Towards strategic e-waste management using green technology approach: A brief review on green product development process

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Abstract. Electrical and electronic wastes are commonly known as e-waste is becoming a global issue. It contains dangerous substance that pose environmental and health risk which dominated by gold, silver, copper, platinum, palladium and plastic contents. Therefore, e-waste management needs to be well managed since the amount of e-waste generated will increase substantially. Focusing on waste computer component, this paper highlights the importance of recycle and reuse of computer components that can be transformed into new green technology product. We discuss briefly on benefits of this green approach to mankind and the Eight-Phase of Product Development Process, which pertain to transformation of waste computer component into new green technology product. It is hoped that this preliminary idea will assist developers to complete one functionable yet energy-efficiency model that may create awareness and motivation to our youngsters on utilization of e-waste components.

1. Introduction
At the present time, borderless world has urged human to be dependent on technologies, especially on electrical and electronic gadgets. Unfortunately, this rapid technology advancement has caused tremendous global electronic-waste, known as e-waste. Based on The Global E-waste Monitor 2017, the intrinsic material value of global e-waste is estimated to be 55 Billion Euro in 2016 [1]. Figure 1 illustrates the analogy of e-waste amount generated yearly is equivalent to the weight of 5000 Eiffel Towers [1]. Due to this issue, e-waste management needs to be well arranged with well-structured and beneficial strategy that may contribute return-on-investment to users.

We therefore plan a new green technology approach to support the e-waste management strategy, by focusing on waste computer component. A discussion on active Malaysia’s green development provided by [2] exposes that our country is looking forward for a bright vision of green future, which required good implementation of various green initiatives and plan.

In this paper, we focus on a brief review of two key points for development of green technology approach; which are benefits of green technology approach and Proposed Green Product Development Process (GPDP) to complete one functionable and energy-efficiency green technology model.
Benefit of green technology approach

Green computing (also called green technology) is an initiative to promote to a social community towards environmentally computer equipment design and the use of communication technologies. It promotes eco-friendly approach to use computers and related technology gadgets [3]. Furthermore, the choice of utilizing the e-waste product may reduce the developing materials which can last indefinitely and can slowly give benefit on preservative our environment [4]. Viewing from the return-on-investment perspectives for the users, there are four benefits of green technology approach that will be discussed [5].

2.1 Generate good income
First, this approach may generate good income from the disposal e-waste. Computer components are produced in different small parts that may workable on its own. That has become the important justification on how we can recycle and reuse dismantle electrical computer components and set them into new solitary product. It is similar to the initiatives made by e-commerce logistics in China where they tend to organize dynamic innovation and application of green packaging energy saving technology that can reduce the waste of e-commerce logistics package waybills [6].

2.2 Create an innovative design
Second benefit is referred to the innovative way of developing a new product. By using workable e-waste products, it can add more varieties and choices towards different design of an aquaponics product. Varieties of innovative design with strategies proposed seem capable of elevating the dignity and market of green technology in today’s market [5].

2.3 Reduce cost of e-waste disposal
This innovative and economic benefit also relates to third benefit on worthy contribution of reducing cost of e-waste disposal for country. It is an important issue to be tackled parallel to the drastic volume of e-waste caused by shorter life span of electrical and electronic products [7].

2.4 Increase sustainability of nature
The last benefit that needs to be highlighted is the increment sustainability of nature as we practice good management of e-waste disposal. This e-waste management reported as crucial issue that has not been taken seriously by most household in Malaysia [8].
3. Proposed Green Product Development Process for aquaponics system

Green technology or low carbon technology can be defined as “product, process or service that is less polluting or more resource-efficient than equivalent normal products that furnish a similar utility [5].” Prior to commencing a new product development, there must be several crucial phases need to go through by developer [9]. To benefit our future works, there are eight specified phases that will be going through for our product development. Our proposed green technology model will be focused on reusable and renewable of computer component.

Aquaponics System is design as a green technology product. The aqua is referred to the use of water as cooling system. It made from recycle and reuse computer components, and embed with water cooling system. This product design mainly to reduce the number of discarded component which contributed to as an e-waste item. This product can demonstrate that the recycle and reuse computer component can be produce as a new product. It also helps to create awareness and promoting good e-waste management etiquette in order to promote green technology product to conserve our health and environment.

The overview of the phases is shown in Figure 2.

![Diagram of Proposed green product development process (GPDP).](attachment:image.png)

**Figure 2.** Proposed green product development process (GPDP).
3.1. Dismantle PC parts
According to Figure 1, the first phase is dismantling the PC parts. Developer initiated the product development with dismantle the unused and disposed PC. All of the PC components such as hard disk, processor, LCD, LEC or screen monitor and motherboard are being tested by its functionality. Then, any of the PC components that still can function well are chosen. This further utilization of dismantle parts can support and may assist to solve the issue raised by [10] on raising awareness among the public about the importance of reusing PC parts on used laptops.

3.2. Product design
The second phase is product design. Based on the selected PC components, developer drafted a design by drawing to illustrate the expected product appearance. After that, a discussion was made among the team members and some redesign of the product will be made based on the comments and suggestion from team members. This is an important issue since the complex product design had been reported as one of the main future e-waste scenario in this era [11]. A final design then selected before further to the next phase of development.

3.3 Build casing & aquarium
Next, the third phase is built the casing and aquarium. In order to build a perfect appearance for product, the prototype of PC and aquarium were built beforehand. Designing innovative casing and aquarium is another interesting research, where Artificial Intelligence strategies such like neuro-fuzzy logic, can be implemented for pump control [12]. The prototype then presented and discussed about its deficiencies and advantages among team members. According to the comments and suggestions from the discussion, the prototype was rebuilt to get the best appearance. The real product was built referred to the finalize prototype.

3.4 Installing PC parts
The fourth phase is installing the PC parts. The PC components that have been previously dismantled from the first phase were installed in the casing following the specified measurement. After the installation was finished, all of the PC components were tested to ensure that there is no error occurred.

3.5 Troubleshoot
The next phase is troubleshoot which is one of the crucial part as it need to be ensured that both software and hardware are functional. Troubleshoot was made gradually and straight away fixed if there is any error occurred which may affects the functionality of the product.

3.6 Paint the mirror
The seventh phase is paint the mirror. First of all in this phase, developer measured and draws the particular targeted area to paint. Then, the mirror was tested to gain the suitable measurement with the PC casing. Once it was okay, developer proceed to painting and drying process. The mirror was straightaway tested for its painting. Repaint would be done if there is any part of the mirror did not paint properly. Once the second painting was done, the mirror was rechecked again.

3.7 Assemble all parts
The second last phase is assembling all parts. The casing, aquarium and mirror were integrated which was affixed based on the previous design that has been agreed by all of the members team. Then, the water pump, filter and LED lamp were installed altogether with the decoration likes rocks and plants at the bottom of aquarium. The additional living things such as fishes and plant were also added in the aquarium. After that, the overall test was did for CPU functionality, water pump and cooling system.
3.8 Deploy
The last phase is deploying. In this phase, the overall test of cooling system, hardware including CPU functionality and water pump, software, and lighting system were tested to ensure the functionality of the product was working properly.

4. Discussion
Green computing technology is highly necessary and recommended to find many ways of solution to reduce more electrical waste [5]. It would be getting from the usage of recycle and reuse electrical computer components which based on e-waste products. It is beneficial to generate incomes even with disposal e-waste, reduce development of product cost and certainly would contributes in reducing large amount of e-waste disposal cost for our country from times to times. Moreover, aquaponics system can also provide high sustainability for organic agriculture and helps in Central Processing Unit (CPU) cooling system used from water which as well contributes to green technology aside than being decoration. In addition, the planted plants in aquatic system can be as food resources, simultaneously may reduce the cost if the yield can be taken and sold. Consequently, it is confirmed that our world is potentially to turn into green healthy environment due to reduction of e-waste disposal. Hence, the sustainability of nature and our ecosystem will rising with good management of e-waste disposal and potentially to gain friendly environmental [10].

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