Environmental Product Assessments for Small Computer and Laptop Companies – MicroPro's Experience with Eco-Design of Product Service Systems

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Abstract

1 Introduction

The development of a Green Computer - one that contains no toxic waste and is relatively easy to reuse or recycle - is a persistent dream for environmentally aware IT developers. Over the past 16 years, a number of computer manufacturers have claimed one or more of their products to be more or less "green". Some models have, indeed, secured one or more of the many energy and environmental labels available on a world-wide basis. One notable example is the Siemens Nixdorf PCD-4Ls (1993), which Siemens described as "the world's first Green PC". This model was produced - "using recyclable materials and claimed to have an energy consumption of up to 90% less than earlier PC's, without any noticeable effect on functionality and processing power".

The manufacture of a Green Computer has also been a long-standing aspiration of Multimedia Computer Systems Ltd. (MicroPro). Paul Maher and Anne Galligan set up a small family company in 1991 and, inspired by a strong environmental ethos, MicroPro today employs over 22 staff. The company set out to define and develop Europe's first Green Computer. From Rathfarnham in South Dublin, they manufacture and retail their own range of computer systems, software packages, networking and peripherals. They also provide a repair and maintenance service, which has helped extend the operational lifetime of equipment sold.

2 Environmentally Superior Products (ESP) and the development of the MicroPro XPC

In 1999, the company sought and received support from Enterprise Ireland - under the Environmentally Superior Products (ESP) Programme (part-funded by European Regional Development Funds). As part of this Programme, MicroPro was able to carry out a feasibility study of the environmental, technical, legal, marketing and cost implications of greening their current models. The Feasibility Study was carried out by EMA International (Dublin) on their behalf.

This study examined a number of areas where improvement was possible, including -

- the extension of the operational life of the hardware, via an upgradable chassis with modular interface design
- developing the assembly potential of the design to increase recycling and reuse options – and
- increasing the energy efficiency of the current model.

In addition, a simplified Life Cycle Assessment (LCA) was undertaken to establish and assess the opportunities for reducing environmental impact - together with a review of the environmental performance of competing PC manufacturers, to determine the existing status of the market and a review of customer requirements, including the importance of environmental performance. Compliance with the European Eco-Label for PCs - as well as future legislative obligations - was also ascertained, as well as suggestions on the technical and cost implications of improvement.[i]

This was MicroPro's first use of an LCA as an eco-design tool. At this early stage MicroPro realised the importance of a comparative LCA in terms of informing design choices, something that it has continued to do to this day in the progressive development of its Eco-Computer

The ESP project culminated in 2000, with the development of a new model - the MicroPro XPC - which incorporated most of these recommendations. This model became MicroPro's main production line, with about 200 machines manufactured every year.

3 Project Heatsun and development of the iameco v1

In 2001, Project HEATSUN was formed - as a Partnership comprising 3 local authorities, 2 private companies and 2 social economy enterprises.

Dublin City Council (Lead Partner) was awarded funding under the LIFE Environment Programme for the development of an integrated project based in the Greater Dublin region, to reduce, reuse and recycle IT waste. The Project included a number of targets, which were aimed at pre-empting the objectives of three European Directives - the Waste Electric and Electronic Equipment (WEEE), the Reduction of Hazardous Substances (RoHS) and the Energy Using Products (EuP) Directives - as well as achieving added social value through training and job creation.

At the time of joining the Project, MicroPro was already planning to develop a greener computer – so, taking on these tasks for Project HEATSUN fitted ‘like a glove’.

Project HEATSUN agreed to support and help to progress MicroPro’s pioneering work in the following ways -

- making available and helping to secure additional financial resources
- commissioning relevant support from specialised agencies on the development of the Green PC (R&D)
- promoting and disseminating progress on the Green PC as it unfolded.

In 2004, with support from Project HEATSUN, MicroPro secured additional funding under the Cleaner Greener Production Programme (CGPP), managed by the Environment Protection Agency (EPA). This support has helped to meet some of the company’s costs in developing the Green PC.

KERP Center of Excellence Electronics & Environment, Vienna undertook to carry out a comparative Life Cycle Assessment (LCA) of the two MicroPro models - the MicroPro XPC and the new IAMECO Prototype. This LCA aimed to identify, analyse and evaluate the ecological impact of the two models throughout their entire lifespan - in relation to allocation of raw materials, assembly, distribution, use, end-of-life and recycling. The LCA would be mainly based on energy indices (a universal means of gauging environmental impact). The aim of this study was to identify the shortcomings of each model, so that recommendations could be made for improvement.

KERP also undertook to carry out a market analysis of the Green PC and its acceptance by customers. MicroPro’s sales experience was been analysed and compared with current market survey results, which takes into account relevant factors (such as how much consideration is given to the environment when considering a purchase). In addition, KERP has assessed the IAMECO PC from the point of view of its recycling and reuse potential. This analysis has been carried out making use of KERP’s software package “ProdTect”, which analyses the recycling potential of products and their cost/profit and recycling/recovery rates. KERP advised on design ideas - making proposals to improve design in line with the findings of the above research.[ii]

4 Policy Requirements

Any computer or peripherals on the European market must comply with all current regulation relating to the sector. In that respect, the Green Computer must be compliant with the Low Voltage Directive (LV) and the Electromagnetic Compatibility (EMC) Directives - and, also, the more recent WEEE (Waste Electrical and Electronic Equipment) and the RoHS (Reduction of Hazardous Substances) Directives. In addition to these product standards, MicroPro has secured ISO 14001 and EMAS accreditation.

MicroPro set the European Eco-Label as the benchmark for the iameco v1, as the key criteria to be achieved.

However, the intention was that the iameco v1 should exceed these standards, especially as far as Life Cycle impacts, both in terms of energy use and carbon footprints.

For the MicroPro, however, the Eco-Label represented a “bottom-line” accreditation that – the Project partners believe - should be in place before any European computer can be called “Green”.

MicroPro believed that, by using the European Community’s own Ecological criteria as the benchmark, they would support the validity of the standard and the EC’s authority to set such standards. In particular, the Project partners appreciate and supported the Commission’s attempt to summarise and specify key sustainability criteria that are both comprehensive and achievable within the Eco-Label criteria.

5 The iameco v1 PC

Based on the Eco-Label criteria - but also building on previous manufacturing and marketing experience - MicroPro has developed the iameco v1 model and corresponding peripherals.

The iameco v1 comprised a module in aluminium housing, and a screen and mouse made of wood. Although the iameco v1 was not actually submitted for Eco-Label accreditation, its was designed to be fully compliant with the Eco-Label standards.

The iameco v1 housing was manufactured of recycled aluminium, thereby exceeding the reuse and recycling requirements of the Eco-Label criteria.

This approach also maximises energy savings, as minimal additional energy is required for re-manufacture with recycled aluminium. No plastic is used in the computer housing. IAMECO parts and components have been carefully selected to meet RoHS requirements and to minimise electricity consumption, electromagnetic emissions and noise. The use of an upgradable chassis and modular internal port design maximises the options for upgrading and reuse of the PCs.

The first iameco v1 prototype was previewed at the European Commission's Energy Action Day in Brussels on 30.05.06. It generated considerable enthusiasm and interest - especially among European Commission staff - that were impressed by the environmental specification, as well as the pleasing design and generous use of wood.[iii]

6 The iameco 2 project and the iameco v3 prototype

The iameco2 Project aimed to build on, and consolidate, the R&D projects carried out to date by MicroPro. In particular by developing a marketable model that secured the European Eco-Label, at the same time as improving on these standards by incorporating additional key environmental criteria. These include the recommendations of the Eco-Design of Energy Using Products (EuP) Directive.

The Project also aimed at incorporating additional Eco-design approaches, including Design for Reuse (DfR) and Design for Disassembly (DfD). The Project also aimed to identify and reduce the carbon footprint of the product and to reduce the use of fresh water in manufacture.

Key Environmental Performance Indicators (KEPI) set out originally by the iameco2 Project was as follows:

- 75% reduction in CO_2 emissions
- 75% reduction in fresh water use
- 98% of materials recyclable (by weight)
- 20% materials reusable (by weight)
- Hazardous materials eliminated
- Non-recyclable plastics eliminated
- 2 W or less energy consumption in Sleep State (for PC)
- No energy consumption in Sleep Mode (for PC and Monitor)
- Life extension to 10 years demonstrated
- All working parts accessible, upgradable, and reusable
- Disassembly time reduced to 10 minutes or less
- Noise level no more than 25DB in operating mode and 35 DB when accessing disc drive
- Electro-magnetic emissions no more than 259 GHz
- Packaging 100% recyclable
- Comprehensive user Information provided
- Guaranteed take back for reuse offered

All the above indicators were exceeded or complied with in relation to the prototype's performance as documented below.

6.1 Project Implementation

MicroPro's strategy to identify prevention opportunities was guided by the integration of eco-design criteria identified by research. These additional environmental criteria included:

- Selection of compliant peripherals and components
- Reduction in use of materials
- Integration of renewable and recycled materials
- Reduction of parts
- Design for Reuse (DfR)
- Design for Disassembly (DfD)

Some of these considerations were already implicit in the Standards used as benchmarks. MicroPro also identified three key environmental objectives at the start of the Project:

- Combating climate change and reduce dependency on fossil fuels
- Implementing the recommendation of the EuP Directive, by reducing energy use in Stand By and Off modes and by carrying out an LCA of the prototype in terms of its CO_2 footprint.
- Reducing proliferation and obsolescence of IT equipment

Implementing Design for Reuse (DfR) and Design for Disassembly (DfD) was also important to ensure that a proposed Life Extension of 10 years was achieved. This requires the putting in place of service arrangements that would allow the product to be upgraded and taken back for reuse. It required the development of a Product/Service Strategy for the iameco.

Promoting resource efficiency and sustainability involves substituting the non-recyclable and hard to recycle materials used in conventional computer design, with renewable and recyclable materials. Also simplifying the design to use less material and have fewer parts. Also by eliminating or reducing hazardous and toxic substances beyond the level required by the Eco-Label and other Directives.

MicroPro knew from previous research that the major environmental benefits depended on the implementation of the DfR approach, that is the extension of the life of the product through upgrading and reuse of whole equipment or parts and components. "Smart" selection of materials and components for the original prototype, which is selection with a view to both performance and durability, was important. But the benefits of this would only be achieved by the implementation of reuse.

MicroPro's conclusions mirrored those of the Xerox Company's concept of a "reuse as a manufacturing strategy". In the early 90's, Xerox made this approach central not only to the design and marketing of their office equipment, but also to their entire business strategy. This is documented in

Adam Werbach's book, Strategy for Sustainability: A Business Manifesto. In it he recounts how Xerox from 1993 onwards, transformed itself from a loss making concern into a thriving success story on the basis of comprehensive integration of this strategy. They called it their North Star Goal, and defined it as: "The production of waste-free products in waste-free facilities, to provide waste free offices for customers".

This reuse strategy is relevant to MicroPro, promoting the following paradigm shifts:

- Products to Services (Product/Service Strategy). This implies moving away from the conventional sale of a product, to sale of an upgradable product with the possibility of accessible upgrade services and guaranteed take back for reuse.
- Industrial design, to design with re-manufacturing in mind. This means being able to take a used machine and renewing it so that it operates as a new machine. This implies materials, parts and components have to be selected with a view to durability and universality. This concept implies being able to test the parameters of useful parts and components so as to be able to guarantee extended optimal operation.
- Avoiding the down-cycling of parts or components, until all possibilities of reuse in its present state are exhausted. The design must be simplified and the number of working parts in the computer reduced.
- Setting standards for the quality of reused parts and components. Xerox pioneered the development of the ISO 24700 "Standard for Qualified Performance of Office Equipment with Reused Parts". This standard aims to confirm to customers that a remanufactured product meets basic quality criteria. MicroPro will develop equivalent standards in its equipment using reused parts.
- Developing universality in design. The housing and chassis must be designed, and parts and components selected so that the same parts can be used in different models. MicroPro is aiming for universality in the design and connections in the housing, and in other parts and components.
- Applying Life Cycle Cost Assessment, to establish the full economic benefits of this mode of design manufacture and re-manufacture. This must cost the process over the life of the parts and components, not just in its initial investment. The initial investment could be high, but subsequent product lives – that is upgrading or remanufacture of the prototype so the entire computer system or its constituent materials/components can be purchased again by another consumer for a second useful life or for another purpose entirely (e.g. whole machine reused as cash register, reuse of LCDs in advertisement panels, reuse of wooden frame as picture frame). The reuse strategy will generate further savings that will more than repay the initial investment.
- Design for reuse (DfR), design for disassembly (DfD) and design for durability (DfDr), both of the entire appliance and its parts and components. Easy access to working parts, use of snap on fasteners, only basic tools required for disassembly without damage, and speed of disassembly, facilitates upgrading and extends the product life.
- Reduce energy use, both embedded energy, energy in production and in use, is another key goal, which has both cost and environmental benefits.
- Maximise the used materials from sustainable sources is another consideration. The computer housing is manufactured from FSC certified wood from sustainable forests. Also use of recycled stainless steel/aluminium for the PC housing.

Apart from the environmental gains, this strategy should result in long-term cost-effectiveness.

7 MicroPro and the LCA to Go Project

The iameco v3 and its predecessors were designed with the benefit of a simplified Life Cycle Analysis, which helped to adjust the design concept, but nevertheless was a complex undertaking, not suitable to be implemented on a regular basis in SME's business processes.

MicroPro's evident interest in an eco-design of future products and a need to know which service and reuse strategy leads to minimized environmental impacts means that simplified assessment tools are key. MicroPro's historical aspirations and experience has led to understanding and insights that could be helpful in the implementation of the LCA to Go project, which intends to develop such tools for SMEs. [iv]

MicroPro contributes a Case Study to the Project, based on the needs of establishing the best Eco-design solutions for the iameco range of PC's and laptops that the company is currently developing.

This involved:

- inputting its Eco-design needs to the Project Team
- assessing proposals made by the Project Team in relation to the LCA package to be developed

- feeding back response to proposals made by the Project Team
- testing the LCA prototypes as they are developed
- providing feedback to the project team on such prototypes
- supporting the promotion of the LCA package developed by the project, especially in Ireland
- taking a lead on the development and professional accreditation of a training package based on the LCA package produced by the project
- assisting in dissemination of the LCA package by presenting its own experiences

7.1 Benefits of the LCA to Go tool

The LCA to Go tool for the electronics sector is intended to provide eco-design support tools, making LCA results directly applicable within the respective decision context situation. Information on environmental impacts has to be translated into an "engineering language" to assist product developers or designers optimising the environmental performance of a product or component by setting the technical parameters right. It is the intention, that product developers / designers do not need to compile a LCA themselves, nor do they need to be familiarised with LCA at all, but the tool has to make transparent for them, which technical settings are optimal to reduce environmental impacts.

As a starter, the experiences of MicroPro with various kinds of "green computers" are being addressed (see above), based on a modular approach to assess the various components and sub-assemblies of a computer and to compile a Product Carbon Footprint, first on a rough level, but with the option to identify further improvement options for product development.

By now, such assessments are applied by SMEs as ex-post evaluations, but should provide guidance already during the actual design process to allow an early uptake of relevant design aspects. SMEs in the electronics equipment segment have got influence on some design decisions only (e.g. high influence on housing design and general choice of components), but very limited influence on e.g. electronics components design and manufacturing as such, which can be reflected in the methodology by shading out all design parameter, which are not under control of an SME. Furthermore, the needs assessment unveiled an interest to get aspects of lifetime extension and reuse reflected properly in the methodological approach.

The potential users are electronics manufacturers, but could also be assemblers, and retailers (company, which brings a product to the market). The manufacturer should enter the major settings in the tool (product configuration). Results are meant to be communicated to customers, both B2B and B2C. An experienced consumer might use the assessment tool as well to make individual settings regarding use patterns to calculate own footprint, when using a certain product, but component related entries need to be made by the manufacturer

The input data to be entered by the user comprises the product configuration (choice of sub-assemblies, including some technical parameters), product lifetime and foreseeable repair and upgrade needs, power consumption (scenario or measured data), and a use scenario or user profiles (home, office user), if deviation from the EnergyStar profiles is intended.

Output data should comprise energy consumption, Product Carbon Footprint, resource consumption as regards key metals, which are also relevant for recyclability (ferro, copper, aluminium, silver, gold, PGM), and life cycle costs from the consumer perspective.

The database of the "electronics" tool has to comprise generic, parameterised LCI (primary energy, carbon footprint, material composition) datasets for major assemblies, electricity grid mixes, and a default end-of-life scenario. There will be highly aggregated data from the PCB activities in LCA to Go, leaving two parameters for the user: type of PCB and area, but not other parameters such as layers as this is not known to an SME in the computer business. Semiconductor data shall be derived from the Taiwanese project activities, but on a very generic level, i.e. pre-definition of some "typical" computer ICs. For passive components the tool should work as a library, but not with a direct link to the overarching electronics tool, for which more aggregated (default) data sets will be provided (mixed SMD components, mixed THT components).

The LCA to go tool for electronics equipment will provide a rough environmental assessment of the total product life cycle and in comparison to a pre-defined "standard" product. The benchmark with a product that is not designed for a similarly long lifetime and thus sustainable consumption will unveil how environmentally efficient the product.

A rough environmental assessment of the major subassemblies will help to identify immediately those sub-assemblies with the highest environmental impact at production.

The user makes individual settings regarding computer configuration, likely use patterns, and electricity price. Recycling is reflected in the tool with a scenario, applying typical recycling quotas and related carbon credits.

Based on these parameter settings the tool calculates:

- Product Carbon Footprint
- Life cycle costs
- Energy consumption
- Resource efficiency

Based on this analysis the optimal configuration can be chosen.
Once a repair or upgrade is due or intended, cost and energy implications can be recalculated versus buying a new unit.
Based on the analysis an SME can decide, for which sub-assemblies longevity, repairability and reusability is most important. This analysis enables a manufacturer to judge, for which sub-assemblies lifetime extension is most useful in terms of resource savings and carbon footprint reduction.
The calculation results will be usable for publication as a simplified, but customized environmental declaration.
To limit the complexity of the tool, only well-defined market segments will be covered namely "computer-like" devices (laptops and PCs, any kind of control units).

7.2 Target user of the LCA to Go Tool

Target users of the methodology are product managers and developers with an engineering background in SMEs, specifying and assembling electronics products. The user enters technical parameters, which he is familiar with, or which are easily accessible. The user shall not be confronted with the technological specifics of parts or components which are not under his own control or where inquiries among suppliers would be required, as the latter typically remain unanswered also among large companies.
Besides the SMEs also educated users with a technical background might be potential users, but they do not constitute the priority target group. An SME might provide as a service that the client uses the tool to model his / her use patterns and to calculate a personal carbon footprint

8 Conclusions

MicroPro has used the Life Cycle Assessment approach to Eco-design from the development its first prototype in 1999. While understanding the principles involved, MicroPro has to date relied on the buying in of LCA expertise from private consultants and research agencies, more recently, based outside of Ireland.
MicroPro has therefore welcomed participation in the LCA to Go project. It has contributed its practical experience to help the identification of technical parameters, which are closely related with production related environmental impacts.
MicroPro understands that it will be able to use the methodology implemented in the upcoming LCA to Go tool solely by referring to technical data they need to specify anyway. This translation of environmental performance into technical terms is the required step to allow SMEs also an efficient eco-design approach, which does not require any external help, thus also overcoming the tremendous cost barrier of conventional LCA studies so far.
However, it is also aware that for some of the modules and components a refinement of the approach will be required as, for example on electronics components progresses, where methodological issues for printed circuit boards, passive components and semiconductors are under development.
Additional aspects of the LCA to Go are still being explored, such as modelling batteries, sub-components of displays, and end-of-life of electronics.
The methodology research succeeded in implementing aspects of resource savings, although communication of this aspect still has to be explored, as it is much less straight forward than communication solely the indicator Product Carbon Footprint. The meaning of saving a certain amount of e.g. indium is not clear to any consumer, nor to an SME besides the fact, that it seems to be an important resource issue.
The methodology as it stands today covers design for recycling aspects, lifetime extension, and repair and reuses strategies and allows a quantification of the positive effects of such a business strategy, meeting in particular the expectations of MicroPro to make this aspect measurable.
The Project researchers have also identified the outstanding challenge of developing a simple, but credible approach to state lifetimes of components. As lifetime in reality depends on numerous factors, such as use patterns, hazardous impact, system design, manufacturer specific differences etc. etc., is a statistical question as lifetime of an individual component cannot be forecasted and as almost no data is available on technical lifetimes, this aspect will require further investigation and a consensus, how much simplification might be allowed, and how much guess work can be left for the SME.
However, what has been achieved so far makes MicroPro confident that the LCA to Go approach will be successful.

9 Acknowledgement

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