Journal of Cleaner Production 156 (2017) 828–837

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Life cycle assessment study of an integrated desktop device -comparison of two information and communication technologies: Desktop computers versus all-in-ones

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ARTICLE INFO

Article history:
Received 25 January 2017
Received in revised form
10 April 2017
Accepted 14 April 2017
Available online 21 April 2017

Keywords:
Life cycle assessment
LCA
All-in-one PC
Desktop computer
Comparison
ELCA
Electronic products

ABSTRACT

The All-in-one PC (APC), considered as a space saving wonder, represents one of the most recent developments within computer industry which has been replacing conventional desktop PCs at a rapid pace. This work presents the results of the first attempt to analyse the environmental implications of the APC by using Life cycle assessment (LCA). The APC manufacturers also market the eco-friendliness of this product over the conventional desktops considering the fact that all electronic components are in-built into a single monitor and hence is supposed to reduce the energy and material consumption. This hypothesis of whether APC is a model developed to reduce environmental impacts compared to a conventional desktop PC is also tested. In order to conduct the LCA study, hand disassembly was carried out to identify the composition of the APC and Eco invent V2.2 database in-built in the SIMAPRO 7 libraries was used for modeling the product systems. The environmental profile of the APC was dominated by the use stage, followed by the production phase. Within the use phase, home use of the APC in sleep/standby mode was dominant in creating impacts. It is clear that if increased usage in sleep mode is assumed, environmental impacts are observed to be much higher than in the active mode besides the higher energy efficiency of the APC in the sleep/standby mode. Taking into account all the assumptions made in this work, the comparison shows a clear reduction in the environmental impacts created by the APC both in the use and the production phase as against the conventional desktop computers. However to enable much effective comparisons, detailed information on the composition of the involved products must be accessible.

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1. Introduction

Electronic products are the real rulers of this world (Balaji Arumugam and Ganesan, 2014). With technology driving people and the planet at an unimaginable pace, and every company or brand trying to outperform the others, we find so many new innovative consumer electronic products in the market every day. All-in-one desktop otherwise called as All-in-one personal computers (APC) or integrated desktops is one such user-friendly version of desktop PCs. Personal computer (PC) has become very popular globally since early 90s. After three decades, we can see such rapid growth and development within this product category. Central processing Units (CPUs), keypads and mouse are no longer essentials to use a computer; we still can work on desktops without any of these at a faster or equal pace like before. The integrated desktop or commonly known as All-in-one PCs have become a household name in recent years. The desktop sales have come down tremendously because of this All-in-one PC segment. This is due to the ability of an All-in-one PC to be used in a kitchen, bedroom or a living room without much hindrance to the surroundings, especially in households with young children; the hassles of handling a huge CPU and keypads can be avoided while using All-in-one PCs (www.compreviews.about.com). And with the newly updated touch screen models, All-in-one PCs are definitely grabbing more attention from both industry and the consumers.

An All-in-one PC integrates all the computer components into a single case called display. The less number of cables needed for use, less heat generating components and lower power requirement are added advantages of All-in-one PCs (www.compreviews.about.com). An All-in-one PC without any

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http://dx.doi.org/10.1016/j.jclepro.2017.04.089
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additional devices is supposed to create less environmental implications than conventional desktops that incorporate a separate CPU/tower. In this work, this hypothesis was investigated and quantified considering the life cycle of the products. The environmental implications of the two Information and communication technology (ICT) options are examined using the well-established Life cycle assessment tool (LCA) tool.

1.1. Literature review

To assist industry people to design and develop eco-friendly products and help consumers in their buying decision, systematic analysis tools have been developed. These include LCA or Environmental LCA (ELCA) - for assessing the environmental profile of products. The application of this tool ELCA within electronics started way back in early nineties and is now well-established within the electronics industry (Rhodes, 1993). It has a wide array of applications within consumer electronics products especially ICT devices, the major commonalities and conclusions derived from the existing desktop and laptop related LCA studies in the literature are presented by Subramanian in their work (Subramanian and Yung, 2016). This tool is used in this present work to evaluate the environmental profile of an All-in-one PC and determine whether it an eco-friendly alternative when compared to the conventional desktops.

From an environmental point of view, different kinds of desktops and laptops were all evaluated using conventional LCA techniques to assess environmental impacts or carbon footprint more specifically, using secondary data sources in most cases (Subramanian and Yung, 2016). A Chinese desktop PC was evaluated for its environmental implications; results show that manufacturing and use are the dominant phases (Duan et al., 2009). A Korean PC was examined for its environmental implications using LCA and it was confirmed that recycling of waste PCs clearly reduces environmental loads created by the product (Choi et al., 2004). A desktop PC with 17inch CRT screen was evaluated using hybrid LCA methodology combining process and economic input and output; results showed that computer manufacture is very energy intensive and considering the kind of production rates, it definitely is responsible for a huge annual life cycle energy burden (Williams, 2004a, 2004b). The environmental impacts of a color computer monitor (Seungdo Kim, 2001); notebooks (laptops) in Taiwan (Lu et al., 2006) were both evaluated using LCA; a 2001 Dell Inspiron 2500 was evaluated for its energy use and carbon emissions using hybrid LCA methodology (Deng et al., 2011). A DELL laptop was also evaluated for its product carbon footprint and results were elaborated (Stutz, 2010).

Regional analysis was carried for a group of ICT devices, desktops, office computing systems in some studies. The operational electricity use and carbon emissions relating to ICT products in Sweden, activities like data centers, data transport networks etc that were not studied in previous studies were analysed in this work, PCs were found to be mainly responsible for carbon emissions followed by data centers and then access networks (Malmodin et al., 2014; Malmodin et al., 2010). The significance of geographical factor and uneven distribution of energy consumption during the different life cycle phases of ICT products was illustrated using spatial environmental balance using LCA (Daiyue et al., 2015). Environmental impact assessment of IT/IS solutions with a possibility of defining functional units and build inventory models (Stiel and Teuteberg, 2014) using flow based LCA method. The increasing number of electronic devices in households and its consequences was examined, and whether the newly added products like tablets are really energy efficient options or these just increases the energy consumption due to increase in the number of devices in individual households in recent years was evaluated (Patric and Wager, 2015a, 2015b).

A few environmental studies have compared two competing computer display technologies (CRT and LCD) using ELCA (Maria Leet Socolof, 1999; Noon et al., 2011; Song et al., 2012; Zhou and Schoenung, 2007). It was majorly concluded that LCD monitor disposal has lesser ecoimpacts when compared to CRT (Subramanian and Yung, 2016). Carbon emissions of a range of ICT products was carried out and found the emissions increase with the increase in mass of the product (Kandlikar, 2012), in another study a thin client computing solution was compared to a desktop PC considering carbon emissions only (Maga et al., 2012). Environmental impacts of print media and electronic media were individually evaluated and then compared against each other for its environmental implications (Hischier et al., 2014).

Overall, most of desktop/laptop related studies concluded that, production phase followed by use phase is the dominant one in creating impacts except a few ones in which production phase dominates the use phase; use phase is impacted due to operational energy; Ecommerce when used creates lesser impacts and transportation phase hardly created any major impacts (Subramanian and Yung, 2016). Printed circuit boards and integrated circuits are the dominant modules in desktops that are criticized for creating huge environmental impacts within the manufacturing phase (Kandlikar, 2012).

1.2. Research motivation

From the literature review it is clear that numerous ICT devices have been individually analysed and in some cases compared against each other for their environmental implications using LCA. However, concerning the recently developed All-in-one PC segment no detailed environmental studies are known. The question as to the All-in-one PC's overall environmental performance, especially as compared with the conventional desktops has so far remained open. It has to be taken into account that ICT devices especially computer related products have considerable impacts on the environment. This impact is due to the fast changing technological advancements made in this product category which results in increase in number of devices produced. Production phase is concluded as most dominant phase in terms of creating environmental impacts in many studies (Kandlikar, 2012; Subramanian and Yung, 2016). Moreover, ICT devices can have indirect impacts on sustainable production (supply chains involved in the production of these products), usage pattern and buying decisions of consumers. The end of life of this product category is also very dangerous, as this type of products result in the most complicated waste stream and tackling them is a rapidly growing problem worldwide. Hence researchers and industrialists have become very interested in this field.

Hence this work attempts to evaluate an All-in-one PC for its environmental implications, it is hoped that such initial attempt to evaluate new technologies will contribute to the body of knowledge within the research needs in this sector (ICT) by identifying key problematic areas in the production level and usage patterns that influence environmental impacts. It is to be noted that, two ICT solutions have been previously compared using LCA (Maga et al., 2012), but the focus has mostly been on global warming potential, hence an LCA study enabling a comparison of ICT solutions considering all impact categories is essential. More so, since this product (APC) is rapidly diminishing the sales of conventional desktops, it is essential to understand whether this change is an environmentally friendly transition. Hence a comparison of an All-in-one PC and a normal desktop PC is carried at device level in this work.

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