Green Electronics? - An LCA Based Study of Eco-labeling of Laptop Computers

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Abstract

According to the ISO14020 standard eco-labeling of products is intended to guide consumers towards the more environmentally friendly segment of products available on the market. To investigate if this is successful for laptop computers, a life cycle assessment (LCA) model of a generic, up to date laptop was created. The constraints imposed by two different eco-labels for laptops were implemented in the LCA model; the eco-labels used for this purpose were EPEAT (based in the US) and TCO (based in Sweden). The analysis of the eco-labels criteria revealed that the labels impose few changes on the design of the laptop as describe in the LCA model and that their influence on the life cycle impact was minimal. The labels do promote energy efficiency, but the marked demand for long battery life is a push so strong that the average lap top on the market well fulfills these criteria. It was notable that the lap top power efficiency together with short product life, resulted in that the use phase environmental impacts was less compared to the production phase environmental impacts (partly opposed to some earlier studies, where the electricity consumption during use was a more important driver). To promote better environmental performance the energy efficiency could be improved further; but useful life of lap tops is an increasingly important issue to be addressed. Criteria for eco-labels must be continuously updated to actually guide toward a more environmentally friendly market segment for fast developing products like electronics.

1. Introduction

The environmental impact of electronic products is increasingly a source of concerns. Electricity consumption during the use phase and the toxic substances contained in the products are the issues getting the most attention. Energy used for the production of electronic devices, although less discussed, is also an important issue. Electronic products being complex, it is difficult for consumer to have a realistic idea of the environmental performance of a product by considering only visible characteristics and information usually provided by the manufacturer. Eco-labels are tools that allow consumers to identify environmentally preferable products [1]. They have the potential to reduce the environmental impact of a group of product by promoting the introduction on the market of models with less impact and by facilitating the marketing of the environmental qualities of those models. Ideally, an eco-label would be widely adopted by the industry and the environmental performance of labelled products would be much higher than the one of other products [2]. However, in a sector as competitive as electronics, it is difficult to achieve simultaneously both goals. Eco-labels with criteria easier to reach are more likely to be adopted by the industry but there is a risk that the environmental performance of labelled products being only slightly better than the one of non-labelled products. To achieve the highest overall improvement of environmental performance, organizations managing ecolabels must set criteria achieving a balance between environmental superiority of the labelled products and potential market penetration.

2. Method

The Laptop Life Cycle Assessment (LCA) models in this study are based on a non-labelled generic laptop, available in the Ecoinvent inventory [3] updated regarding energy use and chemicals legislation. On this LCA model the restrictions arising from complying with the TCO Notebooks 3.0 and with the EPEAT Gold labeling criteria respectively were implemented. Regarding the EPEAT Gold case, there is a choice between criteria to implement and the 21 most commonly used criteria were considered. The full inventory description is available elsewhere [4]. A summarized overview will be given here. The laptop modelled in Ecoinvent is a HP Omnibook with a 12.1" (30.7 cm) LCD, a Lithium-Ion battery, an expansion base containing a CD/DVD drive and a power adapter. The weight of the kit is 3.51 kg. The printed wiring board (PWB) is a mix of lead-containing and lead-free types. The laptop has one cold cathode fluorescent lamp (CCFL) backlight unit containing 0.558 mg of mercury. The concentration of mercury in the CCFL lamp (a part of the backlight unit) is 0.2% [5]. The laptop packaging weight is 977 g and consist of recycled cardboard (85.7%), polystyrene foam (9.1%) and polyethylene foil (5.2%).

The polystyrene and polyethylene are disposed of in an incinerator. No disposal is specified of the cardboard. For this study, the Ecoinvent model was updated to more accurately represent modern laptops in the following ways. The expansion base was suppressed and the CD/DVD drive was assumed to be in the laptop. All PWBs were lead-free to reflect the ban of this substance by the RoHS legislation. The PWBs were assumed to contain 45 g of bromine per kg of glass fibre board. The annual use phase electricity consumption of the laptop were estimated by a weighted sum of the energy consumed in different operational modes [6]. The following repartition of operational modes were assumed: Off - 43,5%, Sleep - 33,5%, Idle - 19% and Load - 4%. The environmental impacts from the use phase electricity were based on the average European (UCTE) electricity production mix [7]. The original LCI model did not include waste handling, only production. 10% of the laptops were estimated to be processed by recycling facilities and the rest were calculated as being landfilled. To analyse the eco-labels criteria to establish their impacts on the inventory models, the eco-labels criteria were grouped into eight categories: corporate practices, energy consumption, toxic content, lifetime extension, material selection, design for recycling, take back system and packaging. Both the eco-labels under study use Energy Star [8] as criterion on energy use. No change was modelled in the life cycle regarding electricity use since the average power consumption of modern laptops is already lower than the Energy Star. No change was modeled for criteria equivalent to or less strict than the RoHS directive requirements, since these were already implemented for the non labeled inventory model. The only change was that PVC was replaced by HIPS in the power adapter. The assumed use lifes of the laptops were 3 years based on estimations made by Jönbrink [9] and MetaFacts [10]. The functional unit was the use of a laptop computer for one year.

3. Results

The results for the generic lap top inventory model and the inventory models with restrictions from the two labeling schemes, characterized using the ReCiPe 2008 method and indices [11] are shown in figure 1. As can be seen in the figure, the introduction of the eco-labels criteria into the life cycle model influenced the environmental impact only to a minor degree for all indicators. The only notable reduction of impact was for the TCO label, were the toxicity potential parameters of the TCO laptop model was lower due to a higher proportion of laptops recycled (20% instead of 10%) if the labeling criteria are met. The most important sources of contribution to climate change were the PWB, the battery and the LCD. For the human toxicity and freshwater ecotoxicity the production of the litium ion batteries have a significant impact, to a large extent connected to waste handling of plastic and other production waste.For the category metal depletion the most important contributor was use of gold, followed by copper an tin. The impact of the disposal phase was small compared to the impact of the production

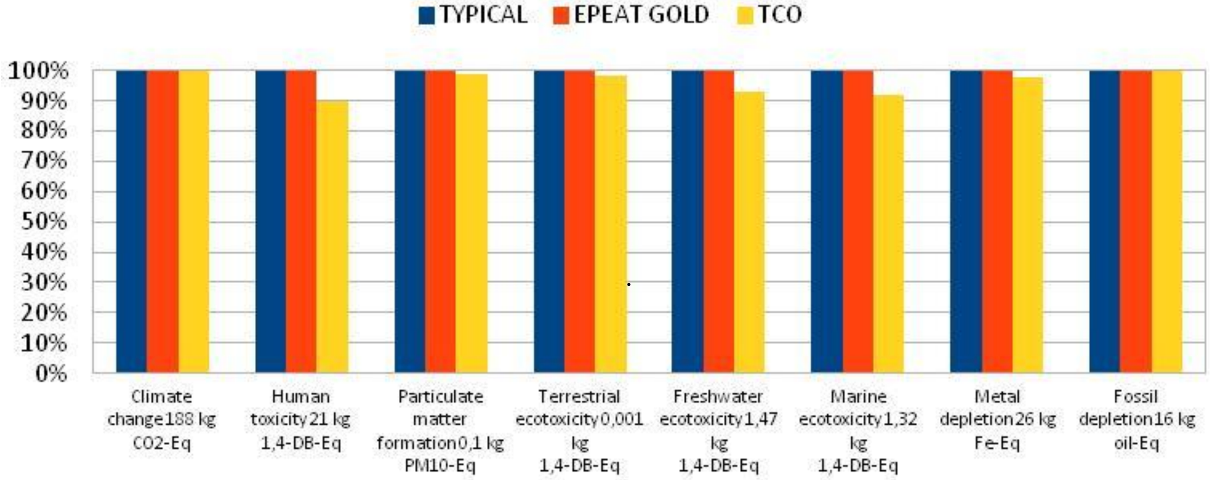

Figure 1: Life cycle impact of generic and labeled laptops. *The impacts of the model having the largest impact, in each category, are at the bottom of the graph. Impacts are given in percentage of this value.*

4. Discussion

The results obtained from this study indicate no clear difference between the environmental impact of labelled laptops and other laptops on the market. Most of the laptops sold nowadays already fulfill the criteria on energy consumption set by the eco-labels studied. The situation is simular regarding the criteria on toxic content, which are approximately equivalent to the RoHS directive requirements. The remaining changes imposed to the toxic content by the labeling are for substances that were only used in small amount in the inventory model of the generic laptop. The GHG emissions found in this study can be compared with those published by Apple for their 13-inch MacBook Pro [12]. According to Apple, the production of their laptop causes the emissions of 260 kg of CO2 equivalent. That is less than half of the emissions found for the inventory model here. This could be due to a different set of system boundaries between the studies, but it can also indicate that there are products on the market that performs significantly better than average. The labels criteria should be improved to make sure that labelled laptops have less environmental impact and are clearly environmentally preferable when compared to what is already on the marked. To do so, labeling program managers should concentrate on the aspect of laptops life cycle that have the greater environmental impacts. The results, even if this was not the primary goal for this study, give an indication that significant parts of environmental impacts from a modern laptop life cycle occurs during its production. The impact can be reduced, directly, by improving design and production techniques or indirectly, by extending laptop's use life or by reusing parts. Generally, the criteria of the eco-labels could be positive for the environment, but they do not impose much more than what is generally done by companies, either voluntarily or by following regulations. The current criteria of eco-labels still have their place to avoid the worst product designs and corporate practices but are not enough to push the industry to improve. The labels do not impose criteria targeting directly impacts during production, such criteria could preferably be added. According to a recent social LCA by Ekener-Petersen and Finnveden [13] the largest social impact occurs during the production phase. Improved criteria addressing the production phase could thus preferably include both ecological and social aspects. To generate the maximum of improvement, eco-labels must push for targets that are ambitious but remain achievable. To do this, criteria must be regulary reviewed and tightened and adapt to progress made by the market. Since a large part of laptop's impact originates from the production phase, their annual impact would be less if consumers were replacing them at longer intervals. Upgrading a laptop is another option with the potential to increase use life. Upgrades are more likely to be done if they are affordable and easy to do. Adding memory is usually affordable and can often give a performance improvement. It can also be done easily if the memory slots are easily accessible. For example could a labeling criterion specify that the amount of supported memory should be at least four times the amount installed at the moment of sale and that memory should be upgradeable by removing less than e.g. three screws. Similar criteria could be used to ensure that the hard drive and battery are easily replaceable. Processor upgrades are more expensive and less common. Possibly, they could be included in criteria for higher ratings. A common reason for computer replacement is that they cannot run recent software at a reasonable speed. Swan [14] argues that software design practices and marketing strategies have worsened the problem of e-wastes. Software functionality may consume more or less computing resources (CPU time, drive space, memory) depending on the time and attention that software developers put in efficiency optimization. Software producers often consider that time is a bigger constraint than computing resources. Therefore, they sometimes might neglect computing efficiency to instead be able to release their product earlier [15]. Developers of open source software might be less subject to such time pressures. The various adaptations of the Linux operating system to old PCs and embedded devices can serves as illustration of what can be achieved when efficient use of computing resources is a priority [16, 17, 18]. However, eco-labels certify hardware. They have no influence on the software industry; therefore, they cannot encourage it to move towards practices that would be more compatible with a long hardware life cycle.

5. Conclusions

This analysis of some eco-labels criteria revealed that the labels impose few changes on laptop design. The production phase dominated the life cycle environmental impact. The disposal was responsible of about the same amount of human health impact as the production. Obtained results suggested that managers of eco-labelling programs at present preferably should direct their efforts toward reducing impacts from the laptops production phase. This could be done by criteria limiting GHG emissions and other impacts during production, and by implementing criteria directed toward extending the use life of the product.

6. Literature

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