FINAL REPORT: Scoping Study for the Update of the Environmental Assessment of UK Forestry, Sawmilling, and Panel Production based on Life Cycle Assessment

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Executive Summary

This report represents the final deliverable within the Forestry Commission contract CFS09/06 “Scoping study for the Update of the Environmental Assessment of UK Forestry, Sawmilling and Panel Production based on Life Cycle Assessment”. It was commissioned in response to the growing demand for information on the environmental performance of timber and timber products used in UK construction. Upstream data is required for those Environmental Profiles that use UK-grown timber. This includes the UK forestry model and its life cycle impacts. Models that were established as part of a DETR Partners in Technology project in August 2000 (Contract CI38/19/133 cc1440) now need updating.

This report represents an update of the draft report delivered in March 2007 (BRE report 231-933). It is the final deliverable that provides outline guidance on the work that will be needed to bring existing information and data on UK forestry and primary processing up-to-date with the latest versions of the BRE Green Guides to Specification. Subsequently, it may be fed into other work or tools that make use of Life Cycle Assessment information. The updated Green Guides will cover homes, offices, health, educations, retail and industrial retail. The update was released in April 2007 for specifications covered by The Code for Sustainable Homes and later in 2007 for specifications not covered in the Code.

This report incorporates the update of BRE Methodology for Life Cycle Assessment which was published in April 2007.

Solid timber used in the UK construction is predominantly imported softwoods. This means that the UK forestry models are most relevant to panel products production. However, if the environmental performance of UK-grown softwoods can be shown to be better than their imported competitors, then this could be used to encourage greater use of home-grown timer of comparable performance. This scoping study is focusing on the need for a full LCA update study that could clarify this hypothesis.

The full Life Cycle Assessment for UK forestry and primary processing project will consider commercial forestry only differentiating and including both softwood and hardwood forestry systems in both public and private ownership. The selected species are spruce, pine, larch, oak and low impact silvicultural practices for a number of regional instances (Appendix A). Additionally, the full study will also include assessment of environmental impacts of alternative use of solid timber and harvesting residues, as biomass, for mulching and horticultural use and as pallets and pellets. Inside-out oak beams, green oak timber frame, and modified wood were selected to be the full project’s case studies.

BRE has contacted a number of universities (e.g. University of Wales, Bangor and Napier University) as potential partners for a thesis based on and around data collection in the field, in particular in the North of England, Wales and Scotland. It is foreseen that should this project start early in 2008 that further discussions would ascertain the details of this potential collaboration.

The full project will be guided by a steering group and LCA quality work will be pier reviewed by external organisations (Appendix B). BRE will raise awareness about the full project at various meetings (a minimum of 5) with the industry. Following the delivery of the full LCA update project two dissemination events will be organised by BRE with FC guidance and advice.

Contents

Introduction

This project was undertaken under the contract CFS09/06 for the Forestry Commission in response to the growing demand for information on the environmental performance of timber and timber products used in the UK construction.

An increasing number of timber product manufacturers particularly those engaged in public housing are seeking to actively promote their Life Cycle Assessment Environmental Profile scores and hence their Green Guide ratings to registered BREEAM assessors and designers working on buildings which are to be assessed. Environmental Profile's upstream data for those that use UK grown timber includes the UK forestry model at the beginning of their product(s) life cycle impacts. This model was established as a DETR Partners in Technology scheme (Contract CI38/19/133 cc1440) in August 2000. The data are now nearly 10 years old and require an urgent update that should be provided by a full LCA update project.

Solid timber used in the UK construction is predominantly imported softwoods. This means that the UK forestry models are most relevant to panel products production. However, if the environmental performance of UK-grown softwoods can be shown to be better than their imported competitors, then this could be used to encourage greater use of home-grown timer of comparable performance. This scoping study is focusing on the need for a full LCA update study that could clarify this hypothesis.

This report provides outline guidance on the necessary work that will need to be undertaken to bring existing information and data on UK forestry and primary processing up-to-date with the latest versions of the BRE Green Guides to Specification. Furthermore, this activity will also inform the Code for Sustainable Homes and future versions of EcoHomes, or any other work or tools that make use of Life Cycle Assessment information as presented by BRE. The updated Green Guides will cover homes, offices, health, educations, retail and industrial retail. The update was released in April 2007 for specifications covered by the Code for Sustainable Homes and will be later in 2007 for specifications not covered in the Code.

The report allows for inclusion of the new BRE LCA methodology and associated consequences for the full study following this scoping study. This time allocation is due to the update of BRE Methodology for Life Cycle Assessment which was published in April 2007 as various changes to the LCA categories and method of processing of data may have had an impact on this project's outline and pricing. This report includes final details of a work plan for a full project that is envisaged to begin early in 2008.

This scoping study outlines background to the selection of activities and end products as well as relevant details concerning the scope of information and data gathering exercise required to produce generic, industry representative (manufacturer non-specific) profiles.

This final report identifies a plan for the full LCA project which will directly feed into the new generation of the Green Guides in their digital form, therefore reaching ever increasing numbers of construction projects within the UK.

Description of the project

This scoping study followed up data and scenarios used for Life Cycle Assessment Environmental Profiles for the main UK commercially utilised forest species and regional forestry types (e.g. pine, spruce and oak representing the UK practice but including a focused case studies on selected regions) and primary processing from data gathered between 1997 and 1999 for the report in 2000. Originally, panel production was also included in this scoping study proposal; however, this industry segment has already participated in the Green Guide update project. Therefore, this deliverable and any subsequent documents only focus on forestry and sawmilling activities.

The following section is a summary of the work plan agreed with Forestry Commission at the opening meeting in Edinburgh in September 2006 based on a roadmap for assessing the environmental impacts associated with UK forests and sawmilling is presented in Appendix A.

1. BRE will consider potential partnering with universities and other bodies in the full study to share knowledge.

BRE has contacted a number of institutions with a proposal for an MSc (or similar) thesis that can be based on and around data collection in the field, particularly should this activity be based in North of England, Wales or Scotland (e.g. University of Wales, Bangor and Napier University). A preliminary agreement was reached on this topic; however, precise details depend upon the timescale of the full project and the academic year structure. It is foreseen that should this project start early in 2008 that this could fit into the thesis timetable of the selected universities.

2. The Life Cycle Assessment for UK forestry and primary processing will consider the following:

- Commercial forestry only (any implications with amenity functions of forestry will be addressed in close relationship with the work done by Marcus Sangster's team at FC only as the need arises)
- Commercial forestry will differentiate between and include softwood and hardwood forestry systems from both public and private ownership. More information on bodies, organisations and individuals suggested to be involved in the full project are presented in Appendix C.

3. Modified wood will be considered.

The technology of choice is being discussed with BSW. Their agreement to collaborate with BRE was reached and they fully support the full LCA study for UK forestry and sawmilling. A modified wood product could either be chemically modified (such as the acetylated wood product Accoya™) or thermally modified (such as Thermowood®).

4. *The management practices of plantations or other relevant systems for the following species will be included in the scope of the full project:*

    a) spruce (Scotland as representative of GB)

    b) pine (Scotland as representative of GB but consideration should be given to England)

    c) larch (Scotland or England)

    d) low impact silvicultural practices (Wales)

    e) broadleaf forestry – oak (GB)

5. Green oak use will be considered

A case study within the full LCA project will be green oak timber frame companies in Wales and collaboration on this work package has been preliminarily discussed and agreed with Wood Knowledge Wales.

6. Red logs (grading system)

The final report will give consideration to the issue of red logs and the associated environmental impacts. The variation in value may indicate different environmental impacts.

7. A project Steering Group will be formed

Suggested Steering group members that will be invited to participate in the full study are presented in Appendix B.

8. Sawmilling industry contacts

Contacts within sawmilling practices are presented in Appendix B.

9. Raising Awareness

BRE will raise awareness about the full project at various meetings and events with the forest and forest products industries (minimum of 5 relevant meetings). Following the delivery of the full project, two dissemination events will be organised and delivered by BRE. The Commission will guide and advise on these.

10. Alternative uses of solid timber

The full study will include environmental impacts of alternative uses of UK-grown solid timber, as well as the harvesting residues. These will include:

- Biomass
- Mulching and horticultural use
- Pallets and pellets

And a maximum of 2 other relevant, significant[1] end-use of co- and by-products

11. Not included in the full study

Short Rotation Coppice (SRC) and bio-ethanol will not be included (these topics may be considered in future separate work). However, some consideration should be given to energy from hardwood

[1] How to judge significant functions will be agreed at the onset of the full LCA update project.

Findings

This section presents the basic outline of information data sets for the forestry and sawmilling stage. It is essential to establish the progress in forest management practices and primary processing to upgrade the UK forestry & primary processing environmental profile. Gathering representative data will focus on determining of all benefits and burdens of forestry and sawmilling in the UK as measured by BRE's Environmental Profiling Methodology. The data will be collected for these species and forest types:

a) spruce (Scotland as representative of GB)

b) pine (Scotland as representative of GB but consideration should be given to England)

c) larch (Scotland or England)

d) low impact silvicultural practices (Wales)

e) broadleaf forestry – oak

The species that were selected for this project were chosen for their strategic importance and regional representation by FC.

The data will be collected for the following life cycle stages* for forestry:

i. Nursery (establishment, weeding, pesticides/ fertilisers use, animal/pest control, burning)

ii. Infrastructure construction and its maintenance (including motor manual, machine-work, move between sites)

iii. Management practices

iv. Thinnings, final thinning and harvest

v. Rotation periods, growth models, forwarding

The data will be collected for the following life cycle stages* for sawmilling:

i. Techniques, location, practices and energy use

ii. Kiln drying

iii. Preservative treatments

*Waste disposal routes at all of the above stages will be included. This is a draft and therefore not an all inclusive list.

The above stages will be represented by the Forestry Commission practices while taking into account any significant differences with the private sector. The following figure indicates some of the relationship between the required data and stages of forestry.

This document focuses on the basic foundations relevant to a full LCA of the UK forestry and primary processing. The implications of changes to BRE LCA methodology have further informed both BRE and FC on how to proceed with all relevant details.

In the last LCA report on UK forestry the conclusions indicated that:

- For UK softwood the primary source of impacts from emissions is through the combustion of fossil fuels, and the use of heavy equipment is the largest use of fossil fuels. The largest single consumption of fossil fuels is associated with the production, up-grading and maintenance of forest roads. Of the less significant sources of impact, the provision of metals for fencing and equipment dominates the sources of Human toxicity potential, principally through emissions of arsenic and other metals.
- For UK continuous cover softwood the primary source of impacts from emissions is through the combustion of fossil fuels, and the use of heavy equipment is the largest use of fossil fuels. The largest single consumption of fossil fuels is associated with the up-grading and maintenance of forest roads. The extent of both roadway and fencing which are required for a specific forest site varies greatly over time and location, and will greatly affect the profile of a specific site, given the generally low impacts of the other aspects of timber production
- For UK plantation grown oak the primary source of impacts from emissions is through the combustion of fossil fuels, and the use of heavy equipment is the largest use of fossil fuels. The largest single consumption of fossil fuels is associated with the up-grading and maintenance of forest roads. The extent of both roadway and fencing which are required for a specific forest site varies greatly over time and location
- The UK continuous cover grown oak was found to be a very low impact form of forestry. The exact benefits of the system will depend upon the actual long term yields achieved, and on whether the expected reductions in requirement for seedlings, fencing and agrochemicals are achieved.

These impacts vary for different forestry types. Additionally, some activities, such as roadway and fencing which are required for a specific forest site varies greatly over time and location. Therefore, new data sets on forestry practice and the new BRE methodology, however, may indicate different hotspots in forestry practice and associated environmental impacts. This would be fully assessed in a full project following this scoping study's final report (second stage deliverable).

The following two sections illustrate the data required at each life cycle stage for forestry (Figure 1) and sawmilling (Figure 2).

Environmental Profiling for UK Forestry

1. **Goal**

   To assess the environmental performance of producing timber from a range of different UK forestry types.

2. **Scope**

   From the nursery stage to the product at the forest roadside

3. **Process**

   The data collection with forestry managers will follow this

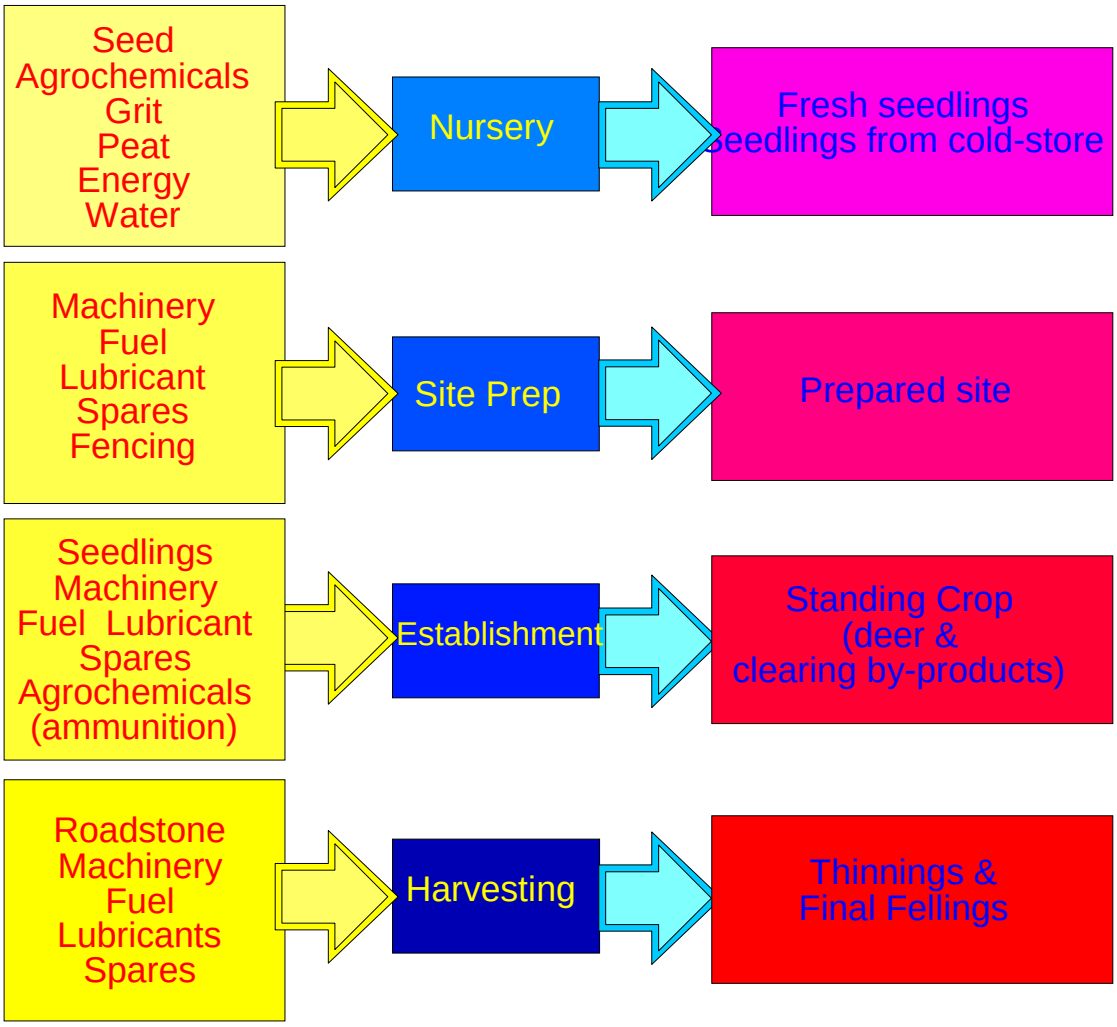


Figure 1: Generic process flow diagram for forestry

4. Forest types

The following types will be assessed within the full LCA update project. The GB practice will be used for the BRE Green Guides purposes to represent generic practice but consideration will be given to those that specifically focus on regional practices as selected by the FC.

a - Coniferous forestry - Spruce
- Overall GB forestry
- Scotland

b - Coniferous forestry - Pine
- Overall GB forestry
- Scotland
- England

c - Coniferous forestry - Larch
- Overall GB forestry
- Scotland
- England

d - Low impact silvicultural practices
- Wales

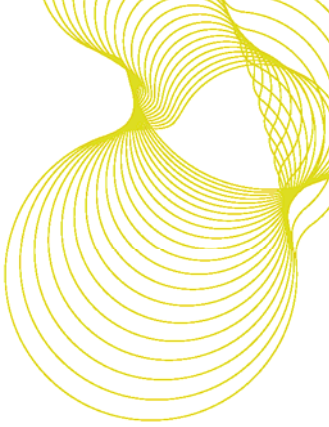
e – Broadleaf forestry - Oak
- Overall GB forestry
- Wales
- Scotland
- England

5. Boundaries

As described in the BRE's Environmental Profiles Methodology (Appendix D).

6. Product assessed

1 green tonne logs
- 8 softwood types of forest considering regional practices (3 species)
- 1mixed type (low impact silvicultural practices)
- 4 hardwood types of forest considering regional practices (1 species)



7. Data

A - Materials (e.g. seedlings, herbicides, energy, blades, belts)
B - Transport to site (Unless arrives at the site by cable or pipeline)
C - Direct consumption of fuel
D - Water use
E - Capital equipment (forestry machinery [producing forest machinery – generally tends to process fewer product units over its life than the equipment used in sawmilling])
F - Emissions and discharges (e.g. emissions to air, water, and land)

A number of representative sites and specific sites in all the selected regions will have to be finalised at the start of the full LCA project. It is envisaged that there will be a workshop (in each region, total of 3 workshops) for the FC personnel selected to participate in this project to which private growers and management companies will be invited. These workshops will inform in a cohesive way of the project itself, the aims and objectives of the exercise, the data requirements and timetable. This approach facilitates streamlining between FC practices and private growers.

Environmental Profiling for UK Sawmilling

1. **Goal**
   To assess the environmental performance of the UK log conversion process.

2. **Scope**
   Collection of roundwood (including bark) from the UK forest roadside to the product at the mill gate.

3. **Process**

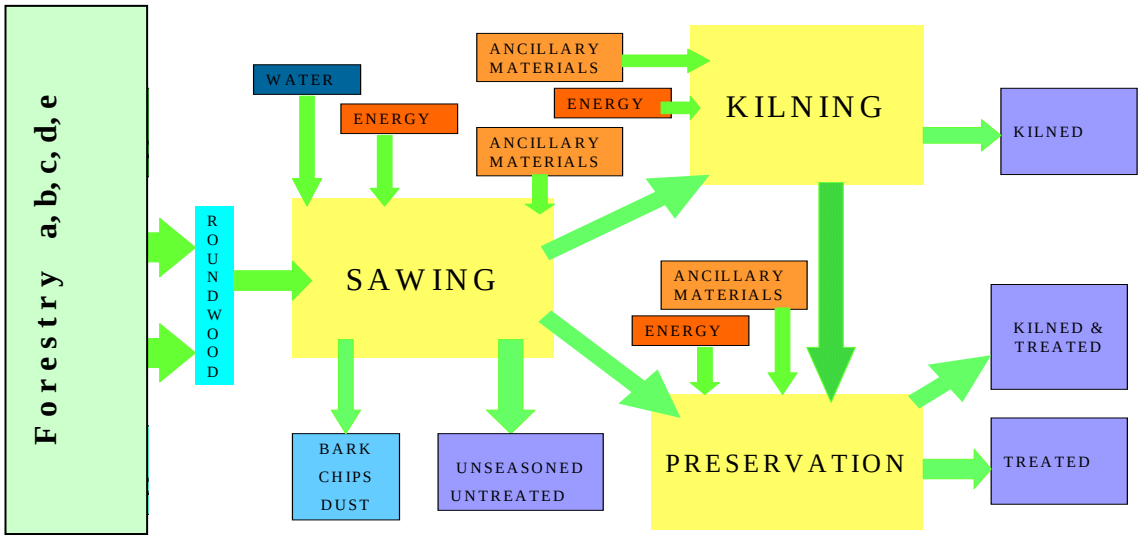


Figure 2: Generic process flow diagram for sawmilling

4. **Sites**
   Related to the forestry types (see previous section) and the utilisation of the raw material from forestry.

5. **Boundaries**
   As described in the BRE's Environmental Profiles Methodology (Appendix D).

6. **Product assessed**
   Species as per forestry types for 1m^3 of
   - unseasoned, untreated timber
   - kiln dried timber
   - treated timber
   - kilned and treated timber

7. Outputs

Solid timber

a. $1m^3$ of unseasoned/untreated timber (basic)
b. $1m^3$ of kiln dried timber (basic + kiln drying)
c. $1m^3$ of treated timber (basic + preservation)
d. $1m^3$ of kilned & treated (basic + kiln drying + preservation)

Note that to consider alternatives for these products, co-products will also be profiled.

8. Data

A - Materials (e.g. logs, packaging, preservatives, lubricants, energy)
B - Transport to site (Unless arrives at the site by cable or pipeline)
C - Direct consumption of fuel
D - Water use
E - Capital equipment (To assess the assumption that a process' capital equipment converts a large enough quantity of material and therefore it does not have an appreciable contribution to the environmental impacts of each unit of product produced.)
F - Emissions (e.g. emissions to air, water, and land)

A number of representative sites and particular sites in all regions will have to be selected at the start of the full LCA project. It is envisaged that there will be a workshop (in each region, total 3 workshops) for the FC personnel selected to participate in this project to which primary processors, private growers and management companies will be invited. These workshops will inform in a cohesive way of the project itself, the aims and objectives of the exercise, the data requirements and timetable. This approach facilitates streamlining between FC practices, private growers and primary processors.

Environmental Profiling for case studies

The following case studies were selected:

1. Inside-out oak beams
2. Green oak timber frame
3. Modified wood

Full study deliverables

1. There will be up to three progress reports and a final report at the conclusion of the full LCA update project issued as six monthly milestones.
2. Dissemination of the results will be delivered primarily through two seminars and a BRE publication
3. Up-to-date LCA Environmental profiles for selected species for UK forestry (five in total representing the UK practices). These will include a brief analysis of regional practices in order to assess the degree of similarity with the UK representative profiles.
4. Up-to-date LCA Environmental profiles for UK sawmilling (4 in total)

Full study duration

2 years

Full study fees

The charges associated with the full LCA project are in the range of approximately £100,000 to £180,000 + VAT.

Milestones and resources (time and fees)

A Gantt chart for the full LCA project is presented in Appendix E.

All of the work will be directly linked to the EFORWOOD project to maintain presentation of cohesive information regarding the environmental impacts of the Forestry Wood Chain in the UK. The UK Forestry information will be interlinked with the work of FC Research (Barry Gardiner, Module 3 – harvesting and with Bill Mason, Module 2 – forestry). The UK Sawmilling information (and any other wood-based products manufacturing) will be feed into Module 4 that is led by BRE.

BRE will explore the possibility to include other research organisations into the full project (most probably on a basis of an MSc student's thesis work, or two if this project lasts 2 years and there is a sufficient interest). This will have to be clarified at the start of the project in order to fit together with the academic year requirements. Given the complexity and diversity of forestry practice as well as primary processing, the study must ensure that scientific rigour is maintained with the selections made for study and that the

work is implemented in line with practicability of data collection. This will avoid any omissions or any potential double counting.

The following table is an estimate of charges based on the 25 models detailed in this report.

Task	**Calculation basis**	**Total**
Data gathering & assessment	25 models	£125,000
Student management	Subject to number of assignments	£12,000
Reporting	3 progress reports and final report	£8,400
Workshops	3 workshops	£4,500
Steering Group meetings	3 meetings	£4,500
Seminars	2 seminars	£3,000
Extra analysis	Green Guide updating, mop-up, reanalysis	£6,000
Project management		£18,000
		£181,400

This translates into the following milestone and fee schedule.

Milestone No	**Description**	**Target Date**	**Fees (£)**
1	Workshops	Month 3	15,000
2	Progress report 1	Month 6	40,000
3	Progress report 2	Month 12	35,000
4	Progress report 3	Month 18	40,000
5	Dissemination seminars (2)	Month 20	35,000
6	Final report – Update environmental profile	Month 24	16,400
		Total	**181,400**
		Calendar year 1	90,000
		Calendar year 2	91,400
		Financial year 07/08	15,000
		Financial year 08/09	75,000
		Financial year 09/10	91,400

The following table is an estimate of charges based on a reduction in the number of models from 25 to 12. This illustrates the scope for consideration of the scale of the project and how it directly impacts on the overall budgets required. However, the selection of the model systems will be crucial to the success of this work and they should be selected so as not to reduce the impact of the work.

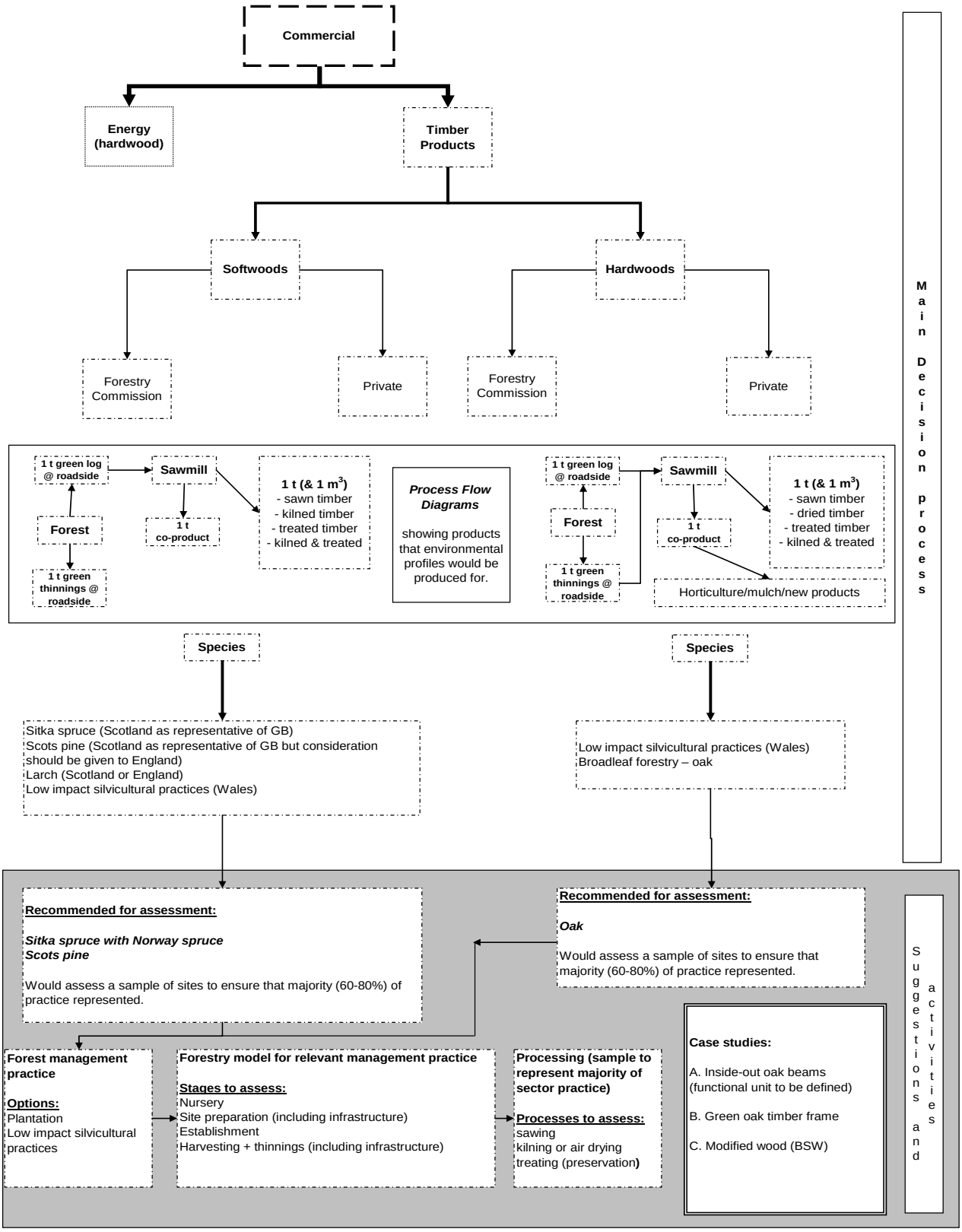
Task	**Calculation basis**	**Total**
Data gathering & assessment	12 models	£62,500
Student management	Subject to number of assignments	£9,600
Reporting	3 progress reports and final report	£6,600
Workshops	3 workshops	£3,900
Steering Group meetings	3 meetings	£3,900
Seminars	2 seminars	£3,000
Extra analysis	Green Guide updating, mop-up, reanalysis	£3,000
Project management		£10,200
		£102,700

This translates into the following milestone and fee schedule.

Milestone No	**Description**	**Target Date**	**Fees (£)**
1	Workshops	Month 3	13,000
2	Progress report 1	Month 6	23,000
3	Progress report 2	Month 12	19,000
4	Progress report 3	Month 18	19,000
5	Dissemination seminars (2)	Month 20	18,000
6	Final report – Update environmental profile	Month 24	10,700
		Total	**102,700**
		Calendar year 1	55,000
		Calendar year 2	47,700
		Financial year 07/08	13,000
		Financial year 08/09	42,000
		Financial year 09/10	47,700

Appendix A

This appendix represents roadmap for assessing the environmental impacts associated with UK forestry and sawmilling. This has been tailored to meet regional needs and strategies.



Appendix B

The following list outlines the suggested Steering Group members. We suggest that there should be a maximum of 6 members that will be selected from this outline. The scope of the steering group's work will be to advice and provide an on-going guidance to the full project. It is foreseen that there should not be more than 2 physical meetings throughout the project duration.

Names and organisation:

1. Forestry Commission (Jim Dewar)
2. University of Wales, Bangor
3. Building Research Establishment (Geoff Cooper)
4. Forestry Engineering Group
5. ConFor
6. Woodland Trust
7. Tilhill
8. Napier University

The following list outlines potential peer review organisations to support robust scientific standards in the field of LCA (and forestry). We suggest that there should be a maximum of 3 organisations on the peer review board that will be selected from the following list.

Peer review organisation:

1. BFH Hamburg (Federal research Centre for Forestry and Forest Products, Institute for Wood Physics and Mechanical Technology of Wood)
2. Technical Research Centre of Finland (VTT)
3. Oy Keskuslaboratorio - Centrallaboratorium Ab (KCL Science and Consulting)
4. Bath University
5. Imperial College, London

Appendix C

Suggested stakeholders for the full LCA study include:

1. ConFor
2. Members of COST Action E9 LCA of Forestry and Forest Products[2] (including Imperial College)
3. Forestry Commission district managers for selected areas:

   e.g. G Gill (Kielder)
   K Sinclair (Inverness)
   A Corson (England)
   B Coombes (Ae Forest)
4. Forestry Commission statistics department
5. Forest Engineering Group
6. Forest Research
7. Independent Forestry
8. Institute of Wood Research
9. Napier University
10. Sawmills (here representing only softwood sawmills)
    - Gordons
    - James Jones
    - Balcas
    - BSW Timber plc
    - Howies
    - Adam Wilson
    - Callanders
11. Scottish Woodlands
12. Tilhill
13. Timber Trade Federation
14. UK Forest Product Association
15. UK Timber Frame Association

[2] www1.uni-hamburg.de/cost/e9/

Appendix D

This Appendix presents an overview of BRE's updated LCA Environmental Profiling Methodology. The full Methodology[3] will be published in the summer of 2007.

Target audience: information users, who may include trade associations, manufacturers in the manufacturing chain, designers, developers, architects, contractors, facility managers and their clients.

1. Goal & Scope

Environmental Profiles are a form of Environmental Declaration based on Life Cycle Assessment, and are compliant with the relevant ISO Standards for Life Cycle Assessment and Environmental Declarations, ISO14040:2006, 14044:2006, 14025: 2006 and ISO/FDIS 21930.

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.

The purpose of this methodology is to describe the principles and framework for environmental declaration of construction products, including consideration of the reference service life of the construction products, seen over a building's life cycle.

The methodology identifies all the significant environmental aspects associated with the life cycle of construction products, as identified 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.

[3] Methodology for Environmental Profiles of Construction Products. Product Category Rules for Type III environmental product declaration (Environmental Profiles) of construction products. BRE. 2007.

2. Terms and definitions

For the purposes of this methodology, the terms and definitions given in ISO 6707-1, ISO 14001, ISO 14025, ISO 14050, ISO/DIS 21932,ISO/FDIS 21930 and the following 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.

2.1

ancillary product

complementary product

building product (2.2) that enables another building product to fulfil its purpose in the intended application

EXAMPLE Fasteners used to attached structural panels to framing members

2.2

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 Profiles** (2.16) 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

2.3

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

2.4

declared unit

quantity of a **building product** (2.2) for use as a reference unit in an **Environmental Profiles** (2.16), based on LCA, for the expression of environmental information needed in **information modules** (2.7)

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

2.5

functional unit

quantified performance of a product system for a **building product** (2.2) for use as a reference unit in an **Environmental Profiles** (2.16) based on LCA

2.6

gate

point at which the **building product** (2.2) 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

2.7

information module

compilation of data to be used as a basis for a **Type III environmental declaration** (2.16), covering a unit process or a combination of unit processes that are part of the life cycle of a product

2.8

non-renewable resource

resource that exists in a fixed amount that cannot be replenished on a human time scale

2.9

PCR review

process whereby a **third party** (2.16) panel verifies the **product category rules** (2.11)

2.10

product category

group of **building products** (2.2) that can fulfill equivalent functions

2.11

product category rules

PCR

set of specific rules, requirements and guidelines for developing **Type III environmental declarations** (2.16) for one or more **product categories** (2.10) . 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.

2.12

reference service life

service life of a **building product** (2.2) 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** (2.5)/**declared unit** (2.4)

2.13

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.

2.14

secondary fuels

fuels or fuel products that are derived from primary fuels

EXAMPLE Gasoline, gasified coal and lubricants

2.15

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.

2.16

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.

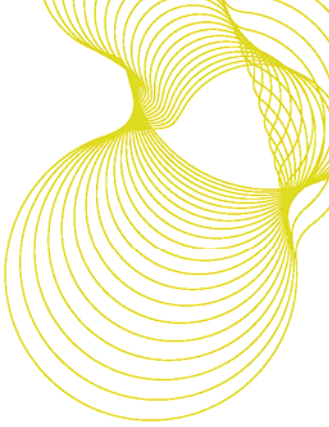
NOTE 2 The additional environmental information may be quantitative or qualitative.

2.17

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



3. Terms and definitions

Symbols

Energy	mega joule	MJ
Energy	kilowatt hour	kWh
Mass	tonne (metric ton)	t
Mass	kilogram	kg
Mass	gram	g
Surface	square metres	m2
Volume	cubic metres	m3

Acronyms & Initialisms

EPD	environmental product declaration
GWP	global warming potential
LCA	life cycle assessment
LCI	life cycle inventory
LCIA	life cycle impact assessment
PCR	product category rules
VOC	volatile organic compounds

4. Methodological framework

4.1 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.

4.2 Data Collection

Data is collected by manufacturers using a standard questionnaire. The latest version is available at www.bre.co.uk/.

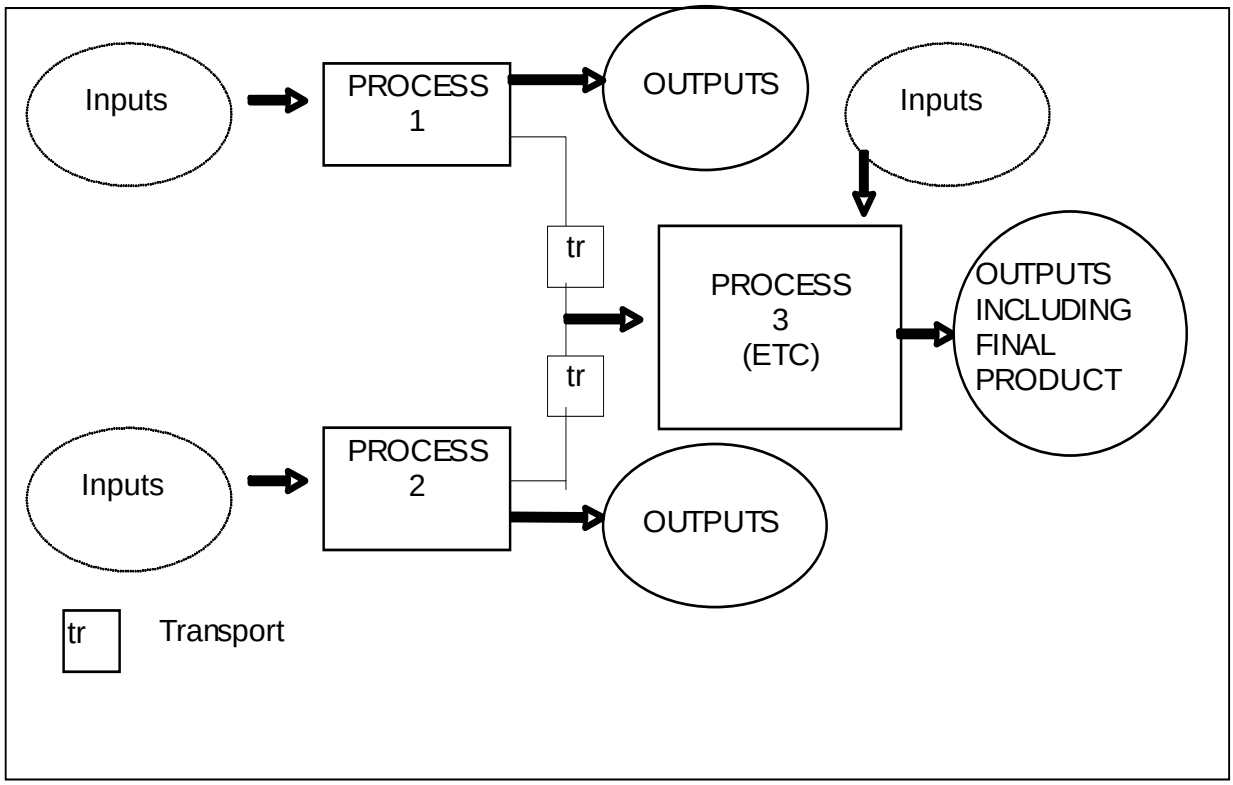
Inventory data is collected for following items:

Inputs:
- Materials
- Transport of materials
- Process Fuel and energy use
- 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



4.3 Declared and functional units

Table 5 Life cycle stages

Assessment	Life Cycle Stages considered
One tonne of product	"Cradle to gate" - Raw material extraction and manufacture through to the point the product leaves the factory gate.
One square metre of a building element	"Cradle to site" - Raw material extraction and manufacture through to installation at the construction site, including transport to the site. (Theoretically, impacts of construction would also be included here, but in practice are excluded due to their relatively small size.)
One square metre of a building element	"Cradle to grave" - Raw material extraction, manufacture, installation and use in a building for a 60-year study period including any associated maintenance and replacement, and with an assumed demolition which may take place at any time at or after the end of the study period.

"Cradle to gate" assessment

This type of assessment evaluates the environmental impact of the production of 1 tonne of product. The resulting BRE Environmental Profile is useful for both the comparison of identical products produced differently – e.g. in different locations or with different processes - and for the monitoring of production improvements over time. This Profile also provides the basic data to allow the impact of the whole life cycle to be considered.

"Cradle to site" assessment

This type of assessment evaluates the environmental impact on the basis of 1 m² of element (e.g. a wall with blocks, plasterboard and insulation).

A building element is likely to be made up of several products and Environmental Profiling takes this into account by adding together the contribution of the component parts. This allows specifiers to compare one type of element with another. The comparison may be between different product types or the same product from different manufacturers.

The “cradle to site” Profile allows the user to see the burden from the product in the context of different components in a specific function. However, they must apply their own life time factors for replacement, maintenance and disposal to achieve a true life cycle. This type of Profile is deliberately left free of replacement and maintenance data to allow the user to customise the data.

“Cradle to grave” assessment

This type of assessment evaluates the environmental impact on the basis of 1 m² of a building element and takes into account the maintenance, replacement and disposal rates of the element for a sixty study period. The resulting BRE Environmental Profile can be compared to other elements which perform the same function in the building (e.g. for a wall the thermal resistance, acoustics and damp proof properties will ideally be identical to make a comparison between different types of construction). To make comparisons, the building elements should be exposed to the same assumptions on construction impacts, maintenance, replacement, demolition and disposal.

Only this type of profile provides the results of a full life cycle assessment and is therefore the type of data on which it is most appropriate to make claims about one product compared to others.

4.4 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.

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 pro-rata input inventories 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. 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.

Boundary rule: Cut-off criteria for environmental impacts

No cut-off criteria are provided for environmental impacts – all are included within the assessment and all environmental impacts are reported.

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. Maintenance of equipment is also not included in the LCA except for frequently consumed items if they meet the data cut-off rule. Frequently “consumed” items such as saw blades and sanding paper and mould oil are included in the inventory again if they meet the cut-off rules.

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.

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.

Boundary rule: Site wastage

Site wastage during the construction process is included.

A costing handbook, Laxtons[4] 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

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

(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.

Boundary rule: Lifetime Use: Maintenance

Maintenance is considered where the impacts are significant. Transportation impacts for personal and plant are not included in maintenance models.

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.

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 Part L. 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.

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. However the impact of disposal of material arising from demolition is considered based on the disposal boundary rule.

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. The impacts of recycling and reuse are allocated in accordance to the procedures in ‘electricity models’ and ‘renewable electricity’. Models for the amounts for construction materials going to landfill, incineration, recycling and reuse are based on ‘disposal routes for construction materials’. For other materials, the disposal route is based on specific data provided by the manufacturer.

4.5 Energy

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.

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 using ecoinvent data. The environmental impact associated with the manufacture of the equipment and its anticipated lifespan is accounted for in the model.

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.

Where a manufacturer uses a “green tariff” which involves investment for future generation of renewable energy rather than production today, the energy is calculated with standard national energy burden.

See also waste-derived fuels (0) and biofuels (0).

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. The environmental impact associated with the manufacture of the equipment and its anticipated lifespan is accounted for in the model.

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.

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.

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.

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.

Combined Heat and Power (CHP)

Where CHP plants have been installed, these will also be assessed based on the operation of the particular plant.

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.

4.6 Transport

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 (DfT) from the continuing Survey of Road Goods Transport[5].

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 DfT's Survey of Road Goods Transport.

Calculating inventory data for transport

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[6] and the overall distance travelled.

ecoinvent models for the infrastructure associated with road transport (including vehicle manufacture, tyre and brake wear etc) are calculated using the overall tonnes km travelled and the appropriate ecoinvent model for the vehicle type.

Both fuel and infrastructure models are then combined to provide the full impact of transport.

[5] 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).

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

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.

4.7 Disposal

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.

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

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. These models are used in the calculation of an Environmental Profile.

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.

4.8 Allocation

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:

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

Where two product streams come from a single process (or inseparable parallel processes), and physical data (e.g. on the basis of mass or surface area) is not appropriate, burdens are allocated according to the proportion of product revenue earned from the two product streams. Any output from a process will attract burdens on the basis of the relative income it generates compared to the overall income generated by the process. Any co-products or wastes 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.

Allocation, waste and recycling

The output products may include by-products 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. An allocation rule is needed to assign the burdens appropriately between the co-products and reusable or recyclable wastes.

"Waste" is not defined for the purposes of creating the environmental profile.

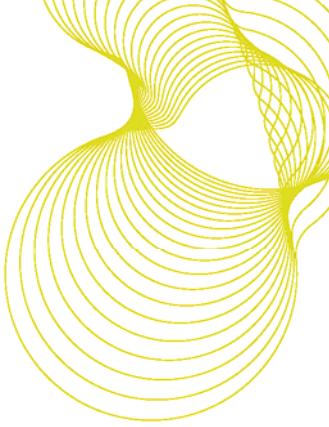
Particulates collected from gas streams and de-watered sludge and solids from treated effluents, mine overburden waste from mining and extraction operations and furnace slag, ash, bark and sawdust are all considered as outputs. Some materials produced during a manufacturing process may be:

- reused in the process
- sold
- sent to a waste disposal or
- taken away free of charge by another company

All outputs from a system (a product, waste or service) are treated equally. If it is not appropriate to apportion the impacts by physical allocation, the methodology allocates to any output from a process identically, on the basis of the value of the output.

Any output from a 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 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.

The impact from primary production is allocated forward to future recycling, where the product has value at the end of life (i.e. as post consumer waste). 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 for construction 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.

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

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 in the development of this methodology.

Only the impacts up to the base point are allocated to future recycling. Any further processing impacts will be 100% allocated to the primary product. 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.

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.

Allocation to reuse

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

It will be based on the cost of the final product, and the amount of final product manufactured. This will be 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).

4.9 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

4.10 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.

4.11 Carbon cycle

Carbon sequestration within products is considered over a timescale of 100 years and is included within the environmental profile. Waste from manufacturing processes which includes sequestered carbon is considered in terms of both sequestration and the impact of disposal. Where this waste is recycled, the sequestered carbon is passed to the recycle and the product does not benefit from the carbon sequestered within the waste.

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

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. The impact of timber within landfill has been modelled on the typical UK situation using the Environment Agency's GASSIM program and includes CO_2 and methane emissions for the release and combustion of landfill gas and other greenhouse gas releases from the decay of timber over a 100 year timescale.

The CO_2 and methane emissions at the end of life for timber is modelled based on current average disposal model for timber based on incineration, landfill and reclamation.

Life Cycle Impact Assessment

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[7].

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)

[7] 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.

- Stratospheric ozone depletion: kg CFC-11 eq
- Eutrophication: kg phosphate (PO_4) eq
- Acidification: kg sulphur 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

The background to each impact category including a summary description, category scope, and characterisation approach is provided in Annex 1.

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.

Sources of normalisation data

For each environmental impact category based on the CML characterisation method, normalisation scores have already been calculated by CML[8] 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 'Nuclear waste' uses the same methodology.

The normalisation data for CML categories are described in a spreadsheet which can be downloaded from the CML website[9]. Normalisation data for the other five categories has been obtained from Eurostat[10] and national statistics using the same year and population[11] as CML.

[8] 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

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

Normalisation factors for the Environmental Profiles methodology can be seen in Table 1.

Table 1. 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)[12]
Solid waste	3.75 tonnes solid waste[13]
Radioactivity	23700 mm^3 high level waste[14]
Minerals extraction	24.4 tonnes minerals extracted[15]
Water extraction	377m^3 water extracted[16]

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 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.

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

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

[12] 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.

[13] 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.

[14] 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

[15] 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.

[16] 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 data is not provided, an average from the closest years reported has been used.

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 are provided in a separate BRE Digest[17].

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

Table 2. 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

[17] 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.

Annex 1 - Impact categories considered in BRE LCA methodology (2007)

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 Intergovernmental 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.

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:

- Sea water
- 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.

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 the Eurostat website[18].

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

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

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.

Stratospheric ozone depletion (CML 2000)

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.

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.

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[19], which is based on EUSES, the EU's toxicity model[20]. 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

[19] 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.

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

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.

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[21]. Other characterisation methods, such as the Swiss Ecopoints, use the volume of highly active radioactive waste as a category.

The characterisation factor for the category is measured in mm3 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.

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[22] and the Swiss Ecopoints[23]. The characterisation factor is based on the mass of solid waste. Key points for this characterisation factor are:

- 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;

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

[22] http://www.pre.nl/eco-indicator99/

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

- 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.

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).

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 NOx emissions from the combustion of fossil fuels. Eutrophication potential is based on the work of Heijungs (1992)[24], and is expressed using the reference unit, kg PO_4 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.

Photochemical ozone creation: summer smog (CML 2000)

In atmospheres containing nitrogen oxides (NOx, 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[25] (including fate), and expressed using the reference unit, kg ethene (C_2H_4) equivalents/kg emission.

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

[25] http://www.environment-agency.gov.uk/commondata/acrobat/burdens_air_519036.pdf

Acidification (CML 2000)

Acidic gases such as sulphur dioxide (SO_2) and nitrogen oxides (NOx) 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[26].

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

Appendix E

Gantt Chart for proposed full LCA project

ID	Task Name	Start	Finish	Duration
1	Steering Group kick-off meeting – confirmation of models (currently 25) & selection of sites.	01/01/2008	01/01/2008	.2w
2	Steering Group mid-point progress meeting	01/01/2009	01/01/2009	.2w
3	Steering Group project review meeting	01/01/2010	01/01/2010	.2w
4	Workshop 1	11/02/2008	11/02/2008	.2w
5	Workshop 2	18/02/2008	18/02/2008	.2w
6	Workshop 3	25/02/2008	25/02/2008	.2w
7	Data gathering - Spruce	01/04/2008	30/09/2008	26.2w
8	Data gathering – Pine	01/04/2008	30/09/2008	26.2w
9	Data gathering - Larch	01/04/2008	30/09/2008	26.2w
10	Data gathering – low impact	01/04/2008	30/09/2008	26.2w
11	Data gathering - Oak	01/04/2008	30/09/2008	26.2w
12	Data gathering – biomass	01/10/2008	03/04/2009	26.6w
13	Data gathering - mulching	01/10/2008	03/04/2009	26.6w
14	Data gathering - pallets	01/10/2008	03/04/2009	26.6w
15	Data gathering – alternative 4	01/10/2008	03/04/2009	26.6w
16	Data gathering – alternative 5	01/10/2008	03/04/2009	26.6w
17	Data gathering – sawmilling (sawing; kilning; & treating)	01/07/2008	31/12/2008	26.4w
18	Data gathering – green oak framing	01/07/2008	31/12/2008	26.4w
19	Data gathering – inside out oak beams	01/07/2008	31/12/2008	26.4w
20	Data gathering – modified wood	01/07/2008	31/12/2008	26.4w
21	Reporting – Progress report 1	01/07/2008	31/12/2008	26.4w
22	Reporting – Progress report 2	02/03/2009	02/03/2009	.2w
23	Reporting – Progress report 3	01/07/2009	01/07/2009	.2w
24	Reporting –Final report	01/01/2010	01/01/2010	.2w
25	Dissemination seminar 1	01/12/2009	01/12/2009	.2w
26	Dissemination seminar 2	07/12/2009	07/12/2009	.2w
27	Student participation potential 1	01/04/2008	30/09/2008	26.2w
28	Student participation potential 2	01/05/2008	30/10/2008	26.2w
29	Student participation potential 3	03/07/2008	01/01/2009	26.2w
30	Student participation potential 4	01/07/2008	30/12/2008	26.2w
31	Analysis	01/04/2008	01/12/2009	87.2w
32	Green Guide data update - forestry	02/09/2008	01/01/2009	17.6w
33	Green Guide data update - sawmilling	01/07/2009	30/10/2009	17.6w
34	Project management	01/01/2008	31/12/2009	104.6w