A11 - Ethical and Environmental Analysis

Year: 2025 Semester: Spring Team: 20 Project: Encrypted USB Drive

Creation Date: April 12, 2025 Last Modified: April 12, 2025

Author: Stanley So Email: sos@purdue.edu

Assignment Evaluation: See the Rubric in the Brightspace Assignment

1. Environmental Impact Analysis

The physical parts of our product include a PCB, various integrated circuits, a keypad, a fingerprint sensor, an LCD display, and a 3D printed case. Our product has little environmental impact during normal use, since there are no parts coming in or out of it, but it does have environmental impacts during the manufacturing and disposal stage.

During the manufacturing stage, we need to manufacture a PCB, which involves handling hazardous chemicals and using a significant amount of energy [1]. The hazardous chemicals are used when manufacturing the substrate of the PCB, FR-4. The energy consumption comes from the machines that make the PCB, especially reflow ovens that need to heat up the PCB in order to melt solder. Since the PCB manufacturing and potentially the soldering would be done by another company, there’s not much we can do about this besides making the PCB as small as possible.

We also need to manufacture various integrated circuits that live on our PCB. The manufacturing process involves dealing with chemicals like fluorinated gases that are excellent greenhouse gasses. It also requires a lot of energy, which can lead to even more greenhouse gas emissions [2]. Since these chips are manufactured by different companies, I’m not sure there’s much we can do as designers to mitigate these environmental effects.

The keypad, fingerprint sensor, and LCD display also need to be manufactured. All these components include a PCB, so we chose the smallest versions of these components that met our requirements. In addition, the LCD display requires hazardous chemicals, a lot of water, and a significant amount of energy to manufacture [3]. That can lead to greenhouse gas emissions and waste generation. Choosing a small LCD display will mitigate these effects as well.

Making the 3D printed case requires heating up filaments, which consumes energy, and can lead to greenhouse gas emissions depending on where the energy is coming from. 3D printing requires about 10 times more energy than standard production processes like injection molding [4]. 3D printing is a good solution for prototyping / not that many sales, but if there are a lot of sales, it would be environmentally friendly to switch to another production process. In addition, we can make our case as small as possible while still holding all the components.

During the disposal stage, you can’t just simply throw the product in the trash. The PCB, integrated circuits, keypad, fingerprint sensor, and LCD display all contain harmful chemicals and are considered e-waste. The 3D printed case is not biodegradable under normal conditions [5]. What the user should do is give the product to an e-waste recycling facility or electronics store and see what they can do with it. The PCBs can be smelted to recover valuable metals [6]. The 3D printed case could go through an extruder, which would recycle the plastic and turn it back into filament, but this is not a widely available option and often leads to weaker filament. Instead, we could switch to something like injection molding and use a plastic that is widely recyclable (like #1 or #2 plastic).

1. Ethical Challenges

The male to male USB cable poses a safety risk. The user can plug in both ends of the cable into a computer, and the computer can get damaged because of it. To address this, we can add text to the user manual saying, “don’t stick both ends of cable into computer”, along with an image with a cross through it of someone doing that.

When it comes to usage, I can see this product potentially being used by criminals. The target audience is supposed to be companies protecting their secrets, but criminals can use these to give secret messages to their network. In the past, encrypted phones have been used by large criminal organizations for this exact purpose, and as a result, law enforcement have shut down many encrypted phone companies [7]. I think the main difference between our product and encrypted phones are that this product cannot communicate over the internet, so criminals would have to meet in person to give each other files. It might be helpful, sure, but it’s not going to be a gamechanger for criminals. I think this problem is interesting to think about, but I don’t think it’s a big enough concern for us to put any features against this. And I’m not sure how to put any features against this without compromising security.

Since we want to keep data on these chips secure, we need some sort of onboard encryption. We can’t simply write the raw data to the flash chips, or else someone can go into our case, desolder the flash chips, and then get all the data off. One of our stretch PSDRs is to have onboard encryption, and in a real product, this would be an essential requirement before we could bring the product to market.

There is also the problem that the user can brute force different passwords. One approach would be to erase the data after too many failed attempts, but that might lead to abuse since the data is so easy to erase. Instead, what we will do is implement a timer, where the USB drive has to be plugged in for a certain amount of time before the user can try a password. This time will increase with the number of failed attempts.

3.0 Sources Cited

[1] M. Media, “The Environmental Impact of Circuit Board Assembly,” Nova, Sep. 20, 2023. <https://novaenginc.com/the-environmental-impact-of-circuit-board-assembly/>

[2] J. C. Hess, “Chip Production’s Ecological Footprint: Mapping Climate and Environmental Impact,” Interface-eu.org, Jun. 20, 2024. <https://www.interface-eu.org/publications/chip-productions-ecological-footprint>

[3] Reshine-Display, “What Are the Environmental Impacts of Manufacturing LCD Displays? - Reshine Display,” www.reshine-display.com, May 20, 2024. <https://www.reshine-display.com/what-are-the-environmental-impacts-of-manufacturing-lcd-displays.html> (accessed Apr. 12, 2025).

[4] Perch Energy, “3D Printing: Eco-Friendly & Sustainable? (Not Quite) | Perch Energy,” www.perchenergy.com, Sep. 17, 2022. <https://www.perchenergy.com/blog/innovation/is-3d-printing-eco-friendly-sustainable>

[5] R. Toor, “The Truth about the Biodegradability of PLA Filament,” https://www.filamentive.com/, 2024. <https://www.filamentive.com/the-truth-about-the-biodegradability-of-pla-filament/>

[6] General Digital, “What You Need to Know about Recycling LCD Monitors & Displays,” General Digital Corporation, Mar. 11, 2014. <https://generaldigital.com/what-you-need-to-know-about-recycling-lcd-monitors-displays/>

[7] fern, “ANØM: The Most Genius FBI Operation,” YouTube, Dec. 08, 2024. <https://youtu.be/f6FRIDG8TPY> (accessed Apr. 12, 2025).