Lcaid™ Software: Measuring Environmental Performance Of Buildings

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Summary: **With a move towards achieving sustainablility in the construction industry, there is an increasing need to measure the environmental performance of buildings. At present many buildings are claiming to be "green" but the basis of these claims are often unclear, subjective or narrow in focus. What is needed is an objective and quantitative measure of performance across a range of environmental indicators. One possibility is Life Cycle Assessment (LCA), an internationally accepted environmental accounting system of all the inputs and outputs of a product, material or building. This paper looks at LCAid™, a life cycle assessment software developed by the NSW Department of Public Works and Services (DPWS) that provides quick, comprehensive, and scientifically based environmental assessment of buildings. LCAid™ evaluates environmental performance, identifies impacts against eleven eco-indicators and separates impacts into four stages of the building's life cycle. It is aimed at the building designer as a user friendly decision-making tool for evaluating the environmental performance and impacts of designs and options over the life cycle of a building, product or system. The software has a number of unique capabilities: it can import material quantities from CAD drawings, can import LCI data directly from Boustead and SimaPro and can compare up to 5 design options at once. A Life Cycle Costing module has been completed, which adds an economic dimension to the comparison, as a monetary value. LCAid™ is an easy-to-use tool that aims to help move the Australian building and construction industry towards more sustainable practices.**

Keywords. Sustainable Buildings, Life cycle assessment, LCAid™

1 INTRODUCTION

Buildings are major consumers of resources both in their infrastructure and in their operation. This is a major concern in achieving sustainability, "according to Worldwatch Institute building construction consumes 40 percent of the raw stone, gravel and sand used globally each year and 25 percent of virgin wood. Buildings also account for 40 percent of the energy and 16 percent of the water used annually worldwide" (Lippiat 1998). As noted by the US National Pollution Prevention Centre (1999) "the construction and operation of buildings consume the majority of the world's natural resources and energy, and contribute the bulk of landfill waste "and this is supported by CIRIA (2001), "construction activities generate waste flows on a large and unsustainable scale."

The built environment contributes significantly to overall environmental degradation. By improving design and construction of buildings we can reduce this impact (DPWS 2001). Addressing the environmental performance of building materials through their life cycle is a crucial factor in achieving sustainable buildings. This is supported by Lippiat and Norris (1996) who state that "selecting environmentally preferable building materials is one way to improve a buildings environmental performance." The built environment plays a vital role in both in human health and well-being as well as in achieving sustainable development.

The issue of sustainable buildings has been achieving recognition as an important sustainable development issue and is clearly a matter of worldwide concern. (Remkes 2000). This is supported by Zachmann (2000), "sustainability is also for construction and our built environment, one of the biggest challenges for the 21st century". Parts of the construction industry have also embraced the challenges and opportunities offered by sustainability believing that "anticipating change and responding to the wider sustainability agenda is critical to long term competitiveness" (CIRIA 2001).

The way buildings are measured for performance has been changing. Over the past few decades, environmental factors have played an increasing role in how a building's performance is measured. With the realisation that many practices within the building and construction industry are unsustainable and a heightened awareness of the environmental impacts of materials, products and buildings there has been a move to address the economic, social and environmental performance of buildings.

Many new projects claim to have improved environmental performance but the basis of these claims is often unclear or narrow in focus. To substantiate these claims a measurement methodology and tools are required that are objective and cover a wide range of environmental impacts. Life cycle assessment (LCA), an internationally accepted environmental assessment methodology is a possibility. LCA encapsulates both the operational resource consumption of a building and the material resource consumption from resource extraction through to final disposal.

2 LIFE CYCLE ASSESSMENT (LCA)

Life cycle assessment is defined as the "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system through its life cycle" (Australian/New Zealand Standard (no 14040) 1998). LCA is endorsed by the international standards association and criteria for LCA are contained in the ISO 14040 series. LCA is defined in ISO14040 as "a technique for assessing environmental aspects and potential impacts associated with a product by:

- compiling an inventory of relevant inputs and outputs of a product system;
- evaluating the potential environmental impacts associated with those inputs and outputs;
- interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study."

LCA evaluates resource use and emissions of a product in a cradle-to-grave approach studying potential environmental impacts from raw material extraction, through manufacturing, construction, operation, demolition and disposal.

LCA has been used to improve process and product design and provide data for benchmarking. In designing the built environment LCA can provide both designers and specifiers with quantitative options for integrating environmental improvements, seeking environmentally friendly alternative materials and substantiating environmental performance claims. In this way, LCA can be used as a tool to promote and achieve sustainable development, particularly in the design and construction industries by providing quantifiable comparisons between various design and construction options, as well as between different buildings by way of benchmarking.

Environment Australia commissioned a project consortium led by the Centre for Design at RMIT to "assess the status of life cycle assessment (LCA) tools in the building and construction (B&C) industry and to develop strategies to improve the uptake and use of these tools". The aim of the project was to "improve the environmental performance of the B&C industry, by promoting LCA as a tool to assess environmental impacts of building materials and building systems in Australia." (Centre for Design RMIT, 2001). This study highlighted the absence of a suitable commercially available LCA tool in Australia for building simulations, similar to tools available elsewhere in the world.

DPWS has undertaken extensive LCA research in the past decade. This work can be divided into 2 distinct periods. Prior to 1999 work focused on LCA research and development of DPWS Life Cycle Inventory (LCI) database using the Boustead Model. In the period 1995 to 1999 DPWS had a group of specialists consisting of environmental engineers and chemists who carried out extensive research into the life cycle performance of materials and buildings. The database created of materials consisting of over 100 LCIs and over 200 composite building materials are considered one of the most extensive in Australia. After 1999 work moved from research to application, focussing on the development and use of LCAid™ software. There was recognition of the need for a quick, easy and effective LCA tool for designers and architects – a tool that easily fits into the design process. LCAid™ was conceived as a designer's LCA tool.

3 LCAID™

LCAid™ is a computer software developed by NSW Department of Public Works and Services (DPWS) with Dr. Andrew Marsh (formerly of University of Western Australia and now with Cardiff University, Wales). The softwares aim is to make LCA more accessible to design and building practitioners for environmental assessments and design improvements. As noted by Hall and Peshos (2001) "LCAid™ arose from the need to provide a fast, comprehensive and scientifically based environmental assessment of buildings. It is aimed at the building designer, and is a user friendly decision making tool using LCA methodology to evaluate the environmental performance of design options and to identify the largest impacts over the entire life cycle of a building".

LCAid™ uses quantities of building components combined with operational energy and water consumption to calculate environmental outputs. These are calculated over eleven eco-indicators covering atmospherics, resources and pollutants. It also separates the environmental impacts within each eco-indicator into four stages; construction, operation, maintenance and demolition. The following diagram illustrates the environmental issues and scope considered by LCAid™.

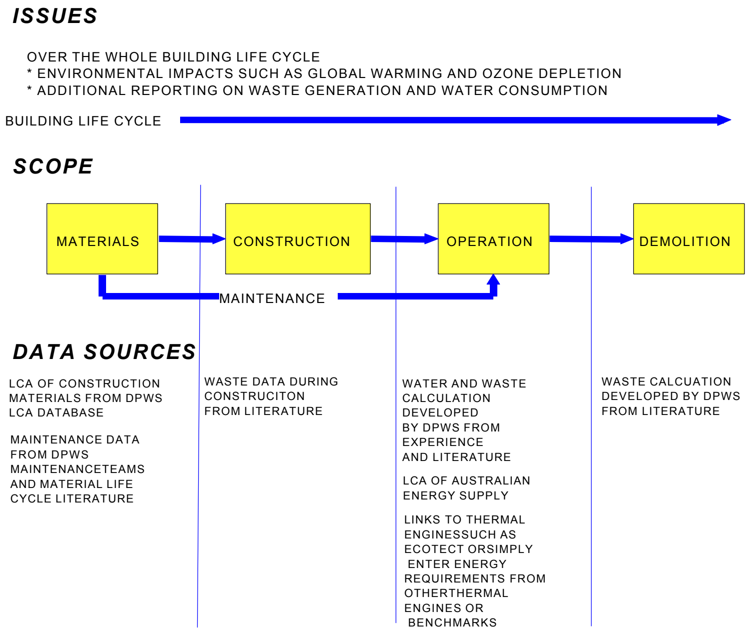

Figure 1. LCAid™ Scope and Issues

3.1 Inputs

3.1.1 Project and Operational Data

Project and operational input is required covering the areas of project type, climate zone, operational energy, waste management, water management and water use. This data is used to perform specific calculations for issues such as waste generation and water consumption. Figure 2 demonstrates one of the user input screens.

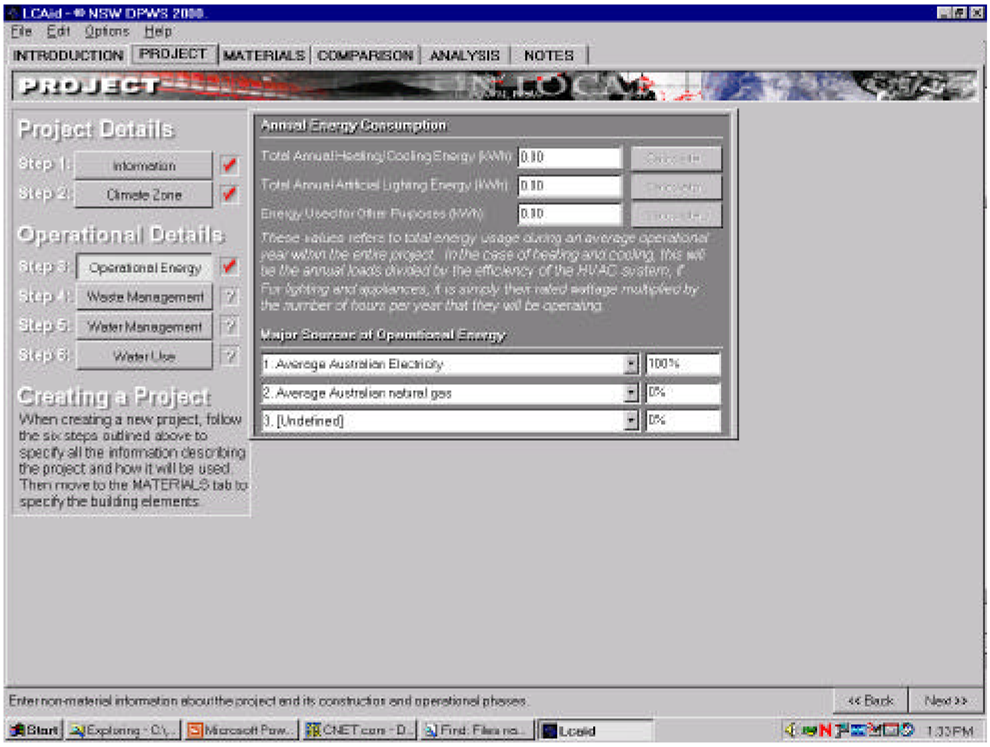

Figure 2. Project and Operational Information user input screen

3.1.2 Building Materials

Building material quantities and types can be entered in a number of ways. A unique feature of LCAid™ is that building material quantities can be imported from 3-D architectural models through CAD drawings (dxf) and Ecotect (.eco or .zon) models. As noted by Hall & Peshos (2001) "this link to CAD packages provides the basis through which LCAid™ can be integrated into the design process" and the software's "power stems from its seamless integration with other environmental software - it can work on a 3D model created in Ecotect" (Hall & Peshos 2001).

Building materials quantities extracted from the 3-D models or manually entered by the user are then assigned material types by selecting from the LCI library as shown in Figure 3 below. The LCAid™ library draws upon the DPWS LCA database consisting of over 200 composite common Australian building materials. LCAid™ can import LCI data directly from other LCI databases including Boustead Model and Sima-Pro.

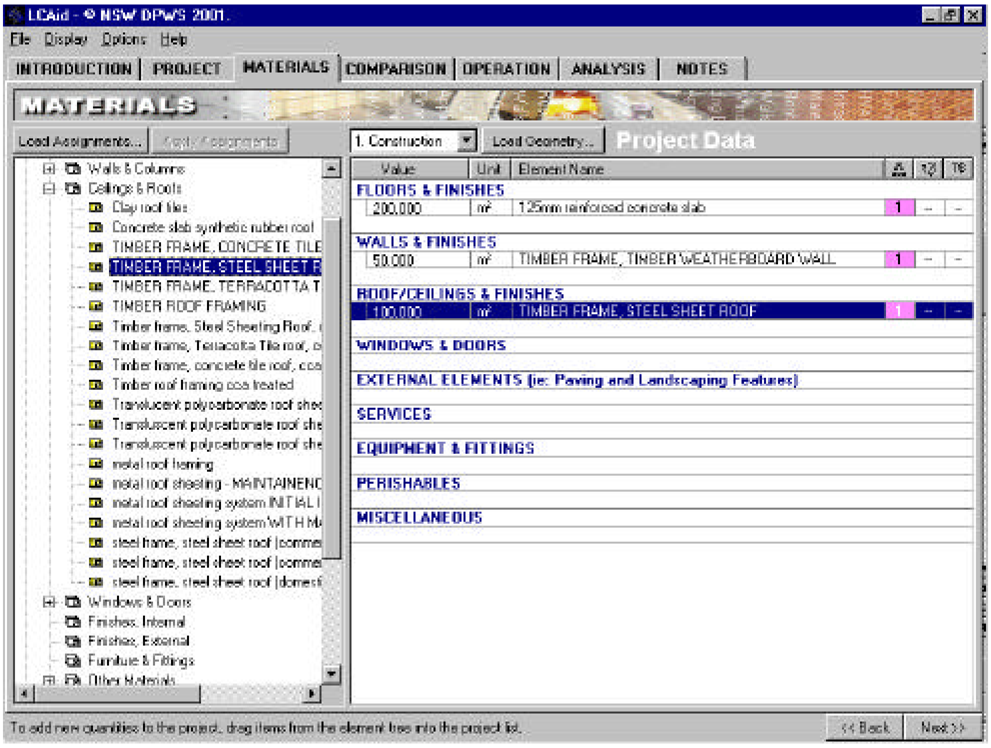

Figure 3. Materials Input Screen

3.2 Outputs

LCAid™ currently has two main outputs, reporting the environmental impacts of a building in two different ways. Firstly the environmental performance is determined by comparing a design to a benchmarked building and the tool also identifies the environmental impacts for a design at each stage of the buildings life cycle (Hall & Peshos 2001).

3.2.1 Environmental Comparison

For each design the environmental outputs are graphed with quantities shown for each Eco-indicator, as shown in Figure 4. The data is calculated using the impact categories of Eco-indicator 95 with the additional reporting of water and solid waste. There is the potential for the impact categories to be expanded to include eco-indicator 99 and other environmental impacts such as biodiversity and indoor air quality.

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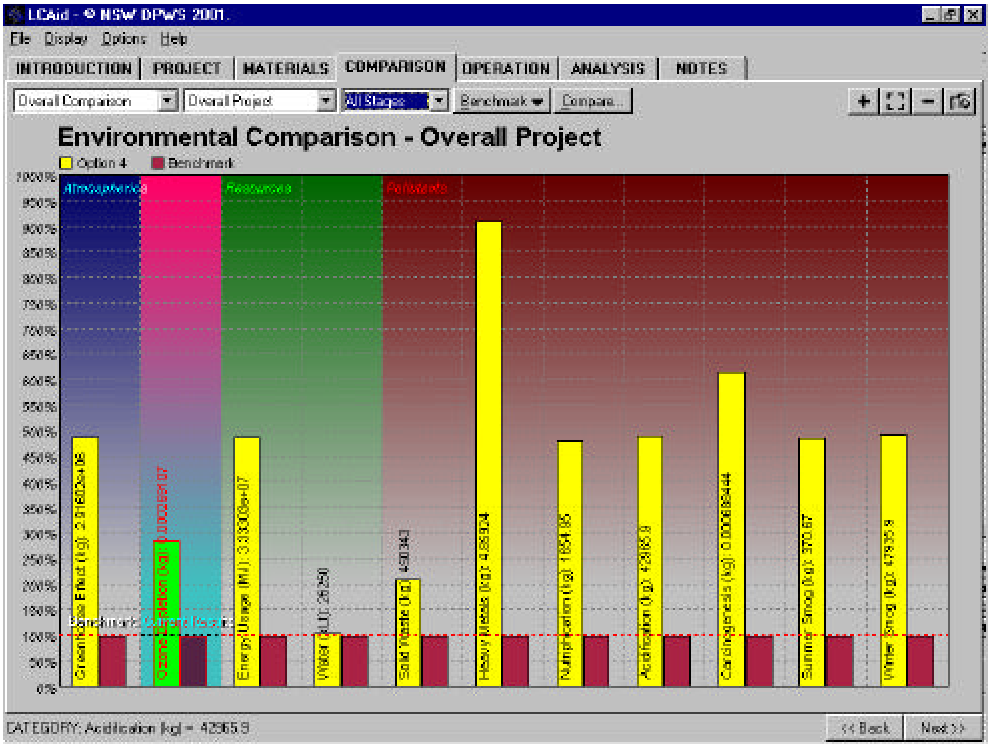

Figure 4. Environmental Impacts

As a comparative tool, a design can be benchmarked and other design options can be compared against it. This allows the designer to assess the performance of an option relative to a determined benchmark and provides data for informed decisions to be made. LCAid™ can compare up to 5 options at once as shown in Figure 5.

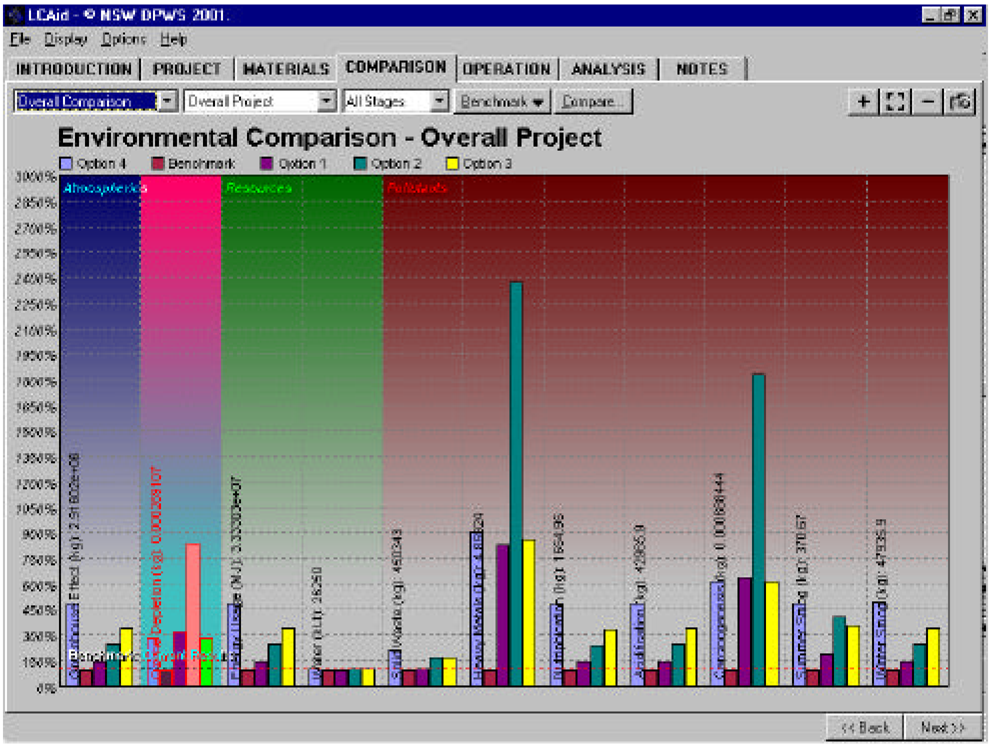

Figure 5. Comparison of Options

3.2.2 Environmental Impacts

For a design option the contribution of each stage of a building's life is shown for each eco-indicator. The impacts from construction, operation, maintenance and demolition are indicated and for each eco-indicator the materials contributing are ranked. Their contribution of the total is identified as shown in Figure 6 below. This allows the user to easily identify materials or combinations of, which are of greatest potential impact, allowing the user to easily identify areas for improvement.

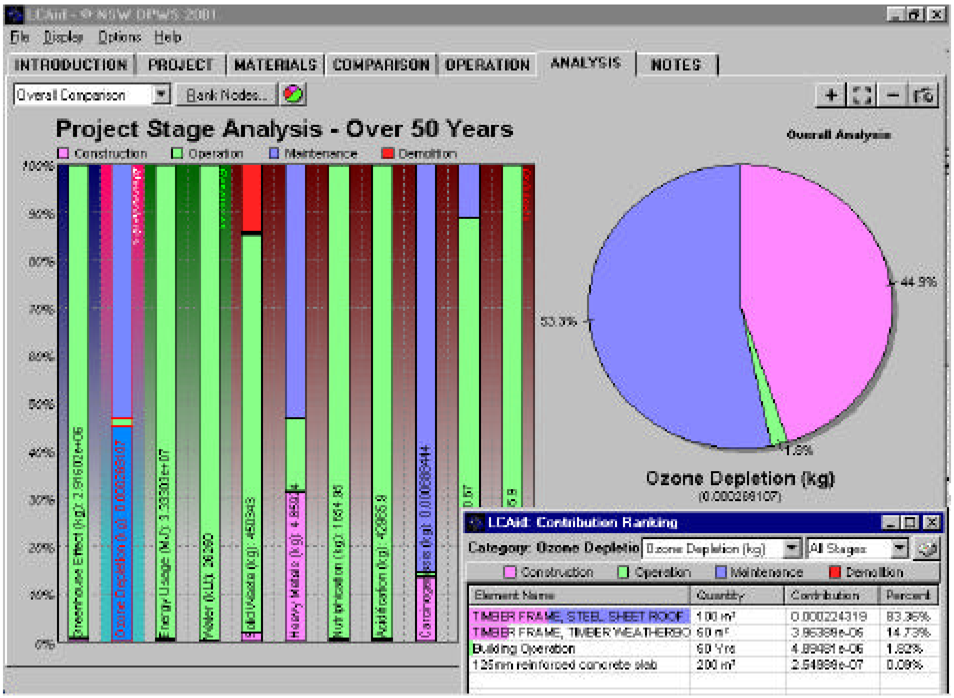

Figure 6. Project Stage Analysis and Materials Contribution Ranking

3.3 Life Cycle Costing Module

A life cycle costing (LCC) module has been completed, which adds an economic dimension to the comparison, as a monetary value. Life cycle costing is a mathematical method of measuring the life costs of a building. It takes into account ongoing maintenance and replacement costs over the full life of the project, not just the initial capital outlay. This allows the users to fully assess the initial costs of a venture as well as the ongoing maintenance and operation against the environmental performance, although it is not possible to put a monetary cost on all environmental impacts. As noted by Lippiat and Norris (1996) "Even the most environmentally conscious building designer or building materials manufacturer will ultimately want to weigh environmental benefit against economic costs". The data for the costing module has been provided by the DPWS Quantity Surveying section, who have collected data on building and material costs and maintenance regimes. The LCC methodologies used are a hybrid of *Nett Present Value* and *Internal Rate of Return* methods.

LCAid™ uses the materials and operational data provided to graph the life cycle cost of building options. Figure 7 following shows the life cycle costs display.

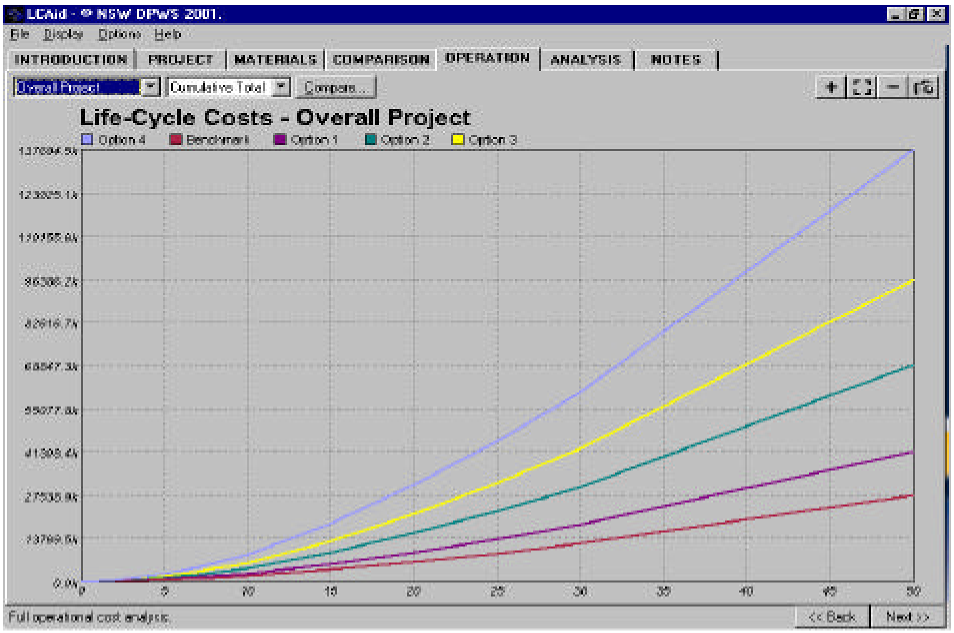

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Figure 7. Life Cycle Costing Display

4 ROLE AND BENEFITS OF LCAID™

As a tool to measure environmental performance, particularly at the design stage, the strength of LCAid™ is that it allows the user to gauge where design improvements can be made and how an option performs against a benchmark. LCAid™ is an easy to use tool, providing information on the relative impact of options and allows the comparison of single materials, complex composites and whole buildings. As stated in the background report for the *Greening the Building Life Cycle* project undertaken by RMIT for Environment Australia this idea is supported: "LCA tools are most useful in the design stage of the life cycle" (Centre for Design at RMIT 2001).

In addition to this, LCAid™ can measure both built and proposed buildings, allowing benchmarking between buildings, an important factor for building owners and potential leasees, especially with the inception of performance standards for the awarding of government leasing contracts. LCAid™'s strength is as a design tool where the informed environmental decisions can be made allowing the overall environmental impact to be reduced.

5 CONCLUSION

The construction industry's performance is increasingly being measured in environmental terms and as environmental systems become more sophisticated, this performance is increasingly measured over the total life cycle of the product. Building materials and systems can and do have significant impacts on the environment throughout their life cycle and there is a need to measure and quantify these environmental impacts, particularly in the design phase of a building. Life cycle assessment is an environmental methodology for assessing the potential impacts of a material, product or building and can provide the building and construction industry and in particular designers, tools to move towards more sustainable practices. LCAid™ a LCA software aimed at the building designer is an easy to use tool that provides quantifiable information on potential environmental impacts, allows for design options to be compared against a benchmark and provides information to allow for informed environmental decisions to be made.

6 REFERENCES

1. Australian/New Zealand Standard 1998, AS/NZS ISO 14040:1998 Environmental management-Life cycle assessment-Principles and framework, Standards Australia & Standards New Zealand.

2. Centre for Design at RMIT 2001, Background Report: LCA Tools, Data and Application in the Building and Construction Industry, Greening the Building Life Cycle project for Environment Australia.

3. CIRIA 2001 Measure, Manage and Minimise: the route to sustainable resource use http://ciria.org.uk/conferences_051201.htm, 01/10/2001.

4. DPWS (Various) 2001, Green Room, Department of Public Works and Services New South Wales.

5. Ecotect website : http://www.squ1.com/

6. Goedkoop M 1995, The Eco-indicator 95: Final Report, National Reuse of Waste Research Programme (NOH), Netherlands

7. Hall, M. & Peshos, Z. 2000, LCAid™ Software and its use in the Building Design Process unpublished.

8. Hall, M. & Peshos, Z. 2001, 'LCA tool for easy design support' in Sustainable Building, 4-2001, 38-39.

9. Lippiat B.1998, Building for Environmental and Economic Sustainability (BEES) Invited for presentation at CIB World Building Congress 1998: Construction and the Environment, Galve, Sweden, June 1998.

10. Lippiat B.C and Norris G. A.1996, Selecting Environmentally and Economically Balanced Building Materials Reprinted as Chapter 2 of Sustainable Building Technology manual, Green Building Design, Construction, and Operations; edited David Gottfried. Public Technology, and US Green Building Council.

11. National Pollution Prevention Center (NPPC) , Michigan University Sustainable Architecture http://www.umich.edu/-nppcpub/resources/compendia/architecture.htm, 01/10/2001.

12. Remkes J. 2000, Opening Address at the International Conference Sustainable Building 2000, Conference proceedings from Sustainable Building 2000 Maistriche.

13. Zachmann K. 2000, Sustainable Construction A Challenge for the Europeen Union-Europeen view point, Conference proceedings from Sustainable Building 2000 Maistriche.