A11 - Ethical and Environmental Analysis

Year: 2024 Semester: Fall Team: 12 Project: Microphone Interface
Creation Date: April 6, 2024 Last Modified: April 6, 2024
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Assignment Evaluation: See the Rubric in the Brightspace Assignment

1.0 Environmental Impact Analysis

Our senior design project has six major components including a microcontroller, a LCD display screen and the LCD screen which will be held on top of the PCB. We will use ABS(acrylonitrile butadiene styrene) 3D printer filament as our packaging material, and the standoffs and screws will be stainless steel.

Highly complicated PCB manufacturing that may involve in some cases up to 50 steps [7], is stated to contain potentially harmful processes to the environment [10]. Some of the chemicals fed into process streams are carcinogenic in nature or classified as reproductive toxicants [7]. Besides, heavy metals and chemicals such as tetrabromobisphenol A (TBBPA) are released as wastes during the typical production of PCBs [9]. Manufactured PCBs on the other hand may contain a variety of toxic components such as heavy metals and flame retardants that make their further recycling a challenge [11]. The figure 1 below shows the contribution of fabrication of board and manufacturing of PCB on various environmental impact categories. One way to reduce the environmental impact of a product is to design the PCB to be as small as possible. In this way, the amount of material can be reduced, thereby reducing the weight of toxins produced per item.

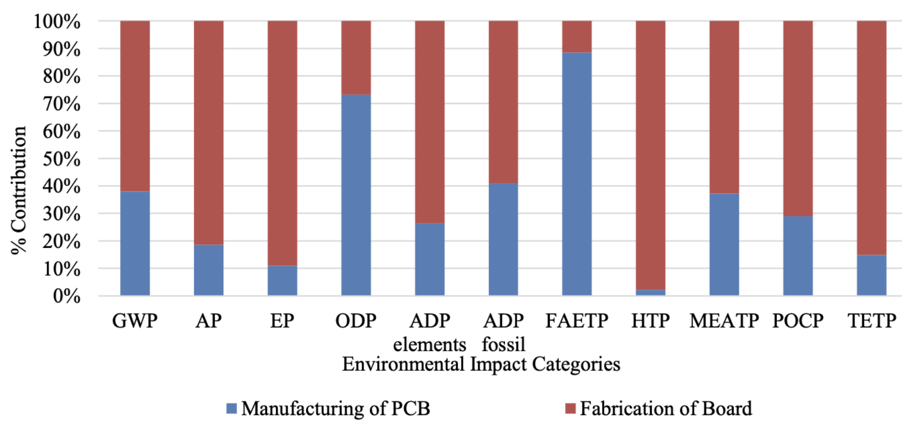

Figure 1. Contribution of fabrication of board and manufacturing of PCB on various environmental impact categories

PCB will not have any environmental impact when users are using our device.

For the end-of-life phase, PCB is an inevitable component of e-waste which contains the highest amount of precious metals like Au and Ag along with other metals like Al, Cu, Zn, etc. and weighs about 6% of the total e-waste [12]. These crucial parts carry both valuable and hazardous metals (28–30%) with a few amounts of non-metals like glass fiber and resin (70–72%) [3]. Recycling or material recovery of PCBs can be fruitful in resource conservation and obtaining high valued metals [4]. On the other hand, it helps to eliminate landfill site management and incineration which reduces the negative impacts on air, water, and soil pollution and ultimately reduces waste management costs.

The manufacturing of a LCD monitor is a complex process, involving many hazardous materials as well as precious metals. For example, liquid crystal mixture of LCD and LED monitors contains benzene, cyano-group, F, Cl, etc., which are potentially harmful to human health and environment [5]. Similarly, plastic housing and frames contain brominated flame retardants such as PolyBrominated Di-phenyl Ethers (PBDE) and PolyBrominated Bi-phenyls (PBB), which are harmful to brain, kidneys, nervous system, liver, endocrine and reproductive systems [6]. Figure 2 shows the average composition of an LCD. To minimize the impact, we will use the smallest possible LCD and try to place it as far away from where the user "hits" it as possible to avoid any accidental damage that may be needed.

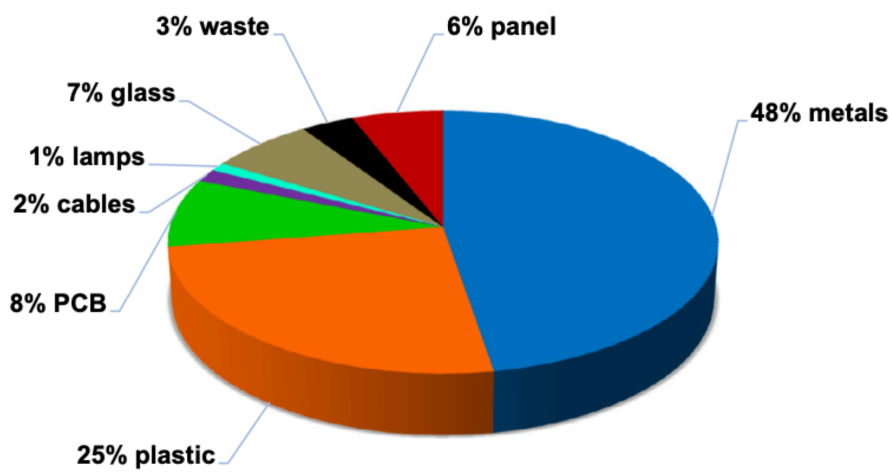

Figure 2. Average composition of an LCD

During the usage phase of LCD, it is evident that electricity consumption contributes to the environmental impacts obviously. The LCD we are using is as low power as possible to decrease the total energy consumption.

According to the RoHS Directive, end-of-life LCD risks could be connected with the content of lead, mercury, cadmium, chromium [13]. In addition, LCDs contain a potential carcinogenic compound, arsenic, usually added to glass in oxide form in order to improve the optical clarity of the glass panel [14]. The risk connected with this element is due to an improper disposal or to a possible dispersion in the shredding process during waste pre- treatment [15].

Nevertheless, the negative potential of end-of-life LCDs, and in general with WEEE if improperly managed, is combined with the possibility to recover many valuable materials. In order to reduce these negative effects, recycling strategies should be used with the final target to make the waste a source of secondary raw materials.

3D printing has several benefits like a simpler and reduced supply chain, increased longevity of the product, eradication of tooling needs, and shorter assembly chains [2]. The growing trend of this technology comes with the need to incorporate sustainability into the process to minimize negative environmental impact. ABS (acrylonitrile butadiene styrene) is used as a filament in 3D printing [16]. Disposal in landfills or burning is an unwise idea as they have negative impacts for the environment. The processing of the materials before they can be reused also requires energy and this adds to the impact that the respective materials have on the environment. Therefore, the choice of filament-type plays an important role in the circular economy of filaments[8].

ABS 3D printer filament as an advanced packaging material has great potential to reduce environmental impacts compared to traditional packaging materials. It has no negative impact on the environment during the usage phase. After using it, we recommend to reuse or recycle it instead of landfills or burning to reduce the environmental impacts.

Stainless steel is a recyclable material with a high scrap value. Recycling stainless steel reduces the need for raw materials, energy consumption, and waste generation, contributing to environmental sustainability and resource conservation. Also, since we rarely use stainless steel, we can actually ignore its environmental impact.

2.0 Ethical Challenges

Powering devices through USB ports presents several ethical challenges, especially in safety, user privacy and environmental impact. For safety concerns, USB ports are usually designed to deliver low power for charging so high-energy devices or overloading USB ports may lead to overheating, short circuits and fires. Our device was using USB 1.0 and 2.0 standard downstream ports which are able to deliver up to 500 mA. However, considering the overloading problem, we can use USB 3.0 which can provide up to 900 mA. For environmental impact, USB-powered devices are considered as electronic waste (e-waste) when they are discarded. It is necessary to design electronic devices for long life, promoting recycling and proper disposal, and minimizing energy consumption during use. In order to do that, we used abs 3d filament material as our packaging material. Compared to most inexpensive polymers, ABS is quite flexible, resists high temperatures, and can easily be machined [1]. Also, we use stainless steel for standoffs and screws to extend the lifespan of our device, since stainless steel is highly resistant to corrosion, rust, and staining, making it ideal for applications exposed to moisture, chemicals, or harsh environments. For user privacy, our device may transport user data through the USB port to the master device like desktop or laptop, and this will cause privacy risk. In order to avoid that, we disconnect the data transfer pin between the USB port and microcontroller so that the master device is unable to collect data when powering our device.

The ethical challenge of LCD and rotary encoders is mainly on user privacy because both components will collect information from the user. The LCD screen has a touch module built-in so that the user can make any change to the parameter displayed on LCD. Touch screens store sensitive information such as biometric data (e.g., fingerprints), user input patterns, and browsing history. Ethical concerns arise regarding the collection, storage, and sharing of this data, especially without users' explicit consent or knowledge. Users may not always be fully aware of the extent to which touch screens collect and utilize their data. Ethical considerations include providing transparent information about data collection practices, obtaining informed consent, and giving users control over their data. For rotary encoders, it can be integrated into devices to collect data about user interactions, such as rotational movements and speed. Ethical concerns arise when this data is collected without transparent disclosure to users or without their explicit consent. Users may not be aware of the extent to which their movements are being tracked and how the collected data is used.

One ethical challenge associated with using ABS (Acrylonitrile Butadiene Styrene) filament material in 3D printing is Health and Safety. ABS filament contains chemicals that may pose health and safety risks during handling, especially when heated or melted during the 3D printing process. The shape of our packaging may cause risk to users. For example, sharp edges or corners on a rectangular product or packaging could pose a safety hazard, especially if not adequately rounded or protected. When designing products or packaging with a rectangle shape, especially for items intended for children, ethical safety considerations include preventing choking hazards, ensuring non-toxic materials, and incorporating child-resistant features if necessary.

3.0 Sources Cited

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