METHODOLOGY FOR ENVIRONMENTAL PROFILES OF CONSTRUCTION PRODUCTS

Product Category Rules for Type III environmental product declaration of construction products

DRAFT

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Contents

Acknowledgement

The Environmental Profiles methodology was first published in 1999. This 2007 update has been made possible with the kind support of:

- BRE Trust
- Department for Education and Skills
- Department of Trade and Industry
- Energy Savings Trust
- English Partnership
- HSBC
- National House Building Council (NHBC)
- Office of Government Commerce
- Royal Bank of Scotland
- Willmott Dixon
- WRAP

Peer review statement

The following experts in LCA and buildings have undertaken a peer review of this methodology:

- Wayne Trusty, Athena Sustainable Materials Institute, Canada (Chair)
- John Bowdidge, Independent LCA expert, UK
- Eva Schminke, Five Winds Consultancy, Germany

The peer review team congratulates BRE Ltd on the production of a well-researched and well-developed PCR methodology. The PCR methodology closely follows the requirements of the relevant ISO standards, while at the same time providing the necessary detail to enable the derivation of Type III Environmental Product Declarations (EPD).

Suggestions to improve the clarity of the report and to modify a number of technical issues were made and these were implemented by BRE.

BRE statement on the completeness of this document

This is a provisional draft of the Environmental Profiles Methodology. Because this is a draft document certain sections remain incomplete.

This document has been compiled to reflect the conclusions of the industry consultation exercise including discussions with the Construction Products Association and its members, the Project Steer Group, and the BRE Certification Sustainability Board. Every attempt to accurately reflect the agreed conclusions of these discussions has been made.

Introduction

Manufacturers of construction products, designers, users and owners of buildings and others active in the building and construction sector are increasingly demanding information that will enable them to make decisions which address environmental impacts of buildings and other construction works. An increasingly popular approach is to create environmental product declarations.

Environmental product declarations are similar to the nutritional information found on the back of food packets. They list the impacts caused throughout the life of a particular product.

It is essential that there be uniformity in the means of expressing environmental product declarations. This includes having a consistent way of arriving at the declaration and providing the information. The user expects unbiased, accurate and verified information, which is consistent with the best current practice and understanding.

To help achieve this, work has been ongoing at both national and international levels. According to the International Standards of the ISO 14020 series, environmental labels and declarations are divided into three principal types:

- Type I (ISO 14024) – label: a defined environmental standard with "ecolabels" awarded to those who pass
- Type II (ISO 14021) – claims: self declared claims (e.g. "recyclable")
- Type III (ISO 14025) – declaration: 'nutritional labelling' style environmental product declarations within a prescribed formula

These documents are supported by a fourth document: ISO 14020, *Environmental labels and declarations – General principles*. Additionally, a further ISO Standard has been specifically developed to create appropriate rules for applying the ISO 14025 standard to construction products:

- ISO FDIS[1] 21930 *Sustainability in building construction – Environmental declaration of construction products.*

Type III environmental product declarations must be based on Life Cycle Assessment (LCA), an area which has been covered by the ISO standards:

- ISO 14040:2006, *Environmental management - Life cycle assessment. Principles and framework*
- ISO 14044:2006, *Environmental management - Life cycle assessment - Requirements and guidelines.*

This document provides information about the Environmental Profiles methodology for construction products[2], a "type III" environmental labelling scheme for construction products and elements. The methodology has been prepared to be in conformity with the relevant ISO standards – FDIS 21930, ISO 14025, and standards relating to Life Cycle Assessment in general, ISO 14040 and 14044.

BRE first published the Environmental Profiles methodology, "BRE Methodology for Environmental Profiles of construction materials, components and buildings" in 1999, with funding from the DETR and the involvement of over 20 trade associations and industry bodies. Following developments in LCA

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[1] FDIS refers to the status of the standard at the time of preparing this document: 'Final Draft International Standard'. When finalised, the standard will be referred to simply as ISO 21930

[2] For Definition see Chapter 3 paragraph 3.2

techniques and the work undertaken for the ISO Standards, BRE chose to update the methodology, a process which has involved extensive stakeholder consultation.

The purpose of this methodology is to describe the principles and framework for environmental declarations of construction products, including consideration of the reference service life[3] of construction products over a building's life cycle. This methodology forms the basis for the Environmental Profiles Scheme, a Type III environmental declaration programme which enables manufacturers and trade associations to make Type III environmental declarations of construction products as described in ISO 14025.

The overall goal of Environmental Profiles is to encourage the demand for, and supply of, construction products that cause less stress on the environment, through communication of verifiable and accurate information on environmental aspects of those construction products, thereby stimulating the potential for market-driven continuous environmental improvement.

This document will be of interest to individual construction product manufacturers and construction product trade associations wishing to prepare an Environmental Profile and data users, including designers and clients, who wish to have a detailed understand of the basis of the information they are using.

There are two clear benefits to having a single, industry agreed method that is applicable to all types of building product:

1) The application of the Environmental Profiles methodology will allow manufacturers and trade associations to publish data about their products on the basis of a "level playing field", i.e. in a way that is comparable and robust for competing product types.

2) Using data produced by this methodology will give confidence to designers and building clients who wish to ensure that they have taken full account of the life cycle environmental impacts of the construction products they are using, using the latest developments in life cycle assessment and that the data they are using has been produced such that competing products have been evaluated in a fair and independent manner.

For more information about the Environmental Profiles Scheme see *http://www.bre.co.uk/envprofiles*

[3] For Definition see chapter 3 paragraph 3.12

Environmental Profiles: a scheme for the environmental declaration of construction products in the UK

1 Scope of this document

This document provides the principles and requirements for the Environmental Profiles Scheme, a scheme that produces Type III environmental product declarations for construction products. The declaration is called an Environmental Profile.

The document describes the general programme requirements and the product category rules (PCR)[4] for the Environmental Profiles of construction products. This methodology is based upon International Standard ISO FDIS 21930 *Sustainability in building construction – Environmental declaration of construction products*. This International Standard contains specific requirements for construction products and complements International Standard ISO 14025 *Environmental labels and declarations Type III environmental declarations – Principles and procedures,* ISO 14040:2006, *Environmental management - Life cycle assessment. Principles and framework,* ISO 14044:2006, *Environmental management - Life cycle assessment - Requirements and guidelines.*

NOTE: In ISO FDIS 21930 *Sustainability in building construction – Environmental declaration of construction products*, EPD is an abbreviation used to represent both the single and plural full form designation of 'environmental product declaration(s)', which is intended to be synonymous with the designation 'Type III environmental declaration'. In the practice of developing EPD, programmes or their declarations are referred to by various names such as Eco-Leaf, eco-profile, environmental declaration of products and environmental profile. This scheme uses the name Environmental Profile.

This document describes in detail the consistent approach to the identification and assessment of the impacts of all construction products over their life cycle that is used in the Environmental Profiles Scheme, including:

- Goal and scope,
- Inventory data collection procedures,
- Preferred data sources,
- Consistent treatment of transport,
- Calculation of emissions from fuel use,
- Allocating impacts to products from multiple product lines,
- Allocating impacts to products which are recycled,
- Impact assessment procedures-for classification, characterisation and normalisation,
- Format for Environmental Profiles.

The Environmental Profiles are intended for business-to-business use, i.e. from manufacturer/trade association to designer/client. They may also be used for the communication of information from business to consumer.

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[4] For Definition see chapter 3, paragraph 3.11

Published Environmental Profiles will be based on two types of data:

- manufacturer-specific data
- average data created by the submission of several manufacturers, for example within a trade association

The Environmental Profiles methodology is the basis for two schemes designed to produce LCA and EPD:

- the BRE Environmental Profiles Certification Scheme, which provides a service to enable manufacturers to publish certified EPD about their proprietary products
- the BRE Environmental Profiles Scheme, which provides a service to allow groups of manufacturers or a trade association to obtain, and voluntarily publish, verified LCA data and EPD about generic or typical construction products

Both types of Environmental Profile are held in the UK database of Environmental Profiles of construction products, which is available at *http://www.bre.co.uk/envprofiles*

Manufacturers and trade associations can add new Environmental Profiles to the database if they comply with this methodology.

2 Normative references

Document ISO FDIS 21930, Sustainability in building construction – Environmental declaration of construction products contains provisions, which, through reference in this text, constitute provisions of this methodology. The methodology is based upon the version current at the time of publication.

ISO FDIS 21930 draws on other related International Standards. To provide an indication of the range of related Standards a list is provided here. The related standards include:

- ISO 6707-1:2004, Building and civil engineering – Vocabulary – Part 1: General terms
- ISO 14001:2004, Environmental management systems – Specification with guidance for use
- ISO 14020:2002, Environmental labels and declarations – General principles
- ISO 14021:2001, Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling)
- ISO 14024:2001, Environmental labels and declarations – Type I environmental labelling – Principles and procedures
- ISO 14025:2006, Environmental labels and declarations – Type III environmental declarations – Principles and procedures
- ISO 14040:2006, Environmental management – Life cycle assessment – Principles and framework
- ISO 14044:2006, Environmental management – Life cycle assessment – Requirements and guidelines
- ISO/TR 14047:2003, Environmental management – Life cycle impact assessment – Examples of application of ISO 14042
- ISO 14050:2002, Environmental management – Vocabulary ISO/DIS 15392, Buildings and constructed assets – Sustainability in building construction – General Principles
- ISO 15686-1:2000, Buildings and constructed assets – Service life planning – Part 1: General principles
- ISO 15686-2:2001, Buildings and constructed assets – Service life planning – Part 2: Service life prediction methods
- ISO/DIS 15686-8 Buildings and constructed assets – Service life planning – Part 8: Reference service life
- ISO/TS 21929-1:2006, Buildings and constructed assets – Sustainability in building construction – Sustainability indicators – Part 1 – Framework for development of indicators for Buildings
- ISO/TS 21931-1:2006, Buildings and constructed assets – Sustainability in building construction – Framework for Assessment of Environmental Performance of Construction Works – Part 1 - Buildings
- ISO/CD 21932:2006, Buildings and constructed assets – Sustainability in building construction – Terminology

3 Terms and definitions

For the purposes of this methodology, the terms and definitions given in ISO/FDIS 21930 apply.

NOTE Terms are not defined where they retain their normal dictionary definition. Where bold type is used within a definition, this indicates a cross reference to another term defined in this clause, and the number reference for the term is given in parentheses.

3.1
ancillary product
complementary product
building product (3.2) that enables another building product to fulfil its purpose in the intended application

EXAMPLE Fasteners used to attached structural panels to framing members

3.2
building product
goods or services used during the life cycle of a building or other construction works

NOTE 1 In this methodology, the term “product” used alone relates not only to product systems but can also include service systems. In either case, the declaration is presented in a manner that clearly indicates whether the declaration applies to goods, or only to a part of the goods or packaging, or to an element of service. This is discussed in ISO 14025:2006, 7.2.2.

NOTE 2 The manufacturing or processing of goods used as a building product may take place at the factory or on the construction site.

NOTE 3 The use of services can occur at any stage of the life cycle of the building or other construction works.

NOTE 4 It is possible to have an **Environmental Profile** (3.16) for a material, a building product, a component, an assembly and/or a building element. The Environmental Profiles of a component, assembly or building element can incorporate the results of the Environmental Profiles of all the assembled materials and construction products. This is described in *Principle 5.4 Modularity* in ISO 14025:2006, 5.4.

NOTE 5 Adapted from the definition of product in ISO 6707-1 and ISO 14021

NOTE 6 Whereas ISO use ‘building product’, in this methodology the term ‘construction product’ is used. There is no difference in meaning intended between the two terms as defined above and the choice is based on the more common usage of ‘construction product’ in the UK.

3.3
characterisation factor
factor derived from a characterisation model which is applied to convert an assigned life cycle inventory analysis (LCI) result to the common unit of the category indicator

3.4
declared unit
quantity of a **building product** (3.2) for use as a reference unit in an **Environmental Profiles** (3.16), based on LCA, for the expression of environmental information needed in **information modules** (3.7)

Example: Mass (kg), Volume (m^3)

NOTE The declared unit will only be used where the function and the reference scenario for the whole life cycle, on the building level, can not be stated

3.5
functional unit
quantified performance of a product system for a **building product** (3.2) for use as a reference unit in an **Environmental Profiles** (3.16) based on LCA

3.6
gate
point at which the **building product** (3.2) or material leaves the factory before it becomes an input into another manufacturing process or before it goes to the distributor, a factory or building site

3.7
information module
compilation of data to be used as a basis for a **Type III environmental declaration** (3.16), covering a unit process or a combination of unit processes that are part of the life cycle of a product

3.8
non-renewable resource
resource that exists in a fixed amount that cannot be replenished on a human time scale

3.9
PCR review
process whereby a **third party** (3.16) panel verifies the **product category rules** (3.11)

3.10
product category
group of **construction products** (3.2) that can fulfill equivalent functions

3.11
product category rules
PCR
set of specific rules, requirements and guidelines for developing **Type III environmental declarations** (3.16) for one or more **product categories** (3.10) . The BRE methodology applies to the product category “construction products”.

NOTE The term PCR has been replaced by ‘methodology’ in this document. The two terms may be used interchangeably.

3.12
reference service life
service life of a **building product** (3.2) that is known or to be expected under a particular set, i.e., a reference set, of in-use conditions and which may form the basis of estimating the service life under other in-use conditions

NOTE The reference service life is applied in the **functional unit** (3.5)/**declared unit** (3.4)

3.13
renewable resource
resource that is grown, naturally replenished or cleansed on a human time scale

EXAMPLE Trees in forests, grasses in grasslands and fertile soil.

NOTE A renewable resource is capable of being exhausted, but may last indefinitely with proper stewardship.

3.14
third party
person or body that is recognized as being independent of the parties involved, as concerns the issues in question

NOTE "Parties involved" are usually supplier ("first party") and purchaser ("second party") interests.

3.15
Type III environmental declaration
environmental product declaration
Environmental Profiles
environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information

NOTE 1 The predetermined parameters are based on the ISO 14040 series of standards, which is made up of ISO 14040 and ISO 14044.

NOTE 2 The additional environmental information may be quantitative or qualitative.

3.16
waste

This method does not seek to define waste. ISO 21930 defines waste as ‘substances or objects which the holder intends or is required to dispose of’. This definition is included here as a useful description.

NOTE The ISO definition is taken from the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* (22 March 1989) but is not confined to hazardous waste

4 Terms and definitions

4.1 Symbols and Abbreviations

Energy	mega joule	MJ
Energy	kilowatt hour	kWh
Mass	tonne (metric ton)	t
Mass	kilogram	kg
Mass	gram	g
Surface	square metres	m^2
Volume	cubic metres	m^3

4.2 Acronyms

CFC	chloro-fluoro-carbons
EPD	environmental product declaration
GWP	global warming potential
HCFC	hydrogenated chloro-fluoro-carbons
LCA	life cycle assessment
LCI	life cycle inventory
LCIA	life cycle impact assessment
ODP	ozone depletion potential
PCR	product category rules
VOC	volatile organic compounds

5 General aspects of the Environmental Profiles Scheme

5.1 Goal

The overall goal of Environmental Profiles is to encourage the demand for, and supply of, construction products that cause less stress on the environment, through communication of verifiable and accurate information on environmental aspects of those construction products, thereby stimulating the potential for market-driven continuous environmental improvement.

This document provides information about the methodology for preparing Environmental Profiles for construction products.

This common methodology used to create Environmental Profiles allows for comparisons to be made between different types of construction products, based on units of equivalent functional performance at a building level, created according to the standards required by 2006 Approved Building Regulations for England and Wales.

5.2 Scope

This methodology provides the rules necessary for the declaration of environmental information of construction products in the form of Environmental Profiles. Environmental Profiles are used for the assessment of the environmental performance of the fabric, structure, finishes and fittings of buildings.

The methodology identifies all the significant environmental aspects associated with the life cycle of construction products, according to the guidance on identifying significant environmental aspects in ISO 14001.

Only environmental impacts and aspects are considered. The social and economic aspects of sustainability are excluded.

The working environment is not included.

The impacts in use/operation (e.g. heat loss avoided by use of insulation) are excluded, except maintenance. However these aspects should be considered through the use of Environmental Profiles within a building level assessment.

NOTE: The impacts in use/operation depend on a number of factors outside the scope of an Environmental Profile for construction products, including the size, form and function of the building and occupant behaviour.

Environmental information in an Environmental Profile covering all life cycle stages (“*cradle to grave*”) comprises data from the following four life cycle stages:

- product stage (raw material supply, transport, manufacturing of products, and all upstream processes from cradle to gate);
- construction process stage (transport to the building site and building installation/construction);
- use stage (maintenance, repair and replacement, refurbishment);
- end of life stage (recycling and disposal; all including transport).

From distinguishing these different levels, it is clear that there are two types of Environmental Profiles: for **products** and for **building elements**. These have distinct properties, as shown in Table 1.

Providing the data for these is the responsibility of different parties and the table distinguishes this.

This document can therefore be used in two ways: to identify the basic requirements of a manufacturer who wishes to prepare an Environmental Profile and for interested parties to identify how the data is treated to create an Environmental Profile once it has been provided to BRE Certification Limited, the programme operator.

Table 1: The three types of Environmental Profile.

Profile type	Life Cycle stages include	Study units	Use for Comparison	Responsible party
Cradle to gate	Production stage (raw material supply, transport, manufacturing of products, and all upstream processes from cradle to gate).	Information module: per tonne	Shall not be used for comparison	In-factory (gate to gate) data collected by manufacturer Pre-factory data for raw materials provided by BRE Certification Ltd
Cradle to site	Product stage (raw material supply, transport, manufacturing of products, and all upstream processes from cradle to gate). Construction process stage (transport to the building site and wastage from building installation/construction only) including transport and disposal of waste.	Information module: per square metre installed element	Shall not be used for comparison	As above and Construction process data provided by BRE Certification Ltd
Cradle to grave	Product stage (raw material supply, transport, manufacturing of products, and all upstream processes from cradle to gate). Construction process stage (transport of materials to the building site and wastage from building installation/construction only) including transport and disposal of waste. Use stage: repair, replacement, maintenance and refurbishment including transport of any materials and disposal of waste over the sixty year study period. Demolition: is expected to occur any time at or after the end of the study period and is included within this Environmental Profile. It includes transport and disposal of waste.	Functional unit: per square metre installed element over a sixty year study period in the building	Can be used for comparison if the functional unit is equivalent	As above and: Life-time data provided by BRE Certification Ltd

NOTE It is possible to have an Environmental Profile for a material, for a product and for a component, an assembly and/or a building element. The Environmental Profiles of a component, assembly or building element can incorporate the results of the Environmental Profiles of all the assembled materials and construction products. This is described in Principle 5.4 Modularity in ISO 14025:2006, 5.4.

NOTE Transport of people for any form of labour at any stage in the life cycle is not included – e.g. construction or maintenance.

5.3 Objectives

The purpose of an Environmental Profile for construction products is

1. To provide a measurable and verifiable input for the assessment of the environmental performance of buildings.

2. For interested parties to compare the environmental impacts of different construction products as they are used within a building, based on units of equivalent functionality.

3. To provide a means of collecting relevant data for the preparation of tools for comparing the environmental impacts of construction products, including the Green Guide to Specification[5] and the envest2 software for the environmental assessment of whole buildings[6]. These are used to give credits for the use of materials with a lower than average environmental impact in the BREEAM family of environmental assessment tools for buildings and the Code for Sustainable Homes.

5.4 Audience

Environmental Profiles of construction products are intended to provide information for planning and assessing buildings and are intended mainly for business-to-business communication. This does not preclude their use for business to consumer purposes, where third party verification has been obtained.

The users of this methodology are information users, who may include trade associations, manufacturers in the manufacturing chain, designers, developers, architects, contractors, facility managers and their clients.

5.5 Programme operator

The programme operator is BRE Certification Ltd. Third Party verification is provided by BRE Certification Ltd. (Section 9)

5.6 Involvement of interested parties

The process of developing this methodology included an open, participatory consultation with interested parties and effort was made to achieve a consensus throughout the process.

5.6.1 Industry Stakeholders

This document has been produced by BRE. The research was undertaken in consultation with three groups:

1. The Green Guide steering group
2. The Construction Products Association Manufacturers Advisory Group
3. A panel of LCA expert advisors

The technical quality of the methodology development process has been overseen by the BRE Trust Sustainability Board.

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[5] The Green Guide to Specification, Anderson et al, 4th edition, due for publication Autumn 2007. IHS BRE Press

[6] www.envest.co.uk

5.6.1.1 *Group 1 – Green Guide steer group*

This work has been made possible with the financial sponsorship of the Green Guide steering group:

- BRE Trust
- Department for Education and Skills (DfES)
- Department of Trade and Industry (DTi)
- Energy Savings Trust (EST)
- English Partnerships
- HSBC
- National House Building Council (NHBC)
- Office of Government Commerce (OGC)
- Royal Bank of Scotland (RBS)
- Willmott Dixon
- WRAP

A number of additional interested parties had membership to the steering group to ensure construction industry representation:

- John Bowdidge, Independent LCA expert
- Construction Products Association*
- Housing Corporation
- National Building Specification (NBS)

*NOTE The Construction Products Association was a member of this group as representatives of the construction products industry but made no financial contribution to the project. This status was established to ensure no conflict of interest and to reflect the substantial contribution of the construction products sector in meeting the cost of processing new Environmental Profiles LCA data. None of the additional parties were financial sponsors of the project.

5.6.1.2 *Group 2 – Construction Products Association: Manufacturers Advisory Group (MAG)*

This was a special working group convened by the Construction Products Association and was called the Manufacturers Advisory Group (MAG). Other trade associations not affiliated to the Construction Products Association and industry members of the BRE Environmental Profiles Certification Scheme were also consulted throughout the development process.

5.6.1.3 *Group 3 – LCA expert advisory panel*

The following experts in LCA and building materials contributed during the development of this methodology:

- Wayne Trusty, Athena Sustainable Materials Institute, Canada.
- John Bowdidge, independent LCA expert, UK
- Jean Luc Chevalier, Head of the Environment and Durability Division, Materials Department CSTB (Centre Scientifique et Technique du Bâtiment), France.
- Sverre Fossdal, Senior Researcher, Norwegian Building Research Institute.
- Rolf Frischknecht, ESU-services, Switzerland
- Tarja Hakkinen, Chief Research Scientist, VTT Building and Transport, Finland.

5.6.2 PCR review committee

The following experts in LCA and buildings have undertaken a peer review of this methodology:

- Wayne Trusty, Athena Sustainable Materials Institute, Canada. (Chair)
- John Bowdidge, Independent LCA expert, UK
- Eva Schminke, Five Winds Consultancy, Germany

The PCR review committee report will be published with the final version of this document and a summary statement is included within the methodology introduction.

5.7 Responsibility for the Environmental Profiles

The manufacturer, group of manufacturers or Trade Association who have provided the data for the building product is the owner of the LCI data and takes responsibility for the Environmental Profile of the **construction product**.

BRE Certification takes responsibility for the Environmental Profile of the **construction element.**

BRE Certification Ltd has an agreement with the manufacturers and trade associations it works with to use the LCA data that it prepares on their behalf within BRE tools and to publish Environmental Profiles with their permission.

5.8 Product Category

At its highest level, the scheme is applied to a single product category: building materials. This document sets out the Product Category Rules for all building materials. Where exceptions apply for particular groups, these are clearly stated.

5.9 Comparability of Environmental Profiles of construction products

Comparison of construction products using Environmental Profiles shall only be carried out at the building level, using a functional unit of an installed element within a scenario. The Environmental Profile “Per installed element over 60 years study period in the building (cradle to grave)” provides this. This document describes the rules and requirements for how the 60-year scenario is created. Comparability of construction products using Environmental Profiles is in accordance with the requirements for comparability as described in ISO 14025:2006, Clause 4 and 5.6.

Environmental Profiles for the equivalent functional unit prepared using the methodology set out in this document are deemed to be comparable.

5.10 Data management

BRE and BRE Certification Ltd are UKAS accredited under ISO 9001. All records and documents are controlled such that they are

a) approved for adequacy prior to issue,

b) revised on a regular basis and re-approved when re-issued ,

c) clearly marked with their revision status,

d) available in their relevant version at points of use,

e) legible and readily identifiable,

f) kept distinctly marked from obsolete versions which may be retained for a particular purpose in order to prevent the unintended use of obsolete documents.

5.11 Data confidentiality

Data from manufacturers is stored securely. Access is limited to staff working as part of the Environmental Profiles Scheme. Data confidentiality as a restriction on publication is described in Section 8.

5.12 Keeping the methodology (PCR) up to date

This is the second iteration of the Environmental Profiles methodology. The first edition was published in 1999. An addendum to the first edition was published in 2000.

Developments in the LCI data sources and standards and Building Regulations for England and Wales will be reviewed by BRE at a minimum interval of three years. BRE as the programme operator will form an opinion on significance of the changes identified, with contribution from the PCR Review Panel. The BRE Trust Sustainability Board will make the final decision. The intention is to maintain the PCR according to latest best practice, within the financial constraints of operating the scheme such that it is commercially viable and accessible to new and existing manufacturer participants.

6 Methodological framework

6.1 General

The methodology is designed to be consistent, scientifically robust and to ensure that burdens and impacts are comprehensively accounted for without any double counting or undercounting.

The methodology is designed to be consistent for all stages of the life cycle across all material classes – i.e. the winning of raw materials and fuels, energy conversion, chemical processes, manufacture, fabrication, transport, operation and use, repair and maintenance, refurbishment, demolition, reuse or recycling and disposal.

6.2 Data collection

Data is collected by manufacturers using a standard questionnaire.

Inventory data is collected for following items:

Inputs: Materials
Transport Fuel
Process Fuel
Heat
Water

Outputs: Emissions to air
Discharge to water
Emissions to land
Products, co-products, by-products and wastes

Manufacturers provide a process tree, including any major transportation stages with a clearly marked system boundary to indicate included and excluded processes. The resulting inventory is checked for balance in mass and in energy terms (taking due account of any phase change processes like evaporation in order to be thermodynamically correct). The total energy or mass flowing into the system boundary must be accounted for with an equivalent mass or energy flow out of the system boundary. Figure 1 illustrates the generic components of a process tree.

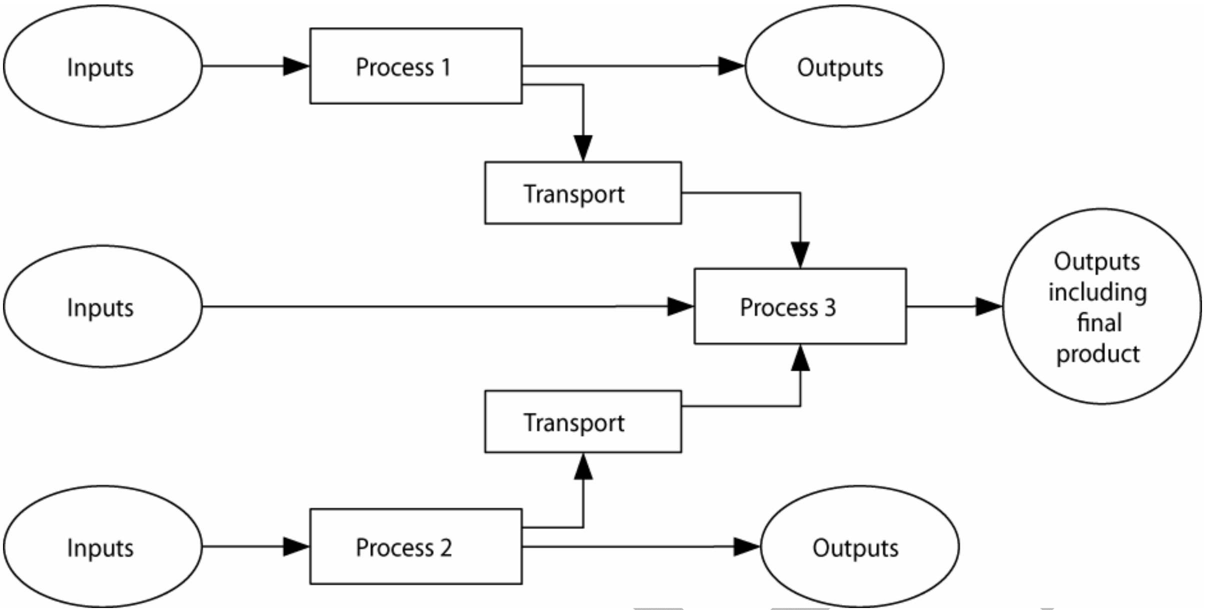

Figure 1 Generic Process Tree

6.3 Declared and functional units

The product category units used by the Environmental Profiles methodology are fully explained in Appendix 4.

6.4 System boundaries

System boundaries have been established in accordance with the provisions of ISO 14044:2006, 4.2.3.3 and 4.3.3.4.

6.4.1 Boundary rule: Cut-off criteria for the inclusion of inputs and outputs

The inventory process gathers all the inputs to the plant that are associated with a product, including product ingredients, packaging materials and consumable items.

For many processes, a large number of substances and materials are used in very small quantities and it is unrealistic to gather data on all of these. However, it is important that significant environmental effects are not omitted by ignoring these low mass substances. Sensitivity analysis may later reveal that these substances do not significantly affect the overall result but it is important that data is provided to enable this conclusion to be drawn. To achieve this, the following conventions are applied:

Data should be included for 98% of all inputs by mass. The inputs must be sufficient to produce all the outputs including waste arising. The methodology will adjust input inventories proportionally to 100% where it is not possible to quantify internal process waste.

Data is included on all materials with a mass greater than 2% of the output from the process subject to the 98% rule above. Information is provided for materials which contribute less than 2% by mass, but possibly:

- have significant effects in their extraction, their use or disposal, or
- are highly toxic, or

- are classed as hazardous waste.

Materials with a low mass input but which contribute a significant proportion of the energy input are included.

6.4.2 Boundary rule: Cut-off criteria for environmental impacts

No cut-off criteria are provided within this methodology for environmental impacts resulting from the included material flows; all are included within the assessment and all environmental impacts are reported.

6.4.3 Boundary rule: Capital equipment and infrastructure

The contribution of capital equipment and infrastructure is not normally considered in LCA and is not included here unless it is significant, in accordance with the data cut-off rule in **Error! Reference source not found.**. Maintenance of equipment is also not included in the LCA except for frequently consumed such as saw blades and sanding paper and mould oil which are included in the inventory if they meet the data cut-off rules in **Error! Reference source not found.**.

6.4.4 Boundary rule: Energy use in factory and factory support offices

All energy used in factories and factory support offices is included. Head offices and sales offices etc are excluded.

6.4.5 Boundary rule: Construction impacts

Construction process impacts are not accounted for except for waste. Data sets are not widely available and the impact is considered to be small and unfeasible to allocate to products.

6.4.6 Boundary rule: Site wastage

Site wastage during the construction and refurbishment process is included.

A costing handbook, Laxtons[7] includes wastage rates for most popular specifications. This is used to collate wastage rates for construction materials within particular contexts, in terms of use within the building (e.g. timber as studwork, within window frames and as floorboards), whether the project is new build or refurbishment, and size of project. The rates are checked with manufacturers or trade associations for appropriateness and tailored models are created where evidence is available for particular construction practices.

To create the Environmental Profile for a specification, the appropriate context for each material used is selected as part of the specification process and the relevant wastage rate for first installation and any subsequent replacements are calculated.

6.4.7 Boundary rule: Lifetime use: maintenance

Maintenance is considered where the impacts are significant as per 6.4.1 and may vary depending on the use of the product within the building. Typical maintenance for a product within a given specification will be considered. Transportation impacts for personnel and plant are not included in maintenance models.

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[7] Laxtons Building Price Book 2006, Elsevier . ISBN: 0750665610 1488

The quantity and transport of any significant materials used (e.g. in painting and varnishing) over the lifetime of a product will be included.

For flooring a model of cleaning impacts over the lifetime is included. This takes account of water, materials and energy used but not transport of cleaning staff to the site.

6.4.8 Boundary rule: Lifetime use: contribution to lifetime: energy use in a building

The functional unit for elements is based on 2006 Building Regulations for England and Wales and includes a U-value provided by BRE which is likely to ensure that any resulting building would satisfy Approved Documents Part L1A and B and Part L2A and B (2006). All the element specifications have been designed to achieve this requirement. This allows the designer to consider the overall impact from quantities of different materials required to produce different building solutions without having to consider differences in energy consumption resulting from different thermal resistance values. In general comparison between elements with the same functional unit can ignore life time energy use within the assessment. However, care should be taken where aspects such as thermal mass may have implications on energy consumption in the building.

Where a product, for example a modular construction system, is normally built to a better U value than the functional units defined in Appendix 1, BRE will adapt it to meet the U value defined in the functional unit.

6.4.9 Boundary rule: Demolition

The impact of the demolition process is not included. Data sets are not widely available and the impact is considered to be small and difficult to allocate to specific materials. However the impact of disposal of material arising from demolition is considered based on 6.4.10.

6.4.10 Boundary rule: Disposal

The boundary of the LCA includes the impacts of disposal of all materials. The LCA model of waste disposal used includes the development of the infrastructure, transport to waste treatment, and any emissions arising from the waste treatment according to the ecoinvent 2000 model within 100 years of disposal. The impacts of recycling and reuse are allocated in accordance to the procedures in 6.6.1 and 6.1.2. Models for the amounts for construction materials going to landfill, incineration, recycling and reuse are based on 6.8.1. For other materials, the disposal route is based on specific data provided by the manufacturer.

6.5 Data quality requirements

The data quality requirements of the Environmental Profiles methodology are fully explained in Appendix 2.

6.6 Energy

6.6.1 Electricity models

Detailed LCA models for electricity production for national production across Europe have been developed on behalf of the Swiss Government, as part of the ecoinvent database

These models:

- are based on generation in 2000
- are based on national models of energy mix for electricity production

- cover all resource use and emissions to air, water and land, for all stages of the electricity system, from resource extraction, fuel refining, storage, generation and distribution of electricity
- include imports and exports of power between countries
- cover impacts from infrastructure which includes the building of power stations, wind farms, dams, and supply network including pylons and cables) over the lifespan of the power production
- includes different LCA models for High Voltage (direct supply to some major industries), Medium Voltage (most industry) and Low Voltage Supply (domestic and offices). Distribution losses increase as voltage lowers

For non-European countries where electricity models are not available in ecoinvent, national electricity models can be created based on the national energy mix for electricity generation using ecoinvent models for electricity generation from specific fuels.

The most appropriate voltage model will be used.

6.6.1.1 *Company specific electricity model*

Where a company has invested in the construction of a specific power plant from which it takes the majority or all of the supply, then the use of a specific LCA model for that power plant will be considered based on ecoinvent data, but adapted where relevant for the specific installation, for example in terms of emissions or infrastructure (where significant as per 6.4.3). The environmental impact associated with the manufacture of the equipment and its anticipated lifespan is accounted for in the model.

6.6.2 *Renewable electricity*

For electricity purchased from "green tariffs" for renewable or other generation, then the profile will be based on the specific mix using ecoinvent data.

Green tariffs within the UK will need to demonstrate that Renewable Energy Guarantees of Origin certificates (REGOs) are held, and that Levy Exemption Certificates (LECs) and Renewable Obligation Certificates (ROCs) have been retired for the electricity supplied. Overseas green tariffs will need to demonstrate a similar level of renewable sourcing and additionality. Any other green tariffs will be calculated with the standard national electricity mix.

See also waste-derived fuels (6.6.4) and biofuels (6.6.5).

6.6.2.1 *Onsite generation or renewable electricity*

If a manufacturer has invested in the generation of renewable electricity on site, then the appropriate renewable electricity model will be used for that supply which is used by the manufacturer based on ecoinvent data or actual data if available. The environmental impact associated with the manufacture of the equipment and its anticipated lifespan is accounted for in the model. The manufacturer will need to provide evidence that LECs and ROCs for the onsite supply have not been sold on to any other parties, in which case the standard national electricity mix will be used.

6.6.3 Fuels

LCA data for fuels is derived from the ecoinvent database. This data:

- is the latest available data source for fuels (2000)
- includes all upstream extraction, production and distribution impacts
- includes infrastructure (e.g. building of oil wells and refineries) and supply network (e.g. building and operation of pipelines) over the lifespan of fuel production

Profiles are available for the production of different fuels (including natural gas, coal, coke, light and heavy oil, wood) and for their performance in boilers or furnaces, according to their different sizes (e.g. >100 kW) and different technologies (e.g. modulating/condensing boilers).

The ecoinvent LCA models are adapted for use with measured emissions, for a specific factory where these are available.

6.6.4 Waste derived fuels

Where a manufacturer buys or is given a waste fuel, the emissions from its use are all allocated to the manufacturer. If the manufacturer is paid to take a waste fuel, the emissions from the use of the fuel and the process are allocated between the waste producer and the manufacturer, based on the income received by the manufacturer (Section 6.5).

EXAMPLE A manufacturer receives 10% of their income from taking waste fuel, and 90% from selling the product they manufacture using the waste fuel. 10% of the impact (including waste fuel use) are allocated back to the waste producer and not accounted for in the LCI of the product.

The impact of transport of waste fuels will be carried by the manufacture if they pay for the fuel or pay for the delivery of the fuel, and by the waste producer if they pay for the disposal for the fuel or the delivery of the fuel.

If a manufacturer is paid to treat or dispose of waste as part of their manufacturing process, for example by burning waste fuel, then this waste treatment process is considered as a co-product from the process, and impacts from the whole system will be allocated back to the waste producer on the basis of value (6.9.2).

6.6.5 Biofuels

As plants grow they absorb CO_2 from the atmosphere and convert the carbon in it to plant matter such as cellulose. This process is known as sequestration.

Fuels derived from agriculture or forestry (e.g. wood or bio-diesel) or from organic wastes such as paper or food waste, have sequestered the carbon they contain within the time period of the last 100 years. Any emissions of CO_2 from burning these fuels (biogenic emissions) are therefore returning it to the atmosphere without causing any net increase in CO_2 over this timescale. Both sequestered and biogenic CO_2 emissions are included within the Environmental Profile. However the processing and transporting of biofuels will also have environmental impacts which mean that biofuels will have an overall environmental impact.

6.6.6 Combined Heat and Power (CHP)

Where CHP plants have been installed, these will also be assessed based on ecoinvent data, but adapted where relevant for the specific installation, for example in terms of emissions, output or infrastructure (where significant as per 6.4.3.

Where the power and heat from CHP are both used within a process, there is no need to consider the relative impacts of the power and heat. All impacts are included within the system and allocated to the products according to value. Where either heat or power are exported to other systems, then the heat or power will be treated as another product of the system and impacts allocated on the basis of the relative value of the products.

Ecoinvent models for CHP using economic allocation will be used where no specific data on values is available.

6.7 Transport

6.7.1 Transport to factory gate

For transport of materials to the factory, data is obtained from the manufacturers for the distance travelled, mode of transport (e.g. sea, rail, and road), vehicle or ship type and average loads or number of deliveries and return load. If data is not provided, then BRE will use default data provided by the Department for Transport from the continuing Survey of Roads Goods Transport[8].

6.7.2 Transport from factory to site

Manufacturers are asked to provide data on the typical methods of transport of the product to the site. This includes distance travelled, vehicle type and average load and return load if any. In the absence of this information, then BRE will use default data described in 6.7.1.

6.7.3 Calculating inventory data for transport

6.7.3.1 *Road transport excluding municipal waste collection, tractor and trailer and Van < 3.5 tonnes*

For road transport, the overall distance and tonnes km travelled by each vehicle type is calculated based on the average number of deliveries. Fuel consumption is calculated based on direct fuel consumption figures obtained from UK DfT Road Freight Statistics 2005[9] and the overall distance travelled.

Infrastructure for road transport including road building and maintenance, lorry and tyre maintenance and replacement is not included within the Environmental Profiles.

6.7.3.2 *Rail, water and air transport and municipal waste collection, tractor and trailer and van < 3.5 tonnes*

For rail and ship transport, the overall tonnes km travelled by each transport type is calculated.

Ecoinvent models for the infrastructure and energy associated with transport are then used based on the total tonnes km travelled by each mode of transport.

Rail transport is assumed to be a mix of electric and diesel, based on a European average.

Infrastructure for rail, water and air transport is not included within the Environmental Profiles.

6.8 Disposal

6.8.1 Disposal routes for construction materials

Disposal route models have been produced for construction materials at disposal, consisting of the percentage of material sent to each disposal route (landfill, incineration, recycling and reuse). Where relevant, they are also specific to construction waste, refurbishment waste and demolition waste. These models are used to calculate the relevant impacts of the disposal route using the ecoinvent data.

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[8] typical load and haul data for 2005 calculated for common commodities used in construction and product manufacture from an extract from the Continuing Survey of Road Goods Transport provided to BRE by the Department for Transport in a personal communication (21.11.2006).

[9] *http://www.dft.gov.uk/162259/162469/rfs05complete?version=1*

The models are checked with manufacturers for appropriateness and tailored models are created where evidence is available for particular disposal practices.

6.8.2 Waste models for waste treatment and disposal

The ecoinvent database has a number of waste treatment models for incineration, landfill and waste sorting which are detailed and include a number of models for specific wastes and technologies. They cover the development of the infrastructure, transport to waste treatment, and any emissions arising from the waste treatment. Only impacts over 100 years from disposal have been included from these models and are used in the calculation of an Environmental Profile.

Infrastructure associated with waste treatment and disposal is not included within the Environmental Profiles.

6.8.3 Waste water treatment models

The ecoinvent database has produced an LCA model for waste water treatment which allows the exact content of the waste water to be evaluated in terms of its impact. This model allows different sizes of waste water treatment facility (from 800-230,000 per capita facilities) to be evaluated.

6.9 Allocation

6.9.1 Allocation of material flows

A standard procedure is used to calculate how materials produced should share the environmental burdens resulting from the manufacturing process. This is called allocation.

The materials, energy flows and associated emissions are allocated to the different products according to the following order of preference:

1. Avoid allocation, by division of a single process into sub-processes
2. Allocate by physical property
3. Allocate by product value

Avoiding allocation, by division of a single process into sub-processes, can be undertaken for example when a production line produces more than one product. Sub-division can be undertaken through the use of metering when the specific product is being manufactured. Another example of subdivision can be undertaken through the use of sub-metering where there are two separable parallel processes, but only one energy flow reported.

Allocation by physical property can be undertaken, for example, where a plant applies paint to different products. The impacts of paint application can be allocated to the different products based on the surface area of the product.

Where two or more outputs come from a single process, and sub-division and physical allocation are not appropriate, then burdens are allocated according to the proportion of product revenue earned from the different outputs. This is known as economic allocation. Any output from such a process will attract burdens on the basis of the relative income it generates compared to the overall income generated by the process. Any outputs which do not generate income for the manufacturer do not attract any impacts from the manufacturing process.

The price that is used to make the allocation is the average three year market price of the relevant materials.

For sequential processes, the system boundary is expanded to account for them collectively.

In cases where the data cannot be separated for the two processes, the system boundary can be expanded to encompass both processes, and allocation by product stream value will be used to allocate burdens between the products.

6.9.2 Allocation, waste and recycling

The outputs may include co-products, by-products and reusable and recyclable wastes all of which might find application in further processes, together with wastes which must be disposed of and pollution which must be carried by the environment. The same allocation hierarchy as per 6.9.1 is used for by-products and reusable and recyclable wastes as for co-products, but because sub-division and physical allocation are rarely appropriate for these outputs, economic allocation as per 6.9.1 is normally used.

“Waste” is not defined for the purposes of creating the Environmental Profile.

Particulates collected from gas streams and de-watered sludge and solids from treated effluents, mine overburden waste from mining and extraction operations and furnace slag, ash, bark and sawdust are all considered as outputs. Some materials produced during a manufacturing process may be:

- recycled or reused in the process
- sold
- taken away free of charge by another company for recycling
- sent to waste disposal at a cost to the producer or
- recycled by another company at a cost to the producer.

Other outputs from a process may include services (eg waste disposal) or energy (eg electricity), some of which may generate revenue for the process.

All outputs from a process (a product, waste or service) where sub-division or physical allocation cannot be used are treated using the economic allocation procedure as per 6.9.1.

Economic allocation means that each output from the process will attract burdens on the basis of the relative income it generates compared to the overall income generated by the process. Any output which is given away or which the manufacturer has to pay to dispose of will not attract any burdens from the manufacturing process. Outputs which the manufacturer pays to dispose of will attract burdens from the disposal/treatment process back into the manufacturing system.

6.9.3 Allocation for post-consumer materials which are recycled and reused

Many processes manufacture a primary product which after use is likely to be recycled or reused. The recycling may be into the same product as the original or into one with a lower-grade application. The problem faced is how to ensure that the recycled or reused product carries an appropriate amount of the environmental impact from the original process into the new product.

The thinking behind the Environmental Profiles procedure follows that for allocation to co-products and is therefore based on economic value. This is one of the allocation approaches for recycling recommended in ISO14044.

The underlying concept is that when manufacturing a primary product, some of the primary manufacturing impact will be transferred forward to any future recycling on the basis of the relative values of the primary product and the material arising in the waste stream for recycling or reuse. Therefore any post-consumer recycled input will incur a proportion of primary impact calculated in the same way, according to its value relative to that of the primary manufacturing process.

For example, when a steel frame building is demolished, the steel sections within the building have a value as a resource for recycling, and a proportion of the impact of their primary manufacture is allocated forward to this recycling, based on the relative values of the primary production stream and the waste arising.

Allocation to post-consumer recycling is undertaken from the point in primary manufacture at which further processing is no longer useful in terms of recycling. This is called the "base point", and the material the "base material". Only the impacts up to the base point are allocated to the recycled product. Any subsequent manufacturing beyond the base point will be totally allocated to the primary product.

Examples of this include:

- a glass bottle recycled into another glass object – the base point is just before the glass (base material) is made into bottles
- aluminium foil – the base point is the aluminium ingot (base material) before it goes to rolling
- steel section – the base point is the manufacture of steel slab (base material) before section manufacture

Therefore, in the example above of the glass bottle, the impact of bottle manufacture is only carried by the first use of the bottle, but some of the impact of glass manufacture will be allocated to post-consumer recycling. For the aluminium foil, some of impact of aluminium ingot production is allocated forward to recycled aluminium, but the foil manufacturing process will only be allocated to the use of the foil.

6.9.3.1 *Allocation to post-consumer recycling*

The allocation to recycling is based on the cost of the base material at the base point and this is compared to the cost of the material arising for recycling to give the proportion of impact which is transferred to any recycled product.

However, this allocation for recycling can only be undertaken when recycling actually happens. This means a further calculation for the proportion of material recycled must also be used in the equation, based on the current recycling rate.

In other words, of products manufactured today, the proportion assumed to be recycled in the future is the percentage based on current recycling rates. Recycling rates for demolition waste have been collected by BRE and consulted on with industry iin the development of this methodology.

Using the examples above, for the aluminium foil, the amount of impact allocated to recycled aluminium will be based on the relative value of aluminium ingot being produced and the corresponding value of aluminium which would be expected to arise for recycling.

For one tonne of ingot, the 3 year average is approximately £1250, the product yield from 1 tonne of ingot is 0.988 tonnes, and the estimated scrap arising is 90% of this figure, 0.9 tonnes, with a value of approx £750/tonne.

The amount of impact allocated forward to future recycling is therefore (0.9*£750)/(1*£1250) = 53%

Any post-consumer recycled input into a process will carry impact calculated in this way, and this is calculated in the same way for pre-consumer waste as post-consumer recycling. For closed loop pre-consumer recycling, the per tonne impacts carried forward to recycling will match the per tonne impact brought with the recycled input, though there may be additional impacts for the recycled input based on any secondary processing.

For the above example, any recycled aluminium includes the burdens carried forward from primary manufacture. However as recycled aluminium has a similar value to primary aluminium, and is as likely to be recycled, then a similar proportion of impact will be carried forward to its own next use.

Where a product with recycled input is recycled again at the end of life, then the impact from primary manufacturing will again transfer forward to this future recycling. Reprocessing and remelting of scrap into ingot etc is of no value to any future recycling process, so the “base point” is the value of the scrap, compared to the value of the scrap after use, so there is no change in value, therefore only the losses through recycling rate and yield need to be accounted for and this impact from primary production will remain with any recycled input.

6.9.3.2 *Allocation to reuse*

Allocation to reuse follows a similar principle to that above, but with a different base point. In this respect, allocation to reuse is undertaken from the point of final manufacture at which further processing is no longer useful in terms of reuse.

For example for a steel section which is reused, the manufacture of both steel slab and steel section is useful to the reused product, and therefore the base point is after steel section manufacture.

Allocation is based on the cost of the final product, and the amount of final product manufactured. This is compared to the cost of the product arising for reuse and the amount of product arising for reuse based on current reuse rates (again sourced by BRE). Any additional impacts of manufacturing that are not useful for reuse (e.g. labelling or packaging) are allocated to the primary product (in the scenarios common within construction, these impacts are not generally significant as per 6.4.1).

6.10 Units to be used for inputs and outputs

energy: mega joules, MJ; or kilowatt hours, kWh

mass: tonne, t; or kilogram, kg; or gram, g

6.11 Imports

The inputs and outputs attributed to imports of materials and products are, wherever possible, based upon analyses appropriate to the country of origin and include the energy of transportation. Where data for the country of origin are not available, the input and output data are based upon the closest domestically produced product with an addition made for the transportation from the country of origin.

6.12 Carbon cycle

Carbon sequestration is considered over a timescale of 100 years and is included within the Environmental Profile.

Carbon dioxide emissions from biomass that is burnt are assumed to match the CO_2 absorbed in carbon sequestration but are included within the Environmental Profile.

For biomass that is recycled or reused at the end of life, the sequestered carbon is passed to the recycled or reused product as it is an inherent physical property. As the carbon is not emitted to the atmosphere, no CO_2 emission will be recorded for the primary product at end of life, but a mass balance and carbon balance will be achieved.

For timber and biomass that is landfilled, the release of sequestered carbon over 100 years has been modelled based on the Environment Agency’s Gassim[10] program and included within the ecoinvent models. The Gassim model includes the effect of collecting and burning landfill gas.

[10] http://www.gassim.co.uk/

The CO_2 and other greenhouse gas emissions at the end of life for timber are modelled based on current average disposal model for timber based on incineration, landfill and reclamation.

Timber and other biomass cannot be assumed to be CO_2 neutral according to the assumption above because not all timber and biomass is recycled, reused or burnt at the end of its life and there are also CO_2 emissions associated with the processing and transport of timber and biomass products.

6.13 Adjusting carbon dioxide emissions for re-carbonation

For lime and cement based products, small proportion of the carbon dioxide emitted during their production will be "carbonised" back into the finished products after manufacture. An adjustment is made for this in the Environmental Profile. The carbonation is considered over a 100 year timescale.

A detailed explanation of the calculations made is provided in Appendix 5.

7 Life Cycle Impact Assessment

7.1 Characterisation factors

Where available, the characterisation factors applied have been developed by the University of Leiden (CML) in the Netherlands. Where there are gaps in areas of environmental impact important to building materials, characterisation factors have been developed by BRE.

CML prepares its characterisation factors by basing them on work undertaken by the most expert groups or researchers in the respective area, e.g. their climate change characterisation factor is based on the findings of the Intergovernmental Panel on Climate Change.

In 2000, CML published an updated characterisation methodology. The CML indicators use a midpoint approach which has a direct link between the inventory and endpoint. Further information on the CML method can be found on their website[11].

Characterisation categories have been created for five additional areas of environmental impact which are significant for construction products and which are not considered by CML. The areas are Fossil Fuel Depletion, Waste Disposal, Nuclear Waste, Minerals Extraction and Water Extraction.

The Environmental Profiles methodology uses and reports the following environmental impact categories and reference characterisation units:

- Climate change: kg CO_2 eq (100 yr)
- Stratospheric ozone depletion: kg CFC-11 eq
- Eutrophication: kg phosphate (PO_4) eq
- Acidification: kg sulfur dioxide (SO_2) eq
- Photochemical ozone creation - (summer smog): kg ethene (C_2H_4) eq
- Human toxicity: kg 1,4 dichlorobenzene (1,4-DB) eq
- Ecotoxicity to water: kg 1,4 dichlorobenzene (1,4-DB)eq
- Ecotoxicity to land: kg 1,4 dichlorobenzene (1,4-DB) eq
- Fossil fuel depletion: tonnes of oil equivalent (toe)
- Waste disposal: tonne solid waste
- Water extraction: m^3 water extracted
- Mineral resource depletion: tonne of minerals extracted
- Nuclear waste: mm^3 high level waste

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[11] Guinée et al, Life cycle assessment: an operational guide to the ISO standards. CML, Leiden University 2000.. This can be downloaded in 4 parts from

Part 1: LCA in perspective: *http://www.leidenuniv.nl/cml/ssp/projects/lca2/part1.pdf*

Part 2a: Guide: *http://www.leidenuniv.nl/cml/ssp/projects/lca2/part2a.pdf*

Part 2b: Operational Annexe: *http://www.leidenuniv.nl/cml/ssp/projects/lca2/part2b.pdf*

Part 3: Scientific Background: *http://www.leidenuniv.nl/cml/ssp/projects/lca2/part3.pdf*

Part 2b provides more detail on the exact baseline methodologies and characterisation factors for the chosen category indicators.

The background to each impact category including a summary description, category scope, and characterisation approach is provided in Appendix 4.

7.2 Normalisation

Characterisation measures the level of environmental impact caused by a product or functional unit studied in an LCA. Because the impact categories are in different units, it is difficult to see which categories are causing the most impact. This is why normalisation is often undertaken.

Normalisation is the calculation of the magnitude of the category indicator results relative to reference information. Normalisation compares the level of impact in each category to a reference impact.

For an Environmental Profile, the reference information is the impact of a European citizen over a year. The normalised impacts are an easily understandable quantity for the user.

7.2.1 Sources of normalisation data

For each environmental impact category based on the CML characterisation method, normalisation scores have already been calculated by CML12 for the year 1995 covering Western Europe (the EU-15 nations plus Norway and Switzerland), with an overall population at that time of 384 million. Normalisation data for the impact category.

The normalisation data for CML categories are described in a spreadsheet which can be downloaded from the CML website[13]. Normalisation data for the other five categories has been based on the same geographic area (EU-15 plus Norway and Switzerland) and data has been obtained from Eurostat[14] and national statistics using the same year and population[15] as CML where possible. Further information is provided in the notes to Table 1.

Normalisation factors for the Environmental Profiles methodology can be seen in Table 2.

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[12] Huijbregts M.A.J., Van Oers L., De Koning A., Huppes G., Suh S. & Breedveld L. (2001) Normalisation figures for environmental life cycle asssessment: The Netherlands (1997/1998), Western Europe (1995) and the world (1990 and 1995), Journal of Cleaner Production, 11, 737-748

[13] http://www.leidenuniv.nl/interfac/cml/ssp/index.html

[14] http://epp.eurostat.cec.eu.int/portal/page?_pageid=1073,46587259&_dad=portal&_schema=PORTAL&p_product_code=KS-AO-01-002

[15] Population: 1995 for EU15, Norway and Switzerland : Eurostat

Table 2. Normalisation data for the Environmental Profiles methodology – the environmental impact of one European citizen (1995).

Category	Per Citizen Unit
Climate change	12.3 tonne CO_2 eq. (100 yr)
Ozone layer depletion	0.217 kg CFC-11 eq.
Human toxicity	19.7 tonne 1,4-DB eq.
Fresh water aquatic ecotoxicity	13.2 tonne 1,4-DB eq.
Terrestrial ecotoxicity	123 kg 1,4-DB eq.
Photochemical oxidation	21.5 kg C_2H_4eq.
Acidification	71.2 kg SO_2 eq.
Eutrophication	32.5 kg PO_4 eq.
Fossil fuel depletion	6.51 tonnes oil equivalent (toe)[16]
Solid waste	3.75 tonnes solid waste[17]
Radioactivity	23700 mm^3 high level waste[18]
Minerals extraction	24.4 tonnes minerals extracted[19]
Water extraction	377m^3 water extracted[20]

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16 Source: Fossil fuel Consumption for EU15 and Norway for 1995, Eurostat, based on total Energy Consumption less Renewables.

Source: Swiss fossil fuel consumption for 1995 from Schweizerische Gesamtenergiestatistik 1997.

17 Waste Generated : 1995 : EU15, Norway and Switzerland Eurostat website

Note that data for Spain, Luxembourg, Finland and Switzerland were not provided and that the figure was calculated on the basis of the remaining population.

18 Volume of high and intermediate level waste in final repository per kWh, and % of nuclear energy used in EU15, Norway and Switzerland: Ecoinvent energy report.

Ecoinvent Energy Report: Life Cycle Inventories of Energy Systems: Results for Current Systems in Switzerland and other UCTE Countries Data v1.1 (2004) Roberto Dones et al.

Amount of electricity generated for EU15 and Norway in 1995: Eurostat website

Amount of electricity generated in Swizerland in 1995: Schweizerische Gesamtenergiestatistik 1997

Schweizerische Gesamtenergiestatistik 1997 3.34/98 d/f Sonderdruck aus Bulletin SEV/VSE, Nr. 16/1998, August. Bundesamt für Energie Schweizerischer Energierat Table 14 Production of Electricity

19 Data from “Material Use in the EU: 1980-1997” for EU15 in 1995. Page 23. Given per capita.

Material use in the European Union 1980-1997: Indicators and analysis. Luxembourg: Office for Official Publications of the European Communities, 2001 Prepared for DG Environment and Eurostat by Stefan Bringezu and Helmut Schütz Wuppertal Institute

No data available for Norway and Switzerland.

20 Source: Eurostat data for total fresh water (ground and surface) abstraction per capita for 1995. Deductions made for water used in 1995 for cooling for industry and electricity based Eurostat except for Italy and Norway where an average for the rest of Western Europe has been used. Where 1995 is not provided, an average for the closest years reported has been used.

7.3 Weighting

Once data has been assigned to a functional unit for a whole building element, it is helpful to the user to provide LCA data which has been treated with a weighting factor in addition to the normalisation factor given above. This provides impartial value on the relative importance of different environmental issues which may be helpful to non-experts in environmental issues. A study[21] to identify weightings for a range of environmental sustainability issues informs this methodology. An international panel of ten experts was set up to judge the importance of the thirteen parameters. Their individual responses have been aggregated to create a single set of weightings.

Weightings are used in the Environmental Profile to create an Ecopoint score, a single score for overall environmental impact. 100 Ecopoints are equivalent to the environmental impact of one Western European Citizen for one year. Further details about the creation of Ecopoints are provided in BRE Digest[22].

Weightings for the Environmental Profiles methodology can be seen in Table 3.

Table 3. Weightings for Environmental Profiles

Environmental Issue	Weighting (%)
Climate Change	21.6
Water extraction	11.7
Mineral resource depletion	9.8
Stratospheric ozone depletion	9.1
Human toxicity	8.6
Ecotoxicity to water	8.6
Nuclear waste	8.2
Ecotoxicity to land	8.0
Waste disposal	7.7
Fossil fuel depletion	3.3
Eutrophication	3.0
Photochemical ozone creation	0.20
Acidification	0.05

21 BRE Information Paper. Environmental Weightings and their use in the Environmental Assessment of Construction Products. Aizlewood et al. BRE 2007

22 BRE Digest 446. Assessing environmental impacts of construction. Industry consensus, BREEAM and UK Ecopoints, Nigel Howard and Ian Dickie 1999. ISBN 1 86081 398 4 CRC Ltd.

8 Reporting

8.1 General

The manufacturer provides the required Environmental Profile documentation, in the form of a completed questionnaire.

Once the data is processed and an Environmental Profile created, these are written up into an accompanying report and presented to the verifier.

8.2 Project report

The project report summarises the project documentation, (see 7.3), in a systematic and comprehensive way in order to support effective verification of the Environmental Profiles (Section 9).

The project report supports the data published in the Environmental Profiles and sets out how the Environmental Profile was prepared in accordance with the PCR, including a list of all the assumptions made. Manufacturers are asked to review the assumptions made. The report demonstrates in a transparent way how the data and information declared in the Environmental Profiles result from the LCA study.

8.3 Project documentation

The Environmental Profiles project documentation is made available to the verifier in order to demonstrate that the requirements of this International Standard have been met (see ISO 14025:2006, 7.2.2, 7.2.3 and 7.2.4).

The project documentation contains the information required to establish the content of the Environmental Profiles for the Environmental Profiles. This includes:

a) The input and output data of the unit processes that are used for the LCA calculations;

b) The documentation (measurements, calculations, estimates, sources, correspondence, traceable references to origin, etc.) that provides the basis from which the process data for the LCA is formulated;

c) The specification used to create the manufacturer's building product;

d) Data that demonstrates that the information is complete.

e) Referenced literature and databases from which data have been extracted;

f) Documentation demonstrating that the building product can fulfil the intended use;

g) Documentation that demonstrates that the chosen processes and scenarios satisfy the requirements set in this International Standard;

h) Documentation that substantiates the chosen life cycle stages of the building product;

i) The data used to carry out the sensitivity analyses;

j) The documentation that substantiates the percentages or figures used for the calculations in the end of life scenario;

k) Documentation that substantiates the percentages and figures (number of cycles, prices, etc.) used for the calculations in the allocation procedure;

l) Information showing how averages of different reporting locations have been calculated in order to obtain generic data;

m) Documentation that substantiates how the additional environmental information is determined (see ISO 14025:2006, 7.2.4);

n) Procedures used to carry out the data collection (questionnaires, instructions, informative material, confidentiality agreements, etc);

o) The criteria and substantiation used to determine the system boundaries;

p) Documentation used to substantiate any other choices and assumptions;

q) Documentation that demonstrates the consistency when using information modules.

Table 4 is provided within the report to list the scenario choices used for each product and element.

Table 4. Example of matrix to meet requirements of 8.3 (g), (h), & (j)

Material	Life Cycle Stages			
	Transport to site	Construction	Use, Maintenance, Repair	Disposal
OSB	Manufacturers data	5% wastage rate	20 year life	Wood end of life

8.4 Rules for data confidentiality

Product-specific data is very often confidential, because of:

- competitive business issues
- intellectual property rights; or
- similar legal restrictions

Such confidential data are not made publicly available.

The Environmental Profile only presents data that has been aggregated over the life cycle or relevant portions of it and the aggregation obscures the underlying competitive information.

9 Content of an Environmental Profile

The content of an Environmental Profile is fully detailed in Appendix 3.

10 Environmental Profiles Scheme programme development and operation

10.1 Responsibilities of the programme operator

BRE Certification Ltd is the programme operator and is responsible for:

- establishment of the Environmental Profiles Scheme
- development of general participation rules and PCR/methodology for the Environmental Profiles Scheme, including open consultation
- including: definition of product category
- collection and creation of product category LCA based information
- development of the PCR document
- recording and publication of the Environmental Profile
- updating the Environmental Profile

10.2 Responsibilities of the PCR review panel

The PCR review committee with three independent experts is responsible for the review of the PCR.

10.2.1 Competence of the PCR Review panel

The PCR review panel members all have:

- good general knowledge of the construction products sector and product-related environmental impacts
- expertise in LCA and methodology for LCA work
- awareness of relevant standards for environmental labelling and LCA

They are national experts representing their country on international standards committees or run their own programme.

10.3 Responsibilities of the manufacturer / trade association

Manufacturers submit data and are responsible for:

- generating LCI data (voluntary)
- communicating their Environmental Profile (voluntary)
- Updating their data

10.4 Verification

The Environmental Profiles Scheme provides independent verification. There are two levels of verification:

10.4.1 Verification for generic data sets based on data from two or more manufacturers

Data are verified through an independent review of the manufacturer's data in a desk based exercise. They are evaluated for accuracy, completeness, precision and representativeness. Data from different manufacturers are compared to each other and their submitted data are compared to existing data sets.

10.4.2 Verification for proprietary data sets from a single manufacturer

Data are subject to third party verification by BRE Certification. This takes place through both a site visit and a desk top review, including comparison to existing datasets. The data collection and analysis process is then verified as complete according to the method and scheme procedures by a technically competent independent reviewer working on behalf of BRE Certification. This authorised person is not party to the data collection or processing of the Environmental Profile.

NOTE BRE Certification Ltd is owned by the BRE Trust.

10.4.3 Competency of verification staff

With regard to review and verification procedures, provisions given in ISO 14025:2006, Clause 8 apply. Verifiers are required to have the following competencies:

- general knowledge of the construction products sector and product-related environmental impacts
- expertise in LCA and methodology for LCA work
- knowledge of relevant standards in the fields of environmental labelling and LCA
- knowledge of the regulatory framework within which requirements for Type III environmental declarations have been prepared
- knowledge of Type III declarations programme

Appendix 1 Performance and service life

A1.0 Introduction

To undertake an LCA of a building material or product it is important to consider and define its life cycle and use scenario. To ensure objectivity and fairness this cannot be considered by examining a quantity of material such a 300 bricks or a tonne of insulation in isolation. This is because a construction material or product can only really be defined in life cycle terms when considered in the context in which it is used, e.g. as a wall.

A wall, or any other type of building element, can be assigned a service life within the study period of an LCA model. In a scenario like this the LCA considers the functions of the building element for a set amount of time (a study period). In order for it to do this, it will commonly require maintenance (and/or intermediate replacements) and at the end of the life, or the study period, an allowance will be made for the building element to be dismantled and disposed of.

By using this approach different materials can be compared on a like-for-like basis, as groups of components that fulfil the same or similar functions. This means that important variables such as the mass of material required to fulfil a particular function are correctly taken into account. This is critical within an LCA because material mass has direct linkage to environmental impact.

In this part of the Environmental Profiles methodology an explanation is provided for how functional comparison is undertaken and how study period, service life and replacement rate are defined.

A1.1 Terms and definitions

A1.1.1

Service life

The period of time from installation during which a building or its parts meets or exceeds its performance requirements

A1.1.2

Study period

The period of time over which the environmental impacts of a building or its parts will be measured

A1.1.3

End of life

The point of time after installation when a building or its parts no longer meet the performance requirements and when physical failure is possible and/or when it is no longer practical or economical to continue with corrective maintenance. End of life may also be reached due to fashion or image related factors.

A1.1.4

Reference service life

The service life that a material, component or building element is expected (or is predicted to have) in a certain set (reference set) of in-use conditions

A1.1.5

Reference service life value

The material, component or building element reference service life figure used in an Environmental Profile

A1.1.6

Functional unit

Quantified performance of a product system for use as a reference unit [ISO 14040:2006]

A1.1.7

Replacement factor

The number of times that a material, component or building element will experience replacement during the study period

A1.2 Declared and functional units

Functional units are used as the basis for ensuring comparability in the Environmental Profiles methodology. They work based on standardised units and defined study periods.

A1.2.1 Environmental Profiles and units of assessment

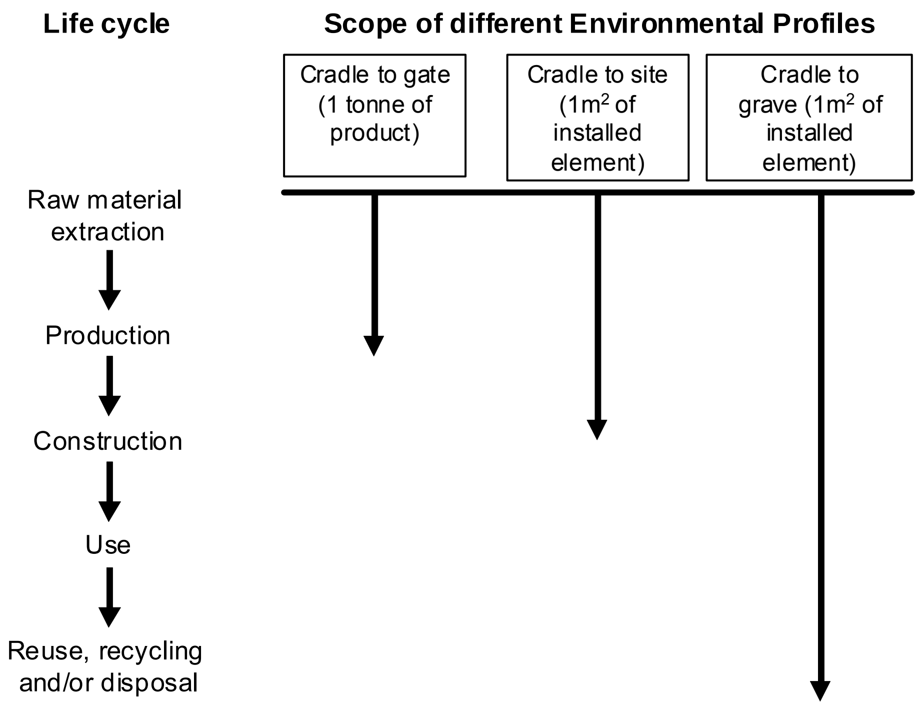
Environmental Profiles can be created for materials, components or building elements. Within this scope three common types of Environmental Profile are typically reported. Figure 1 illustrates these within the life cycle context. They include:

1. a material "cradle to gate" Environmental Profile presented on a “per tonne” basis

2. an installed building element "cradle to site" Environmental Profile presented on a "per square metre" basis

3. a building element "cradle to grave" Environmental Profile using a sixty year study period; these take into account maintenance, replacement and disposal activity for the study period and an assumed disposal of any part of the element remaining after the end of the 60 year study period, at whatever time that might occur, and are calculated on a "per square metre" basis

Figure 1: The three different types of Environmental Profile and the life cycle stages that they include.



A1.2.2 Per tonne and building element Environmental Profiles

Table 1 describes the processes included within each type of Environmental Profile including the units used to declare environmental impacts and where they can be used in comparison.

Table 1: The three types of Environmental Profile.

Profile type	Life Cycle stages include	Study units	Comparison
Cradle to gate	Production stage (raw material supply, transport, manufacturing of products, and all upstream processes from cradle to gate).	Information module: per tonne	Shall not be used for comparison
Cradle to site	Product stage (raw material supply, transport, manufacturing of products, and all upstream processes from cradle to gate). Construction process stage (transport to the building site and wastage from building installation/construction only) including transport and disposal of waste.	Information module: per square metre installed element	Shall not be used for comparison
Cradle to grave	Product stage (raw material supply, transport, manufacturing of products, and all upstream processes from cradle to gate). Construction process stage (transport of materials	Functional unit: per square metre installed element over	Environmental Profile can be used for comparison if the functional

	to the building site and wastage from building installation/construction only) including transport and disposal of waste. Use stage: repair, replacement, maintenance and refurbishment including transport of any materials and disposal of waste over the study period. Demolition: is expected to occur any time at or after the end of the study period and is included within this Environmental Profile. It includes transport and disposal of waste.	a sixty year study period in the building	unit is equivalent

NOTE 1 Transportation is not considered as a life cycle stage. However to avoid data gaps or double counting, inclusion of transportation into any information module is clearly documented.

NOTE 2 Disposal of waste takes account of waste treatment practice including landfill and incineration burdens. It will also include the allocation of waste to reuse or recycling routes but does not include the burdens arising from these activities.

A1.2.3 Functional unit

To understand the life cycle of a product, it is essential that it is considered in the context of its application. For the purposes of undertaking LCA studies this is called the functional unit. In this respect the functional unit can be defined as the performance characteristic of a product system. For Environmental Profiles it is used as a reference unit in comparative assessment.

This makes the functional unit the basic unit of Elemental Profiles, which allows comparative assessments. It allows material flows (inputs and output data of an Environmental Profile) to be normalised mathematically. This allows building elements with the same function, but different technical characteristics to be compared.

The functional unit of a building product is related to a building, or part of a building and its performance. Therefore a functional unit of a building product is expressed on the basis of the relevant technical performance characteristics of the building product when integrated into a building.

For the Environmental Profiles methodology, the functional unit for building products has been chosen to be:

> *1m^2 of the typical as-built element, over a "study period" of sixty years, with - where appropriate - a fixed U-Value set using the 2006 Building Regulations (England and Wales) and some other physical characteristics (e.g. load, span, sound transmittance) as may be relevant*

A full listing of Environmental Profile functional units can be found in Table 2.

A1.3 Study period (60 years)

The study period is the period over which the environmental impacts of a building element will be measured. The Environmental Profile will include for any maintenance, refurbishment or replacement of the building element over the study period.

The Environmental Profiles methodology uses a sixty year study period for measuring the environmental impacts of building elements in all cradle to grave Environmental Profiles. This means the Environmental Profile includes burdens which occur during the sixty year period and also those of disposal that will occur at any time after the end of the sixty year study period.

NOTE 1 The use of a sixty year time period to define study boundaries does not imply that long life components (ie those with a service life in excess of sixty years) will have reached the end of their service lives in sixty years.

A1.4 Service life

In cradle to grave assessments some materials, components or building elements may be expected to need maintenance, refurbishment or replacement before the end of the sixty year study period. This is dealt with in the Environmental Profiles methodology by determining a reference service life for each material, component or building element. Note this is not the same as the study period.

The number of maintenance, refurbishment or replacement operations is calculated by considering the likelihood that the component will be replaced within the sixty year study period.

The Environmental Profile will take account of maintenance, refurbishment or replacement operations by increasing the environmental impacts associated with these activities based on the likelihood of replacement over the sixty year study period.

If a component in an element is expected to be replaced within the sixty years study period and can be replaced without removing the rest of the building element, then only the materials associated with that particular component will be replaced. If other components of the building element, or the entire element, must be replaced because of the shorter lived components, then all the relevant components or element will be replaced within the assessment, even if the materials removed have a potentially longer lifetime.

A1.4.1 Estimating reference service life values for Environmental Profiles

In order to undertake the cradle to grave assessment for Environmental Profiles, it is necessary for BRE to estimate a reference service life value for each material, component or building element considered.

An Environmental Profile is not project or site specific and therefore does not consider either aspect in identifying a reference service life value. The following relevant factors which affect durability (based on ISO 15686-1) are considered in making the expert assessments of values.

The reference set (i.e. the conditions under which the specified material will be used) is defined as:

1. Material and component quality: complying with relevant BS/ISO standards

2. Design: To good practice standards

3. Workmanship: To good practice standards and BS 8000

4. Indoor environment: Dry and warm

5. Outdoor environment: Inland with normal urban pollution

6. Maintenance: Maintenance in accordance with manufacturers recommendations

7. Use: Specifications adjusted to building sector (office, domestic, education, healthcare and retail and warehouse type buildings)

A1.4.2 Reference service life data for Environmental Profiles

Independently verified manufacturer-specific service life data is used as the preferred source. In addition, service life data provided by trade associations are also a valid source. Appropriate evidence includes:

1. Evidence of service lives from installations supported by photographs and evidence of installation dates.
2. Where evidence has been provided from outside the UK, confirmation that similar products with similar specifications have been installed in the UK.
3. Third party certification covering reference service lives.
4. Evidence from long-term site exposure and/or accelerated testing.
5. Confirmation that the product or material complies with relevant codes of practice and standards.
6. Where manufacturer or trade association data are not available, independent sources of service life data will be applied.

A1.4.3 Independent sources of reference service life data

The following data sources provide reference service lives:

1. BLP Construction Durability Database (http://www.componentlife.com/) amalgamates and updates :
    - HAPM (1992) Component life manual (Spon)
    - BPG (1999) Building fabric component life manual (Spon)
    - BLP (2000) Building services component life manual (Blackwell Publishing)
2. CIBSE (2000) Guide to ownership, operation and maintenance of building services (CIBSE)
3. BMI (2001) Life expectancy of building components (BCIS)
4. PSA (1991) Costs-in-use tables (HMSO)

A1.4.4 Reference service life values

Once BRE has identified a reference service life for a material or product, a *"reference service life value"* is determined. This is based on more specific in-use conditions, in terms of materials, design, use and maintenance scenario.

A reference service life value is determined for all materials or components used in building elements for functional unit cradle to grave Environmental Profiles. It is used as the basis for material and product replacement rate in these studies.

Where there are differences between varying sources of reference service life data, an expert assessment is made. The final values have been reviewed by Faithful + Gould.

The reference service life values used are solely for the purposes of undertaking an Environmental Profile.

The reference service life values will be generic unless manufacturer specific information has been provided to allow BRE to derive a specific reference service life value.

Reference service life values will be provided in multiples of 5 years, and will range from 5 to 80 years. Where a reference service life value is given, it is the average and represents a spread of values likely if the component or element was used in a wide range of buildings. Based on data provided in the RICS study (2001)[23], BRE have assumed that the spread of service live values is distributed equally over a period of the service life value, or 40 years, which ever is the shorter.

So for a component with a reference service life value of 5 years, replacement is considered to start at 2.5 years, with 50% likelihood that the component will have been replaced after 5 years, and with the component having been completely replaced after 7.5 years. Over the sixty year study period, the component will therefore have been replaced 11.5 times on average.

For a component with a reference service life of 30 years, replacement is considered to start at 15 years, with a 50% likelihood of the component having been replaced at year 30, and the replacement being completed by year 45. At the end of the study period, there will be a 50% likelihood that the component will have been replaced twice, therefore the number of replacements will be 1.5.

For a component with a reference service life period of 50 years, replacement is considered to start at year 30, with 50% likelihood of components having been replaced at year 50, ending at year 70. Thus at the end of the sixty year study period, there will be a 75% likelihood that the component will have been replaced, giving a replacement factor of 0.75.

A reference service life value of 80 years implies that the material, component or building element has a life in excess of 80 or more years, and replacement will not start until the end of the sixty year study period at the earliest, so no replacement will be assumed. The use of a sixty year study period does not imply that long life components (ie those with a reference service life in excess of sixty years) will have reached the end of their service lives in sixty years.

A1.5 End of Service life

A1.5.1 What marks the end of service life?

The end of service life occurs at the point of time after installation when a building or its parts no longer meet the performance requirements and when physical failure is possible and/or when it is no longer practical or economical to continue with corrective maintenance.

For functional units that look at floor coverings, kitchen units, work tops and other building elements similar affect by image, end of service life is also considered to occur when the item requires replacement due to fashion and image related drivers.

A1.5.2 Replacement factors

Replacement factors are important to the Environmental Profiles methodology because they are used in the calculation process to determine the amount of material (ie. mass) that is required for a building element to perform its functional requirement over the sixty year study period used in a cradle to grave assessment.

Material mass is important as it is used within an Environmental Profile to determine life cycle inventory flows (NOTE 1) and hence environmental impact.

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[23] Life Expectancy of Building Components: Surveyors experiences of buildings in use, a practical guide; Building Cost Information Service; The Royal Institution of Chartered Surveyors (2001).

A type of fractional method is used to calculate replacement factors for building element functional units. This avoids step changes in Environmental Profile models where the life time of the building is not known and cannot be accurately predicted, and where the study is defined by the sixty year study period.

NOTE 1 Inventory flows are the environmental interactions that take place between the study system examined by the LCA and the environment around it. They consist of all the inputs and outputs to the study system and include extraction of raw materials and fuels, heat and water consumption, and emissions to air, discharges to water and emissions to land.

A1.5.3 Replacement factor formula

When a replacement is likely to occur within the sixty year study period, the likelihood of replacement can be calculated giving a replacement factor. The amount of material required for the replacements is calculated by identifying a replacement factor. These are determined by using the following formula:

For reference service life values of 0 to 40 years:

Replacements = (60/RSLV) - 0.5

For reference service life values of 40 to 80 years:

Replacements = (80-RSLV)/40

The concept of the model is one of spreading the replacement period around the point of reference service life value. This is because the service life of materials, components or building elements, in the real world, is always a distribution of replacements around an “average life period”.

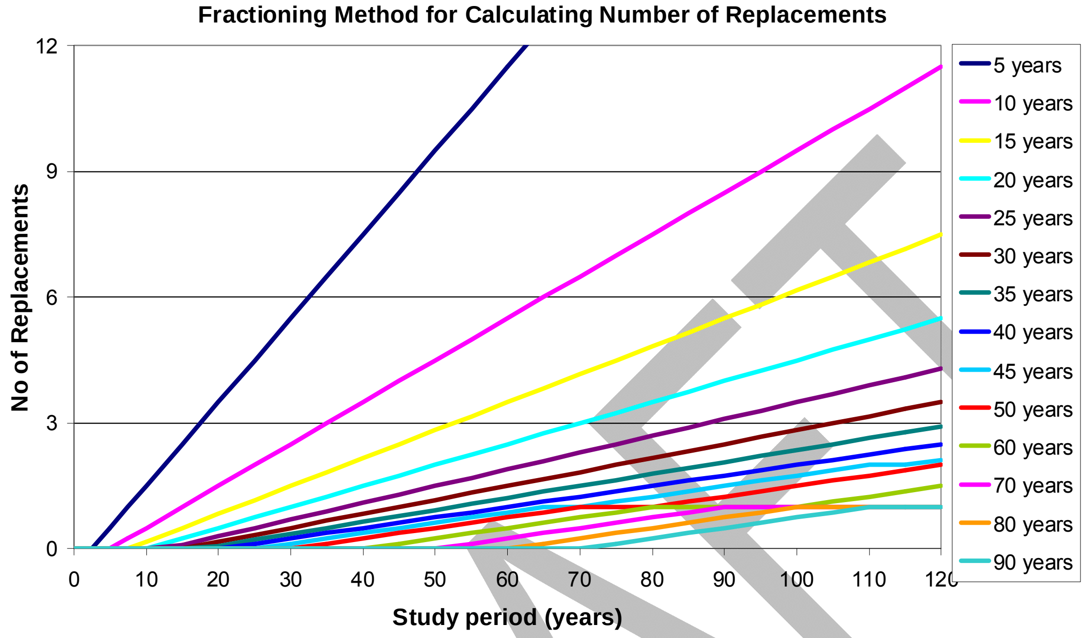
Therefore, the trend recognised by this methodology is one which distributes the service live values equally over a period about the service life reference value. This leads to its characterisation as a fractional method based on the probability of replacement either side of the reference service life value.

A summary of replacement factors for different reference service life values can be seen in Table 3. The graphical trend lines for these different service life periods are shown in Figure 2.

Table 3: Replacement factors that a construction component will experience after initial installation within a study period of 60 years.

Service Life (years)	5	10	15	20	25	30	35	40	45	50	60	70	80	100
Replacement factor	11.5	5.5	3.5	2.5	1.9	1.5	1.22	1.0	0.88	0.75	0.5	0.25	0.0	0.0

Figure 2: Replacement trends for all product estimated service lives from 5 to 90 years as assessed in the Environmental Profiles cradle to grave assessment.



A benefit of the approach is that definitive determination of reference service life values is not necessary as a spread can be used; it also avoids the necessity to determine a reference service life value in excess of 80 years for long life components such as structure where it is inherently difficult to do so.

The cradle to grave Environmental Profile is where this methodology is used. Once a replacement factor has been calculated it can be applied to determine the required material mass over the sixty year study period for the building element and its distinct material components.

In calculating the material masses resulting from product replacement only those items which require replacement and which are integral to the replaced item are included in the assessment. This means that in many instances retained materials exist.

For example, for a double skin profiled roof consisting of coated steel and insulation on a steel structure. The profiled coated steel is determined to have a reference service life value of 25 years. Because the insulation is integral to that component it will also undergo replacement using the same factor. The steel structure however will not be changed and would be retained in the roof component throughout the sixty year study period.

Each cradle to grave Environmental Profile uses this approach whereby replacement factors and specification design details can be used to calculate material masses and subsequently allow the determination of life cycle inventory flows.

Table 2: The functional units commonly used by the Environmental Profiles methodology for comparative assessment.

U values quoted in Table 2 and in other parts of this document represent what BRE consider to be realistic maximum values to satisfy Part L of the Building Regulations 2006. Performance is measured at the whole building level. All functional units, unless otherwise stated, include any repair, refurbishment or replacement over the 60 year cradle to grave study period.

Element	Elemental sub-sections	Offices	Domestic	Schools	Health	Retail	Retail/Industrial	Notes
Upper Floors		1m² of upper floor construction, to satisfy building regulations, capable of supporting a live floor load of 2.5 kN/m², including any additional beams to span a 7.5m column grid and surface ready for addition of sub-structural floor system.	As offices but based on a 4m span and area of 40m², a live loading of 1.5 kN/m² and a surface ready for the addition of a sheet carpet and underlay.	As offices but based on a floor between classrooms with a 8m span and a live loading of 3 kN/m², and a maximum weighted BB93 standardized impact sound pressure level 60 L′nT (Tmf,max),w (source BB93) and surface ready for the addition of a sheet flooring.	As offices but based on a 6m span, a live loading of 2 kN/m² and surface ready for the addition of a sheet flooring.	As offices but based on a 6m span, a live loading of 4 kN/m² and surface ready for addition of sub-structural floor system.	Where relevant, see commercial	
Separating Floor		N/A	1m² of upper floor with a live loading of 1.5 kN/m² to satisfy England & Wales Building Regulations, in particular a minimum airborne sound insulation Dntw+Cx of 45 DB and impact sound insulation Lntw of 62 DB (source Approved Document E 2003) and a span of 5m.	N/A	N/A	N/A	N/A	
Ground Floors	Suspended	N/A	1m² ground floor of 40m² area and exposed perimeter of 18m to satisfy England & Wales Building Regulations and a U	N/A	N/A	N/A	N/A	
	Solid							

Element	Elemental sub-sections	Offices	Domestic	Schools	Health	Retail	Retail/Industrial	Notes
			value of 0.22 W/m²K.					
External Walls		1 m² of external wall construction, to satisfy current building regulations, and a U value of 0.3 W/m²K. Where relevant, the specification will also include an internal wall finish.					1m² of external wall construction, to satisfy current building regulations, and a U value of 0.3 W/m²K.	
Roofs (flat or pitched)	Flat (pitch not exceeding 10°) Pitched	1m² of roof area, (measured horizontally), to satisfy building regulations and a U value of 0.16 W/m²K (pitched) or 0.25 W/m²K (flat). Based on an overall span of 15m with support at 7.5m.	1m² of roof area (measured horizontally), to satisfy England & Wales Building Regulations, particularly a U value of 0.16 W/m²K (pitched) or 0.25 W/m²K (flat). Span of 8m.	As offices and based on a span of 15m with supports at a central corridor.	As offices with a span of 8m.		1m² of roof area, (measured horizontally), to satisfy building regulations and a U value of 0.16 W/m²K (pitched) or 0.25 W/m²K (flat). Based on an overall span of 15m with support at 7.5m.	
Attic Roofs (pitched)		N/A	As domestic roofs above, but to a U value of 0.2 W/m²K.	N/A	N/A	N/A	N/A	Attic roofs considered separately due to their use having an impact on materials used in the floors, roof and external walls and ceilings.
Floor Finishes and Coverings	Hard	1m² of floor finish or covering as fitted to a level surface, e.g. sub-structural floor	1m² of floor finish or covering as fitted to a chipboard floor or concrete slab or	1m² of floor finish or covering as fitted to a leveled floor structure.		As offices.	N/A	

Element	Elemental sub-sections	Offices	Domestic	Schools	Health	Retail	Retail/Industrial	Notes
	Soft	system or screeded concrete.	floorboards, with underlay or leveling as appropriate.				N/A	
Heavy duty floor finishes		N/A	N/A	1m^2 of floor finish or covering suitable for a corridor as fitted to a leveled floor structure, to meet severe duty criteria (SD) according to BS6234-2.		N/A	N/A	
Sub-structural floor systems (SFS)/floor surfacing		1m^2 of sub-structural floor system or floor surfacing suitable for the addition of a tiled flooring (e.g. carpet).	N/A	N/A	N/A	As offices.	N/A	The use of SFS's can add to the total impact of the upper and or ground floors and although considered separately here guidance will be given on how to minimise overall impact of SFS's and floors together.
Windows and glazed curtain walling (up to 3 storeys)		1m^2 of double glazed window or clear glazed curtain walling, to satisfy building regulations, a U value of 1.8 W/m^2.	Double glazed window of approximately 1m^2 in area with one fixed and one opening casement.	As offices.				
Windows and curtain walling (4 or more storeys)		1m^2 of double glazed window or clear glazed curtain walling, to satisfy building regulations, a U value of 1.8 W/m^2.	Double glazed window of approximately 1m^2 in area with one fixed and one opening casement.	As offices.			N/A	

<table>
<tr><th>Element</th><th>Elemental sub-sections</th><th>Offices</th><th>Domestic</th><th>Schools</th><th>Health</th><th>Retail</th><th>Retail/Industrial</th><th>Notes</th></tr>
<tr><td rowspan="3">Internal Walls and Partitioning</td><td>Loadbearing</td><td rowspan="3" colspan="2">1m² of internal wall or partitioning, to satisfy building regulations.</td><td rowspan="3">1m² of internal wall or partitioning between a corridor and classroom; to satisfy building regulations, in particular airborne resistance to sound, minimum 40 Rw (dB) (source BB93) and mid-frequency reverberation time, Tmf, in classroom not to exceed 0.6 seconds (source BB93). Corridor wall to be specified to Severe Duty as per BS5234-2.</td><td rowspan="3" colspan="3">As offices.</td><td></td></tr>
<tr><td>Non-loadbearing</td><td></td></tr>
<tr><td>Proprietary</td><td></td></tr>
<tr><td>Internal walls and partitioning - additional for schools</td><td></td><td>N/A</td><td>N/A</td><td>1m² of internal wall or partitioning between classrooms; to satisfy building regulations, in particular minimum 45 DnT (Tmf,max),w (dB) airborne sound insulation (source BB93), and mid-frequency reverberation time, Tmf, in classroom not to exceed 0.6 seconds (source BB93).</td><td>N/A</td><td>N/A</td><td>N/A</td><td>It should be noted that these specifications may not be comparable in terms of loadbearing capacity, fire resistance, acoustic performance, thermal mass or transparency and hence may not be suitable in every situation.</td></tr>
</table>

Element	Elemental sub-sections	Offices	Domestic	Schools	Health	Retail	Retail/Industrial	Notes
Separating walls		N/A	1m² of party wall to satisfy England & Wales Building Regulations; in particular the provision of minimum airborne sound insulation Dntw+Cx of 45 DB (source Approved Document E 2003).	N/A	N/A	N/A	N/A	
Suspended ceilings and ceiling finishes		1m² of suspended ceiling or ceiling finish, to satisfy building regulations.	N/A	As offices.			N/A	
Internal doors	No fire resistance	1m² of door, to satisfy building regulations.					N/A	
	1/2 hour fire resistance							
	1 hour fire resistance							Where kick plates and impact protection may be needed (e.g. schools and hospitals) it is assumed that they would add a small and similar environmental impact to each door and so are ignored.

Element	Elemental sub-sections	Offices	Domestic	Schools	Health	Retail	Retail/Industrial	Notes
Internal paint finishes		The painting of 1m² of internal wall surface with white paint to opacity of 98%.					N/A	
Insulation		1m² of insulation with sufficient thickness to provide a thermal resistance value of 3 m²K/W, equivalent to approximately 100mm of insulation with a conductivity (k value) of 0.034 W/mK						
Landscaping: Hard Surfacing (Car)		1m² of hard surfacing, suitable for the parking of cars, to satisfy building regulations.						
Landscaping: Hard Surfacing (Heavy Goods Vehicle)		1m² of hard surfacing, suitable for HGV loading, to satisfy building regulations.						
Landscaping: Hard Surfacing (Pedestrian only)		1m² of hard surfacing, suitable for pedestrian loading, to satisfy building regulations.						
Landscaping: Boundary Protection		1m² of boundary protection or balustrading up to 2m high (costs based on 1.5m high).						
Worktops		N/A	1m² of worktop plus any additional support needed to fit standard kitchen units.	N/A	N/A	1m² of worktop plus any additional support needed to fit standard kitchen units.	N/A	
Kitchen Cupboards		N/A	1m² of kitchen cupboard frontage, with standard chipboard carcass.	N/A	N/A	N/A	N/A	

Element	Elemental sub-sections	Offices	Domestic	Schools	Health	Retail	Retail/Industrial	Notes
Refurbishment: External and Internal Wall Insulation		N/A	1m² of internal or external wall insulation with protective cladding where necessary to upgrade the thermal performance of a solid 9 inch masonry wall to provide a U value of 0.45 W/m²K. In all cases, we have assumed that the internal wall surface was sound, and that the external surface required rendering or some other form of protection.	N/A	N/A	N/A	N/A	

Appendix 2 Data Quality Requirements

awaiting final draft

Appendix 3 Content of an Environmental Profile

A3.1 Declaration of general information

All Environmental Profiles issued under this scheme follow the format presented here and include the parameters identified in this document.

The following information is declared within the Profile format:

a) The name and address of the manufacturer(s);

b) The description of the building product's use and the functional or declared unit of the building product to which the data relates;

c) Building product identification by name (e.g. including production code) and a simple visual representation of the building product to which the data relates;

d) Name of the programme and the programme operator's address, logo and website;

e) The reference for this methodology.

f) The date the declaration was issued and period of validity.

g) Environmental Aspects Data from LCA or LCI or information modules (see 0).

h) Additional environmental information: An Ecopoint Score and a Green Guide Rating; other information as required.

i) Content of the product is provided.

j) Information on which life cycle stages are not considered, if the declaration is not based on an LCA covering all stages.

k) A statement that environmental declarations from different programmes may not be comparable.

l) The site(s), manufacturer or group of manufacturers or those representing them for whom the results of the LCA are representative.

m) Information on where explanatory material may be obtained.

A3.2 Declaration of environmental aspects

A3.2.1 Environmental impacts expressed with the impact categories of LCIA

- Abiotic depletion
- Global warming (GWP100)
- Ozone layer depletion (ODP)
- Human toxicity
- Fresh water aquatic ecotoxicity.
- Terrestrial ecotoxicity
- Photochemical oxidation
- Acidification
- Eutrophication
- Solid waste
- Radioactivity
- Minerals Extraction

- Water Extraction

A3.2.2 Use of resources and renewable primary energy (data derived from LCI and not assigned to the impact categories of LCIA)

- depletion of non-renewable energy resources;
- depletion of non-renewable material resources;
- use of renewable material resources;
- use of renewable primary energy;
- consumption of freshwater.

A3.2.3 Waste to disposal (data derived from LCA not assigned to the impact categories of LCIA)

The waste allocated to the building product during its life cycle is separated into two categories in the Environmental Profile:

- hazardous waste;
- non-hazardous waste.

A3.2.4 Emissions to water, soil and to indoor air

Releases to ground and surface water are included within the LCIA data categories. Information on emissions to indoor air and on human health and comfort due to chemical, biological and physical emissions is not provided in this Environmental Profile.

A3.2.5 Additional environmental information

An Environmental Profile includes additional information related to environmental issues, other than the environmental information derived from LCA, LCI or information modules (see 8.2.1.) and other than emissions to water and to indoor air. This information s separated from the information described in 8.2.2 and 8.2.3.

A3.2.6 Scenarios and technical information

Scenarios and technical information are necessary for the application of Environmental Profiles in building assessment. Therefore Environmental Profiles, when relevant, include information for the building product about:

- reference service life of the building product;
- transportation, construction, use, operation, maintenance and replacements based on the reference service life.

A3.2.7 Differentiation of use of material and energy resources

The use of resources for all stages of the life cycle of the building product is differentiated into the following list:

- hydro/wind power;
- fossil energy;
- bio energy;
- nuclear energy;
- other energy;

- secondary fuels;
- non-renewable resources;
- renewable resources;
- recycled materials;
- secondary raw materials;
- land;
- water;
- hazardous substances.

Figure A1. Format

Company information	**(name & address)**
Date issued + period of validity	
Product description	**(including picture & Brand Name)**
Product content	**including specification of materials & substances that can adversely affect human health & the environment, in all stages of the life cycle.** **Restricted according to confidentiality.**
Information Module/Functional Unit	
Life cycle stages covered	

Note: Environmental declarations from different programmes may not be comparable

ENVIRONMENTAL INFORMATION

Theme	**Unit**	**Value**										
		I. Product stage (cradle-to-gate)			**II. Design & construction process stage**		**III. Building stage**				**IV. End of life stage (grave)**	
		Raw material supply	Transport	Manufacturing	Transport	Construction-installation process	Operation	Maintenance	Deconstruction & demolition	Transport	Reuse/recycling	Disposal

Depletion of non-renewable material resources	kg				
Use of renewable material resources	kg				
Depletion of non-renewable energy resources	MJ				
Use of renewable primary energy resources	MJ				
Consumption of freshwater	m^3				
Climate change	kg CO_2				
Depletion of the stratospheric ozone layer	kg CFC-11				
Formation of tropospheric ozone (photochemical oxidation)	kg ethene				
Acidification of land and water sources	kg SO_2				
Eutrophication	kg PO_4				
Waste to disposal – non-hazardous	kg				
Waste to disposal – hazardous	kg				
Reference service life for product	Years				
Additional Environmental Information					
• Human toxicity					
• Fresh water aquatic ecotoxicity.					
• Terrestrial ecotoxicity					

Green Guide Rating	
Ecopoints	
Representativity of this Profile	
Scenario for reference service life of functional unit	
Scenario for building stage	
Scenario for end of life stage	
References	
Programme name	Environmental Profiles Scheme for Construction Products
Programme operator	BRE Certification Ltd
PCR	Environmental Profile Methodology BRE 2007
Review and verification	
PCR review was conducted by (organisation & name of the chair, & information on how to contact the chair through the programme operator)	
Independent verification on the EPD & data, according to ISO 21930:	○ Internal ○ External

Appendix 4 Background to the characterisation factors used to create the Environmental Profiles

Acidification (CML 2000)

Acidic gases such as sulphur dioxide (SO_2) and nitrogen oxides (NO_x) given off in fuel combustion react with water in the soil or in the atmosphere (where it forms "acid rain"). Acid deposition can damage ecosystems and erode materials. Acidification Potential (AP) is expressed using the reference unit, kg SO_2 equivalent.

The model does not take account of regional differences in terms of which areas are more or less susceptible to acidification. The current method accounts only for acidification caused by SO_2 and NOx. It accounts for acidification due to fertilizer use, according to the method developed by the Intergovernmental Panel on Climate Change (IPCC). CML have based the characterisation factor on the RAINS model developed by the University of Amsterdam[24]

Climate change (CML 2000)

Climate change refers to the change in global temperature caused via the greenhouse effect by the release of "greenhouse gases" such as carbon dioxide by human activity. There is now scientific consensus that the increase in these emissions is having a noticeable effect on climate. Raised global temperature is expected to cause climatic disturbance, desertification, rising sea levels and spread of disease.

The Environmental Profiles characterisation model as based on factors developed by the UN's Inter-governmental Panel on Climate Change (IPCC). Factors are expressed as Global Warming Potential over the time horizon of 100 years (GWP100), measured in the reference unit, kg CO_2 equivalent.

Ecotoxicity to freshwater and land (CML 2000)

The emission of some substances can have impacts on ecosystems. Ecotoxicity potentials are calculated with a toxicity model, USES-LCA[25], which is based on EUSES, the EU's toxicity model[26]. This provides a method for describing fate, exposure and the effects of toxic substances on the environment. Characterisation factors are expressed using the reference unit, kg 1,4-dichlorobenzene equivalents (1,4-DB)/kg emission, and are measured separately for impacts of toxic substances on:

- Fresh-water aquatic ecosystems
- Terrestrial ecosystems

Note: Characterisation factors are also available for marine ecotoxicity, and ecotoxicity to marine and fresh water sediments. The marine and freshwater sedimentary ecotoxicity factors are not included within the CML baseline characterisation factors and are therefore not included here. CML has identified errors in its marine ecotoxicity category and do not recommend its use until these have been corrected.

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[24] www.leidenuniv.nl/interfac/ cml/ssp/projects/lca2/report_mh_iiasa2.pdf.

[25] Huijbregts MAJ, Priority Assessment of Toxic Substances in the Frame of LCA - The Multi-Media Fate, Exposure and Effect Model USES-LCA. Amsterdam: University of Amsterdam (NL) 1999.

[26] European Union System for the Evaluation of Substances. Version 1. Environment Institute, European Chemical Bureau, Joint Research Centre, European Commission, 1997.

Eutrophication (CML 2000)

Nitrates and phosphates are essential for life but increased concentrations in water can encourage excessive growth of algae, reducing the oxygen within the water and damaging ecosystems. Potential sources include fertilisers and NO_x emissions from the combustion of fossil fuels. Eutrophication potential is based on the work of Heijungs (1992)[27], and is expressed using the reference unit, kg PO4 equivalents.

Direct and indirect impacts of fertilisers are included in the method. The direct impacts are from production of the fertilisers and the indirect ones are calculated using the IPCC method to estimate emissions to water causing Eutrophication.

Fossil fuel depletion (BRE)

This impact category indicator is related to the use of fossil fuels. Fossil fuels provide a valuable source of energy and feedstock for materials such as plastics. Although there are alternatives, these are only able to replace a small proportion of our current use. Fossil fuels are a finite resource and their continued consumption will make them unavailable for use by future generations.

BRE use an absolute measure based on the energy content of the fossil fuel. This does not take into account the relative scarcity of different fossil fuels, but in fact these only vary by 17% between coal (the most common) and gas (the most scarce). The characterisation factor is measured in tonnes of oil equivalent (toe).

Human toxicity (CML 2000)

The emission of some substances can have impacts on human health. Characterisation factors, expressed as Human Toxicity Potentials (HTP), are calculated using USES-LCA, as with Ecotoxicity, which describes fate, exposure and effects of toxic substances for an infinite time horizon. For each toxic substance HTPs are expressed using the reference unit, kg 1,4-dichlorobenzene (1,4-DB) equivalents.

Toxicity measurement techniques are still developing. For both human and eco-toxicity measurements, the models are measured based on total emissions, and cannot take into account the location or sensitivity of the ecosystem or organisms affected by the toxic release.

Note: The impact of emissions relating to indoor air quality and their effect on human health are not covered by this category. FDIS 21930 recognises this is an important area where information should be provided. It states that information should be provided using the relevant national guidelines and calculation methods – currently no such standards exist in the UK or for Europe overall.

Nuclear waste (BRE)

Radioactivity can cause serious damage to human health, and as yet, no treatment or permanently secure storage solution exists for higher level radioactive wastes, such as that generated by the nuclear power industry and from decommissioning nuclear power stations. Such wastes need to be stored for periods of 1,000 years or more before their radioactivity reaches safe levels.

The World Nuclear Association states that higher level nuclear waste (high and intermediate level waste) accounts for a very low percentage of nuclear waste, around 10% by volume, but 99% of its radioactivity[28]. Other characterisation methods, such as the Swiss Ecopoints, use the volume of highly active radioactive waste as a category.

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[27] Heijungs et al, Environmental Life Cycle Assessment of products. Guide-October 1992. Centrum voor Milieukunde - Institute for Environment, Leiden University, 1992.

[28] *http://www.world-nuclear.org/education/wast.htm*

The characterisation factor for the category is measured in mm^3 of spent fuel, high and intermediate level radioactive waste. All of these wastes:

- are highly radioactive, accounting in total for more than 99% of the radioactivity attributed to the nuclear industry;
- have no agreed form of permanent disposal anywhere in the world;
- require storage for at least 1000 years before they may be safe.

Mineral resource depletion (BRE)

This impact category indicator is related to the extraction of virgin abiotic material e.g. extraction of aggregates/metal ores/minerals/earth etc. The extraction of such substances can mean that the natural carrying capacity of the earth is exceeded and make them unavailable for use by future generations. This indicator relates purely to resource use, not other environmental impacts which might be associated with mining or quarrying, or the relative scarcity of resources.

The indicator is based on the Total Material Requirement (TMR) indicators used by the European Union and developed by the Wuppertal Institute, based on earlier work for the World Resources Institute. The indicators covering fossil fuel, biomass (mainly agricultural product) and soil erosion (only covered for agriculture, not forestry) are not included. Further details can be obtained in the Eurostat working papers, which can be downloaded from *http://epp.eurostat.cec.eu.int/portal/page?_pageid=1073,46587259&_dad=portal&_schema=PORTAL&p_product_code=KS-AO-01-002.*

The indicator calculates the total resource use associated with any use of any non-energy, abiotic materials within the EU, wherever the resource use occurs. For example, for steel use, it traces back to tonnes of iron ore extraction wherever this occurs. The TMR indicator includes material that is extracted as a result of economic activities, but not used as input for production or consumption activities, for example mining overburden. Excavated and dredged material is also included. For normalisation purposes, the Eurostat data provides relevant figures covering imports of materials as well as resource use within Europe.

Photochemical ozone creation: summer smog (CML 2000)

In atmospheres containing nitrogen oxides (NO_x, a common pollutant) and volatile organic compounds (VOCs), ozone can be created in the presence of sunlight. Although ozone is critical in the high atmosphere to protect against ultraviolet (UV) light, at low level it is implicated in impacts as diverse as crop damage and increased incidence of asthma. VOC sources include solvents (e.g. in paints, glues or cleaning materials), and fuels.

Photochemical ozone creation potential (also known as summer smog) for emission of substances to air is calculated with the United Nations Economic Commission for Europe (UNECE) trajectory model[29] (including fate), and expressed using the reference unit, kg ethene (C_2H) equivalents/kg emission.

Solid waste (BRE)

This category represents the environmental issues associated with the loss of resource implied by the final disposal of waste. Any waste that is disposed of in landfill or incinerated without energy recovery will be included. The aspect is also used in other characterisation methodologies, for example the Dutch EcoIndicator[30] and the Swiss Ecopoints[31]. The characterisation factor is based on the mass of solid waste. Key points for this characterisation factor are:

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29 *http://www.environment-agency.gov.uk/commondata/acrobat/burdens_air_519036.pdf*

30 *http://www.pre.nl/eco-indicator99/*

- reflects the loss of resource resulting from waste disposal (in contrast to recycling or reuse);
- does not include any other impacts associated with landfill or incineration – emissions from decomposition, burning and associated transport and other machinery are included in the relevant categories;
- the mass of waste is used as a proxy for the loss of resource;
- includes waste sent to incineration and landfill or any other form of final disposal (e.g. dumping on land or in the sea);
- does not differentiate between hazardous, non-hazardous, inert or organic wastes;
- different impacts from hazardous, non-hazardous etc will be;
- included within the waste treatment models (landfill, incineration and composting) for these wastes;
- where heat recovery, energy recovery or other material recovery (e.g. recovery/recycling of ash, metal residues etc) are undertaken as part of incineration or landfill, then value is used to calculate the loss of resource.

EXAMPLE If an incineration process makes 50% of its income from processing waste, 25% from heat recovery and 25% from sale of residues/ash, then only 0.5 tonnes of final waste disposal is attributed per tonne of waste treated.

If a landfill site makes 90% of its income from receiving waste, and 10% from energy recovery from landfill gas, then 0.9 tonnes of final waste disposal is attributed per tonne of waste received.

Stratospheric ozone depletion (CML2000)

Damage to the ozone layer by chlorinated and brominated chemicals increases the amount of harmful ultraviolet (UV) light hitting the earth's surface. Although the use of chemicals such as CFCs and HCFCs have been phased out in Europe following the 1987 Montreal Protocol, much existing refrigeration equipment and insulation foam still contains CFCs and HCFCs.

The characterisation model has been developed by the World Meteorological Organisation (WMO) and defines ozone depletion potential of different gases relative to the reference substance chlorofluorocarbon-11 (CFC-11), expressed in kg CFC-11 equivalent.

Water extraction (BRE)

Around the world, water is becoming an increasingly scarce resource, due to increased demand, and changes in patterns of rainfall. To recognise the value of water as a resource, and the damage that over extraction from rivers and aquifers can cause, this category includes all water extraction, except:

- Seawater
- Water extracted for cooling or power generation and then returned to the same source with no change in water quality (water lost through evaporation would be included in the category)
- Water stored in holding lakes on site for recirculation (‘top-up’ water from other sources would be included)
- Rainwater collected for storage on site

This category is measured using m^3 of water extracted.

[31] Methodik für Oekobilanzen auf der Basis oekologischer Optimierung, Schriftenreihe Umwelt no. 133, BUWAL, Bern, Switzerland, October 1990.

Appendix 5 Carbonation calculations

The Environmental Profiles methodology takes into account the carbonation of Calcium Oxide (CaO) within products containing cement and lime.

Different assumptions have been made for different products.

Products containing Lime

For products containing lime, 100% of the CaO is assumed to carbonate within a short time after installation in the building. Therefore the carbonation of lime is considered within the per tonne Cradle to Gate Environmental Profile for both quick lime and hydrated lime. The amount of carbonation is equivalent to the CO_2 driven off from the calcium carbonate in making the lime.

Virgin Products containing Cement

The amount of carbonation for cement based products has been calculated based on a simplified version of the approach provided in Kirsten Pommer & Claus Pade, "Guidelines- Uptake of carbon dioxide in the life cycle inventory of concrete", Danish Technological Institute, October 2005 prepared as part of the Nordic Innovation Centre Project, "CO_2 Uptake During the Concrete Life Cycle" and from information supplied by the Concrete Centre in the UK. This document can be obtained from the Concrete Centre or BRE.

The approach covers two aspects, the depth of carbonation which can be expected in different elements, and the amount of carbonation where it occurs.

Based on results from the study, and advice from the Concrete Study, concrete products have been split into two groups.

Group 1

For the first group, covering concrete blocks, low strength concrete and mortars and screeds, the assumption is that the total depth of the product will carbonate within the building lifetime. This is based on estimates provided within the Danish report which give a depth of carbonation for 'sheltered' and indoors' locations of 97mm over 60 years. Since carbonation occurs from both sides of the block, the total theoretical depth of carbonation would be approximately 200mm, which is greater than the depth of most blocks, low strength concrete and mortars. For screeds, most are less than 100mm thick and will therefore carbonate even though only one face is exposed.

The amount of carbonation is therefore based the % of CaO which will carbonate, and the amount of CaO within the concrete product.

For these products, based on data provided by the Concrete Centre, the assumption is that 63% of the CaO will carbonate.

The amount of CaO can be calculated from the amount of cement within the concrete product (Qc), the % of clinker within cement (80% for ready mix and 90% for precast and paving), and % of CaO within the clinker (65%).

The amount of CO_2 reabsorbed through carbonation can be found by multiplying the mass of CaO which carbonates by the molecular mass of CO_2 and dividing by the molecular mass of CaO (44/56).

Group 2

The second group covers high strength ready mix and precast concrete and paving.

For these, because the strength of the concrete is higher, the amount of carbonation is less during the building lifetime , and the Danish Guidelines provide an estimate of the depth of carbonation expected, and therefore factors which can be used to provide indicative carbonation and mass of carbon dioxide reabsorbed (M) for various elements.

Additionally, where concrete is recycled or landfilled (10% of concrete arising), further carbonation is assumed to take place as the concrete is broken up and exposed to air. The carbonation methodology attributes the carbonation that takes place for recycled concrete within the Environmental Profile for the recycled concrete. For concrete that is landfilled, this carbonation is attributed to the original product. The amount of carbonation within recycled and landfilled concrete is based on the typical particle size, the existing level of carbonation and the likely depth of further carbonation. The Concrete Centre provided BRE with secondary life factors (E) to take account the carbonation of landfilled concrete over a 100 year secondary life, allowing a longer period for the remaining CaO to carbonate. The Secondary Life Factors are:

Ready mix: E = 2.02

Precast: E = 1.39

Paving: E = 1.67

Mass of CO_2 absorbed = K x S x ($\sqrt{SP}$) x Q x 0.65 x (44/56) x C x E

K= depth of carbonation

S= Surface area

SP= Study Period (100 years)

Q= CEM I content (kg/m^3) x clinker content fraction (0.8 or 0.9)

% of CaO within the clinker (65%)

Amount of CO_2 per mole of CaO (44/56)

C= % of CaO which carbonates (63% assumed by the Concrete Centre)

E = Factor to take account of carbonation of concrete in landfill at EOL

Therefore for

1m^2 of ready mix:

M = 0.00125 x 1 x ($\sqrt{100}$) x (290*0.8=232) x 0.65 x (44/56) x 0.63 x 2.02 =

1.88 kg CO_2

1m^2 of precast:

M = 0.00233 x 1 x (√100) x (350*0.9=315) x 0.65 x (44/56) x 0.63 x 1.39 =

3.28 kg CO_2

1m^2 of paving:

M = 0.001 x 1 x (√100) x (300*0.9=270) x 0.65 x (44/56) x 0.63 x 1.67 =

1.45. kg CO_2

Table 4.3 of the Danish report provides carbonation factors for concretes using cement replacements. The following factors are given (by extrapolation) from the table.

30% PFA: 10% higher

50% GGBS: 25% higher

The factors above should therefore be applied to the high strength concretes using these materials.

Recycled Concrete

Concrete which is recycled as either aggregate or hardcore will continue to carbonate.

The amount of carbonation within recycled and landfilled concrete is based on the typical particle size, the existing level of carbonation and the likely depth of further carbonation.

For concrete which is recycled as hardcore, the average particle size has been assumed to be 150mm in diameter (data from The Concrete Centre). For buried infrastructure which is where we assume hardcore is used, the depth of carbonation is 0.75mm*(year)$^{-0.5}$ which over 100 years means that 73% of the concrete will not be able to carbonate. However the existing level of carbonation of concrete post demolition needs to be considered, as concrete which has already carbonated cannot carbonate again. BRE have taken the amount of carbonation which has already taken place as 5% at demolition – this is based on the amount of carbonation within a typical m^3 of RMC, paving or precast compared to the maximum possible.

The amount of carbonation for concrete recycled as hardcore is therefore reduced by 75% to account for the concrete within the 150mm diameter particles which will not carbonate, and by 5% to account for the concrete which has already carbonated. BRE have taken 200 kg/m^3 as the typical amount of cement clinker per m^3.

M = 25% x 95% x 200 x 0.65 x (44/56) x 0.63 = 16.5 kg CO_2

Note that for non-concrete hardcore, and for hardcore sourced from low strength concretes or blocks, there will be no carbonation as the concretes will have fully carbonated during use.

For concrete that is recycled as graded aggregate, the particle sizes are much smaller. Data from the WRAP report, C R Sowerby, TRL Limited, “Low-strength Concrete Ground Engineering Applications for Recycled and Secondary Aggregates”, WRAP, June 2004, Table 5.1 was used to estimate the typical particulate sizes. All particles 14mm and smaller would be able to carbonate, with larger particles carbonating to varying degrees, giving a total ability to carbonate of 91% if the carbonation rate for buried infrastructure is used.

The amount of carbonation for concrete recycled as graded aggregate (not within concrete) is therefore reduced by 9% to account for the concrete within the different diameter particles which will not carbonate, and by 5% to account for the concrete which has already carbonated. BRE have taken 200 kg/m^3 as the typical amount of cement clinker per m^3.

M = 91% x 95% x 200 x 0.65 x (44/56) x 0.63 = 55.6 kg CO_2

However, for concrete that is recycled as aggregate into concrete – recycled concrete aggregate (RCA), the rate of carbonation will relate to the type of concrete. For low strength concretes, the assumption is that the concrete will still fully carbonate. For high strength concretes, the consideration has been to add the uncarbonated cement within the RCA to the amount of cement within the concrete to calculate the additional carbonation. Taking 20% replacement of coarse aggregate, approximately 240 kg of RCA would be used per m^3, which will increase the Cement content, and therefore the typical amount of carbonation by 10%. This factor will therefore be used for concretes containing 20% RCA.

References

Kirsten Pommer & Claus Pade, “Guidelines- Uptake of carbon dioxide in the life cycle inventory of concrete”, Danish Technological Institute, October 2005 prepared as part of the Nordic Innovation Centre Project, “CO_2 Uptake During the Concrete Life Cycle”

C R Sowerby, TRL Limited, “Low-strength Concrete Ground Engineering Applications for Recycled and Secondary Aggregates”, WRAP, June 2004