Print Go Back Next Page

Whole Building LCA With WLC: A New Commercial Software Development For Product Specification In The UK

S Edwards & J Anderson
Building Research Establishment Watford UK

Summary: **In 2000, BRE launched a software tool called Envest. This tool allowed designers to gauge the environmental impacts of a whole building design at the initial stage of the design process, comparing the embodied impact of the building fabric to the impact from operation. The simplicity of the tool hinges upon the use of a single score approach to measuring environmental impacts. The measure is known as Ecopoints. In response to pressure from the market, BRE has developed Envest further to include a Whole Life Costing function that enables the designer to consider the costs of the building delivery and its maintenance scheme together with the environmental impact. Acknowledging that there is a role for generic and specific costs, the new tool will enable users to enter their own costs or use default data. In early 2002, Envest II will go on line. Web based, the tool will be inherently more flexible than its CD ROM predecessor and, for the first time, creates the possibility of adding new products as data becomes available from manufacturers. This function has been developed in parallel with the BRE Certification Scheme for Environmental profiles of Construction Products which allows manufacturers to make independently verified claims about their product. Envest scores can already be used to obtain "material" credits in BREEAM, the whole building assessment scheme and the new version will continue to be used in this way.**

Keywords. Construction products, Embodied impacts, Software tool, LCA, WLC, Ecopoints.

1 INTRODUCTION

The integration of Whole Life Costing and Life Cycle Assessment presents a powerful route to improving the sustainability of the construction industry. Combining economic and environmental assessment tools to obtain "best value" solutions in both financial and environmental terms has the potential to make a significant contribution to achieving sustainable building design.

In 2000, BRE launched a software tool called Envest. This tool allows designers to gauge the environmental impacts of a whole building design at the initial stage of the design process, comparing the embodied impact of the building fabric to the impact from operation. The simplicity of the tool hinges upon the use of a single score approach to measuring environmental impacts. The measure is known as Ecopoints. In response to pressure from the market, BRE has developed Envest further to include a Whole Life Costing function that enables the designer to consider the costs of the building delivery and its maintenance scheme together with the environmental impact. Acknowledging that there is a place for generic and specific costs, the new tool will also enable users to enter their own costs data. As a web based software, the tool will be inherently more flexible than its predecessor and opens up the possibility of adding new products as data becomes available from manufacturers.

This paper begins with definitions of Whole Life Costing and Life Cycle Assessment as they have been used in the development of the software. It goes on to outline the concept of Ecopoints. This is followed by the rationale behind the Envest software and a brief overview of the activities required to integrate WLC into the tool.

2 DEFINING THE TOOLS

'Whole life costing', 'life cycle costing' and 'life cycle assessment' are terms often used interchangeably. This creates a great deal of confusion. For clarity, user friendly definitions are provided in Box 1. These definitions are those used by BRE and which are commonly used within the industry.

WLC and LCA in the construction industry have developed separately in response to economic and environmental issues but the two tools have much in common, as shown in figure 1.

The key similarity is that both utilise data on:

- quantities of materials used,
- the service life the materials could or will be used for,
- the maintenance and operational implications of using the products,
- end of life proportions to recycling (and sale value) and disposal.

The key differences are:

- conventional whole life costs methods do *not* consider the process of making a product, they are concerned with the market cost. Life cycle assessment considers production.
- WLC is usually discounted to present value over time, environmental impacts are not.

2.1 Progress to date

A BRE study of Whole Life Costing conducted for DETR (Clift and Bourke 1999) found that despite substantial amounts of research into the development of database structures to take account of performance and whole life costing, there remains a significant absence of standardisation across the construction industry in terms of scope and data available. The Centre for Whole Life Performance at BRE is working to improve this situation by working with the industry and continuing to develop its own independent whole life cost and performance data.

Box 1: Common definitions

WHOLE LIFE COST (WLC)

The definition from the developing ISO Standard 15686 on service life planning is "a tool to assist in assessing the cost performance of construction work, aimed at facilitating choices where there are alternative means of achieving the client's objectives and where those alternatives differ, not only in their initial costs but also in their subsequent operational costs."

- WLC includes the systematic consideration of all relevant costs and revenues associated with the acquisition, use and maintenance and disposal of an asset.
  - *Procurement costs can include*: initial construction, purchase/lease, interest, fees
- *Recurring costs can include:* rent, rates, cleaning, maintenance, repair, replacement/renewal, energy and utilities, dismantling or disposal, security and management.
  - *Revenues can include:* Sales of recycled materials, interest in asset and rental income.

Note: **Life Cycle Cost** (LCC) and **Through Life Cost** (TLC) are also terms used to describe the same process as WLC. The term is now less commonly applied and therefore WLC is used throughout this document.

LIFE CYCLE ASSESSMENT (LCA)

- A method to measure and evaluate the environmental burdens associated with a product system or activity, by describing and assessing the energy and materials used and released to the environment over the life cycle. The term **life cycle analysis** is also sometimes used to describe the same process.

ENVIRONMENTAL IMPACT ASSESSMENT

- The process of interpreting the effect that removals or releases to the environment will have on particular environmental systems. There is no absolute "end point" at which an impact has to be measured-e.g. burning coal will cause "fossil fuel depletion", "global warming potential" and even "risk of drought"-but common endpoints and measurement techniques may be agreed which allow the impacts of different activities to be compared.

ENVIRONMENTAL PROFILE

- A presentation format for the results of an LCA study. BRE has produced an industry-agreed method for collecting, interpreting and presenting the data according to a standard Environmental Profile format.

SERVICE LIFE

- Life of a product or building element or whole building. May be

Technical (based on physical durability and reliability properties),

Economic (based on value and depreciation to owner) or

Obsolescence (based on factors other than time or use patterns e.g. fashion).

Note: In practice, **Replacement Interval/Life** is also used interchangeably with service life and the same distinctions apply.

LCA

2.2 Stages in the Building Life Cycle

1. Extraction of raw materials
2. Production of building components
3. Construction
4. Use:
   Repair
   Maintenance
   Replacement
5. Demolition
6. Recycling

WLC

Figure 1. Commonality within the Building Cycle of issues relating to WLC and LCA

It is recognised that whole life cost data may not always be readily available and comparisons can be difficult. The concept of option investment appraisal using cost data is however, relatively straight forward. Comparisons on the basis of environmental information have been less easy to make because of the wide range of data available. Simplification of the diverse issues considered has been required - and this has been delivered through the development of a single score for environmental impacts, known as Ecopoints.

Life cycle assessment (LCA) analyses all the environmental impacts from a product cradle to grave. It is now an internationally established analysis technique applied in many industries, including construction. To obtain a single score, such as an Ecopoint, it is essential to start with a sound approach to environmental assessment.

BRE’s ‘Methodology for Environmental Profiles of construction materials, components and buildings’ (Howard, Edwards and Anderson, 1999) provides a standardised way of carrying out LCA on UK construction products. The BRE methodology covers the extraction, processing, manufacture, transport, use and disposal stages of the product's life cycle. It summarises the environmental impacts arising from these stages into thirteen impact categories including climate change, atmospheric and water pollution, and raw materials consumption.

3 ECOPOINTS

Comparisons between Environmental Profiles are always informative, but do not necessarily allow the reader to reach a precise conclusion. For example, which gives less overall environmental impact: a product with high global warming impact but low water pollution impact or a product with low global warming impact but causing significant water pollution?

BRE undertook a consensus based research programme to weight the issues covered by LCA from the perspective of seven UK construction interest groups, including the public sector, construction materials producers and manufacturers, property professionals, environmentalists and academics.

The results showed a surprising degree of consensus about the relative importance of different environmental issues across a broad range of interest groups. This consensus has been used to produce a set of weights to convert Environmental Profiles data into a single score reflecting environmental impact in the UK. The data in the twelve impact categories are multiplied by the agreed weight for each category and combined to produce an Ecopoint score.

Box 2. Environmental impact categories

Climate Change	**Pollution to Water: Ecotoxicity**
Acid Deposition	**Pollution to Water: Eutrophication**
Ozone Depletion	**Minerals Extraction**
Pollution to Air: Human Toxicity	**Water Extraction**
Pollution to Air: Low Level Ozone Creation	**Waste Disposal**
Fossil Fuel Depletion and Extraction	**Pollution to Water: Human Toxicity**

To aid interpretation, Ecopoints are derived so that the annual environmental impact caused by a typical UK citizen creates 100 Ecopoints. *More Ecopoints indicate higher environmental impact.* The Ecopoints scores have been utilised in the Envest software.

4 ENVEST DESIGN TOOL

ENVEST is the first UK software tool for estimating the lifecycle environmental impact of commercial buildings at the building inception stage. The tool provides a holistic approach to the design by:

- Helping to optimise the form of the building, for the least environmental impact over the building life cycle
- Informing choice about the environmental impacts of the main elements of the building structure.
- Providing and maintaining reference data from material manufacturers.
- Aiding designers to balance the environmental impact of the energy and water consumed during the operational life of the building, with the choice of building materials.
- Performing comparisons of various building types.

ENVEST II will be launched in Spring 2002. The original version of ENVEST is for office buildings, and considers the environmental impacts of both the materials used during construction and the energy and resources consumed over the building's life. This is now being extended to allow consideration of schools and hospitals. The most significant change is the addition of WLC results alongside the Ecopoint scores. This is described in more detail below.

Using *minimal* data entered through simple input screens, Envest allows designers instantly to identify those aspects of the building which have the greatest influence on its overall environmental impact and cost.

4.1 Building fabric specifications

Envest provides a choice from most mainstream building materials. The range of specifications presented in the tool is based on a sensitivity analysis, which looked at the sensitivity of each element’s specification parameters to primary embodied energy. At each stage, a 10% error target was selected as the criterion for inclusion of a parameter or for selecting parameter values needed to represent the range of variation encountered. The principle material-consuming elements are generally upper floors, walls, substructure, external windows and roof elements and to predict embodied energy for whole buildings within 10%, then these elements must be accurate to this degree. For the other elements, achieving the 10% target for the element is less critical because these elements will have a much smaller effect on the result for the building.

Embodied environmental impacts (not only energy) are estimated by calculating the quantity of each material used in individual elements over the life of the building and multiplying it with the Ecopoints per tonne of that material.

4.2 Building services specifications

Envest provides a choice from basic building services specifications to enable designers to balance the environmental impact of the energy and water consumed during the operational life of the building, with the choice of building materials. The choices for services include Heating, Lighting, Ventilation, Water, Refrigeration, Office equipment, Lifts and Catering.

Envest calculates the operational environmental impacts of these services by comparing performance against typical performance benchmarks. These benchmarks have been derived from the ECON19 guide, which provides typical and good practice energy and carbon dioxide emission benchmarks for the building as a whole, plus those for individual building services, systems and components.

5 ENVEST: UNDERSTANDING YOUR RESULTS.

1 Ecopoint can be described as equal to any (not all) of the following:

- 320 kWh electricity
- 83 m^3 Water: enough to fill 1,000 baths
- Landfilling 1.3 tonnes of waste
- Manufacturing 3/4 tonnes brick (250 bricks)
- 1.38 tonnes mineral extraction

Envest provides the facility of measuring impacts per square metre of building gross floor area. Using the tool, it is possible to compare results from a current building to any a user has entered previously. For an architect, it is informative to compare the scores for different buildings designed by your company and as a building owner, it is informative to know the score for your building portfolio, as a complement to the new BRE Environmental Benchmarking for Property Portfolios service.

Go Back Next Page

In addition, it is always useful to compare the result of your building to those designed by others. The following graph provides a range of benchmark figures. The lowest score (i.e. better environmental performance) is for the BRE Environmental Building (1997), the middle score for the Wessex Water HQ design in Bath and the next for the BRE Low Energy Office (1981). All these buildings were designed taking into account environmental impact. A typical building designed without consideration for environmental impacts would be expected to score approximately 40 Ecopoints per square metre.

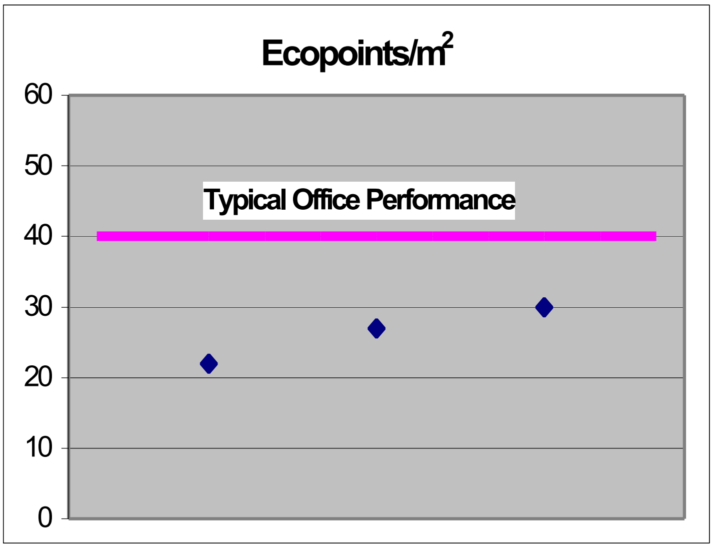

Figure 2: Benchmarking Environmental Performance in Ecopoints

6 ADDING WLC TO ENVEST

The following activities have taken place to ensure compatibility between WLC and LCA:

1. Mapping of BCIS and UNICLASS onto ENVEST framework.
2. Addition to existing embodied Life Cycle Ecopoints, operational Ecopoints and total Ecopoints of the capital cost, operational cost and total whole life cost as whole building summary. The contribution to Life Cycle Ecopoint and contribution to Whole Life cost indicated against options wherever possible on input sheets.
3. WLC graphs added.
4. Identification of relevant input data and calculation methods to facilitate calculation of additional whole building costs currently not considered - e.g. tax.
5. Ammendment of initial processing databases :

- Materials/Components/Elements/Assets vs Masses of Material
- Materials/Components/Elements/Assets vs Environmental Profiles
- Materials/Components/Elements/Assets vs Replacement lives Hi, Av, Lo
- Materials/Components/Elements/Assets vs Cost Hi, Av, Lo
- Materials/Components/Elements/Assets vs Maintenance mats env-profile
- Materials/Components/Elements/Assets vs Maintenance mats costs Hi, Av, Lo
- Materials/Components/Elements/Assets vs Cleaning mats env-profile
- Materials/Components/Elements/Assets vs Cleaning mats costs Hi, Av, Lo
- Materials/Components/Elements/Assets vs Disposal mats env profile
- Materials/Components/Elements/Assets vs Disposal mats costs Hi, Av, Lo
- Utilities Annual - as per ECON 19 categories parameters for modelling energy
- Utilities Annual - as per ECON 19 categories energy costs
- Utilities Annual - as per ECON 19 categories parameters for modelling water

Go Back

- Utilities Annual - as per ECON 19 categories parameters for drainage & effluent
- Environmental Profiles vs weightings vs Ecopoints

7 OTHER APPLICATIONS OF ENVEST: TEACHING

Lecturers have responded positively to using Envest with their students as a teaching tool. Of key importance is that they have found it easy to use, enjoyable and a valuable exercise for their students to undertake. Many consider that Envest could usefully be used by students undertaking large-scale projects as part of an environmental analysis of design. This could be both at an early stage in the design, allowing the students to assess the environmental impacts of different design options, and at a later stage, asking students to identify whether they could have reduced the environmental impacts.

Lecturers can provide teams of students with a base building specification and ask them, bearing in mind the normal principles of construction and structures, to try to make the maximum reduction to the overall impact of their building over its life cycle. The basic learning exercise is often based around the following example. All the base buildings had floor areas of 5000 m^2 and with the default specifications they had impacts of approximately 35-37 Ecopoints/m2 for operational energy and between 5 and 6 Ecopoints/m2 for Embodied Impacts. . In a trial learning exercise, teams managed to reduce Operational Impacts to between 14 and 17 Ecopoints/m2 and Embodied impacts to between 1.3 and 2.3 Ecopoints/m2, a reduction of just over a half, and two thirds respectively, and an overall reduction of 57%. In going through the exercise, teams were able to explore the full potential of Envest, assessing what was causing the greatest impacts over the life cycle, and by initially targeting these areas, seeing whether significant improvements could be made.

8 REFERENCES:

1. ECON19 – Energy Consumption Guide 19 – Energy Use in Offices, Department of Environment, Transport and the Regions Energy Efficiency Best Practice Programme
2. Bartlett & Howard (2000) Informing the Decision Makers on the Cost and Value of Green Building, Building Research and Information, Vol. 28, No. 5/6 Sep 2000, E &FN Spon, London.
3. Bartlett & Simpson (1998), Durability and Reliability, Alternative Approaches to Assessment of Component Performance over time" CIB Congress, June 1998
4. Bourke & Davies, Estimating Service Lives Using the Factor Method for Use in Whole Life Costing, Estimating Service Life, Durability of Building Materials and Components 8. National Research Council Canada 1999.
5. BRECSU (1999) Environmentally smart buildings - a quantity surveyor's guide to the cost-effectiveness of energy efficient offices, DETR Good Practice Guide 274, 1999.
6. CCF (2000) Construction Clients Forum - Client's Guide to Whole Life Costing, London.
7. Clift & Bourke, Study On Whole Life Costing, BRE Report Number CR 366/98, CRC London.
8. Clift M & Bourke K. (1999) Study on Whole Life Costs, BR267. CRC Ltd. 1999.
9. HMSO (1998) HM Treasury Procurement Guidance No 35 Life Cycle Costing, London.
10. Howard, Edwards & Anderson (1999), BRE Methodology for Environmental Profiles of Construction Material, Components and Buildings, BRE report 370, CRC London.
11. Howard N and Dickie I, (2000) BRE Digest 446: Assessing environmental impacts of construction. Industry consensus, BREEAM and UK Ecopoints, CRC Ltd. 2000.
12. ISO (2000) ISO 15686 Part 1 (ISO TC59 SC14) Service life planning. Service Life Planning - General Principles.

Further information: See www.bre.co.uk/envest