestration The average sequestration for Irish produced C16 timber is 632 kgCO2e/m^3

Wood panel products

- OSB & MDF production 808,000 m3 (Source Knaggs and O'Driscoll (2018)
- OSB and MDF export 691,000 m3 (source Comtrade, 2019)

[5] http://www.coford.ie/media/coford/content/publications/2018/3COFORDWoodSupplyandDemand121218.pdf

[6] https://www.researchgate.net/publication/327186968_Irish_Timber_-_Characterisation_Potential_and_Innovation

- OSB (mainly UK, Latvia) and MDF (mainly Germany, Belgium) import 295,000 m3 (source Comtrade, 2019)
- Medite MDF EPD (BRE, expired October 2020) and Smartply OSB EPD (EPD Ireland)

Oriented Strandboard (OSB)

For Irish produced OSB, we recommend the values given in the Irish EPD for Smartply OSB.

Product	GWP from fossil sources per tonne for A1 – A3	Biogenic CO_2 per tonne	Net GWP per tonne for A1 – A3	A1 – A3 GWP per m^3	Biogenic CO_2 per m^3	Net GWP per m^3
SMARTPLY FLAME RETARDANT (FR)	385.66	1,543.90	-1,158.24	231.40	926.34	-694.94
SMARTPLY OSB2	282.06	1,704.75	-1,422.69	169.24	1,022.85	-853.61
SMARTPLY OSB3	323.69	1,683.00	-1,359.31	194.22	1,009.80	-815.58
SMARTPLY OSB3 T&G	358.50	1,656.77	-1,298.27	215.10	994.06	-778.96
SMARTPLY ULTIMA (OSB4)	295.17	1,733.27	-1,438.10	174.15	1,022.63	-848.48
SMARTPLY PATTRESS PLUS	323.69	1,704.44	-1,380.75	194.22	1,073.80	-879.58
SMARTPLY PROPASSIV	438.66	1,636.20	-1,197.54	276.36	1,030.81	-754.45
SMARTPLY SITEPROTECT	518.24	1,636.86	-1,118.62	326.49	1,031.22	-704.73
SMARTPLY TOUGHPLY	547.05	1,732.22	-1,185.17	344.64	1,143.27	-798.63
SMARTPLY WEBSTOCK	293.28	1,543.90	-1,250.62	193.57	926.34	-732.77

Figure 15 GWP values for Smartply OSB products (source EPD Ireland EPD for Smartply OSB)

For imports, we recommend the following EPD:

- International EPD for Norbord OSB produced in Scotland -861 kgCO2e/m^3 including sequestration
- International EPD for Norbord OSB produced in Belgium -941 kgCO2e/m^3 including sequestration

Medium Density Fibreboard (MDF)

For Irish produced MDF, we recommend the values from the expired BRE EPD for Medite MDFs.

Product	Fossil GWP (A1-A3) per tonne (from EPD GWP – given biogenic)	Biogenic CO2 per tonne given in EPD (incorrect in relation to timber content)	Biogenic CO2 per tonne (calculated from wood content in EPD)	GWP (A1-A3) per tonne including sequestration
Medite Exterior	620	-2050	1622	-1002
Medite Ultralite	1303	-1800	1393	-90
Medite FQ	820	-1900	1540	-720
Medite Vent	780	-2050	1617	-837
Medite FR Eco	852	-1800	1402	-550
Medite Ecologique	580	-2100	1650	-1070
Medite Premier FR	1338	-1700	1281	57
Medite MR	890	-1900	1496	-606
Medite Trade	961	-1950	1518	-557

Medite Premier	890	-1990	1542	-652

Figure 16 GWP data per tonne based on expired BRE EPD for Medite products

For imports, we suggest the WoodforGood generic dataset for UK consumed MDF.

- Generic dataset for UK consumed MDF (WoodforGood Database)[7] accounts for 58.5% UK production and typical imports of MDF to UK.
  - GWP including sequestration A1-A3 -6.99kgCO2e/m2 (12mm) equivalent to -790 kgCO2e/tonne or -582 kgCO2e/m^3
  - Sequestration 1090 kgCO2e/tonne, 803 kgCO2e/m^3
  - Fossil CO2 300 kgCO2e/tonne, 221 kgCO2e/m^3

Chipboard/Particleboard

- No production in Ireland.
- Imported from UK (30%) Spain 26%, Portugal 25% (source: Comtrade 2019)

For imported chipboard/particleboard, we recommend the generic WoodforGood dataset for UK consumed chipboard/particleboard.

- Generic dataset for UK consumed chipboard/particleboard (WoodforGood Database)[6] accounts for 84% UK production and typical imports of chipboard/particleboard to UK
  - GWP including sequestration A1-A3 -15.4 kgCO2e/m2 (25mm) equivalent to -962 kgCO2e/tonne or -616 kgCO2e/m^3
  - Sequestration 1503 kgCO2e/tonne, 962 kgCO2e/m^3
  - Fossil CO2 541 kgCO2e/tonne, 346 kgCO2e/m^3

Plywood

- No production in Ireland.
- Imported from UK (35%), China (25%), Brazil (12.5%) Malaysia (5%) (Source: Comtrade 2019)

For imported plywood, we suggest the Woodforgood generic dataset for UK consumed plywood.

- Generic dataset for UK consumed plywood (WoodforGood Database)[6] accounts for plywood imported into the UK (mainly from Brazil, Finland and China).
  - GWP including sequestration A1-A3: -8.17 kgCO2e/m2 (12mm) equivalent to -1387 kgCO2e/tonne or -681 kgCO2e/m^3
  - Assuming 5% adhesive content, then sequestration would be 818 kg CO2/m3.
  - And then fossil GWP = 137 kgCO2e/m3

[7] https://woodforgood.com/lifecycle-database/panel-products

6. Derivation and results of data for class 1 products in Italy

6.1 Summary of Embodied Carbon A1-A3 (GWP) Class 1 products: Italy

Table 17 Embodied carbon GWP (A1-3) for class 1 products for Italy

	Product	Estimated GWP A1-A3 (embodied carbon)
1	Average Cement produced in Italy	759 kgCO2e/tonne
2	CEM I produced in Italy	916 kgCO2e/tonne
3	CEM II produced in Italy	753 kgCO2e/tonne
4	CEM III produced in Italy	566 kgCO2e/tonne
	CEM IV produced in Italy	661 kgCO2e/tonne
5	Average Aggregate for Italy	5 kgCO2e/tonne
6	Average hot rolled steel coil used in Italy	2140 kgCO2e/tonne
	Average cold rolled coil used in Italy	2630 kgCO2e/tonne
	Average galvanised steel value used in Italy	2800 kgCO2e/tonne
	Average organic coated steel used in Italy	2830 kgCO2e/tonne
	Average steel section and steel rail value for Italy	1120 kgCO2e/tonne
	Average reinforcing steel used in Italy	732 kgCO2e/tonne
7	Average aluminium sheet used in Italy	2751 kgCO2e/tonne
	average aluminium foil used in Italy	6780 kgCO2e/tonne
	Average aluminium extrusion used in Italy	4855 kgCO2e/tonne
8	Average float or coated glass used in Italy	1323 kgCO2e/tonne
	Average laminated glass used in Italy	1582 kgCO2e/tonne
	Average toughened or tempered glass used in Italy	2485 kgCO2e/tonne
9	Average “ziegel” perforated brick used in Italy	245 kgCO2e/tonne
	Average facing brick used in Italy	294 kgCO2e/tonne
10	Average CLT in Italy ○ Sequestration ○ Fossil fuel emissions (A1-A3) ○ GWP A1-A3 including sequestration	 733 kgCO2e/ m^3 110 kgCO2e/ m^3 -623 kgCO2e/m^3
	Average Glulam (softwood) n Italy ○ Sequestration ○ Fossil fuel emissions (A1-A3) GWP A1-A3 including sequestration	 742 kgCO2e/ m^3 84 kgCO2e/ m^3 -658 kgCO2e/m^3
	Average solid timber (softwood) in Italy ○ Sequestration ○ Fossil fuel emissions (A1-A3) GWP A1-A3 including sequestration	 754 kgCO2e/ m^3 77 kgCO2e/ m^3 -677 kgCO2e/m^3

6.2 Average Cement, CEM I, CEM II, CEM III, CEM IV: Italy

AITEC Statistics 2018: Production 19300 kTonnes, Exports 2193 kTonnes (11%), Imports 1785 kTonnes (9.2%). Main imports from Slovenia, Turkey, France, Croatia (Comtrade 2019).

Representative Sector EPD plus multiple manufacturer specific EPD (see below)

International EPD for cement produced in Italy

S-P-00404: i.tech ALI PRE and i.tech ALI CEM - Italcementi S.p.A.

EPD Italia EPD for cement produced in Italy

Cement - Buzzi Unicem S.p.A.

Hydraulic binders - Buzzi Unicem S.p.A.

Premix - Buzzi Unicem S.p.A.

Pozzolanic cements TENACEM 32,5R – TENACEM 42,5R - CEMENTERIA COSTANTINOPOLI s.r.l.

Limestone cements CERTOCEM 32,5R – CERTOCEM 42,5R – NOVICEM 52,5R - CEMENTERIA COSTANTINOPOLI s.r.l.,

CEMENT PORTLAND AND POZZOLANICS - CEMENTIROSSI S.p.a.

Cement - Colacem S.p.A.

Cement - Colacem S.p.A.

Cement – CEM IV / A (P) 42,5 N – SR - Colacem S.p.A.

EPD for imported cements from Turkey and France: see https://epdturkey.org/ and https://www.infociments.fr/ciments/ciments-declaration-environnementale-inventaire-analyse-du-cycle-de-vie

Average Cement - AITEC average grey cement EPD – considered representative of Italian production with 22.7% of Italian production included in the study: 759 kgCO2e/tonne

CEM I – AITEC average CEM I EPD – considered representative of Italian production with 16.3% of Italian production included in the study: 916 kgCO2e/tonne

CEM II - AITEC average CEM II EPD – considered representative of Italian production with 23.5% of Italian production included in the study: 753 kgCO2e/tonne

CEM III - AITEC average CEM III EPD – considered representative of Italian production with 1.3% of Italian production included in the study: 566 kgCO2e/tonne

CEM IV- AITEC average CEM IV EPD – considered representative of Italian production with 37% of Italian production included in the study: 661 kgCO2e/tonne

6.3 Aggregates: Italy

Federbeton Rapporto di Sostenibilità (2019). The participating companies used, in 2019, 14,298,625 tons of natural aggregates, 35,861 tons of recycled aggregates (0.25%) and 9,928 tons of industrial aggregates (0.07%).

Manufacturer specific EPD for specialist and recovered aggregates found, but not for natural aggregate. No academic papers found.

International EPD for Italian aggregates, including specialist aggregates

S-P-02398: Glassy sands - Sasil Srl

S-P-02397: Foundry sands - Sasil Srl

S-P-02414: Thermosilex PI 270 - Basic and Co S.r.l.

S-P-02413: Aerosilex: Silica expanded pearls - Basic and Co S.r.l.

S-P-01594: Bituminous conglomerate - Costruzioni Generali Girardini S.p.A

S-P-01592: Recomposed Quartz - Stone Italiana S.p.A.

S-P-01203: i.idro DRAIN Calcestruzzi - special concrete -Calcestruzzi SpA

S-P-00427: AGMatrix® - Secondary raw materials or aggregates of industrial origin - Officina dell'Ambiente S.p.A.

S-P-00426: Sand Matrix® - Secondary raw materials or aggregates of industrial origin - Officina dell'Ambiente S.p.A.

EPD Italia EPD for Aggregates produced in Italy

SINSTONE RECYCLED INDUSTRIAL AGGREGATE - ALFA ACCIAI S.p.A.

Natural inert materials "Sand and gravel" Extracted from an artificial quarry basin - BASSANETTI NELLO S.r.l.

GREENSTONE INDUSTRIAL CONSTRUCTION AGGREGATE - FERALPI SIDERURGICA S.p.A.

LIGHTWEIGHT EXPANDED CLAY AGGREGATE - Laterlite S.p.a.

LIGHTWEIGHT EXPANDED CLAY STRUCTURAL AGGREGATE - Laterlite S.p.a.

ZEROSLAG ARTIFICIAL AGGREGATE - ZEROCENTO Srl

Granella® - FERRIERE NORD S.p.A

The average embodied carbon for generic aggregate found in Anderson and Moncaster (2020) is 5 kgCO2e/tonne (see Figure reproduced in section 5.).

Therefore we estimate:

The GWP of the **average aggregate for Italy**: 5 kgCO2e/tonne

6.4 Steel: Italy

Federacciai Sustainability Report 2019:

Italy is the first European country for steel recycling: in 2018, Italian steel mills remelted about 19 million tonnes of ferrous scrap. Iron ore acquisition was 7.7 million tonnes in the same period. Total production was 24.5 million tonnes, with 18.1% from primary and 81.9% from secondary inputs (World Steel in Figures, 2019). The direct and indirect CO2 emission from the sector (ETS Scope) was estimated at about 23 million tons of CO2 (≈934 kgCO2/tonne).

The ETS scope excludes emissions from iron ore mining, fuel extraction, transport for example, and other GHGs such as methane, N_2O etc. To account for this, we will increase the impact by 20%, so average impact of Italian steel per tonne = 1120 kgCO2e/tonne

I.stat gives the production of non-alloy and alloy steel (excluding stainless steel) from EAF furnaces in 2018 at around 19.5 million tonnes.

No sector EPD.

Hot rolled steel

Net importer. Approx 5 million tonnes imported, mainly from Turkey, France, Germany, India.

- World Steel value for European Hot rolled coil (12% recycled content) 2140 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average hot rolled steel coil** used in Italy: 2140 kgCO2e/tonne

Cold rolled steel

Net importer. Approx 0.9 million tonnes imported, mainly from Turkey, Austria, India, Belgium.

- World Steel value for European finished cold rolled coil (5.4% recycled content) 2630 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average hot rolled steel coil** used in Ireland: 2140 kgCO2e/tonne

Galvanised Steel

Net exporter. Approx 1.1 million tonnes imported, mainly from China, Korea.

- World Steel value for European hot dip galvanised steel (6% recycled content) 2560 kgCO2e/tonne
- World Steel value for European electro-galvanised steel (12% recycled content) 2450 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average galvanised steel** used in Italy: 2800 kgCO2e/tonne

Organic coated steel sheet

(Organic Coated Steel use in construction includes roof, wall and ceiling claddings, lighting, radiators etc)

- World Steel value for organic coated steel (6% recycled content) 2630 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average organic coated steel** used in Italy: 2830 kgCO2e/tonne

Structural Steel

Net exporter. Approx 0.4 million tonnes imported, mainly from Spain, Germany, Luxembourg.

Steel rail

Net importer. Approx 0.17 million tonnes imported, mainly from France, Austria, Spain.

- World Steel value for European section (73% recycled content) 1490 kgCO2e/tonne
- Average impact of Italian steel per tonne = 1120 kgCO2e/tonne

Italian manufacturer-specific EPD for structural steel.

S-P-01342 Steel Beams and Angles – Duferco (1037 and 1541 kgCO2e/tonne depending on plant)

Production of merchant bars - AFV Beltrame Group (726 kgCO2e/tonne)

- Spanish Sector EPD:
  - Spanish Average Steel section: 567 kgCO2e/tonne
- Other relevant EPD:
  - BauforumStahl members (DE, FR, LX, PO, ES, RO) average steel section: 1320 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average steel section and steel rail** for Italy: 1120 kgCO2e/tonne.

Steel bar and rod (reinforcement)

Net exporter. Approx 0.6 million tonnes imported, mainly from Germany, Czech Republic, Switzerland, UK

- World Steel value for rebar (44% recycled content) 2290 kgCO2e/tonne
- Average impact of Italian steel (BOF and EAF) per tonne = 1120 kgCO2e/tonne

Italian Manufacturer specific EPD

S-P-00254: Hot-rolled reinforcing steel for concrete in bars and coils -Alfa Acciai SpA (Brescia) 709 kgCO2e/tonne

S-P-01024: Cold-rolled reinforcing steel and electrowelded mesh - Alfa Acciai SpA (Brescia) 739 kgCO2e/tonne

HOT-ROLLED REINFORCING STEEL FOR CONCRETE IN BARS AND COILS - Alfa Acciai S.p.A. 771 kgCO2e/tonne

COLD-ROLLED REINFORCING STEEL AND ELECTROWELDED MESH - Alfa Acciai S.p.A. 799 kgCO2e/tonne

S-P-00255: Hot-rolled reinforcing steel for concrete in bars and coils - Acciaierie Di Sicilia SpA 685 kgCO2e/tonne

Hot-rolled steels in bars and rolls for reinforced concrete - Acciaierie di Sicilia S.p.A. 734 kgCO2e/tonne

S-P-01025: Stretched coil electrowelded mesh cold rolled - Feralpi Siderurgica S.p.A. 659 kgCO2e/tonne

S-P-00256: Hot-drawn reinforcing steel for concrete in bars and coils - Feralpi Siderurgica S.p.A. 626 kgCO2e/tonne

HOT-DRAWN REINFORCING STEEL FOR CONCRETE IN BARS AND COILS - Feralpi Siderurgica S.p.A. 677 kgCO2e/tonne

STEEL PRODUCTS: STRETCHED COIL ELECTROWELDED MESH COLD ROLLED - Feralpi Siderurgica S.p.A. 720 kgCO2e/tonne

S-P-00253: Steel Deformed Bars for Concrete Reinforcement - Ferriera Valsabbia SpA 527 kgCO2e

STEEL DEFORMED BARS FOR CONCRETE REINFORCEMENT - Ferriera Valsabbia S.p.A. (as above)

HOT-ROLLED REINFORCING 'Steel rod in bars and coils'-FERRIERE NORD S.p.A. 715 kgCO2e/tonne

HOT-ROLLED- REINFORCING STEEL 'Wire rod' - FERRIERE NORD S.p.A. 772 kgCO2e/tonne

Therefore we estimate, from **averaging EPD for Italian reinforcing steel**:

The GWP of reinforcing steel used in Italy: 732 kgCO2e/tonne

6.5 Aluminium: Italy

No publicly available data on Italian production of aluminium or its sustainability found.

Italy is a net exporter of Aluminium but overall imports are only 4% less than export by value. Imports originate 13% by value from Germany, 8% from both China and the Russian Federation, and 5% each from Mozambique, France, and Greece. Other imports come from around the world.

No sector EPD. Two EPD for ingot produced by Hydro Building Systems in Italy.

EPD Italia EPD for aluminium products produced in Italy

Aluminium profiles for doors and windows – series: CX700AS, CX700HP, CX850PH, HX160, MX166 e SX110 - Italbacolor S.r.l.

Aluminum frame for interior doors - LUALDI S.p.A.

- World Aluminium produces LCI and LCIA data for primary aluminium – data is available for Europe
  - World aluminium primary aluminium ingot (European production and processing) 7000 kgCO2e/tonne
- European Aluminium produces LCI and LCIA data for recycling aluminium – data is available for Europe
  - European Aluminium remelted aluminium ingot (European production – "new scrap" pre-consumer scrap) 367 kgCO2e/tonne
  - European Aluminium recycled aluminium ingot (European production – "old scrap" post-consumer scrap) 507 kgCO2e/tonne
- European Aluminium produces LCI and LCIA data for secondary processing (sheet, foil and extrusion) – data is available for Europe
  - Aluminium sheet rolling: ingot + 568 kgCO2e/tonne
  - Additional impact for foil : ingot + 1100 kgCO2e/tonne
  - Additional impact for extrusion: ingot + 759 kgCO2e/tonne

- Passarini et al (2018)[8] gives post consumer (old scrap) recycled content for EU at 12% and states that pre-consumer (new scrap) is over 70% of all recycled content. We therefore assume that any recycled content is 25% post consumer scrap and 75% pre-consumer scrap carrying both primary and pre-consumer scrap recycling impacts.
- We assume the average aluminium ingot used for sheet rolling is 27% primary, 73% recycled content (source WRAP, Opportunities to use recycled materials in building, 2004).
- We assume the average aluminium ingot used for foil is 80% primary, 20% recycled content (source WRAP, Opportunities to use recycled materials in building, 2004).
- We assume the average aluminium ingot used for extrusion is 56% primary, 44% recycled content (source WRAP, Opportunities to use recycled materials in building, 2004).

Therefore we estimate:

The GWP of the average **aluminium sheet** used in Italy: 2751 kgCO2e/tonne

The GWP of the average **aluminium foil** used in Italy: 6780 kgCO2e/tonne

The GWP of the average **aluminium extrusion** used in Italy: 4856 kgCO2e/tonne

6.6 Glass: Italy

Italy produces about 80% of the flat glass that it uses, and in 2018, exports were slightly higher than imports. According to the Assovetro Sustainability Report (Assovetro Rapporto di Sostenibilità 2020), in 2018. the use of renewable energy in the whole sector has increased to 26% from 15% in 2016, with 10% of all energy used being renewable electricity produced on site. Emissions of CO2 covered by Emissions Trading Scheme for the sector are 386 kg CO2 per tonne molten glass, with emissions from the furnace being 338 kgCO2e/tonne. Flat glass however is only around 10% of total Italian glass production (most is for packaging) so it is not clear whether flat glass follows the trends for the overall sector

Most trade is in toughened or laminated glass, where Italy is a net exporter. Most imports are from Europe, although 20% of imported safety glass comes from China

– No Italian sector EPD. Two manufacturer-specific EPD include Italian production.

EPD Italia EPD for Windows

NC-S120STH Montreal Window - E.S.PO. Soc. Cop.

NC 65STH HES WS e NC 75STH HES WS WINDOWS - E.S.PO. Soc. Cop.

- No sector EPD or studies for Europe or global glass production
- A review of 30 EPD for float and coated glass (mainly European) conducted by the authors found the average to be 1323 kgCO2e/tonne.
- A review of 19 EPD globally for laminated glass conducted by the authors found the average to be 1582 kgCO2e/tonne.
- A review of 11 EPD globally for toughened/tempered glass conducted by the authors found the average to be 2485 kgCO2e/tonne.

Therefore we estimate:

[8] Passarini, F., Ciacci L., Nuss P. and Manfredi S., Material Flow Analysis of Aluminium, Copper, and Iron in the EU-28, EUR 29220 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-85744-7, doi:10.2760/1079, JRC111643

The GWP for the average **float or coated glass** used in Italy: 1323 kgCO2e/tonne

The GWP for the average **laminated glass** used in Italy: 1582 kgCO2e/tonne

The GWP for the average **toughened or tempered glass** used in Italy: 2485 kgCO2e/tonne

6.7 Brick and tile: Italy

Data from Osservatorio Laterizi di ANDIL 2020

2019 total production **4.41 million tonnes**

Perforated bricks 1 million tonnes

Lightened blocks

- (45%-55% perforation 0.77 million tonnes)
- (>55% perforations 0.38 million tonnes)

Blocks 0.51 million tonnes

Slab blocks 0.5 million tonnes

Bricks 0.23 million tonnes

Facing bricks 0.15 million tonnes

Roofing tiles 0.6 million tonnes

Trade (from Comtrade 2019)

Data from Confindustria Ceramica, Indagini statistiche sull'industria italiana, 2019. Italy produces 4.4 million tonnes of bricks, all of which are sold domestically. There are 72 brick factories in Italy.

2019 Imports (Comtrade 2019): 71 thousand tonnes (1.6% of production, 89% from Bangladesh)

2019 Exports (Comtrade 2019): 91 thousand tonnes (2% of production, mostly to Europe (DE, NL)

Italy produces almost all the bricks that it uses.

Quote from Andrea Contri, Sustainability Manager at Confindustria Ceramica. "*It is important to consider that the ceramic tiles sector is characterized by heterogenic products with a wide variability of thickness (0.3-30 mm) and shapes. Therefore, it is not representative to draft a product benchmark as the technical and mechanic characteristics and environmental performances have a wide range. It also applies to bricks and roof tiles.*"

No publicly available data on the sustainability of Italian production of bricks found (eg. nothing from Andil).

No sector EPD. Three manufacturer-specific EPD for "ziegel-type" bricks.

EPDItalia EPD for Italian "ziegel" bricks

Brick blocks for masonry - Stabila2 S.r.l. Dosson di Casier site

- SL18+alleggerente 0.166 kg CO2e/kg,
- SL18 0.166 kgCO2e/kg

Brick blocks for masonry –

Stabila2 S.r.l. – Isola Vicentina site*

- SL93+alleggerente 0.0525kgCO2e/kg,
- SL93 0.0524 kgCO2e/kg,

- SL47 0.041 kgCO2e/kg.

Stabila2 S.r.l. – Ronco All'adige site*

- SL124+allegerente 0.0644 kgCO2e/kg,
- SL124 0.0643 kgCO2e/kg,
- SL122 0.0695 kgCO2e/kg

Brick block for masonry and floor - Wienerberger S.p.A.

- Brick block 0.242 kgCO2e/kg

*The energy indicators for the EPD for these site appear to be erroneous, and it is possible that the GWP has not been correctly modelled. They have therefore been excluded from the average below.

- A review of 10 European EPD for "ziegel" type bricks conducted by the authors found the average impact A1-A3 to be 245 kgCO2e/tonne.
- A review of 18 European EPD for facing or masonry type bricks conducted by the authors found the average impact A1-A3 to be 294 kgCO2e/tonne.

Therefore we estimate:

The GWP for the average **"ziegel" type brick** used in Italy: 245 kgCO2e/tonne

The GWP for the average **facing or masonry brick** used in Italy: 294 kgCO2e/tonne

6.8 Timber: Italy

http://dati.istat.it/ provides information on Italian production and "realisation" of timber products. For 2019, this gives sold production of timber of around 1.5 million m3 timber, mainly a mix of spruce and pine, 137 ktonnes profiled coniferous products (including boards), 66 ktonnes of other joinery and carpentry and nearly 80 million m2 of MDF. No data from Federlegno-Assolegno on production, impacts or energy use in the sector.

According to Comtrade (2019), Italy is a net importer of rough wood (mainly from Slovenia, France and Austria) and of sawn wood, from Austria and Germany.

– No sector EPD for Italian timber products. Manufacturer-specific EPD listed below:

Glulam – Rubner Holding AG - S.p.A. -A1-A3: -646 kgCO2e/m3 (including 767 kg CO2 as biogenic carbon stored in the product)

Nordpan CLT – Rubner Holding AG - S.p.A. -A1-A3: -647 kgCO2e/m3 (including 807 kg CO2 as biogenic carbon stored in the product)

S-P-01408: X-LAM Cross Laminated Timbers - Artuso Legnami S.r.l -A1-A3: -360 kgCO2e/m3 (including 667 kg CO2 as biogenic carbon stored in the product)

XLAM – Rubner Holding AG - S.p.A. -A1-A3: -665 kgCO2e/m3 (including 759 kg CO2 as biogenic carbon stored in the product)

holzius – solid wood slab elements - holzius GmbH - S.r.l. -A1-A3: -734 kgCO2e/m3 (including 803 kg CO2 as biogenic carbon stored in the product)

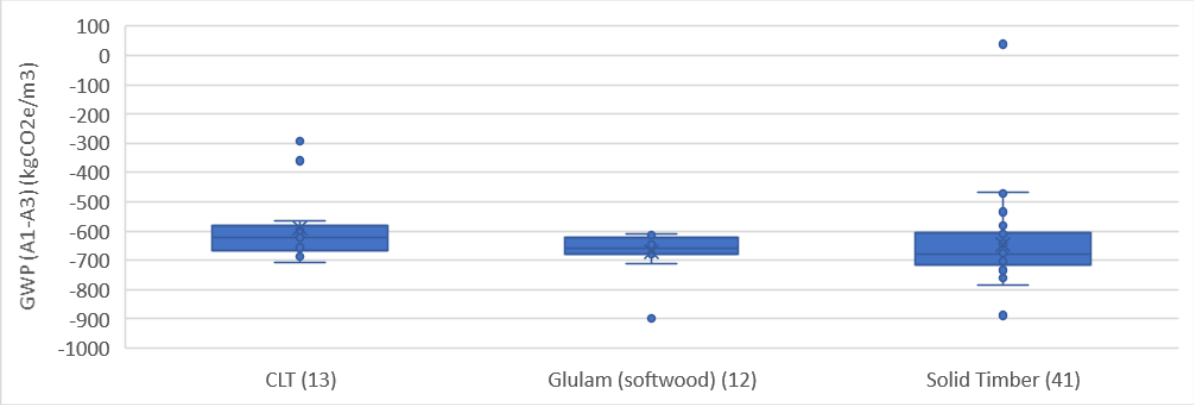


Figure 17 GWP (A1-A3) including sequestered carbon from structural timber EPD

A review of 13 EPD for CLT conducted by the authors found the average impact A1-A3, including sequestered carbon to be -623 kgCO2e/m3, and the average sequestered carbon to be 733 kgCO2/m3.

A review of 12 EPD for Glulam (softwood) conducted by the authors found the average impact A1-A3, including sequestered carbon to be -658 kgCO2e/m3 and the average sequestered carbon to be 742 kgCO2/m3.

A review of 41 EPD for solid timber (softwood) conducted by the authors found the average impact A1-A3, including sequestered carbon to be -677 kgCO2e/m3 and the average sequestered carbon to be 754 kgCO2/m3.

Therefore we estimate:

The GWP for the average **CLT** used in Italy to be -623 kgCO2e/tonne with 733 kg CO2 sequestered carbon

The GWP for the average **softwood Glulam** used in Italy: - 658 kgCO2e/tonne with 742 kg CO2 sequestered carbon

The GWP for the average **solid timber (softwood)** used in Italy: -677 kgCO2e/tonne with 754 kg CO2 sequestered carbon

7. Derivation and results of data for class 1 products in Croatia

7.1 Summary of Embodied Carbon A1-A3 (GWP) Class 1 products: Croatia

Table 18 Embodied carbon GWP (A1-3) for class 1 products for Croatia

	Product	Estimated GWP A1-A3 (embodied carbon)
1	Average Cement produced in Croatia	827 kgCO2e/tonne
2	CEM I produced in Croatia	1040 kgCO2e/tonne
3	CEM II produced in Croatia	884 kgCO2e/tonne
4	CEM III produced in Croatia	572 kgCO2e/tonne
	CEM IV produced in Croatia	579 kgCO2e/tonne
5	Average Aggregate for Croatia	5 kgCO2e/tonne
6	Average hot rolled steel coil used in Croatia	2140 kgCO2e/tonne
7	Average cold rolled coil used in Croatia	2630 kgCO2e/tonne
	Average galvanised steel value used in Croatia	2800 kgCO2e/tonne
	Average organic coated steel used in Croatia	2830 kgCO2e/tonne
	Average steel section and steel rail value for Croatia	1490 kgCO2e/tonne
	Average reinforcing steel used in Croatia	800 kgCO2e/tonne
8	Average aluminium sheet used in Croatia	2751 kgCO2e/tonne
	average aluminium foil used in Croatia	6780 kgCO2e/tonne
	Average aluminium extrusion used in Croatia	4855 kgCO2e/tonne
9	Average float or coated glass used in Croatia	1323 kgCO2e/tonne
	Average laminated glass used in Croatia	1582 kgCO2e/tonne
	Average toughened or tempered glass used in Croatia	2485 kgCO2e/tonne
10	Average “ziegel” perforated brick used in Croatia	245 kgCO2e/tonne
	Average facing brick used in Croatia	294 kgCO2e/tonne
	Average CLT in Croatia ○ Sequestration ○ Fossil fuel emissions (A1-A3) ○ GWP A1-A3 including sequestration	 733 kgCO2e/ m^3 110 kgCO2e/ m^3 -623 kgCO2e/m^3
	Average Glulam (softwood) n Croatia ○ Sequestration ○ Fossil fuel emissions (A1-A3) GWP A1-A3 including sequestration	 742 kgCO2e/ m^3 84 kgCO2e/ m^3 -658 kgCO2e/m^3
	Average solid timber (softwood) in Croatia ○ Sequestration ○ Fossil fuel emissions (A1-A3) GWP A1-A3 including sequestration	 754 kgCO2e/ m^3 77 kgCO2e/ m^3 -677 kgCO2e/m^3

7.2 Average Cement, Lime, CEM I, CEM II, CEM III and CEM IV: Croatia

Cement

Croatia is an exporter of Portland cement, with most cements going to neighbouring countries (Bosnia, Italy, Serbia etc (Comtrade 2019). Imports are about 10% of exports by mass.

No sector EPD or manufacturer-specific EPD for Croatia.

LCA study on cement produced in Lafarge cement factory in Beocin in Serbia (Marinkovic et al.,2008) had an impact of 886 kgCO2e/tonne

The Croatian greenhouse gas inventory for the period 1990 - 2018 (National Inventory Report 2020) (Croatian NIR (2020)) reports there were five active cement producing facilities in Croatia (to 2018), one of which produced aluminate cement (4% of production, ~3 t CO2/t clinker), four produce Portland cement.

The NIR 2020 states for 2018 that production of clinker in Croatia was 2325 ktonne and process CO2 emissions were 1210kt (520 kgCO2e process emissions /tonne).

The total emissions from use of fuels in non-metallic minerals production (cement and lime) in 2018 was 1,316.1 ktonnes CO2 (NIR 2021). The additional emission from fuel use in the cement and lime kilns was 1316.1/(2325+40.1+75.1) = 539 kg CO2/tonne clinker or lime (NIR 2021).

This gives a total emission from fuel and process per tonne clinker of 1059 kgCO2/tonne.

Lime

The Croatian NIR (2020) reports there are two active lime production facilities in Croatia (to 2018), producing 40.1 ktonnes quicklime (640 kgCO2/tonne direct emissions) and 75.1 ktonnes dolomitic lime (840 kgCO2 process emissions /tonne). Total process emissions from lime production in 2018 were 154 ktonnes.

This gives, with the emissions from fuel above, a total CO2 emission of 1179 kgCO2/tonne for quicklime and 1379 kgCO2/tonne for dolomitic lime. Emissions from electricity use are not included in this total.

Average Cement

We have no information on the mix of cements used in Croatia. The average impact of EPD for "average cements" from Anderson and Moncaster was 700 kgCO2e/tonne and the average for CEM I was 880 kgCO2e/tonne, so 79.5% of the impact of CEM I. We therefore estimate:

The GWP of the **average cement for Croatia**: 827 kgCO2e/tonne

CEM I

Emissions from electricity use are not included in this total. The average electricity demand for cement in Europe is 115 kWh/tonne (source https://gccassociation.org/gnr/EU28/GNR-Indicator_33AGW-EU28.html). For Croatia, 115 kWh electricity would have GHG emissions of 15.5 kg CO2e as the carbon intensity is 135 gCO2e/kWh (source: https://www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity-6#tab-googlechartid_go).

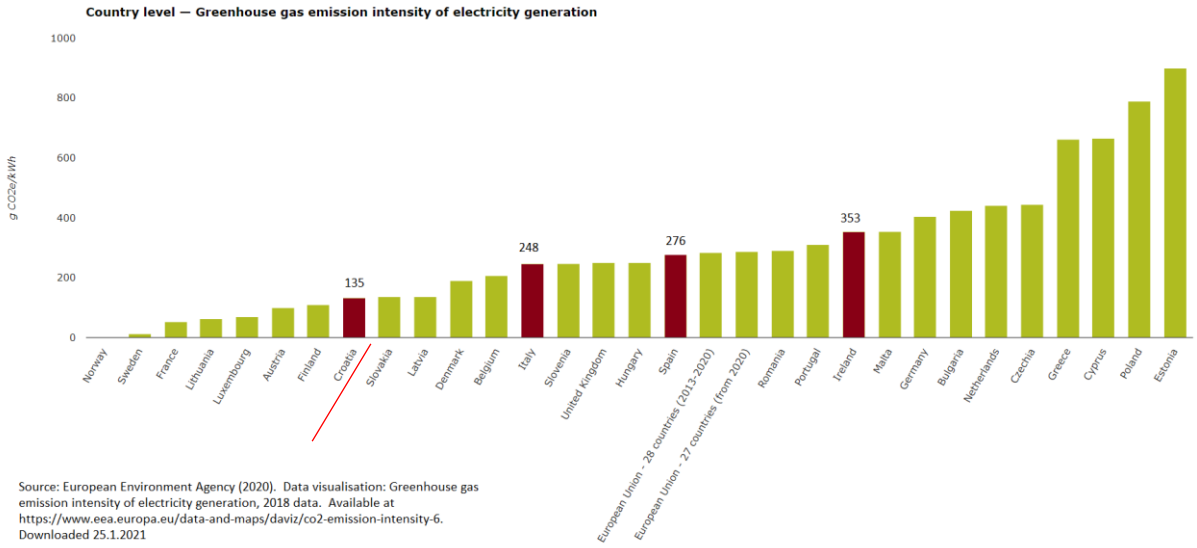


Figure 18 Greenhouse gas emission intensity of electricity generation by country, Croatia underlined

With 95% clinker in CEM I, and impacts of other inputs to CEM I 15-20 kgCO2e, this would give an overall impact for CEM I in Croatia of ~1040 kgCO2e/tonne. This compares to the Cembureau EPD for CEM I of 803 kgCO2e/tonne. We therefore estimate:

The GWP of the **average CEM I for Croatia**: 1040 kgCO2e/tonne

CEM II

The Cembureau EPD for CEM II is 683 kgCO2e/tonne. This is 85% of the impact for CEM I. We therefore estimate:

The GWP of the **average CEM II for Croatia**: 884 kgCO2e/tonne

CEM III

The Cembureau EPD for CEM III is 442 kgCO2e/tonne. This is 55% of the impact for CEM I. We therefore estimate

The GWP of the **average CEM III for Croatia**: 572 kgCO2e/tonne

CEM IV

Cembureau do not produce an EPD for CEM IV. The average impact of EPD for CEM IV from Anderson and Moncaster (2020) was 640 kgCO2e/tonne, and the average for CEM I EPD was 880 kgCO2e/tonne, so CEM IV EPD had 73% of the impact of CEM I EPD on average. We therefore estimate:

The GWP of the **average CEM IV for Croatia**: 759 kgCO2e/tonne

7.3 Aggregates: Croatia

No EPD or LCA studies for aggregate production in Croatia found.

The average embodied carbon for generic aggregate found in Anderson and Moncaster (2020) is 5 kgCO2e/tonne (See Figure reproduced in section 5).

Therefore we estimate:

The GWP of the **average aggregate for Croatia**: 5 kgCO2e/tonne

7.4 Steel: Croatia

The Croatian NIR states pig iron production and production of steel in open-hearth Furnace both stopped in Croatia in 1991. EAF steel has been produced in 2 facilities but only one has been active since 2017, producing 135.8 ktonnes in 2018. Cast iron is also produced in three foundries since 1997, producing 29.5 kTonnes in 2018. The NIR states that the Croatian iron and steel industry had 54.4 ktonnes of CO2 emissions from the use of energy and 9 ktonnes of process emissions in 2018 (63.4 ktonnes).

Ecoinvent (2.2) estimates the impact of cast iron to be 1.52 kgCO2e/kg – so the impact of producing 29.5 ktonnes would be 44.8 ktonnes CO2. This leaves 18.56 ktonnes CO2 to produce 135.8 ktonnes EAF steel (0.137 t CO2/tonne). However the NIR scope excludes emissions from use of electricity (very relevant for EAF which relies on electricity), fuel extraction and transport for example, and other GHGs such as methane, N_2O etc.

No sector EPD or manufacturer-specific EPD for Croatia.

Croatia imports much more steel (around 700 ktonnes per year) compared to its production of 135 ktonnes. Imports are mainly from the EU (Italy, Austria) but with up to 15% for some products from Bosnia and from Serbia, and some from Ukraine. We therefore suggest the World Steel values for most products.

Hot rolled steel:

- World Steel value for European Hot rolled coil (12% recycled content) 2140 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average hot rolled steel coil** used in Croatia: 2140 kgCO2e/tonne

Cold rolled steel

- World Steel value for European finished cold rolled coil (5.4% recycled content) 2630 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average hot rolled steel coil** used in Croatia: 2140 kgCO2e/tonne

Galvanised Steel

- World Steel value for European hot dip galvanised steel (6% recycled content) 2560 kgCO2e/tonne
- World Steel value for European electro-galvanised steel (12% recycled content) 2450 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average galvanised steel** used in Croatia: 2800 kgCO2e/tonne

Organic coated steel sheet

(Organic Coated Steel use in construction includes roof, wall and ceiling claddings, lighting, radiators etc)

- World Steel value for organic coated steel (6% recycled content) 2630 kgCO2e/tonne

Therefore we estimate:

The GWP of the **average organic coated steel** used in Croatia: 2830 kgCO2e/tonne

Structural Steel and Steel rail

- World Steel value for European section (73% recycled content) 1490 kgCO2e/tonne

The GWP of the **average steel section and steel rail** for Croatia: 1490 kgCO2e/tonne.

Steel bar and rod (reinforcement)

60% of imports from Italy, 10% from Germany, 10% from Bosnia, 8% from Austria, 7% from Czech Republic.

- World Steel value for rebar (44% recycled content) 2290 kgCO2e/tonne

However, any rebar produced in Croatia uses EAF (100% recycled content) and imports from Italy are largely of EAF steel (from **averaging EPD for Italian reinforcing steel -** 732 kgCO2e/tonne).

Therefore we estimate:

The GWP of the **average rebar** used in Croatia: 800 kgCO2e/tonne

7.5 Aluminium: Croatia

The Croatian NIR (2020) states that primary aluminium product stopped in Croatia in 1991. It states one plant manufactures aluminium castings in Croatia.

Italy is a net exporter of Aluminium but overall imports are only 4% less than export by value. Imports originate 13% by value from Germany, 8% from both China and the Russian Federation, and 5% each from Mozambique, France, and Greece. Other imports come from around the world.

No sector EPD. Two EPD for ingot produced by Hydro Building Systems in Italy.

EPD Italia EPD for aluminium products produced in Italy

Aluminium profiles for doors and windows – series: CX700AS, CX700HP, CX850PH, HX160, MX166 e SX110 - Italbacolor S.r.l.

Aluminum frame for interior doors - LUALDI S.p.A.

- World Aluminium produces LCI and LCIA data for primary aluminium – data is available for Europe
  - World aluminium primary aluminium ingot (European production and processing) 7000 kgCO2e/tonne
- European Aluminium produces LCI and LCIA data for recycling aluminium – data is available for Europe
  - European Aluminium remelted aluminium ingot (European production – “new scrap” pre-consumer scrap) 367 kgCO2e/tonne
  - European Aluminium recycled aluminium ingot (European production – “old scrap” post-consumer scrap) 507 kgCO2e/tonne
- European Aluminium produces LCI and LCIA data for secondary processing (sheet, foil and extrusion) – data is available for Europe
  - Aluminium sheet rolling: ingot + 568 kgCO2e/tonne
  - Additional impact for foil : ingot + 1100 kgCO2e/tonne
  - Additional impact for extrusion: ingot + 759 kgCO2e/tonne
- Passarini et al (2018)* gives post consumer (old scrap) recycled content for EU at 12% and states that pre-consumer (new scrap) is over 70% of all recycled content. We therefore assume that any recycled content is 25% post consumer scrap and 75% pre-consumer scrap carrying both primary and pre-consumer scrap recycling impacts.

- We assume the average aluminium ingot used for sheet rolling is 27% primary, 73% recycled content (source WRAP, Opportunities to use recycled materials in building, 2004).
- We assume the average aluminium ingot used for foil is 80% primary, 20% recycled content (source WRAP, Opportunities to use recycled materials in building, 2004).
- We assume the average aluminium ingot used for extrusion is 56% primary, 44% recycled content (source WRAP, Opportunities to use recycled materials in building, 2004).

* Passarini, F., Ciacci L., Nuss P. and Manfredi S., Material Flow Analysis of Aluminium, Copper, and Iron in the EU-28, EUR 29220 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-85744-7, doi:10.2760/1079, JRC111643

Therefore we estimate:

The GWP of the average **aluminium sheet** used in Croatia: 2751 kgCO2e/tonne

The GWP of the average **aluminium foil** used in Croatia: 6780 kgCO2e/tonne

The GWP of the average **aluminium extrusion** used in Croatia: 4856 kgCO2e/tonne

7.6 Glass: Croatia

The Croatia NIR (2020) states that there was a flat glass producer in Croatia until 2009. Since then the Croatian glass industry has worked with imported glass, for example for cutting, grinding, laminating etc. Most imports come from Europe, e.g. Hungary, Poland, Germany, Italy.

– No sector EPD.

Therefore, from a study of EPD, we estimate:

The GWP for the average **float or coated glass** used in Croatia: 1323 kgCO2e/tonne

The GWP for the average **laminated glass** used in Italy: Croatia kgCO2e/tonne

The GWP for the average **toughened or tempered glass** used in Croatia: 2485 kgCO2e/tonne

7.7 Brick and tile: Croatia

The Croatia NIR (2020) reports that there are 17 ceramics producers in Croatia using carbonates as a raw material, 12 are larger factories, 5 are smaller. They produce bricks and roof tiles, vitrified clay pipes, refractory products, wall and floor tiles, as well as household, sanitary and technical ceramics. Use of carbonates at these factories in total was 25.9 ktonnes and the total emissions were 11.5 ktonnes CO2 (direct process). (444 kg CO2/tonne Carbonates).

No sector EPD or manufacturer-specific EPD for Croatia. Imports of 81 ktonnes in 2018, over half from Slovenia, and from Italy, Serbia and Bosnia.

- A review of 10 European EPD for “ziegel” type bricks conducted by the authors found the average impact A1-A3 to be 245 kgCO2e/tonne.
- A review of 18 European EPD for facing or masonry type bricks conducted by the authors found the average impact A1-A3 to be 294 kgCO2e/tonne.

Therefore we estimate:

The GWP for the average **“ziegel” type brick** used in Croatia: 245 kgCO2e/tonne

The GWP for the average **facing or masonry brick** used in Croatia: 294 kgCO2e/tonne

7.8 Timber: Croatia

The Croatian NIR (2020) gives the production of sawn wood in 2018 as 1,420,630 m3, and of timber panels as 183,359 m3.

According to Comtrade (2019), Croatia imports 500,000 m3 of sawn wood (mostly from Austria, then Bosnia) but exports 1.27 million m3 of sawn wood; imports 160,000 m3 of rough wood (mainly from Slovenia, then Hungary) but exports 234,000 m3 rough wood; and imports 123 ktonnes particleboard, OSB or similar (from Austria, Hungary, Romania..) and exports 79 ktonnes of particleboard, OSB or similar.

No data found on energy consumption in the Croatian timber sector.

No sector EPD or manufacturer-specific EPD for Croatia.

GWP (A1-A3) including sequestered carbon from structural timber EPD

A review of 13 EPD for CLT conducted by the authors found the average impact A1-A3, including sequestered carbon to be -623 kgCO2e/m3, and the average sequestered carbon to be 733 kgCO2/m3. A review of 12 EPD for Glulam (softwood) conducted by the authors found the average impact A1-A3, including sequestered carbon to be -658 kgCO2e/m3 and the average sequestered carbon to be 742 kgCO2/m3. A review of 41 EPD for solid timber (softwood) conducted by the authors found the average impact A1-A3, including sequestered carbon to be -677 kgCO2e/m3 and the average sequestered carbon to be 754 kgCO2/m3. (See Figure for structural timber in previous chapter).

Therefore we estimate:

The GWP for the average **CLT** used in Croatia to be -623 kgCO2e/tonne with 733 kg CO2 sequestered carbon

The GWP for the average **softwood Glulam** used in Croatia: - 658 kgCO2e/tonne with 742 kg CO2 sequestered carbon

The GWP for the average **solid timber (softwood)** used in Croatia: -677 kgCO2e/tonne with 754 kg CO2 sequestered carbon.

SECTION B: CREATING A NATIONAL DATABASE

8. Review of databases and recommendation for National Database Structure

8.1 Introduction

This section reviews existing database platforms such as INIES, and includes the creation of digital hubs by ECO Platform and their collaboration with InData (there are proposals to merge these organisations) and the data exchange formats ILCD+ EPD and protocols. These are reviewed for usability, connectivity, ability to maintain and network to other datasets.

8.2 Review of existing databases and platforms

Non-digital and digital database platforms, and generic and product specific (EPD) data

Most current database platforms offer either non-digital "conventional" EPD data as pdf, or digital data. EC3 and the EPD Registry™ provide links both to conventional EPD as pdf, and to digital data.

EC3 is a free online tool, the development of which was incubated and led by The Carbon Leadership Forum. It is now managed by Building Transparency, a charity based in Washington State which was set up by the project partners, which include Skanska, Interface, Google, Autodesk and Perkins and Wills. The tool provides two main functions – one is to find EPD, which is the function of relevance to this report, and the second is to provide a building LCA function. It contains EPD to EN 15804 and ISO 21930, and currently has over 40,000 EPD, mainly concrete EPD to ISO 21930.

The EPD Registry™ is a non-profit collaborative effort involving industry experts, LCA/EPD consultants, manufacturers, Green Building Councils, designers and green building assessment schemes, with links to the UK EcoLabel Centre and the consultancy Metsims. It is free to list (and anyone can submit EPD) and search for EPD on the EPD Registry, which included 656 EPD at start of January 2021.

The Digital Environmental Hub for Global Construction Products is another initiative from Metsims which provides free digital access to EPD from around the world, and to generic datasets sourced from industry or generated by Metsims.

The majority of both types of database (conventional and digital) provide product-specific (EPD) data, rather than generic data.

Of the "conventional" platforms, only inies (in France) provides access to both EPD and generic LCA data, as pdf of "default declarations" provided by the Government. The other conventional platforms only provide EPD data and do not include generic LCA datasets.

Most digital platforms also only provide EPD, although oekobaudat (Germany) and the Digital Environmental Hub for Global Construction Products provide both EPD and generic data.

Search facilities

The most effective "conventional" platforms allow you to search by product type (for example using the specific PCR as in IBU) or by product classification, by manufacturer name, and by product name and by language. The table below provides an overview of all the search parameters provided by the common platforms.

Table 19 Use of Search Criteria by Data Platform

Search Criteria	ECO Platform EPD Registry	EPD Registry™	Digital Environmental Hub	EC3	Inies*	IBU EPD (non-digital)**	IBU.data (digital)	Interntional EPD digital	EPD Norge digi	ECO Platform EPD Portal	InData EPD Portal	Oekobau.dat
Links to Digital EPD	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y
Links to pdf EPD	Y	Y	N	Y	Y	Y	N	N	N	Y	N	N
EPD Programme	Y	N	N	Y	n/a	n/a	n/a	n/a	n/a	Y	Y	N
Core PCR used	n/a	n/a	N	Y	n/a	n/a	n/a	n/a	n/a	Y	Y	n/a
Product family	Y	Y	Y	Y	Y		Y	Y	Y	Y	N	Y
Sub-category PCR used	N	N	N	Y	n/a	Y	N	Y	N	Y	N	N
Type of EPD (Sector/manufacturer EPD etc)	N	N	Y	Y	Y	N	N	N	Y	N	Y	N
Manufacturer name	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Plant name and Location	N	N	N	Y	N	N	N	N	N	N	N	N
Product name	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Keyword (e.g. product name, manufacturer…)	N	Y	N	N	N	N	N	Y	N	N	N	N
Product Technical Data	N	N	N	Y	N	N	N	N	N	N	N	N
Continent	N	N	N	Y	*	N	N	N	N	N	N	N
Country	N	N	Y	Y	*	N	Y	Y	Y	Y	N	Y
Region (e.g. US State)	N	N	N	Y	N	N	N	N	N	N	N	N
Distance from a specific address	N	Y	N	Y	N	N	N	N	N	N	N	N
GWP threshold	N	N	N	Y	N	N	N	N	N	N	N	N
Validity date	N	N	Y	Y	N	**	Y	Y	Y	Y	Y	Y
Language	N	N	N	N	N	Y	Y	N	Y	Y	Y	N
LCI database used	Y	N	N	N	N	N	N	N	N	Y	N	n/a
LCA Practitioner	Y	N	N	N	N	N	N	N	N	N	N	N
Verifier organisation	N	N	N	Y	N	N	N	N	N	N	N	N
EPD Number	N	N	N	N	N	Y		N	N	N	N	N

* inies splits EPD into France, EU and outside EU
** The IBU EPD Number includes the date of registration so validity can be searched for.

The ECO Platform ECOPortal search facility provides one of the most comprehensive search facilities and this is shown in the figure below, which demonstrates how it allows you to select the parameters that you want to include in the search/filter and display on the table, so allowing many more search options to be included.

The individual EPD programme's digital portals offer almost no additional functionality over the ECO Platform ECOPortal, which with the InData Portal are all based on the ILCD+EPD format, but a couple of useful additional features are provided as below:

- The International EPD Digital hub's "keyword" free search function that will search in all data fields, so this can be used to search for datasets that might otherwise not be found. This is done outside of the main data display.
- EPD Norge Digi's search by EPD type (eg Generic, specific, template).

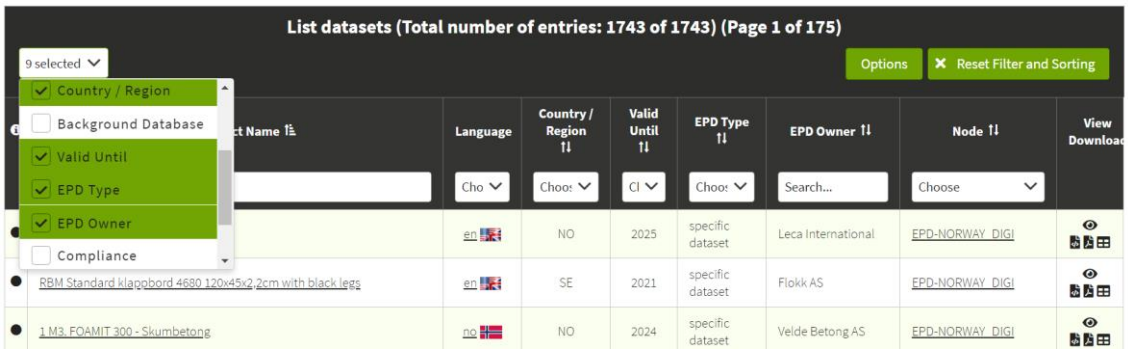


Figure 19 The search facility for the ECO Platform ECOPortal showing the ability to select a long list of search criteria

With EC3, it is possible to search for a product based on its technical specification, the actual location of the plant producing it, and by its impact. For example, for a ready-mix concrete (see Fig (20) the following can be used as search criteria:

- Meets a certain GWP threshold (e.g. <200 kgCO2e/m3)
- Meets a certain compressive strength
- Includes a certain amount of alternative cementitious material
- Is manufactured within 50 km of your project site
- That is manufactured in a particular continent, country or State/Province
- Meets a certain GWP threshold
- Will be valid in 2 years time
- That uses a specific PCR.

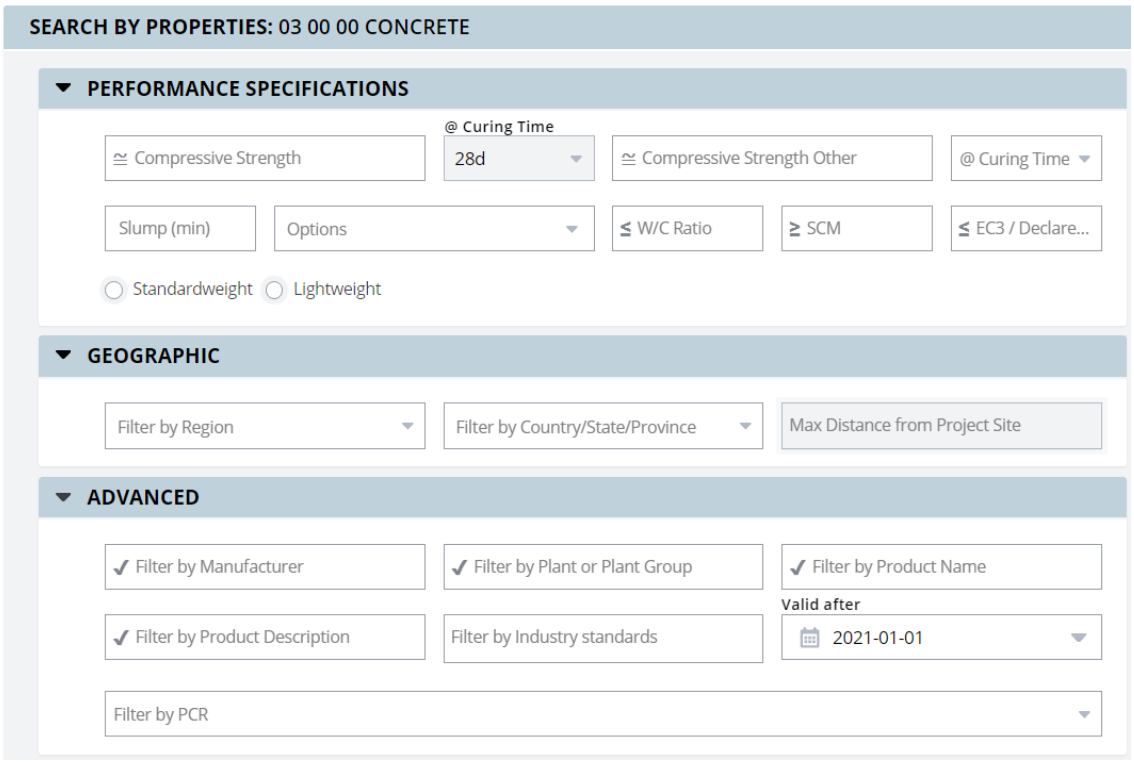


Figure 21 EPD search function (for concrete) in EC3

The EPD Registry™ offers an additional search option to find EPD within a certain distance of a particular location.

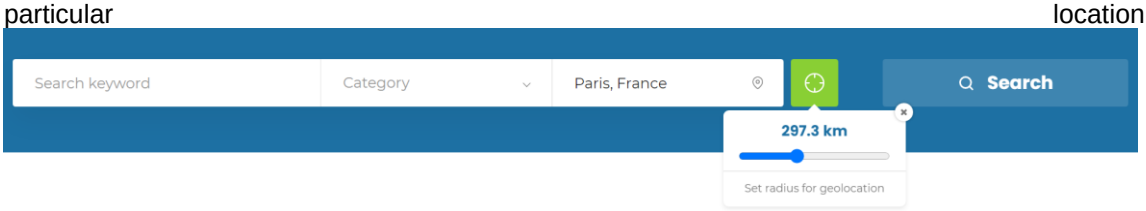


Figure 22 EPD search function within the EPD Registry

As the number of EPD grow, these types of additional functionality with regard to searching, particularly by technical specification and by location, will become essential for users to find relevant datasets.

8.3 Existing data formats

National databases and EPD from EPD programmes are increasingly being made available digitally using the ILCD+EPD format developed by InData. Currently EPD Norge, IBU, International EPD®, EPD Italia, BauEPD, MRPI and BauEPD have produced digital EPD using ILCD+EPD, and some have produced their own Digital EPD hubs, based on the InData/ECO Platform ECO Portal model, eg IBU.data, International EPD Digital Hub and EPD Norge Digi.

Oekobaudat and inies are currently the only digitised national databases which also take digitised EPD. Oekobau.dat is freely available, while a digital version of inies is only available at cost via Tool providers. BRE's IMPACT in the UK is digitised but only available to subscribers; the BRE database and EPD programme itself currently have no digitised EPD, though we understand this is in process and they will be added to the ECO Platform ECO Portal.

ILCD+EPD Format

The International Open Data Network for Sustainable Construction (InData) initiative formed in 2015 provides an open-source structure for EPD and generic Life Cycle Impact Assessment (LCIA) data. It is led by the German Government, with membership from a number of EPD programmes, LCI data providers and consultants specialising in digitalisation and transfer of LCA data.

The InData approach ILCD+EPD is based on the International Life Cycle Database (ILCD) data format, developed by the European Commission's Directorate General Joint Research Centre (DG-JRC), which is widely used in the context of life cycle assessment (LCA). The ILCD format has been extended to integrate EPD-specific information (e.g. scenarios results, modules, and EPD related metadata such as EPD Number and Programme Operator). The chosen format offers a high flexibility, which allows for the adaption of related specific national requirements or changes in the underlying standards (e.g. amended mandate M350 of EN 15804) in the future.

An example of the same EPD submitted through EPD online, and as a digitised EPD using ILCD+EPD can be seen at the highlighted links above.

The InData ILCD+EPD format is open source, and all the information and guidance on its use, including templates, schemas, definitions and compliance rules can be found at https://www.indata.network/.

Tools for creating data in ILCD+EPD format

Some LCA software are able to produce digitised EPD in the ILCD+EPD format. For example, GaBi, one the two most commonly used LCA software, is capable of outputting the data from an LCA for an EPD into ILCD+EPD format, so long as the relevant meta-data has been provided within and about the GaBi model. This will also allow the EPD to be provided as an ILCD formatted dataset, including Life Cycle Inventory data, for use within GaBi. There is also a tool, Soda4LCA,

developed for the European Commission, which provides LCA datasets in ILCD format; it may be possible to use this to produce ILCD+EPD datasets with other tools.

For Simapro, the other commonly used LCA software, a report for SmartBuilt Environment (Welling, Billstein and Erlandsson, 2019) stated, "The current development work for SimaPro aims to enable export of machine-readable LCA and EPD information in the second half of 2019." Pre (the owners of SimaPro) state that "The export function from SimaPro converts dataset into ILCD using a basic mapping. Afterwards, you can add the entry-level documentation in an XML editor"[9].

The International EPD Programme has provided an EPD Editor, an open-source tool for transferring EPD information from non-machine-readable formats into a machine-readable format (XML). The tool uses the ILCD+EPD-format and is a stand-alone application, which can be downloaded from https://github.com/GreenDelta/epd-editor.

Ökobaudat provides a standalone, cross-platform validation tool which can be downloaded from https://bitbucket.org/okusche/ilcdvalidationtool/.

8.4 Forthcoming data formats

This section reviews two further formats which are expected to be available in the near future.

ISO 22057- "EPD for BIM"

ISO TC 59 SC17 WG3 are developing a new International Standard, ISO 22057, to provide a format for the provision of EPD and generic LCA data for use in building level LCA and Building Information Modelling (BIM). The work builds on the ILCD+EPD format developed by InData but provides a more detailed approach to:

- the location of companies/plants;
- provision of technical specification information, based on harmonised standards or similar;
- treatment of scenarios, and the provision of parameterised datasets so that, for example, transport or end of life data provided in the EPD can be manipulated to represent current practice at building level for the building under study.

This work is being done using the "Vienna Agreement", which means the work is being led by ISO, but CEN is following and commenting on the work and can adopt the International Standard as a European Standard if it wishes. The first enquiry draft was be made available in Spring 2021, with comments made through national standards bodies (NSB) such as AFNOR or DIN.

OpenEPD

The OpenEPD format is being developed by Building Transparency (the team behind the EC3 tool) and is the format that they use to digitise the EPD within the tool. It is an open source data format, but currently it is in development and not publicly available, though they welcome interest and have had discussions with InData (and have a mapping of InData fields with their own) and are starting dialogue with ECO Platform. Although the EC3 tool only currently deals with carbon, the OpenEPD format covers all the indicators provided in EPD.

The format has some additional functionality over and above the InData ILCD+EPD format:

- It includes the location data of individual plants (using Discrete Global Grid - PlusCode, base20, WGS84 format) rather than just using the market level data – "Ireland" for example
- It includes data on recycled content generally and post-consumer recycled content (relevant for LEED credits)
- It includes specific technical specification information for different product groups.

Building Transparency have all the major North American EPD program operators signed on to pilot OpenEPD as the digital format to utilise in 2021.

[9] https://pre-sustainability.com/articles/the-ilcd-format-solving-lca-data-exchange-problems/

Building Transparency have built tools to “parse” pdf EPD with standard formats so that they can quickly produce digitised EPD, which is then checked by their QA team. They can also use digitised EPD in ILCD+EPD format, but need to go back to the original EPD to find the additional data that they use in the EC3 tool.

8.5 Product classification – Database hierarchy

There are numerous classification systems used in construction around the world. These normally address building level classification, for example into façade and structure, but can also address construction product level classification.

In Ireland, the National standard building elements and design cost control procedures (EPA, 1993) is used, although Ireland is looking to move to the International Construction Measurement Standard (ICMS) which is being developed by the Royal Institute of Chartered Surveyors. In Italy, national standard UNI 8290 is used. Other common systems internationally include Masterformat (North America), Omniclass (product level classification) used in North America, Uniclass2 (product level classification) currently used in the UK, SfB, TEIM, CoClass, UN SPSC, DIN SPEC 91400 (STLB-Bau) in Germany. The International EPD programme uses the UN CPC system to classify products. The Oekobau.dat has developed its own product hierarchy as shown in the Figure below.

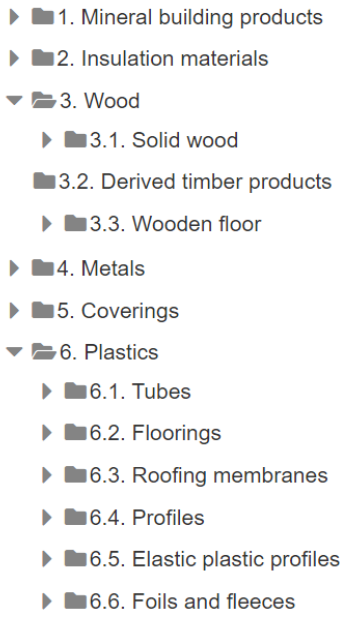


Figure 23 Excerpt from the Oekobau.dat hierarchy

The enquiry version of prEN15942 which provides the format for communication of published EPD states that EPD shall classify products, and provide the code defined by the classification system including subdivisions. It notes that EN ISO 12006-2:2015 (Building construction — Organisation of information about construction works —Part 2: Framework for classification) provides rules to define an object-oriented classification system but other alternatives are possible (e.g. products in the scope of a particular c-PCR).

The BuildingSmart Data Dictionary (bsDD) is intended as a universal approach to enable the coordination of all these different classification systems. It follows EN ISO 12006-3:2016 (Building construction - organization of information about construction works. Framework for object-oriented information). So whichever classification system has been used, it should be possible to see where a product mapped in one way in one product classification system maps within other classification systems.

Within Europe, product technical standards such as harmonised European Standards (hENs) used for CE marking can be used to classify products. The European Commission provides a list of all the hENs which cover construction products. However not all construction products are covered

by hENs, with some using European Technical Agreements or non-harmonised standards (e.g. for concrete). Using these standards is the approach which is being used within the SmartCE marking initiative led by Construction Products Europe, which has produced a CEN Workshop Agreement and a Smart CEMarking template to provide technical performance data.

The EC3 system provides classification by MasterFormat (a precursor to Omniclass), UNSPSC, NAPCS, and the EU's 8-digit European Combined Nomenclature code (EU CN code).

In the ILCD+EPD data format, several classifications (from different classification systems) can be provided for a single dataset. As this is the case, then it makes sense to include more than one classification system within the recommended requirements for the database. This will help with mapping using bsDD, and will help if EPD are used in other systems.

As both Ireland and Italy have their own construction classification systems, it may be sensible to use these to structure the database hierarchy where people are familiar with them. Alternatively, a database hierarchy based on harmonised product standard groupings, with additional classifications for products not covered by CE Marking, may be useful, or based on the UN CPC codes.

8.6 Approach to digitisation of generic data

The ILCD+EPD approach developed by InData appears to be the most accepted and developed approach currently. InData is a group of EPD programmes, national database providers and technical experts who have built on the International Life Cycle Database format developed by the Joint Research Centre of the European Commission for the provision of life cycle inventory data, to provide EPD and generic LCA data. It is already used by generic national databases such as oekobau.dat (Germany) and has been chosen for the Swedish national database for use in Sweden's Klimadeklaration programme.

Members of InData include EPD Italy and the Eduardo Torroja Institute for Construction Science (IETcc), a body of the Spanish National Research Council (CSIC).

The InData ILCD+EPD format is also now being used for EPD, for example by Eco Platform (Association of EPD Programmes following EN 15804) for its Eco Portal for EPDs which links to 839 digital EPD from the EPD Norge programme based in Norway, 807 digital EPD from the IBU programme based in Germany, 269 digital EPD from the International EPD programme based in Sweden), 17 digital EPD from the EPD Italia programme based in Italy, 4 digital EPD from the MRPI Programme based in the Netherlands and 3 digital EPD from the Bau EPD programme based in Austria.

InData and Eco Platform are currently in talks to merge.

On the horizon, the International Standards Organisation has a working group, ISO TC59 SC17 WG3, which is working on developing a standard, ISO 22057, which will build on the ILCD+EPD format to provide data for EPD and generic data for use in BIM. The development is mainly focussed on providing more data about scenarios, and ensuring that more of the data is standardised and can be understood by a machine. The first enquiry draft, prISO 22057, is expected in spring 2021, but the final standard will not be ready until 2022/23 so we would recommend the use of the ILCD+EPD format.

The format and its compliance rules are provided at https://www.indata.network/resources.

9. Variation and ranges in LCA data

9.1 Introduction

There are a number of causes of both variation (actual deviation) and uncertainty (unknown variables) in construction material LCA data. Often therefore ranges of data are used. This section first explains the causes of variation, and reviews published data ranges. It then analyses the data produced for chapter 4, to provide the range and variation data for some of the class 1 materials.

The final section considers the use of safety margins and other approaches to data variation, outlining first the approach followed in existing databases and tools, then providing a critique of this approach.

9.2 Variations and ranges in datasets

Causes of variation

A particular precast block manufacturer has three sites. At site 1, they produce solid concrete blocks. These use more energy to cure when it is cold. Each batch of blocks may also have a slightly different mix and density due to the nature of production. The product is modelled over a year of production with the average mix and density and temperature. Neither the manufacturer nor the customer can choose exactly when the product is procured, so the modelled impact is representative of the product but may be slightly different to the actual impact of this particular batch.

At site 2, the manufacturer produces two types of block, one solid, one hollow. The hollow block cures slightly more quickly than the solid block as it has more surface area. There is a variation in impact per kg between these two products because of this, though it is small because curing energy is only a small part of the product's impact. This site also has machines of a different age from the first, and so the impact of the solid blocks is also slightly different to that of the blocks produced at the first factory.

Site 3 is in another country. This country has a different carbon intensity for its electricity mix, and the temperature is generally warmer. The impact of the solid blocks produced here is different to those produced at sites 1 and 2 because of the difference in electricity generation (technology) and the time for curing in the different climates (geography). Therefore this specific manufacturer has a number of different data points for their solid concrete blocks.

Other manufacturers will have slightly different processes and technologies, and sites in different countries again, and so each will have a different set of data points for their products.

Figure 24 shows how an individual manufacturer's data sits within the range of values for a group of manufacturers, and for a sector average EPD covering all manufacturers. If only a sample of data is used for the sector average EPD, then it is quite possible that individual manufacturer impacts may be outside the ranges. At a national level, generic data or EPD may look to represent the impact of both home produced and imported products which will increase the likely range of values.

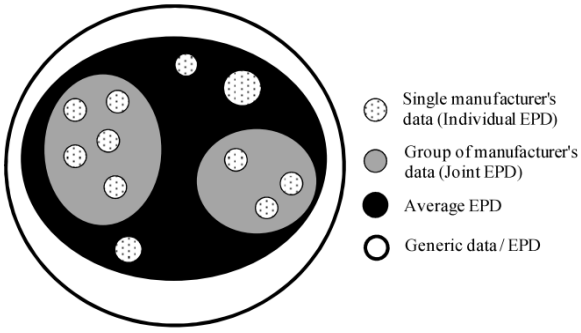


Figure 24 Relation between the different types of EPD data for each building material (Hodková and Lasvaux, 2012)

As data moves from site specific to generic, therefore, its representativeness decreases. The same is also true for data moving from a specific product to a group of products to a generic product. A comparison of two products A and B can be problematic where product A has a site- and product- specific EPD, and product B has a manufacturer's average EPD. The *average* EPD for product B may be lower than the product specific EPD for product A, even if the *actual* product B has a higher impact.

Within a specific project, as the project progresses the knowledge about the product being used increases. This improved knowledge can be matched by using data with an increasing level of

representativeness, for example moving from generic data to average data to specific product and plant data. These relationships are shown in the figure below.

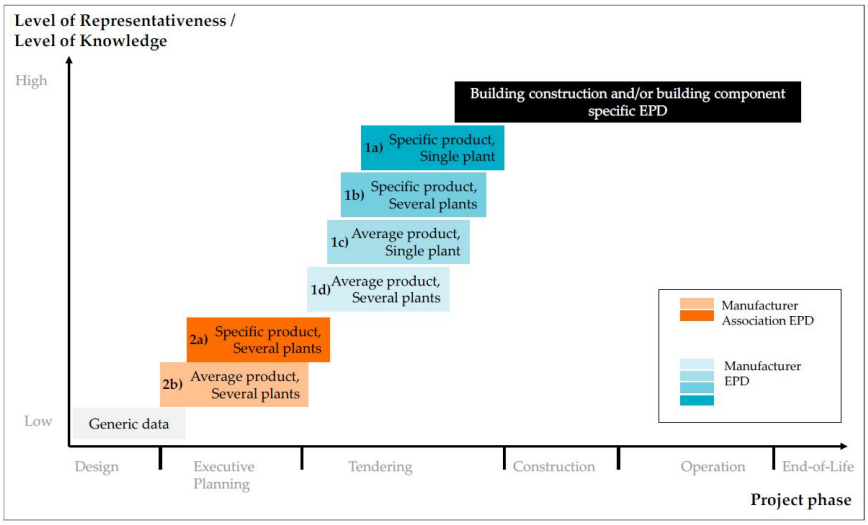


Figure 25 EPD data types and their application in different project phases, Gantner et al. (2018)

Review of published data

EN 15804 requires that a description of the range or variability of the results is provided for average EPD covering several products, where the range is 'significant'. However this is rarely done well, possibly because no guidance on what is significant is provided.

One EPD that has provided this information is a cement EPD for Buzzicem in Italy. This provides the GWP results for each cement product from each site, together with weighted averages for each product and site. Using this data, it is possible to identify the standard deviation for each product.

	Buzzi Cem EPD for 47 Italian Sites	
Cement Type	SD/Mean	Number of sites
All cements (I-V)	15%	47
All CEM I	4%	10
All CEM II	10%	20
All CEM IV	10%	17

Figure 26 Variation in EPD for Buzzi Cem cement manufacturer

It can be seen that there is much less variation for CEM I than for CEM II or CEM IV. Potentially this is because CEM I is a product with a fixed content (95% clinker). The range of variation for all cement products is larger still. If the impacts are normally distributed, then 84% of the products will have lower impact than the mean + 1 standard deviation, 97.5% will be lower than the mean + 2 standard deviations and 99.85% will be lower than the mean + 3 standard deviations

A timber manufacturer, Stora Enso, also provides ranges of EPD data across their different sites, for both planed and sawn timber products. The range is larger for planed timber than sawn timber, potentially because the additional processing associated with planing sawn timber gives rise to greater variation in impact.

		GWP (A1-A3)			**Range**	
Product	Sites	Minimum	Mean	Maximum	Max – Min	Range/Mean
Stora Enso Planed timber	15	-729	-713	-663	66	9.36%
Stora Enso Sawn Timber	18	-712	-698	-665	47	6.73%

Figure 27 Variation in EPD for Stora Enso timber manufacturer.

A number of academic papers provide comparative data for specific products across a number of manufacturers. Hodková and Lasvaux, (2012) reviewed the variability of the primary energy used for manufacture of glass wool. This compared ecoinvent data from 1993 (1 plant, 1 producer) with the average of 80 EPD from French produced products. The average was further split by function (55 thermal/25 acoustic products), and by producer (with between 9 and 25 products each).

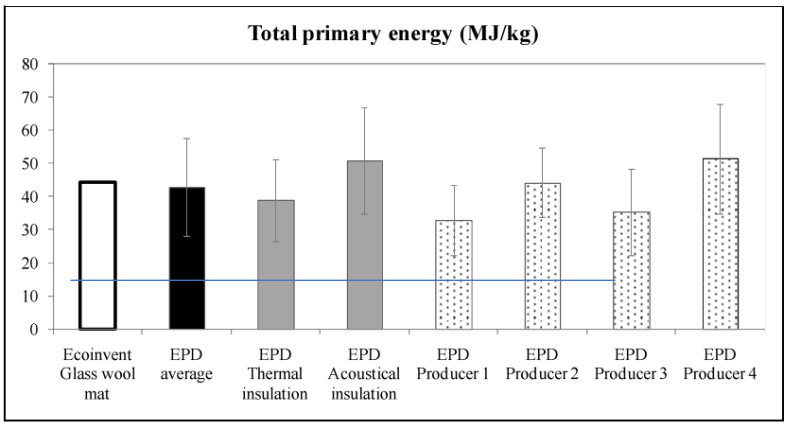


Figure 28 Variation in Primary Energy requirement for French Glass Wool EPD from (Hodková and Lasvaux, 2012).

Silvestre et al. (2015) reviewed generic data and EPD for stone wool insulation, showing there was a close correlation between the primary energy (Non-renewable) demand and GWP, but also quite a range for both indicators.

Ganassali *et al.*, (2018) reviewed a number of EPD for 8 construction product groups, manufactured and sold in Europe after the year of 2010. They determined the reference value to be the median value, as this is not sensitive to the outliers in a sample composed of a small number of data. They then set a target value for best practice as the 1° quartile, and a limit value for the lowest acceptable impact as the 3° quartile.

Materials	Limit value	Reference value	Target value
GWP (kg CO_2 eq)			
Brick	2.63E−01	2.56E−01	2.18E−01
Cement	8.49E−01	7.52E−01	6.48E−01
Ceramic	4.89E−01	3.56E−01	3.25E−01
Plasterboard	2.59E−01	2.22E−01	2.12E−01
Glass wool	1.12E+00	1.08E+00	1.06E+00
Stone wool	1.22E+00	1.19E+00	8.86E−01
Steel	1.24E+00	5.46E−01	5.11E−01
Wood fibreboard	−9.81E−01	−1.20E+00	−1.22E+00

Figure 29 LCA-based benchmarks related to 1 kg of eight construction materials, from Ganassali et al, 2018

For glass wool for some countries the values are considerably outside this defined acceptable range, as shown below.

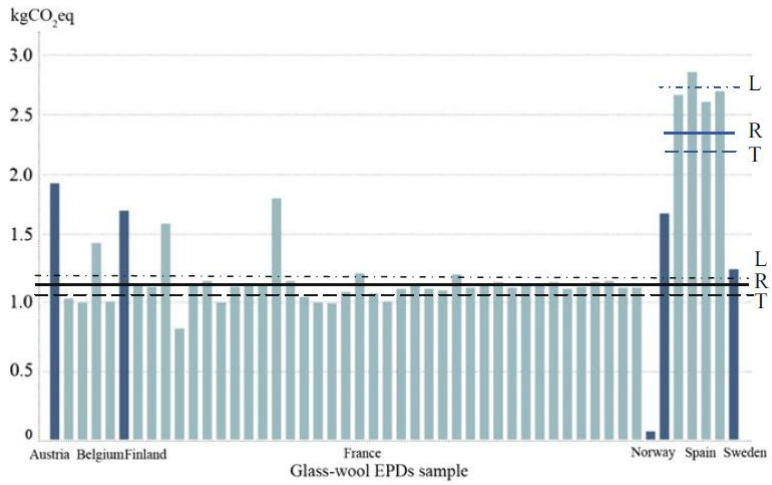


Figure 30 European GWP benchmarks (black lines) and Spanish GWP benchmarks (grey bars) related to 1 kg glass-wool panel (A1-A3). LEGEND limit value (L), reference value (R), target value (T), from Ganassali et al, 2018

Welling and Ryding (2020) analysed the GWP for thermal insulation EPD in the International EPD system, which use a common declared units of thermal performance of 1 m^2K/W of thermal resistance with a view to providing benchmarks. In this case, the 54 EPD cover different types of thermal insulation (mineral wool, foam-based etc). Potentially due to the different types of insulation, the impacts are not normally distributed. They note over 59% of the data (values from 0.4 to 4.8 kg CO2-equivalents) are located in less than 20% of the total span of the distribution (0.4 to 24.3 kg CO2-eq.).

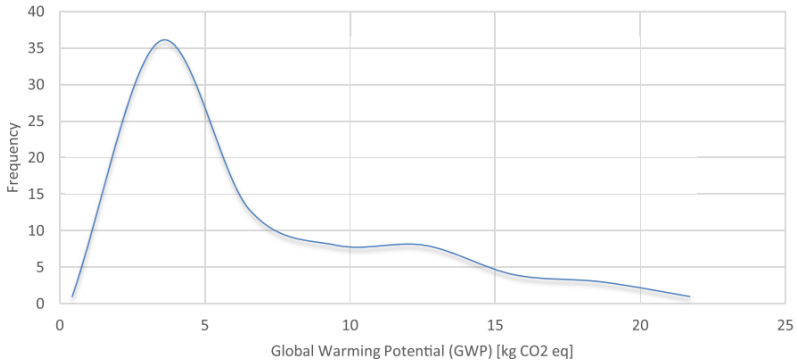
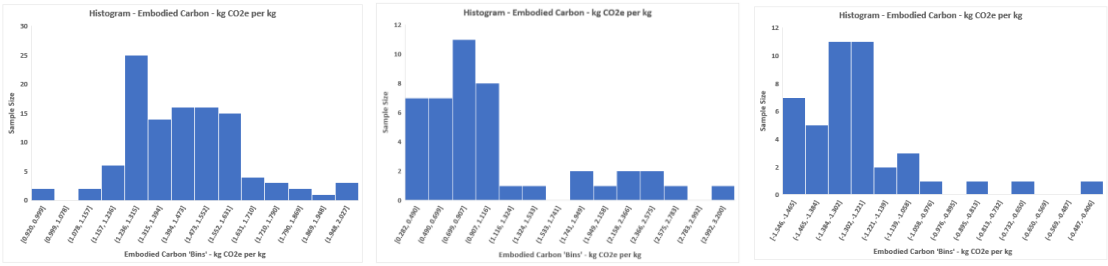


Figure 31 Distribution curve for GWP/unit of thermal performance (A1-A3) for 79 insulation products from Welling and Ryding, (2020)

The ICE Database v3 (Jones, 2019) collected EPD for key materials from various sources[10] to generate generic data for UK construction materials. It provides histograms for some of these materials showing the distribution of GWP impact per kg. Shown below are those for glass, steel (bar and rod) and timber (softwood).

[10] ICE states it includes those considered relevant to the UK but the selection is not exhaustive.



Glass Steel (bar and rod) Timber (softwood)

Figure 32 Distribution of GWP impacts for glass, steel and timber (Jones, 2019)

For glass, the distribution is fairly normal, for steel, there are two clear groups of impact, probably representing EAF and BOF steel respectively. For timber, it is probably the use of fossil fuel which drives GWP and which leads to the non-normal distribution.

Anderson and Moncaster (2020) reviewed all the available EPD globally at the end of 2019 for cement, ready-mix concretes, aggregates and admixtures. The figure below shows the range of GWP (A1-A3) they identified for cements shown by the type of cement described. Their analysis uses "box and whisker" graphs which show the mean (average) and median, and the 25th and 75th percentile.

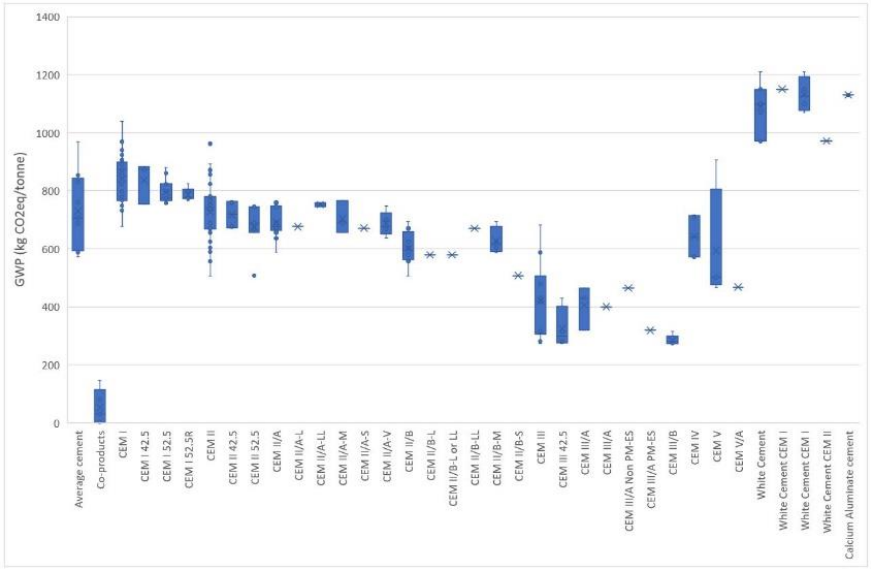


Figure 33 GWP (A1-A3) for cement from all available EPD in 2019 (Anderson & Moncaster 2020)

As with the data from Buzzicem the ranges vary between products, with CEM I having less variability than CEM III or CEM V. Review of EPD data for Life Level(s)

9.3 Analysis of data variation within the EPD for this project

As part of this project, a further review of the variation in data from globally available EPD for the key products cement, concrete, steel and timber was undertaken. This draws on the earlier review of data for cement, concrete and aggregate undertaken by Anderson and Moncaster in 2020 (see above).

Cement

The data evaluated above in Anderson and Moncaster (2020) was reviewed to obtain the standard deviation, and this was compared with the data from Buzzicem discussed earlier.

As shown in the review of Cement EPD, the uncertainty varies by product, with the Standard Deviation below 10% for CEM I and White cements, Standard Deviation between 10-15% for CEM II and CEM IV, and Standard Deviation above 25% for CEM III and CEM V.

Table 20 Variation in cements

Standard Deviation as % of unweighted mean	EPD available globally (from Anderson & Moncaster, 2020)		Buzzi Cem EPD for 47 Italian Sites	
Cement Type	SD/Mean	Number of sites	SD/Mean	Number of sites
All cementitious	31%	198		
All cements (I-V)	25%	179	15%	47
All CEM I	9%	51	4%	10
All CEM II	13%	84	10%	20
All CEM III	29%	25		
All CEM IV	13%	4	10%	17
All CEM V	33%	5		
All White Cements	8%	14		
All average cements	18%	10		

Concrete

For concretes, where the impact is broadly related to the impact of the cement used, it is not surprising that that range for different strengths of concrete vary, particularly as so many different types of cement can be used to produce any particular strength of concrete. It should be noted that at lower strengths, the impact of concrete per m3 increases with strength, but that the EPD for higher strength concretes do not seem to follow this trend. This may demonstrate that only high strength concretes with good environmental performance publish EPD.

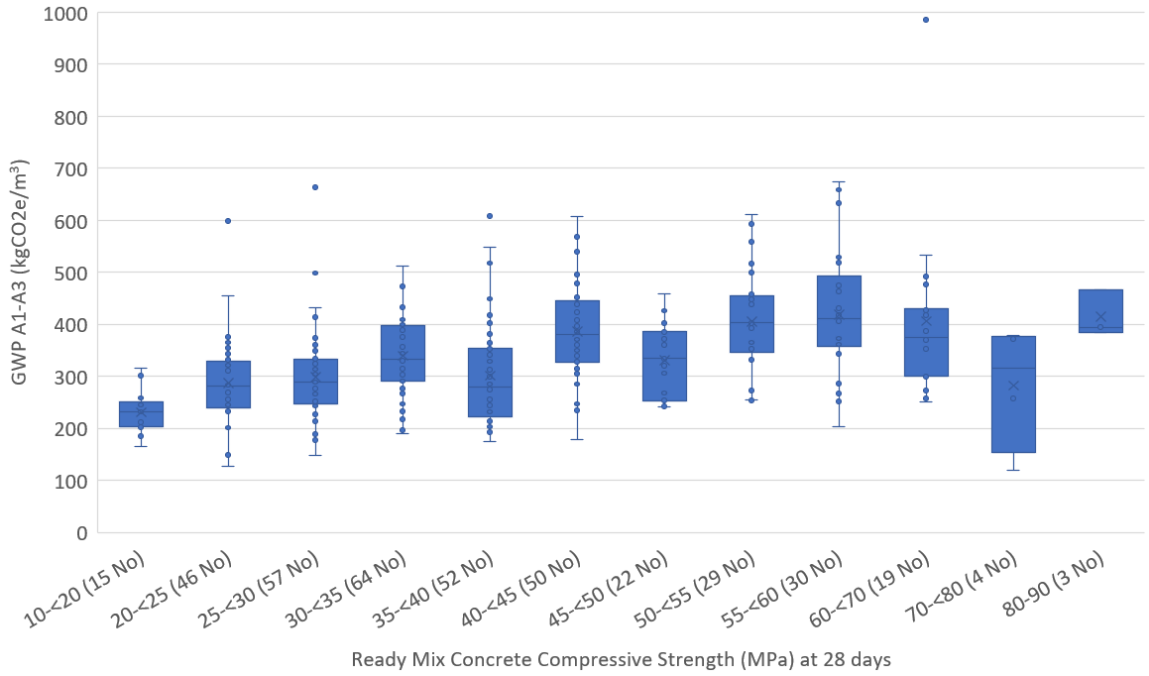


Figure 34 GWP (A1-A3) per m³ for ready mix concretes by compressive strength

Steel

EPD for steel were classified by product type, and key information from the EPD was recorded, including the Global Warming Potential (A1-A3), PERE, PENRE, use of secondary fuels and use of secondary material. If provided, the recycled content declared in the EPD was also recorded. When relevant, the information was converted to a reference unit of 1 tonne of steel. Outlying data was checked, and in some cases corrected following communication with the relevant EPD Programmes.

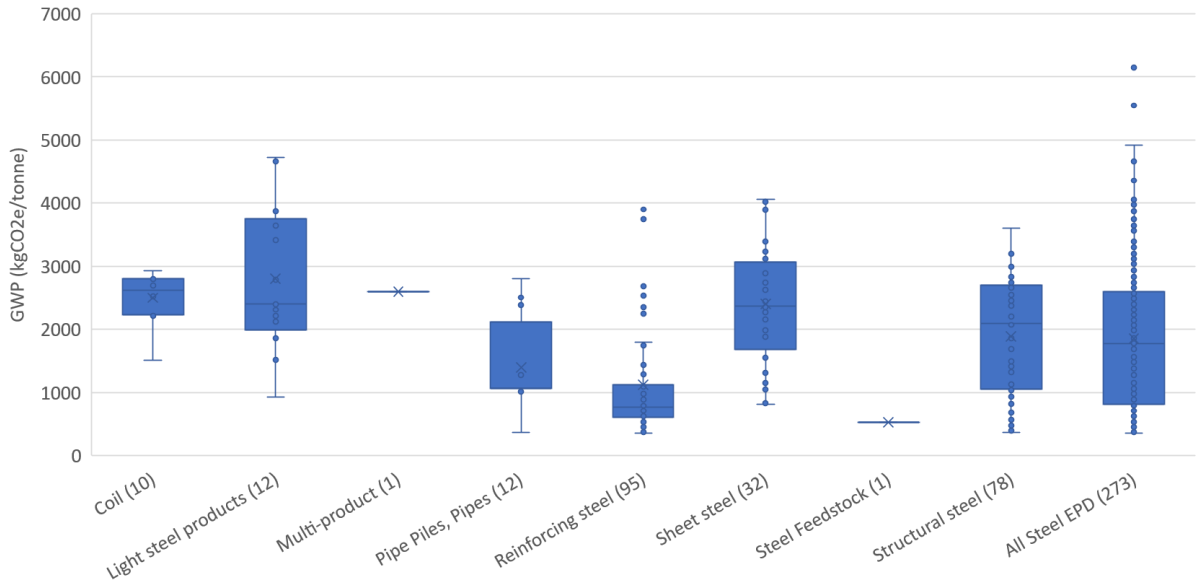


Figure 35 Variation of GWP for steel product EPD by product type

Figure 35 shows that the median, mean and range for the different steel products vary quite considerably. The median and mean are generally close, except for reinforcing steel products, where the mean is very close to the 75% percentile. This is due to a number of products which have much higher impact than most skewing the mean. Figure 36 shows the distribution of GWP

for all steel EPD. As for the distribution for steel shown in **Error! Reference source not found.**, two peaks are shown, potentially due to the use of EAF and BOF processing respectively.

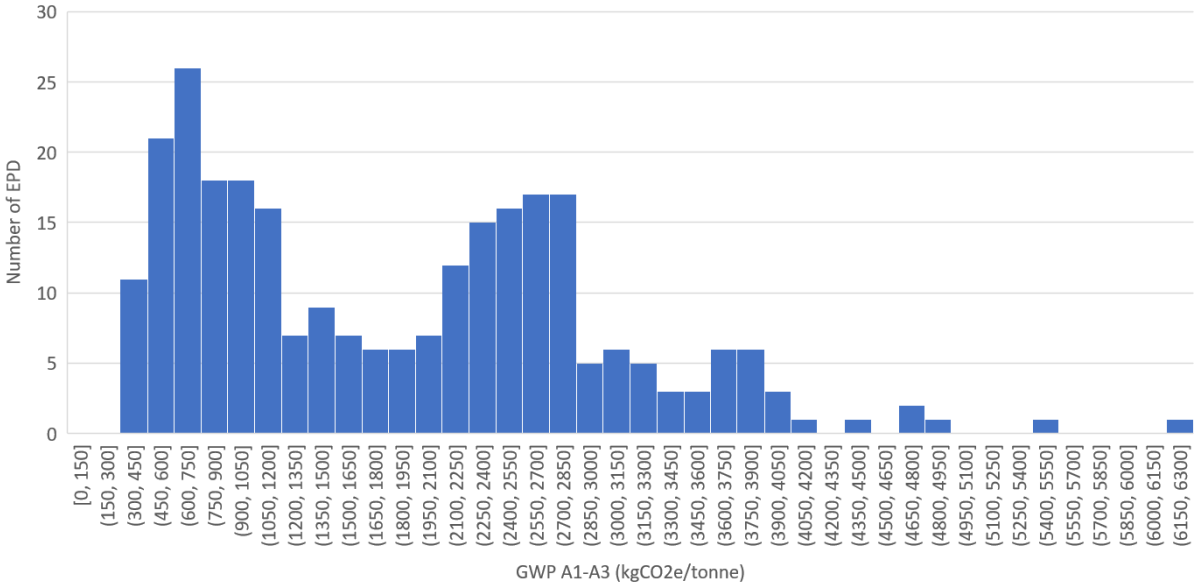


Figure 36 Histogram of GWP for all steel EPD

Figure 37 shows the variation for steel products considered on the basis of their use of secondary material or recycled content. All of the EPD provide results for indicator, "use of secondary material". However 32 EPD report the use of secondary material (scrap steel input) to be zero but also report a recycled content; for 8 of these the recycled content is 40% or higher. As it is not possible to have a recycled content without using secondary material, it is clear that there are errors in reporting the "use of secondary material" indicator. It can be seen that these indicators give smaller variations, in impact, meaning that use of secondary material and/or recycled content are probably better proxies for GWP impact than the type of product. This is logically supported by the different technologies used to make steel products – EAF to make products with near 100% recycled content, and BOF to make product with up to 25% recycled content. Products with recycled content outside these ranges are expected to be a mix of products from EAF and BOF sources.

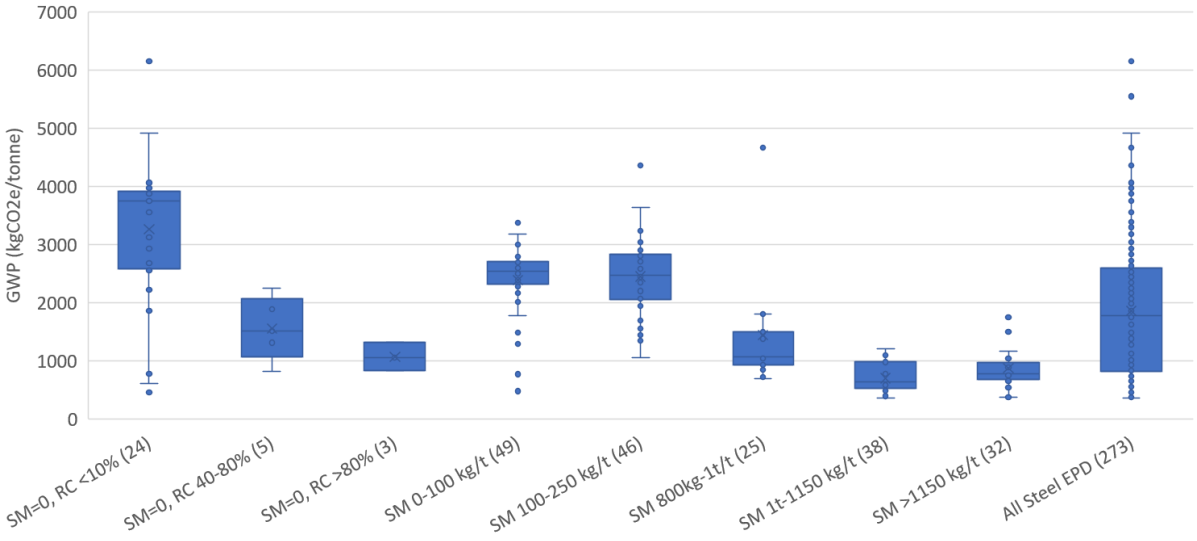


Figure 37 Variation in GWP per tonne for steel products by secondary material content or declared recycled content

Figure 38 shows histograms for the steels with different recycled content, with only 7 of 73 EPD for steels with low recycled content (BOF steel) having impacts below 1200 kgCO2e/tonne and only 5 of 41 EPD for steels with high recycled content (EAF steel) having impacts above 1200

kgCO2e/tonne, suggesting the hypothesis that recycled content drives the non-normal distribution of steel EPD is correct.

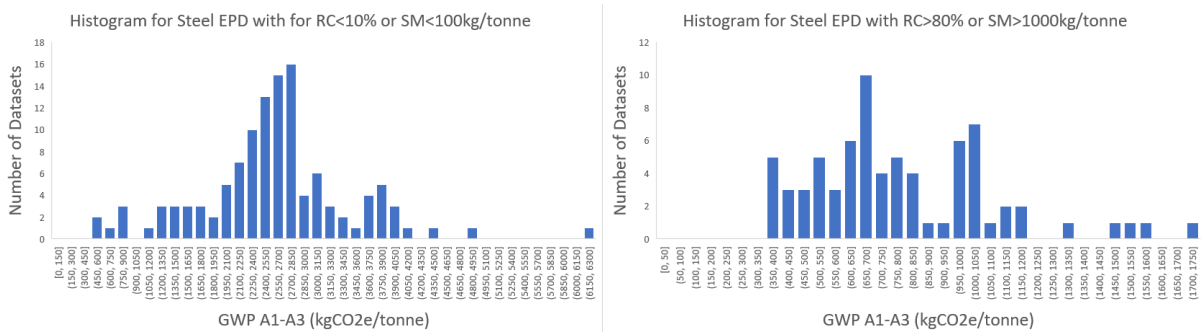


Figure 38 Histograms showing distribution of steel EPD with different recycled content or use of Secondary Material

The table below gives the statistics for GWP impact by product and by recycled content. The higher impacts for coil, light steel and sheet steel are illustrative of the fact that mostly these products are made from BOF Steel. The low impacts for pipe and reinforcing steel are illustrative of the fact that these products are more likely to be made of EAF steel, at least in the regions where EPD are produced.

Table 21 Mean and Standard Deviation for GWP from EPD of Steel Products

		kgCO2e/tonne		
Statistical Data for Steel	**Datasets**	**Mean**	**SD**	**SD/Mean**
Coil	10	2499	422	17%
Light steel products	12	2802	1433	51%
Pipe Piles, Pipes	12	1392	743	53%
Reinforcing steel	95	1116	879	79%
Sheet steel	32	2403	916	38%
Structural steel	78	1891	886	47%
All steel products	273	1853	1129	61%
SM=0, RC <10%	24	3261	1333	41%
SM=0, RC 40-80%	5	1555	546	35%
SM=0, RC >80%	3	1062	241	23%
SM 0-100 kg/t	49	2388	604	25%
SM 100-250 kg/t	46	2446	652	27%
SM 800kg-1t/t	25	1440	1023	71%
SM 1t-1150 kg/t	38	699	235	34%
SM >1150 kg/t	32	867	337	39%

Timber

As with steel and cement EPD, the GWP for timber EPD were analysed by product type.

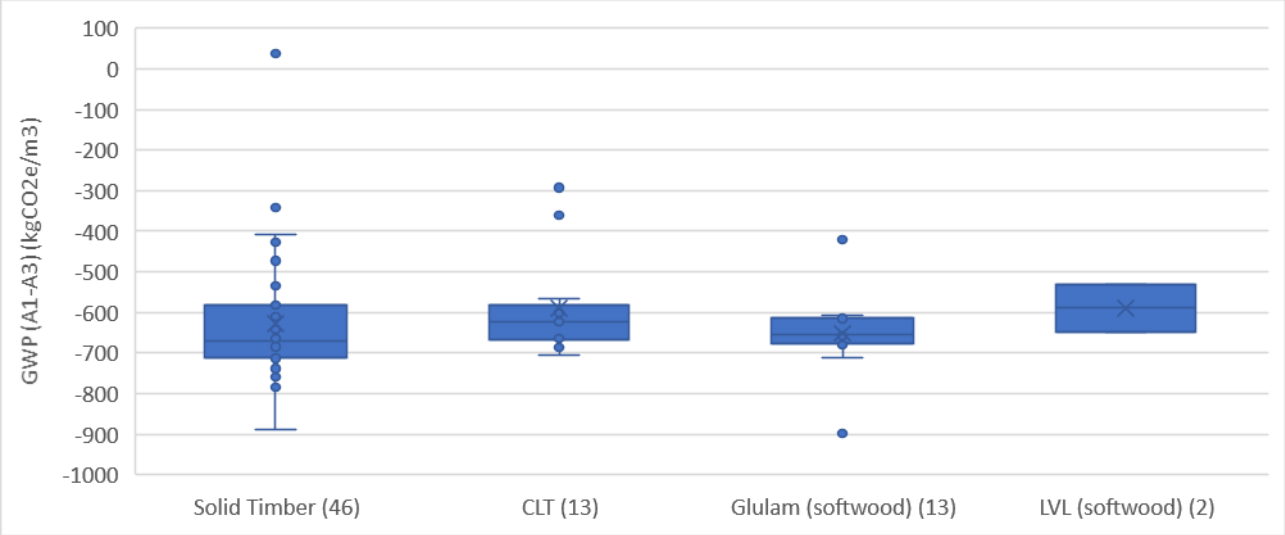


Figure 39 Variation in GWP (A1-A3) from EPD for timber products.

Figure 39 shows the variation in GWP for timber products – as EPD include the sequestration of carbon incorporated in the product in their A1-A3 impacts, these values are often negative. For structural products (solid timber, CLT, glulam, LVL), the GWP can be seen to have a fairly narrow variation between the 25th and 75th percentile. A smaller number of EPD for products using hardwoods, and thermally modified wood were also analysed. The range of variation in impact (and the impact itself) was much higher.

GWP A1-A3 (per m3)	Datasets	Mean	SD	SD/Mean
Solid Timber	46	-628	146	23%
CLT	13	-590	124	21%
Glulam (softwood)	13	-652	102	16%
LVL	2	-590	83	14%

Figure 40 Statistical Data from global Timber EPD

9.4 Safety margins and other approaches to variability in databases

Use in existing databases and tools

Most national databases distinguish between EPD data and other generic data. In this context, generic data means datasets that might be produced from adaptation of existing data, averaging of existing datasets or estimation for example.

Oekobaudat (Germany) aims to source data for construction product from EPD to EN 15804 wherever possible, but also allows data from LCA studies based on EN 15804.

In the absence of EPD or LCA data, BBSR (the Government Department which manages oekobaudat) commissions generic datasets based on EN 15804 using consistent procedures audited by independent third parties. The environmental effects of generic data sets under worst-case assumptions are estimated with the help of a safety margin of 10%, 20% or 30% are assigned and documented in the data set. According to Gantner *et al.*, (2018), the safety margins in oekobaudat are not developed using statistical data, but from a review with regard to completeness of the modelling of the dataset and its technological, temporal and geographical representativeness. For more information, see https://www.zukunftbau.de/publikationen/oekobaudat-basis-for-the-building-life-cycle-assessment

Oekobaudat does not distinguish between manufacturer and product specific EPD and sector EPD which will have more variation. It is only datasets which have not been generated from manufacturer data using EN 15804 which are penalised with a “safety margin”. The database manager has freedom to adjust the penalisation from the default 30%.

EPD data in the **Dutch National Environment Database (NMD)** comes from the Dutch MRPI EPD programme. Where there are no manufacturer specific or trade association EPD generic data has been determined by the NMD management organization. This data is based on public data sources or on tested data from producers or industries, provided they have given permission to use the data for this purpose. A 'multiplication factor' of 30% applies to generic data because NMD experience shows that the environmental impact declared in unverified environmental profiles is "oftentimes too low". The database manager has freedom to adjust the penalisation from the default 30%.For more information, see https://milieudatabase.nl/milieudata/informatie-voor-lca-uitvoerders/

In the **Inies** database, (France), a 'coefficient de sécurité' is used to reflect the representativity of generic data. If there is no EPD but generic data in ecoinvent or the European Life Cycle Database, then that data is used with a coefficient de sécurité of 30%. If there is only one manufacturer EPD for the product then the EPD data is used with a coefficient de sécurité of 100%. If there is more than one EPD, then the maximum of the sample, or mean +2 or +3 Standard Deviations, corresponding to a coefficient de sécurité of 30% is used. For more information, see http://www.batiment-energiecarbone.fr/IMG/pdf/mise_a_jour_methode_ded.pdf

Diogen is a construction database for infrastructure projects in France which uses the data quality of the dataset to consider the appropriate penalisation to create a value below which 95% of all values will fall. For an EPD covering 80+% of the sector production in France, then there will be no adjustment of the values. If it covers 50-80% then there will be a confidence rating of less than 2%, if less than 50%, then a confidence rating of less than 5% in the data. If however a dataset such as ecoinvent is used, then it could have a confidence rating of at least 20%. Other penalties to data are made for reduced data quality in relation to geography, time, methodological approach and validation of data. For more information, see http://www.diogen.fr/images/stories/GC2011_article_DIOGEN.pdf and http://www.diogen.fr/images/stories/Matrice_DIOGEN_26062018.pdf

Similar to Diogen, **Q metadata** can be used in Sweden to adjust data if required. Q metadata contains documentation of modelling and methodology choices that could affect the results of an LCA as part of an EPD, e.g.: representativity in terms of product and/or manufacturers and verification. Q metadata will not give an exact value for the data quality but rather an indication on good and bad data quality and the likely variation. It allows the end user to define their own level of quality for their specific purpose, e.g. comparison, procurement etc. For more information, see https://www.ivl.se/download/18.57581b9b167ee95ab99345/1547122416899/C363.pdf

Some tools use penalisation, outside of that used as part of national databases, to address uncertainty and variation in data. **The EC3 tool** is one example. EC3 has developed a methodology (Waldman, Huang and Simonen, 2020) to apply "uncertainty factors" to the reported GWP of an EPD to obtain upper and lower bounds if these are not provided within the EPD – the EC3 value. These bounds are meant to represent the range of plausible values due to uncertainty in the underlying LCA data and are intended to be useful in comparing datasets and evaluating building LCA. The uncertainty is based on the idea of natural variation and inherent randomness rather than precision of measurement or a lack of knowledge. The upper bound of the uncertainty range is used to sort EPD and for comparison, rather than the value stated in the EPD. Waldman et al. (2020) argue that until all EPD provide such uncertainty information, this approach is required. The approach addresses the following aspects:

- Product specific (+2%) or product average (+20%)
- Manufacturer specific (+2%) or more than 1 manufacturer (+20%)
- One production site (+2%) or more than one site (+20%)
- Time period of assessment < 90 days (+2%) >90 days (+20%)
- Variability in the supply chain (as calculated).

Most contentious is a 20% penalisation for datasets which use a year of data (as required by EN 15804). Assuming a product, manufacturer and site specific EPD with 15% supplier variation, the calculated EC3 factor would be 25%. For a sector specific EPD covering a single product it would have an EC3 of 38% and for a sector product average, 43%. For more information, see https://doi.org/10.5334/bc.31

Criticisms and justifications of safety margins

Use of a safety margin for generic and average data should, in theory, drive the production of specific EPD. If there is an average EPD and products with manufacturer specific EPD, the products with an impact lower than the average EPD are more likely to be assessed using their manufacturer specific EPD, while products with an impact higher than the average EPD will be assessed using the average EPD. The use of a safety margin for the average EPD would therefore encourage the creation and use of manufacturer specific data. This would increase accuracy and reduce double counting.

Certainly, Germany and France which use safety margins for generic data have seen an increase in the number of EPD, although this has also been driven by regulation. However the US has had no safety margin in place until that recently suggested by EC3 recently, but also saw a large rise in EPD due to the use of LEED credits. By contrast, the Netherlands, which has had safety margins for nearly 10 years through its national regulation, is one of the smaller EPD programmes in Europe.

Gantner *et al.*, (2018) provide one criticism of the use of safety margins when they are used without gradation. This issue may be seen as a minor point but gains major importance if future decisions and legal requirements are based on LCA results. Questions such as “How different do options do have to be in order to be really different?” are crucial. Based on the safety margins so far within the life cycle phase production, the results for a generic and specific EPD need at least to differ in magnitude between 10 to 30% to be sure that an specific EPD is worse than the generic.

Safety margins also have the potential to over-emphasise the embodied impact of buildings. This is particularly relevant if safety margins are used for average EPD for example, or if the only available dataset is a generic dataset with a safety margin. This may also cause problems if generic data with safety margins is largely used at early design stage, but specific data without safety margins is used at practical completion. This may lead to an assumption that impacts are reducing through the design process, when in fact what is reducing is the safety margin as generic data gives way to specific data. It may also lead to a lack of correlation between top-down assessments of embodied carbon, based on industry data for emissions, and bottom-up assessments of embodied carbon, based on area of buildings and benchmarks developed with using safety margins.

One final point to note is that safety margins must be adjusted reciprocally for data in Module D – as Module D considers the net benefits of products, the safety margin should reduce any benefit, rather than increase it.

10. Recommendations for proposed national database

10.1 Data for class 1 materials

The best available datasets for the ten class 1 products for generic data, and for Ireland, Italy and Croatia were given in chapters 4-7. These can be used as the basis of a national database. In other countries where no such database yet exists, country-specific data can be developed from the generic data offered in chapter 4. Key factors for the class 1 materials are as follows.

Cement

For cement, the key factors influencing impact are:

- Efficiency of the clinker production process
- Use of renewable fuels, particularly secondary fuels, in producing clinker
- Use of cement replacements in average cements.

Aggregates

The amount of fuel used is the primary influence on the impact of aggregate.

Steel

For steel, the key factors influencing impact are:

- Level of recycled scrap in BF production
- Energy efficiency of BF/BOF process
- Impact of electricity per kWh for EAF steel
- Use of EAF steel as a % of the overall mix for rebar and structural steel.

Aluminium

For aluminium, the key factors influencing impact are:

- Level of recycled aluminium
- Impact of electricity per kWh
- Resource efficiency of the process.

Glass

For glass, the key factors influencing impact are:

- Energy efficiency of the process
- Impact of energy per MJ.

Brick

For brick, the key factors influencing impact are:

- Impact of energy per MJ
- Density of the product
- Energy efficiency of the process.

Timber

For timber, the key factors influencing impact are:

- Energy efficiency of the process
- Use of renewable energy.

10.2 Data and database format, structure and design

The following recommendations are made based on the reviewed information developed through chapters 8 and 9 and current developments in digitisation, and allowing for the easy integration of machine readable datasets.

Data format

- The Platform should include both generic data and EPD data, and should allow the inclusion of EPD from more than one programme or digital database
- The ILCD+EPD format should be used for all generic and EPD data on the platform, with a link to pdf data for EPD also provided so that pdf documents can be downloaded
- Technical performance data as provided in the Declaration of Performance for CE Marking or in other relevant products standards, should be provided using the Smart CE marking template[11] (or similar) for each product group alongside the EPD data, so that data can be searched for using technical performance criteria.

In the near future:

[11] ftp://ftp.cencenelec.eu/CWA/CEN/CWA_17316_E.pdf provides information on the digitisation of CE Marking.

- The OpenEPD format, due to be made public by EC3 later this year, should be considered at that point, at least in relation to the approach to providing manufacturer and plant data and location, as this is not well covered by InData.
- The ISO 22057 format which is due to be published by ISO in autumn 2022 should be considered at that point. This should build on the ILCD+EPD format.

Database structure and design

- The database structure/hierarchy should be open, as any classification system can be used, if the EPD or generic dataset has been classified using some common system. The more classifications that the EPD provides, the easier it will be to correctly place it within any given hierarchy.
- The Platform should be based on the ECO Platform ECO Portal with the options to include additional search criteria, but also including the ability for a separate search as provided by the International EPD Digital Hub.
- There should be a general platform containing all product data
- As the number of EPD increase, particularly in certain product groups, specific search pages should be introduced for these product groups taking account of technical performance and distance for example, similar to that in the EC3 platform.
- All the Search Criteria listed below should be included as search criteria in the Platform. This will future proof the platform for use cases when there are larger numbers of EPD available. All those criteria in bold below are already part of the data provided by the ILCD+EPD format so can be used with data provided in that format.

Table 22 Recommended search criteria for the proposed national database platform

Type of criteria	Search Criteria
LCA/EPD related	EPD Programme
	Core PCR used (e.g. EN 15804+A2, EN 15804+A1, ISO 21930)
	Sub-category PCR used
	Type of EPD (Sector/manufacturer EPD etc)
	Validity date
	LCI database used (relevant where a particular database is recommended in a country)
	GWP threshold
	Language
Product related	Product family (based on the classification chosen)
	Manufacturer name
	Product name
	Product Technical Data
Geographical	Plant name and location
	Continent (based on plant location)
	Country (based on plant location)
	Region (e.g. US State) (based on plant location)
	Distance from a specific address
Other	Keyword (e.g. product name, manufacturer…)

Approach to data variation

Any approach to data variation should take into account the classification of data availability provided in section 3.7. Section 9.3 offers a further level of analysis of the range of data from the EPD for some specific construction products developed for chapter 4.

As explained in chapter 9, the argument for safety margins is stronger for generic data developed from estimates than for average EPD generated from representative industry studies. Therefore the argument for using safety margins for average data is much stronger for use in green public procurement than it is for embodied carbon assessments of buildings. If uncertainty loading or safety margins are to be used for any purpose, it is recommended that they are based on a realistic estimate of the variation of data for individual product groups, and that they are set around either the 75% percentile or one standard deviation above the mean (~84.1% percentile for a normal distribution). On this basis, the safety margin for CEM I should be lower than the safety margin for CEM IV, as the expected variation in data, as seen in Anderson and Moncaster (2020) for these product groups is much larger for CEM IV than CEM I. See chapter 9 for more details.

Inclusion of transport emissions for imported materials

It should be noted that for heavy products the transport emissions for imports can be considerable.

As an illustration, for brick imported from the UK to Ireland:

- Transport from Leicester (typical) to Dublin:
- 194 miles using data for A4 from the UK Brick EPD = 52.7 kgCO2e per tonne
- 119 km by RoPAX Ferry using DEFRA per tonne.km figures (including WTT) = 53.5 kgCO2e/tonne
- Total transport emissions from the UK to Dublin = 106 kgCOe/tonne

Therefore if transport emissions were added for the UK brick imported to Ireland this would increase the emissions to 319 kg CO2e/tonne.

References

Anderson, J. and Moncaster, A. (2020) 'Embodied carbon of concrete in buildings, Part 1: analysis of published EPD', *Buildings and Cities*, 1(1), pp. 198–217. doi: 10.5334/bc.59.

Ganassali, S. *et al.* (2018) 'Green Public Procurement and Construction Sector: EPD and LCA Based Benchmarks of the Whole-Building', in *Designing Sustainable Technologies, Products and Policies*. Cham: Springer International Publishing, pp. 503–513. doi: 10.1007/978-3-319-66981-6_56.

Gantner, J. *et al.* (2018) 'Ökobaudat 3.0-Quo vadis?', *Buildings*, 8(9), pp. 1–33. doi: 10.3390/buildings8090129.

Hodková, J. and Lasvaux, S. (2012) 'Guidelines for the use of existing Life Cycle Assessment data on building materials as generic data for a national context', in A. Ventura and C. de la Roche (ed.) *International Symposium on Life Cycle Assessment and Construction – Civil engineering and buildings*. RILEM Publications SARL, pp. 265 – 273. Available at: https://www.rilem.net/images/publis/7439dd28f7344848b56f6843151a8284.pdf (Accessed: 17 October 2018).

Jones, C. (2019) *ICE Database V3.0 Beta 7/11/2019*. Available at: http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html.

Pomponi, F. and Moncaster, A. M. (2018) 'Scrutinising embodied carbon in buildings: The next performance gap made manifest', *Renewable and Sustainable Energy Reviews*. Pergamon, 81, pp. 2431–2442. doi: 10.1016/J.RSER.2017.06.049.

Silvestre, J. D. *et al.* (2015) 'NativeLCA - a systematic approach for the selection of environmental datasets as generic data: application to construction products in a national context', *International Journal of Life Cycle Assessment*, 20(6), pp. 731–750. doi: 10.1007/s11367-015-0885-8.

Welling, S., Billstein, T. and Erlandsson, M. (2019) *Increased availability of machine-readable EPDs in the ILCD+EPD+ format*. Stockholm.

Welling, S. and Ryding, S. O. (2020) 'Distribution of environmental performance in life cycle assessments - implications for environmental benchmarking', *International Journal of Life Cycle Assessment*. doi: 10.1007/s11367-020-01852-3.

APPENDICES

Appendix 1: Stakeholder participants

Irish Green Building Council

- **Pat Barry**

Stakeholder interview participants for Ireland

- Representative of brick manufacturer
- **Des O'Toole** of Coillte, forestry business which also produces timber products in Ireland
- **David Gil-Moreno**, of NUI Galway, Annette Harte's Timber Engineering Research Group
    - David was present for the interview with Des, then a separate interview was held with David after Des had left due to other commitments
- **Vincent O'Malley** of Transport Infrastructure Ireland
- **Billy O'Keefe** of Transport Infrastructure Ireland
    - Vincent and Billy were both present for the full interview. No recording was made by request of the interviewees.

Italian Green Building Council

- **Valentina Marino**
- **Manuela Ojan**
- **Maria Elena Ghelardi**

Stakeholder interview participants for Italy

- **Benedetta Barozzi, Lorenzo Belussi**: Construction Technologies Institute - National Research Council of Italy (ITC-CNR): ITC-CNR has been involved in a number of projects applying life cycle assessment to construction products at different levels:
    - creation of the first Italian national database of building materials and products (Life Cycle Inventory for ITACA); and corresponding price list based on Life Cycle Costing analysis;
    - definition of the methodological approach and some environmental profiles of national producers;
    - application of the Life Cycle approach to the evaluation of photovoltaic tile prototypes; and high-performance thermo-energy brick mixes.
- **Mikaela Decio,** Corporate Environmental Manager: MAPEI SPA**:** MAPEI uses International Databases (Ecoinvent and Sphera Databases) in order to create models with LCA software (GaBi) and release EPDs.
- **Stefano Cera:** FIVRA (mineral wool producers association): FIVRA publishes EPDs either responding to a request from the Italian branch, or to a central decision from head office.
- **Simona Marinelli:** PhD Student, University of Modena and **Reggio Emilia:** Pursues eco-design studies and environmental evaluations of innovative construction products; carbon footprints of products and organisations. Special interest in plastic waste in construction materials; average cement; aggregates; and brick.
- **Andrea Contri**: Sustainability Manager, Confindustria Ceramica, Italy: Confindustria Ceramica has collaborated with the University of Modena and Reggio-Emilia on an LCA study of the ceramic tile sector: http://www.confindustriaceramica.it/site/home/ricerca/articolo8021.html.

Stakeholder web meeting participants for Italy (19th November 2020)

Micaela Decio – MAPEI Spa
Marco Mazzetti– MAPEI Spa
Anna Della Valle – Politecnico di Milano
Serena Giorgi – Politecnico di Milano
Tecla Caroli – Politecnico di Milano
Simona Marinelli – University of Modena and Reggio Emilia
Benedetta Barozzi - Construction Technologies Institute - National Research Council of Italy
Lorenzo Belussi- Construction Technologies Institute - National Research Council of Italy
Laura Cutaia – ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development
Luca Andriola– ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development
Paola Altamura– ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development
Francesca Ceruti– ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development
Simona Scalbi– ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development Antonella Luciano

Croatian Green Building Council

- **Benjamin Petrović**

Stakeholder interview participants for Croatia

- **Sandro Vlačić**: lead for *YTONG* in Croatia: Has been in the cement industry as a civil engineer for 10yr, particularly aerated autoclaved concrete. Also involved with green buildings for 10 yrs. Gives lectures with the Croatian GBC.
- **Julija Škoro**: Marketing and Communications Manager, *Holcim*: Part of Holcim Lafarge for 30 yrs - an international company with a European network. They have joined the UN Global Compact business initiative, committing to 1.5% de-carbonization over the period to 2030, and in the next two years will define an action plan to reach net zero carbon emissions. She also participates in the Croatian GBC and Sustainable Development Council
- **Nenad Karalija**: Head of Technical Department, *Mapei* (Croatia): Leads technical support unit of 10 experts in a specific niche of the construction industry – adhesive products for installation of ceramics, parquet etc. The company was founded in 1937 in Milan – the Croatian operation is a small part of the European operation. His role is focused on implementation, but main interest is to promote EPDs.
- **Bojan Milovanović**: Professor, *Faculty of Civil Engineering, University of Zagreb*: He has been working on LCA in the Dept. of Materials within Civil Engineering on innovative projects developing new products, and a monitoring programme for sustainable building prototypes. One of the first EPDs in Croatia was for the Eco-Sandwich panel for walls. Other He has been involved in the LIFE projects for the last 10 years.
- **Saša Marenjak**: Full professor, *Faculty of Engineering, University of Osijek*: His research is in civil engineering and construction management. His PhD at the University of Dundee (200-04) was on whole life cost optimization: he simultaneously worked with industrial partner WS Atkins in Epsom on major public sector projects as case studies. Now 50% of his time is spent at the University, 50% as Director and Managing Owner of PPP Centre, a private consultancy commercialising software on whole life cost optimization; and labour forecasting.

Appendix 2: Semi-structured questionnaire for interviews

INTERVIEW NOTES

Date

Name

Organisation

Position

Country

1. Explanation of interview and agreement to participate/record

Team: briefly describe the project, confidentiality of data and 10 key products (Average Cement, CEM I,II & III, Aggregates, Steel, Glass, Brick, Aluminium, Timber).

2. What's your involvement with LCA data/embodied carbon?

3. What LCA tools are available/commonly used in your country?

- How do these relate to verified data sets?

- Are there features of rules/regulations which may need to be varied for your country?

4. Can you give us some idea of LCA data availability in your country?
   - Are you aware of any organisations working on EPD? (eg Irish Cement – if they will have data in Spring we don't need to duplicate this.

   - Are you aware of any organisations that have published EPD outside of EcoPlatform EPD programmes, for example in Company EPD programmes? (for example Tata Steel have a programme).

   - Are there any other ways in which you know companies are providing information, for example carbon footprints to ISO 14067, PAS 2050?

5. What's the best source of statistics on production?

- Are you aware of statistics that would provide data on the production of construction products in your country - particularly for the 10 key products? (We are looking at https://comtrade.un.org/Data/ for data on imports and exports).

- Are all these products made in the country?

- Are you aware of national statistics on the energy used by industry sectors or the emissions from those sectors – eg for UNFCC National emissions inventory reporting?

6. What do you consider to be the most important sectors?

- What materials are typically used for commercial buildings?
- …public buildings such as schools?
- …residential buildings?
- Outside of the 10 core products, are there any manufacturing sectors in your country which are important – eg ceramic tiles in Italy?
- Are there materials, common elsewhere, that aren't much used in your country?
- What specialised or novel materials might be relevant for your national market?
- Are there other relevant local factors, such as fuel mix and primary energy factors for electricity?

7. Who would be other relevant people to interview in your country?
   - LCA experts/academics who may be aware of other LCA studies in the country?
   - For the key sectors (cement, concrete, glass, steel (for construction), brick, construction timber, aluminium (for construction)) where there are no EPDs, a trade association representative that deals with sustainability or carbon?
   -
8. What could be other useful links could you suggest for us?
   - E.g. websites of national trade associations for cement, concrete, glass, steel (for construction), brick, construction timber, aluminium (for construction).

9. Any other points?

Appendix 3: Other Product EPD for Italy

Insulation

S-P-02315: Cork-based thermal insulation panels: Slim and Lisoflex -L.I.S Lavorazione Italiana Sughero S.r.l.

S-P-02279: EUROPAN KP 40 mm - Eurofibre S.p.A.

S-P-02277: FELTRO ALFA KP 60 mm: Eurofibre S.p.A.

S-P-02213: Ultrapan A+ 70 mm - Ultrapan A+ V 70 mm - Eurofibre S.p.A.

S-P-02212: Termoroll A+ 50 mm - Termopan A+ 50 mm - Eurofibre S.p.A.

S-P-02210: Europan A+ V 70 mm - Eurofibre S.p.A.

S-P-02214: Ultrapan A+ V 95 mm - Eurofibre S.p.A.

S-P-02211: Superpan A+ 80 mm - Eurofibre S.p.A.

S-P-02016: ISOVER InsulSafe - Saint-Gobain PPC Italia SpA

S-P-01857: EUROSYSTEM A+/SUPER FR A+ - EUROSYSTEM A+ V/SUPER FR A+ V 45 - 70 - 95 mm - Eurofibre S.p.A.

S-P-01138: Glass Wool Insulation 4+ - Saint-Gobain PPC Italia SpA

S-P-01137: Glass Wool Insulation G3 - Saint-Gobain PPC Italia SpA

S-P-00840: Expanded polystyrene products for thermal insulation - REXPOL Srl

IT - FLEX C1 - EVOCELL&MOBIUS S.r.l

EPS ECO - POR K150 - ISOLCONFORT S.R.L

RÖFIX EPS - F 035 - ISOLCONFORT S.R.L

RÖFIX EPS - F 036 - ISOLCONFORT S.R.L

RÖFIX EPS - F 031 RELAX TAKE IT - ISOLCONFORT S.R.L

RÖFIX EPS - F 031 RELAX - ISOLCONFORT S.R.L

RÖFIX EPS - F 031 GREY - ISOLCONFORT S.R.

RÖFIX EPS - P BASE - ISOLCONFORT S.R.L

EPS ECO - ESPANSO K150 - ISOLCONFORT S.R.L

EPS ECO - POR K100 - ISOLCONFORT S.R.L

EPS ECO - ESPANSO K200 - ISOLCONFORT S.R.L

EPS ECO - ESPANSO K120 - ISOLCONFORT S.R.L

EPS ECO - DUR ZETA - ISOLCONFORT S.R.L.

EPS ECO - ESPANSO K100 - Isolconfort S.r.l.

EPS ECO - POR G031 - Isolconfort S.r.l.

KLIMA AIRTECH - Isolconfort S.r.l.

KLIMA AIRPLUS - Isolconfort S.r.l.

KLIMA AIR - Isolconfort S.r.l.

EPS ECO - ESPANSO 100 - Isolconfort S.r.l.

EUROBATEX HF - Union Foam S.p.A.

EUROBATEX® - UNION FOAM S.p.A.

Stiferite GTE average thick panel - Stiferite

Stiferite FIRE B average thick-Stiferite

Stiferite Isocanale Ai6 average thickness panel - Stiferite

Stiferite Isoventilato average thickness - Stiferite

Stiferite RP1 average thickness - Stiferite

Stiferite RP3 average thickness - Stiferite

Stiferite CLASS SH average thickness - Stiferite

Stiferite CLASS BH average thickness - Stiferite

Stiferite RP average thickness - Stiferite

Stiferite Isocanale A6B average thickness panel - Stiferite

stiferite GTM average thick panel - Stiferite

Stiferite Pendenzato Class S average thickness - Stiferite

Stiferite BB average thick panel - Stiferite

Stiferite Pendenzato Class B average thickness - Stiferite

Isolparma RF6 average thick panel-Isolparma srl

Isolparma RF7 HP average thickness-Isolparma srl

Isolparma RF7 average thickness-Isolparma srl

Isolparma RFK average thickness-Isolparma srl

Isolparma RF8 average thick panel-Isolparma srl

Isolparma RF8 HP average thickness-Isolparma srl

ISOLPARMA ISOLCART average thickness-Isolparma srl

Isolparma RF3 thick panel-Isolparma srl

Isolparma RF2-Isolparma srl

Isolparma RFM-Isolparma srl

Isolparma Pendenzato RF8-Isolparma srl

Isolparma Pendenzato RF7-Isolparma srl

Finishes and coatings

S-P-02255: Outdoor decorative paints - DAW ITALIA GMBH & CO KG

S-P-02254: Indoor decorative paints - DAW ITALIA GMBH & CO KG

S-P-00913: Colorite Matt RFI - water-based reflective paint for railway structures - Mapei S.p.A.

S-P-00692: Interpon D powder coating products - AkzoNobel Powder Coatings BV

PAINTS - VITALVERNICI s.r.l.

WALL COVERINGS - VITALVERNICI s.r.l

Plaster and gypsum products

S-P-01688: Gyproc Igniver plasters - Saint-Gobain PPC Italia SpA

S-P-00943: Aquaroc - Saint-Gobain Placoplatre

S-P-00935: Gyproc DuraGyp 13 mm - Saint-Gobain PPC Italia SpA

S-P-00937: Gyproc Hydro 13 mm - moisture resistant board - Saint-Gobain PPC Italia SpA

S-P-00938: Gyproc Wallboard 13 mm - Saint-Gobain PPC Italia SpA

S-P-00936: Gyproc Fireline 13 mm - Saint-Gobain PPC Italia SpA

Calcium sulphate panels for raised floors in different finishes - Uniflair S.p.A

Concrete, mortars and grouts

S-P-01824: Supergrout tixotropico R4 - CVR S.r.l.

Ready - made concrete – CLS, dryCrystal e BeForce - Colabeton - Società per Azioni con unico Socio

Autoclaved Aerated Concrete - DOC Airconcrete s.r.l.

Self locking blocks for external pavements: CLASSIC, DESIGN and FILTERING - PAVER Costruzioni S.p.a.

Self locking blocks for external pavements: CLASSIC, DESIGN and FILTERING - PAVER Costruzioni S.p.a.

CONCRETE GREEN® 0317 - Tavellin Greenline srl.

Ready - made concrete – EL40002 – Techbau SpA – Cantiere Polo Logistico Teddy – Gatteo (FC) - UNICAL SPA

Ready - made concrete – EL40001 – Techbau SpA – Cantiere Polo Logistico Teddy – Gatteo (FC) - UNICAL SPA

Concrete for supplies “693 Coop Umanitaria Soc. Coop. - Pronto Soccorso Ospedale di Cesena” - UNICAL SPA

Ready - made concrete – EL40003 – Techbau SpA – Cantiere Polo Logistico Teddy – Gatteo (FC) - UNICAL SPA

Linea Betoncini – Vaga srl

Ytong concrete blocks - Xella Italia

Construction systems

S-P-01364: Plastbau floor joist, version C, model 17/6 and Cube floor joist, model 20/5 - Sicilferro Terrenovese Srl - Divisione Edilizia

S-P-01366: Partition Plastbau D200 and H2Wall 6.3/20/9.3 - Sicilferro Terrenovese Srl - Divisione Edilizia

S-P-01365: EPS Crawl Space, model AirCrab H35: Sicilferro Terrenovese Srl - Divisione Edilizia

S-P-01101: Construction systems such as roofs, floors and wooden buildings of Posatori Franciacorta Srl - Posatori Franciacorta Srl

COAT SYSTEM IN POLYSTYRENE AND ROCK WOOL COAT SYSTEM-VITALVERNICI s.r.l.

Ceramic Products

Piastrelle di ceramica italiane - Confindustria Ceramica

Italian ceramic tiles - Confindustria Ceramica

SANITARY CERAMICS - CERAMICA CATALANO Spa

PORCELAIN STONEWARE CERAMIC TILES AND SLABS - Ceramiche Atlas Concorde S.p.A.

PORCELAIN STONEWARE AND SINGLE FIRING WHITE BODY CERAMIC TILES AND SLABS - Ceramiche Atlas Concorde S.p.A.

PORCELAIN STONEWARE CERAMIC TILES AND SLABS - Ceramiche Atlas Concorde Spa

PORCELAIN STONEWARE AND SINGLE FIRING WHITE BODY CERAMIC TILES AND SLABS - Ceramiche Caesar S.p.A.

PORCELAIN STONEWARE CERAMIC TILES AND SLABS - Ceramiche Caesar S.p.A.

PORCELAIN STONEWARE CERAMIC TILES AND SLABS - Ceramiche Marca Corona S.p.A.

PORCELAIN STONEWARE CERAMIC TILES AND SLABS - Ceramiche Refin S.p.A.

Ceramic tiles - Emilceramica S.r.l.

Porcelain Stoneware Ceramic Tiles - Gruppo Ceramiche Gresmalt S.p.A

Portuguese tile type UNICOPPO and TE.SI - INDUSTRIE COTTO POSSAGNO

Ceramic tiles - Marazzi Group S.r.l.

Ceramic tiles - Marazzi Group S.r.l.

Ceramic tiles - Marazzi Group S.r.l.

Ceramic tiles - Marazzi Group S.r.l.

Ceramic tiles - Marazzi Group S.r.l.

Ceramic tiles - Marazzi Group S.r.l.

PORCELAIN STONEWARE CERAMIC TILES AND SLABS - Mirage Granito Ceramico S.p.A.

PORCELAIN STONEWARE - Panariagroup Industrie Ceramiche S.p.A.

PORCELAIN STONEWARE - Panariagroup Industrie Ceramiche S.p.A.

LAMINATED PORCELAIN STONEWARE - Panariagroup Industrie Ceramiche SpA.

Red Marseilles tile in brick - Terreal Italia s.r.l

Ceramic tiles - Glazed porcelain tiles (Casiglie's plant)-Marazzi Group srl

Ceramic tiles - Unglazed porcelain tiles (Casiglie's plant)-Marazzi Group srl

BREG EN EPD 000148 - **Laminam S.p.A.** Laminam 3+ ceramic tile

BREG EN EPD 000149 - **Laminam S.p.A.** Laminam 5 ceramic tile

Plastics

DIVINYCELL IPN GRADES - DIAB S.p.A.

DIVINYCELL PET GRADES - DIAB S.p.A.

PLASTIC PIPING SYSTEMS FOR LIQUID FUELS AND FUEL VAPOURS TYPE SMARTFLEX AND SUPERSMARTFLEX - Nupi Industrie Italiane S.p.A.

PE - RT/AL/HDPE PIPING SYSTEMS FOR HOT AND COLD WATER IN THE BUILDING TYPE MULTINUPI - Nupi Industrie Italiane S.p.A.

Polyethylene piping system for water, gas and industrial applications type “polietilenetubi” and “elofit” - Nupi Industrie Italiane S.p.A.

Plastic piping systems for hot and cold water type “Niron and Polysystem” - Nupi Industrie Italiane S.p.A.

FLAGON® PVC - Soprema s.r.l.

FLAGON® TPO - Soprema s.r.l.

Other products

Doors –

Honeycomb door for interior doors-LUALDI S.p.A.

Electronics –

SMART METERS-Bitron S.p.A.

Panel products –

PRINT HPL (High Pressure Laminate) Compact - Abet Laminati S.p.A.

PRINT HPL (High Pressure Laminate) Thin - Abet Laminati S.p.A.

Flat fibre cement sheets - Società Italiana Lastre S.p.A.

Stone-

Covering in Serena of Firenzuola stone with natural surface and sandblasted with trimmed edges-Casone Group srl.

BREG EN EPD 000236 - **Lapitec S.p.A.**-Lapitec Sintered Stone Slab

Stratified porphyry products-

SAWN PRODUCTS - E.S.PO. Soc. Cop.

SPLIT PRODUCTS - E.S.PO. Soc. Cop.

RAW SLAB - E.S.PO. Soc. Cop.

Appendix 4: Other Product data for Croatia

Insulation

EPD-KIN-20150029-CBB1-EN: Lamella Mat Forte LMF AluR Rock Mineral Wool, Knauf Insulation

EPD-KNA-20150027-CBB1-EN: IPS 680 Rock Mineral Wool Pipe Section, Knauf Insulation

EPD-KNI-20170218-CBD1-EN: DP7 – DP8 Multipurpose Rock Mineral Wool insulation, Knauf Insulation

EPD-KNA-20150026-CBB1-EN: HPS 035 AluR Rock Mineral Wool Pipe Section, Knauf Insulation

Plaster and gypsum products

S-P-00813: Knauf Wallboard type A, Knauf Wallboard impregnated, Knauf fire-resistant board type DF – Knauf d.o.o.