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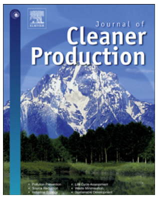

# Sustainable life cycle engineering of an integrated desktop PC; a small to medium enterprise perspective

Colin Fitzpatrick [a], [*], Stewart Hickey [a], Karsten Schischke [b], Paul Maher [c]

[a] *University of Limerick, Ireland*
[b] *Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (Fraunhofer IZM), Berlin, Germany*
[c] *MicroPro Multimedia Computers, Dublin, Ireland*

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ABSTRACT

This paper describes the life cycle engineering of an integrated desktop computer system from the perspective of a small to medium enterprise (SME). Using a novel approach which considers the motivations of actors at various stages during the life cycle of the PC it attempts to engineer the lifecycle through design features which have been chosen to influence these critical decision points leading to more desirable pathways from an environmental perspective. Using these motivations it extracts design principles and ultimately design and service features to (1) promote long lifetime with the original user (2) facilitate refurbishment and reuse (3) be easy to disassemble and (4) contain minimal valueless fractions at end of life. This has been achieved largely through two specific design features and supported by post-sale services to the consumer. The first of these features is a high quality finish using a solid hardwood chassis to create an emotionally durable product that is easy to refurbish and eliminates negative value plastic fractions at end of life. The second feature is a strong focus on ease of disassembly to facilitate upgrade, refurbishment and deep disassembly at end of life. The service offering is also crucial and upgrade services and buy back are available.

## 1. Introduction

The lifecycle of electronics, and ICT products in particular, are fraught with numerous environmental and sustainability problems which have been well documented in academic literature. From extraction of "conflict" minerals to inordinate quantities of energy consumption in manufacture through to low collection and recycling rates, uncontrolled treatment, and finally resource loss, they are among the most studied and problematic of all product groups (Epstein and Yuthas, 2011; Williams et al., 2002; UNU, 2008; Chancerel and et al., 2009). There have been a number of LCA studies undertaken on personal computers to identify the hot-spots in the life cycle and two reviews have been conducted on this body of literature (Teehan and Kandlikar, 2012; Yao et al., 2010). Most of these studies use either energy consumption or global warming potential as indicators of environmental impact and while there is not a consensus on the life cycle stage with the highest impact due to differences in methodologies and assumptions it can be concluded that the manufacturing and use phases are both high for energy consumption. These LCA studies don't however capture the situation regarding informal treatment at end of life or resource loss well. These topics have been well addressed elsewhere in the literature demonstrating that uncontrolled treatment can lead to significant damage to human health and the environment (Robinson, 2009) and resource loss is very high for many critical raw materials due to low collection rates, and inappropriate pre-treatment and final treatment (Reck and Graedel, 2012).

In response to this situation a range of responses have emerged including various pieces of legislation across the world on e-waste collection and recycling, material restrictions and international treaties such as the WEEE and RoHS Directives in Europe, numerous state level e-waste laws and the Dodd Frank Act in the US and the Basel Convention globally. At a product level Eco-labels encourage producers to incorporate a variety of design features which aim to improve their environmental performance across the life cycle including EPEAT and the EU Eco-label.

However, while eco-labels are an excellent design guide for SMEs who cannot afford extensive LCA studies, with supply chains and products reach becoming more and more global, it is becoming increasingly difficult to guarantee that many of these features

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[*] Corresponding author.
*E-mail address:* colin.fitzpatrick@ul.ie (C. Fitzpatrick).

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actually improve the environmental or social aspects of a computer's lifecycle. It can be argued that the features required are considered in isolation and not in an integrative fashion that together influence the pathways that the product will take which ultimately determine its overall environmental impact.

While any individual SME will only have a very small market penetration, in Western Europe in particular their collective market share is significant. Gartner Group have reported that 35% of the PC market for Q3 2013 was shared among those outside the top 5 vendors (http://www.gartner.com/ne, 2619) and during the consultation for lot 3 of the Energy using Products Directive industry estimated that so called “white boxes” had between 10% and 35% of the market share (European Commission).

From an economic rationale there are many reasons for an SME to adopt a leadership position with regard to environmentally superior products. MicroPro have established a reputation in Dublin for being a greener company and have built a strong company brand on this basis. Also, market research indicates that there is a significant consumer segment which can be classified as the “sustainable mainstream”. These are consumers who are well disposed towards purchasing greener products but do not want to compromise on performance. Proctor and Gamble have presented findings of longitudinal market research which estimates this segment to be approximately 75% of the market and that this figure is very stable over time and across geographical locations (Keynote Presentation, 2013). Summing this with the 15% that they estimate to be highly engaged with sustainable consumption indicates that there is significant market potential for products which can satisfy consumer needs in a sustainable fashion (Keynote Presentation, 2013).

This paper will examine the considerations involved in life cycle engineering for personal computers and their feasibility for implementation with an SME. It attempts to engineer the lifecycle through the use of design features which have been chosen with a view to influencing critical decision points throughout the lifecycle leading to more desirable outcomes from an environmental perspective. The proposal is supported with a practical application of life cycle engineering to the development of an integrated desktop computer system. This approach is novel as it differs from the check list approach of eco-labels which may include many good criteria but do not offer any means of checking how the integration of these criteria may lead to different outcomes in different scenarios.

## 2. Materials and methods

### 2.1. The PC life cycle from an SME perspective

Fig. 1 illustrates a conceptual view of the PC life cycle and its potential pathways as viewed by a SME computer manufacturer.

In Fig. 1 the black arrows indicate the preferred channels for end of use equipment while the shaded arrows indicate the channels which are less desirable.

From an upstream perspective, desktop systems are comprised of many complex assemblies from different suppliers. An SME has no control over the selection and use of materials for manufacture of constituent electronics sub-assemblies, nor any influence over the design of the main components themselves. They can only choose the best available commercially off the shelf technologies. This would include low energy consuming parts, reduced toxicity and those which facilitate component exchange. In terms of the PC housing, an SME can choose to source this structure directly from another supplier or undertake the casing manufacturing operation themselves.

For issues such as the use of conflict minerals, energy consumption in production and toxicity reduction these are the only option available to an SME so, for life cycle engineering of upstream impacts, the influence of an SME is very limited. At most, it can mitigate these impacts by ensuring a long and productive usage

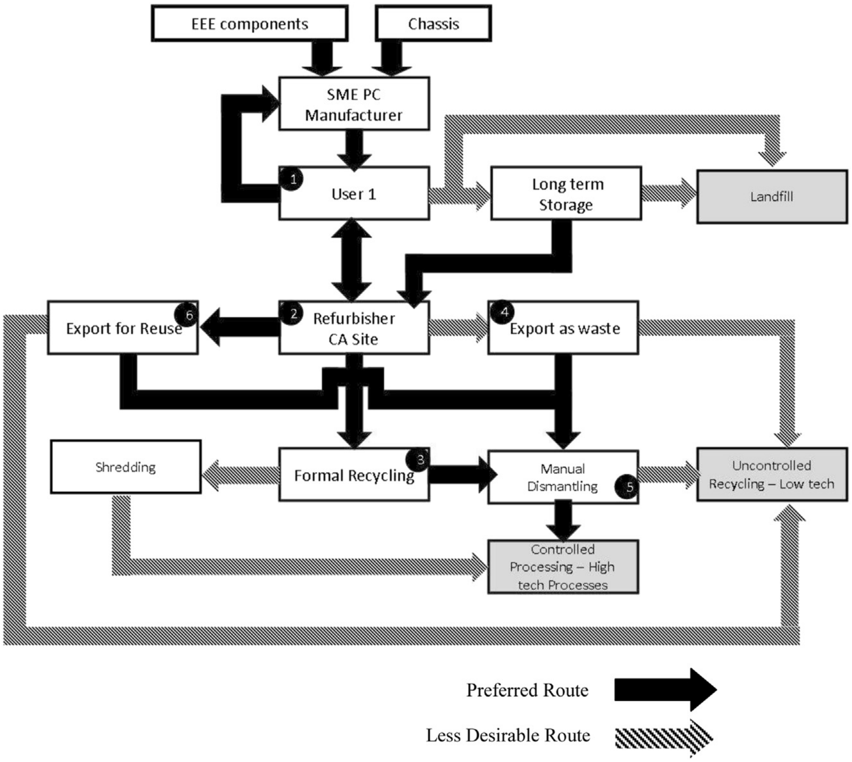

Fig. 1. PC Lifecycle from a SME perspective.

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