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Changing Consumer Tastes and Green Computing as a Response to Climate Change

Junmee Park

Seongnam, Gyeonggi-do, South Korea

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Abstract: **One of the main issues that we face as a society today is our overuse of non-renewable resources and the consequences that have come with mass production and consumption. People are becoming more and more intentional with which products they choose to buy and the interest in the environmental impact of products have led companies to change how they develop and advertise products. This phenomenon is especially shown in the tech industry where green computing has emerged as one of the major methods to meet the demand for sustainable products. Green computing includes multiple strategies, and this paper especially focuses on reducing electronic waste and finding ways to use energy effectively. As people use more electricity and natural resources, there are detrimental effects towards the environment thus leading to concerns about long term consequences. There has definitely been an increase in interest towards the environmental impact of everyday products; especially our electronic devices. By changing companies' strategies to be more sustainable, they can earn goodwill from consumers and become more competitive in their market. It also allows companies to reduce costs for both themselves and the consumer. This paper discusses the role that climate change has had on consumer concerns and interests, what companies are doing to meet this need, and specifically how the tech industry is implementing green computing in order to manage waste and reduce energy consumption.**

Keywords**: Green Computing, Environmental Science, Conservation, Waste Reduction, Technological Impact.**

I. INTRODUCTION

In the modern age climate change is something that is undeniable and it continues to affect more and more of our daily lives. It is clear to see how our consumerist society contributes to the rapid changes we see today; from the melting of the glaciers, the rise of sea levels, and the unusual weather phenomena that now regularly happen as a result. As many of these consequences will directly and most likely negatively affect many people, as a society we have become more conscious about what is "green" or environmentally friendly in an effort to lessen the effects of human production and waste. We can already see changes in industries like fashion as becoming more eco-friendly might now be the economically advantageous move. It was found that in a study when all other factors were the same, customers were more likely to purchase an organic, eco-friendly t-shirt in comparison to a comparable model that was made unsustainably[9]. In this way we can already see how companies and producers are adapting to this new consumer attitude.

In particular as climate change has continued to develop so has our technology, and along with all of these advances also came an exponential increase in the amount of energy and waste needed to be able to produce these things. The chances of technological advancements ceasing or new electronic devices never being made again are slim. Therefore tech companies in particular are trying to reduce their carbon footprint and become more environmentally conscious. In particular "green computing" has been a term that has been coined to refer to the innovations and advances that tech companies have made in reducing waste during and post production. This paper will explore the effects that climate change has on consumer attitudes, and the subsequent response of companies who now need to shift their business models to fit the ethical standards of their consumers. Furthermore, how green computing in particular is helping to make the production of technology more environmentally friendly, and how to more effectively use the energy that we currently have access to. As the concerns

about the environment continue to increase it is important to monitor and modify areas that we as humans are being reckless in treating the non renewable resources available to us.

II. WHY AND HOW CONSUMER TASTES ARE CHANGING

It is clear to see the impact that human technological advancement has had on our environment. Starting from the Industrial Revolution, technological advancement has almost always negatively impacted the natural world around us. Even as early as 1948, the smog and waste from the increasing number of factories led to fatalities and injuries. These types of events made it clear that convenience and innovation often came at the cost of conservation and community safety. One of the most tangible ways to see that consumer thoughts on mass produced products are changing is the fact that google searches for sustainable products in the 'shopping' category increased globally from around 20 percent to nearly 70 percent from 2016 to 2020 (Index 1). This shows that there is an overall growing interest in "greener" products, and that consumers are concerned about how their personal spending decisions affect the environment. The year 2020 was 1.2°C above pre-industrial era temperatures, and although this number might not seem that big, as noticeable changes continue to happen everyday, most people are now aware that this seemingly miniscule change has had irrevocable consequences. The increase of sea level can reduce the overall dimension of the continent, and the world that we know today might not be the same for the future generations. With growing concerns over the environment, consumers have now become more aware of what type of products they buy thus causing the difference in sales for environmentally friendly products.

One of the main concerns for trying to make products and production processes more environmentally friendly is the increased cost to be sustainable. In many cases the "greener" option is also the more expensive one; for example one study showed that "customer benefit and price are key elements for market demand"[5]. So it could be argued that the bottom line for many consumers when choosing a product is its final quality and price, not the sustainability of the item. However there is clear evidence in surveys and studies that show that contrary to this theory consumers are more willing to pay extra for a product if they can confirm that it was produced sustainably. Although the environmental value of a product is not the main benchmark in which consumers choose where to spend their money, in our modern day and age it is becoming more and more of a factor people consider when making buying decisions.

III. COMPANIES RESPONSE TO CONSUMER CHANGES

There is an obvious link between changes in consumer behavior and how companies operate and run their business. For most companies profit is the bottom line and changes in policy often have to do with increasing revenue. As consumer concern for environmentally friendly products increases companies are shifting their business and production model to suit those demands. For example, in Vietnam one of the biggest industries is the motorcycle industry. However, due to growing concerns towards the environment consumers are looking for more "green consciousness," in essence looking for products that are more fuel efficient and environmentally friendly[5]. In many cases consumers have these demands not just because they wish to be more environmentally conscious but also due to rising costs of non renewable energy sources like gas and oil. These demands require companies to change simultaneously through producing more environmentally friendly products or changing their production system to minimize the resources or substances that harm the environment.

In addition to clothing and motor industries, another industry that has become more "eco-friendly" is the tech industry. Many large tech companies such as Apple have recently made changes such as making products that use recycled materials and using renewable energy in their factories. The changes that these mainstream companies are making allow for more options for the people who want environmentally friendly products, but also has a huge benefit to the company itself- it can reduce the cost of manufacturing. For example, Apple is using electricity generated from solar, wind, and other natural power. Even though it does cost a lot to set up the initial systems that generate electricity from solar, wind, or other natural power, once set it allows companies to reduce the cost and amount of electricity needed overall. In addition it is clear that having a greener company also makes a product more competitive in their respective industries. The general overall tone towards being environmentally friendly has changed even within the last decade- most consumers can now agree that mass production and spending is detrimental to our environment. Therefore companies are now more willing to make reforms in policy and production that promote a more environmentally conscious product especially because now it makes their company and product stand out and puts them at an advantage.

IV. GREEN COMPUTING

One area in which human consumption has drastically increased even within the last decade is the electronics industry. The growth of this industry has subsequently led to increased mining and output of waste materials in order to extract the parts necessary to produce these items. According to ICT, the tech industry is "...responsible for 3% of the world's energy consumption. With the rate of consumption increasing by 20% a year, 2030 will be the year when the world's energy consumption will double because of the ICT industry"[3]. Adding on, "In the year 2014, nearly 41.8 million metric tons of e-waste were generated globally"[2] and this number continuously increases every year. Today it is rare to see a person with only one electronic device- when considering laptops, cellphones, televisions, and even appliances like microwaves today almost everyone has more than one technological device. According to the Pew Research Center, the percentage of mobile ownership has increased from 35 percent to 85 percent in just 10 years[7]. Even though this expansion could be seen as positive, the increase in production also can mean an increase in waste, greenhouse gas, and others that could harm the environment as well as increase use of raw materials. Due to this increase in need for electronic devices many tech companies are now feeling their impact and responsibility towards the environment. In order to reduce the factors that harm the environment, many tech companies are looking for a way to minimize cost by practicing a new concept that is being called "Green Computing."

The goal of green computing is to better study and practice being more sustainable in the development of electronics and the use of non-renewable resources in making these products. Due to the growing demand for sustainable products, the attention towards green computing has risen accordingly which has led to expansion and a deeper study of green computing. This eventually allowed more products to develop sustainably, and these approaches can include but are not limited to: reducing waste during production, effective use of energy, virtual clouding, using sustainable materials, and more. In next sections, we will focus especially on the two main aspects of green computing which are reducing e-waste and using the energy we have more effectively.

V. REDUCING E-WASTE

The effect of the electronic industry on the environment is vast, as it would have been incomprehensible even a decade before that electronic waste would play such a large role in climate change today. Electronic waste also known as e-waste are used electronic devices that are no longer needed. In the modern age the life span of not just mobile phones but all electronic devices is shrinking- as major companies tend to flood the market with new releases every year the need for new electronics often make even usable items obsolete. These obsolete electronics are then often disposed of like other trash and sent to either to be incinerated or to a landfill. For reference, in 2014, the world total amount of e-waste was 44.7 million tons whereas currently, it is about 52.2 million tons which is an approximate 15 percent growth in just 7 years. At this rate, by 2050, there will be over 90 million tons of just electronic waste in our landfills. In addition to the environmental harm that this causes there are also studies which show that there is a negative physiological consequence to specifically the waste that comes from the improper disposal of e-waste, "changes in lung function, respiratory and respiratory effects, DNA damage, impaired thyroid function and increased risk of some chronic diseases later in life, such as cancer and cardiovascular disease"[11]. Therefore it is supremely important that all electronic waste be disposed of properly and carefully as the often volatile materials used to make these items can have a long term effect on the environment. For example, if a cell phone is thrown into a regular trash can and makes it through the regular chain of disposal for trash it is possible that it might emit toxins and chemicals into the soil and air. This pollution, although it might seem detached from the consumer, actually has an impact on the soil, air, and game we consume. However, the issue that many people have is that e-waste disposal sites are not easily accessible and the only option in many cases is to just dispose of e-waste as we do trash. As a part of the green computing initiative tech companies who are responsible for making the items are now holding ownership over also the disposal and possible recycling of the reusable raw materials in these devices. Some of the ways green computing is working to reduce e-waste is by making these e-waste specific disposal sites more accessible and plentiful. Also companies are trying to reach out to the community to educate and help manage the amount of e-waste present. They started e-waste management, held e-waste drives, or found other ways to dispose of the devices. Adding on, some people managed to collect unused electronic devices, and they were "given out to economically challenged schools, colleges, orphanages, hospitals etc"[2]. This is one way that these programs have had an even greater benefit- keeping the devices from harming our environment through landfills and also giving to those who might not have had access to these things normally. In addition, one of the most common things that most companies are implementing is trade-in systems. Trade-in systems allow customers to give old phones to the company and get discounts when they are buying new products. This trade-in system can have multiple benefits to customers and companies. According to Apple, they have sent around 10.4 million

used phones to new users in 2020, and through their approaches, Apple could reduce more than 39,000 tons in 2020[1]. Like Apple, companies can fix any component of the device and resell them with a discounted price while customers can get discounts when buying new products. The new customers can get used devices with discounted prices, and it is good for the environment. Because of these benefits, more and more companies are implementing this policy. Although these things will not solve climate change, all of these changes that tech companies are making through green computing initiatives are ways to reduce the negative impact that technology has had without sacrificing the comforts that these developments have brought us.

VI. EFFECTIVE USE OF ENERGY

One of the reasons that the rapid development of technology has had such an adverse effect on our environment is the amount of energy we now consume in order to power these devices. Energy in the form of electricity is one of the largest areas in which non-renewable resources are being used. Electricity is used in almost every second of our lives, energy definitely enhances the quality of our lives, but it also has detrimental effects on the environment. When energy is produced, the power plant that creates electricity emits greenhouse gasses which is one of the major factors that contribute to global warming. Therefore, it is crucial for companies, governments, and society as a whole to find possible solutions to minimize the effect towards the environment and learn how to use the limited resources we have effectively.

The amount of electricity that we consume as a society has increased largely in part due to the exponential increase of electronic devices we need to live our daily lives. Most of these products depend on electricity to function properly, and how the developers design the system has an effect on how much energy is needed to run the device. This applies to both the software and hardware of computers. Some software strategies could include cache skipping, instruction clustering, instructional reordering, and more. These strategies eliminate unnecessary steps to operate the computer thus reducing the energy needed to run those systems. They might not seem significant but in some cases, studies have found that these software strategies can reduce energy consumption, up to even 47 percent for one device[4]. This number might not seem a lot to some people, but if more people started implementing these strategies, the amount of energy consumption would decrease significantly, and success in this sector may possibly lead to more advances and developments being made in this field to allow for finding more approaches towards software strategies for sustainable computing. There are also hardware strategies such as completely turning off the device when it is not being used, power management techniques at the OS level, dynamic voltage, frequency scaling, and more[4]. Realistically, for a normal user, it is hard to implement power management techniques or change the instruction ordering because it could have detrimental effects towards the computing system in general. Although there are physical things a user could and should be doing to reduce waste, many of these implementations are happening at the product development level in order to be more environmentally friendly without any additional user tampering. For example, Microsoft has worked on improving energy efficiency for Windows, Surface, and Xbox where updated Windows use 90% of energy compared to previous version, Surface X have 28 percent reduction of energy with having similar performance with Surface Pro, and Xbox included a feature in standby mode which reduce the power from 15W to 2W[6]. Following big name companies like Microsoft and Apple, even more major companies are changing to find a more efficient way to structure their product output and designs. As consumer concerns develop to be mindful about the environment companies have had no choice but to change accordingly not just to meet consumer needs but also to take responsibility over the very real damage their products are having on the environment. It also helps them to reduce the overall price of the product as previously discussed in the last section. These approaches allow people to buy products that they want, companies to have bigger margins, and the environment to be safer.

VII. CONCLUSION

Today, the increased demand towards environmentally friendly products has led companies especially in the tech industry to produce more sustainable products. As we as a society continue to see the negative impact that human consumption has had on the environment it has become clear that we need to make changes even on an individual level in order to foster change. A natural response to changing consumer tastes has been companies policies and values regarding their environmental impact. As discussed, green computing is a strategy that many tech companies have implemented in order to reduce waste and negative impact on the environment. However, there are some limits of green computing in that these strategies are not as user-friendly and can be only implemented when the companies themselves choose to put in the funds and development to make the policies. Further research should invest more on how customers can buy products in a more sustainable way without companies implementing greener policies. If this idea is widely spread, it will give more options

to customers who want sustainable products and even to regular customers who are interested in the environment but not necessarily wanting sustainable products. It is essential to reduce the e-waste but not everyone is available to e-waste recycle bins or have time to. It is the job of the government to step up and study for legislations that are realistic and easy to implement so that e-waste can be reduced. These approaches find their own way of making products more sustainable, and strategies like green computing should expand on to every industry with appropriate strategies in regards to protecting our environment.

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