Sustainability of the iPhone

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Abstract

In this work, we discuss the sustainability of the iPhone, focused on the stages of the product life cycle. First of all, we give the theoretical background and explain how sustainability is understood in this work and we show that the viewed product life cycle bases on the stages production, usage and disposal. Furthermore, we describe on a technical view our study object, the iPhone in the 5.th generation. Following we look at each stage of the product life cycle and discuss what have a positive or negative influence on the sustainability. We show among other things that Apple reaches economical sustainability by high profit per device. As a result of our work, we come to the conclusion, that even through a lot of good approaches the iPhone is not absolutely sustainable, particularly with regard to ecological and social aspects. Last but not least, we give an outlook for future work.

1. Introduction

Topics like rare becoming resources or those which have to be mined with high effort as well as planned product attrition and the shift of productions in countries with lower pay are in the media again and again.

Currently one can read and hear a lot of “rare earth” which are needed for production of mobile phones, batteries, computers and other things. Due to the fact that 95 per cent of “rare earth” is mined by China this country effectively has a monopoly. To become independent from this fact a usage of “rare earth” as low as possible is advisable.

A lot of consumers deplore that they have to buy a new device because the “old” one brakes down shortly after its guarantee is over or it becomes incompatible with the newest operating system or software generation. Some people go one step further and suppose that many manufacturers endeavour to shorten the product utilization time indendedly to initiate compulsory purchases. To satisfy the customer’s needs the duration of devices should be as long as possible and new software products should be downward compatible.

In the last years the trend was observed that corporate divisions were outsourced in countries with lower pay just with the argument of an increasing cost pressure. But what is about the labour conditions of the employees? During the last years some manufacturers were criticized due to social reprehensible practices, for example child labour or poor health and safety standards. Companies have to keep this in mind and have to avoid it.

In view of these facts we decide to analyse a common daily used device, a smartphone, by economic, social and ecologic aspects. We choose the Apple’s iPhone as our study object and discuss whether it is a sustainable product.

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2 Apple® and iPhone® are trademarks of Apple Inc. 1 Infinite Loop, Cupertino, California, USA, 95014
2. Theoretical Background

2.1 Sustainability

In Germany the term sustainability gained attention in the 18th century. At this time it was noticed that regardless deforestation leads to elimination of the own base of life in the long run. Due to reforestation of wide areas the availability of wood for future generations should be ensured (Spindler). This specific view, which is focused on forestry, can be generalized but also adapted on other systems and resources. In 2002 the Deutsche Bundestag defined sustainability as “usage of a reclaimable system in a way that the system preserved and its resources can be reclaimed in a natural way” (Deutscher Bundestag 2002).

The three-pillar-model of a sustainable development defined by the Enquete-Commission “protection of mankind and environment” can be used to fill the term sustainability with content. It is distinguished between economical, ecological and social sustainability aspects. Among others the long-term reduction of poverty and the increase of economic performance as well as the climate protection are aims of the mentioned sustainability aspects (Deutscher Bundestag 2002).

Based on these pillars the aim of a sustainable development is the maintenance of ecologic, economic and social capital for future generations. The ecologic capital includes resources, land and ecological factors like food cycles and climatic systems. This type of capital can be quantified best (e.g. in monetary units). However, the social capital is more difficult to define. In this paper the focus is laid on social capital combined with immaterial aspects. These goals include points like justice, equality in chances and respect of the human dignity (Kleine 2009).

![Figure 1: Pillars of Sustainability](image)

In this paper each of the mentioned sustainability aspects will be analysed based on the sustainability triangle as it is represented in Figure 1. The single pillars of sustainability cannot be treated independent from one another, because all are bound in mutual interaction. Economic, social and ecologic aspects are influencing each other and therefore they have to be considered integratively. If economic growth is vastly achieved at cost of ecological and social aspects, it has to be determined and included in the contemplation of sustainability.
2.2 Product Life Cycle
The life cycle of a product reaches from “[…] the first idea to the expiry of the last duty to maintain a product” (Schmelzer and Sesselmann 2010). To conduct sustainability analysis of the iPhone as entirely as possible different stages of the product life cycle have to be deduced and analysed.

For the consideration of sustainability the life cycle is divided in the following stages: Production, usage and disposal. This kind of classification makes it possible to analyse the aspects of the sustainability abstractly and sophisticated that collected information can be assigned to the specific stages. In this paper working stages like planning and development of the iPhone production are not considered due to lack of available information. As a result of this it is hard to estimate the influence of every stage on the sustainability.

The production is the first stage of the life cycle and defined as a process of transformation of combinations of inputs to products (Voigt et al.). In other words within the production activities are conducted which lead to the product. Working conditions are also impact factors to sustainability like production processes and production costs.

The product usage is the second stage within the life cycle and is also called product consumption. Factors which influence the sustainability at the usage stage are activities and habits of customers but also the features and means which are came from the product itself.

Disposal is the last stage of the life cycle of a product. This stage contains activities like trash removal and recycling (Klaus 2004). At this stage especially the following aspects have influence on the sustainability: reuse of materials, recycling processes and effort but also pollution caused by waste substances.

2.3 Study Object iPhone
At this stage the iPhone as object of study will be introduced. The iPhone is a smart phone of Apple. A smartphone is a mobile phone which has more computer functionality and connectivity than a traditional mobile phone. Moreover smartphone users have the opportunity to upgrade their smartphones with new and individual functions by installing additional applications (Apps).

Until now Apple released five generations of the iPhone. In June 2007 the first iPhone was released. It was the beginning of new smart phone generation and revolutionized the smart phone market. Due to the optimization for a wide range of applications like touchscreen control, embedded sensors for location determination and movements as well as an operating system with an open application programming interface (API) which the user allowed to install individual apps, the iPhone contrast strongly with competitors in the market. Thus for example the iPhone got the “Erfindung des Jahres 2007” award from the Time-Magazin (Grossman 2007).

The iPhone of the 5.th generation weighs 112 gram, is 12,4 cm high, 5,9 cm broad an 0,8 cm deep. In addition it has a 4 inch retina display with a resolution of 1136*640 pixels. The iPhone 5 is fitted with two 8 megapixel cameras, one in the front and one at the back side. This smartphone is available with 16, 32 or 64 GB memory. Furthermore, this device has various sensors for example a 3-axial-gyro sensor, an acceleration sensor and an ambient light sensor. In comparison to the iPhone 4 the support of the Long Term Evolution standard (LTE) has to be mentioned as new feature. This advancement of the Universal Mobile Telecommunications System Technology (UMTS) makes it possible to reach a data transfer rate up to 300 megabit per second. The built-in accumulator is a lithium-ion battery, which has maximal Standby of 225 hours. As the iPhone 4 the current generation uses iOS 7 as operating system. For the build-in process or A6 are no detailed information available yet, but as the manufacturer said this processor works up to twice as fast compared with the A5 chip. The Apple A5 has a clock speed of 1 GHz and consists of two A9 processor cores (Apple Inc. b). The iPhone 5 consist of 24g battery, 21g aluminium, 18g stainless steel, 18g glass, 13g circuit boards, 11g display, 5g plastic and 2g other materials (Apple Inc. c).
3. Influences on sustainability within the life cycle of the iPhone

To assess the influence of the iPhone on the general sustainability, an examination of its different product life cycle stages is carried out in this chapter. The first part deals with sustainability influences as a consequence of the production stage. In the second part the usage stage of the iPhone is analysed. At last, the disposal stage will be discussed in more detail.

3.1 Production

The first analysed phase of the iPhone life cycle is the production phase. Here, aspects of the development and manufacturing in regards to ecologic, economic and social sustainability are reviewed. Production of iPhone components is carried out by numerous different contract manufacturers, worldwide. By outsourcing the manufacturing overseas, mainly to Asia, Apple is able to reduce cost compared to a complete in-house production. According to Focus, the production cost of a single iPhone 4S is estimated at 134€ (FOCUS Online 2011). The assembly of parts accounts for just a small fraction with 8€ per iPhone. In Germany, the iPhone 4S originally sold for 629€ which results in a difference of 495€ between production costs and retail price. Even when accounting for development costs and dealer’s margin, the monetary advantages by outsourcing the majority of the manufacturing of the iPhone leads to an economically sustainable iPhone production for Apple.

The economically efficient production of an iPhone comes with different shortcomings regarding the labour conditions of the employees working for Apple’s contract manufactures. During the last years especially the Taiwanese contract manufacturer Foxconn was criticized due to social reprehensible practices (Horchert 2012). Since 2006, the focus of the recurring negative coverage is in particular child labour in Foxconn factories, low wages and long working hours without breaks, prohibition to speak during work as well as poor health and safety standards. It is suspected that the resulting pressure on the Foxconn employees is the cause of the suicide series among the Foxconn workers (SPIEGEL ONLINE GmbH 2012b).

Apple admitted the poor labour conditions of their suppliers and attempted, because of the increasing public pressure, to improve them. Independent inspectors now regularly examine the factories of Apple’s suppliers and already confirmed an improvement on labour conditions (SPIEGEL ONLINE GmbH 2012a). However, it must be noted that the production of the iPhone is not completely social sustainable due to the reported social grievances of Apple’s contract manufacturers.

The environmental pollution during the iPhone production leads to further criticism of Apple’s suppliers. According to a report from 2011 created by multiple environmental groups, including the Institute for Environmental issues, 27 suspected Chinese Apple supplier pollute the environment and endanger the health of local residents (n-tv Nachrichtenfernsehen GmbH 2011). The company Meiko Electronics of Wuhan is given as one example. Lake Nantaizi which is located in the vicinity of one of Meiko Electronics factories is according to test results severely contaminated with heavy metals. Other examples are factories of Apple’s contract manufacturer Foxconn located in Shanxi of northern China. There, residents in the vicinity of the factories must often keep their windows shut due to the escaping toxic gas. Similar to the above stated poor labour conditions of suppliers, Apple was willing to discuss the matter and promised an improvement regarding the environmental pollution. Nevertheless, the production throughout the supply chain cannot be called completely environmentally and socially sustainable.

A positive example for Apple taking environmental responsibility can be found in the used materials during the iPhone 4 production (Franzenburg 2008). Neither the official iPhone accessories nor the iPhone 4 contain any PVC plastic, which is difficult to recycle as well as toxic and potentially carcinogenic. Furthermore, during the production of the iPhone no brominated circuit boards as well as mercury and arsenic for its display production are used. Additionally, the packaging materials consist partially of already recycled materials and are therefore environmentally friendly and ecologically sustainable. Through techno-
logical improvements energy efficiency of iPhone components like accumulator and processor are further increased. For example, the Apple A5 processor which is also employed in the iPhone 4S is manufactured in a 32 nm process instead of the 45 nm process since spring 2012 (Shimpi 2012). Thereby it is possible to reduce the base area of the processor by 40% which in turn leads to less energy consumption for equal performance and therefore higher sustainability.

3.2 Usage

In this part, the ecological sustainability during the usage phase of the iPhone is examined. One aspect of sustainability is the usage period, which refers to the time a product is used until disposal. For original purchaser the usage period varies according to user feedback between several months and a maximum of four years. Often the usage period is stated to be two years, which is equivalent to the usual contract period. The usage period of an iPhone can be prolonged if the original owner resells or passes the iPhone to another person instead of disposing it. An assumption of a high reselling rate of iPhones is supported by observations on the internet auction platform eBay. For a used Apple iPhone 4 3616 offers existed on average, with buy-it-now prices between 250 and 600 Euro. In contrast, a comparable, used smartphone Samsung Galaxy i9000 achieved merely 255 offers with buy-it-now prices between 150 and 320 Euro. The higher resale prices of the iPhone in comparison to similar smartphones show its better suitability for the resale market and thus imply a higher degree of longevity. Both the high resale rate and the relatively high resale price support the assumption of a long usage period and durability, and positively influence the environmental sustainability of the iPhone.

An important aspect in the analysis of ecological sustainability during the use of the iPhone is its energy consumption. Compared to conventional mobile phones, the energy consumption is much higher. There are two main aspects responsible for this. On the one hand, the built-in components, such as the larger display, the larger amount of memory, the sensors and cameras as well as the more powerful processor have a noticeably higher energy demand. On the other hand the daily time-of-use of a smartphone is generally much higher than for a conventional mobile phone. A survey in January 2011 among iPhone user revealed that the average time-of-use per day of an iPhone accumulates to 84 minutes (CHIP Xonio Online GmbH 2011). As a conclusion it can be said that the total energy consumption compared to conventional phones is significant higher due to a higher overall consumption and time-of-use.

For the evaluation of the energy demand of an iPhone, it must be noted that the iPhone can also be used as a substitute for various other electronic devices. Products such as navigation systems, radios, gaming handhelds, MP3 player or alarm clocks will be used less, because the functions provided by these products are already integrated in the iPhone. Additionally, functionality normally found in desktop PCs, notebooks and tablet PCs like rapid searches on the Internet for news, weather etc. is also implemented in the iPhone. As a result, energy savings can be realized in these devices and the increased energy demand of the iPhone due to more powerful components and a higher time-of-use is mitigated.

3.2 Disposal

The disposal phase marks the end of the lifecycle of every iPhone. In Germany, the disposal of old mobile phones is regulated through the Elektro- and Elektronikgerätegesetz (ElektroG). Accordingly, the phone can be disposed in either a public collection point or in voluntary collection points provided by the manufacturer or distributor (Bayerisches Staatsministerium für Umwelt und Gesundheit 2012). In this part the iPhone will be analysed with regard to the disposal of potential pollutants and the recycling of reusable materials.
The need for disposal of pollutants significantly depends on the materials used during the production of the device. These materials are determined during the design phase of the product. Apple itself indicates that the use of completely recyclable packaging materials, arsenic-free glass, high-grade aluminum and polycarbonates is the result of their awareness about the importance of the design phase for the sustainability (Apple Inc. a). Independent investigations show a trend towards the reduction of processed pollutants and disposal aggravating materials among the iPhone generations. In later generations, PVC in headphones and cables, and brominated flame retardants on circuit boards were removed, making the disposal of an iPhone easier (Franzenburg 2008). A sustainability problem caused by the design process is the permanently installed accumulator. Through the decision to not allow for an easy exchange of iPhone accumulators, recyclers face the problem of their costly and time-consuming removal (Crocoll 2012).

Furthermore, the recycling and disposal processes influence whether, and how many pollutants are released into the environment and thus affect the ecological sustainability. Through a recycling program initiated by Apple, sold iPhones are disposed and recycled by specialized companies (Apple Inc. a). Apple also conducts payments of the residual value of the submitted products which is an additional incentive for customers to use the recycling program. This partially addresses the problem of exports of used mobile phones to emerging markets and the associated recovery methods for recyclable materials (Crocoll 2012). As a result, since 2009, a collection rate of 65%, based on the total quantity of annually used product materials in the iPhone production, can be achieved (Apple Inc. a). Detailed knowledge about the processes carried out within the recycling program is not available; therefore no specific statement on the recovery rate can be made. Based on current figures in Germany, a recovery rate around 95% and a recycling rate (excludes energetic recovery) around 81% is realistic (Bundesumweltministerium 2010).

4. Summary and Outlook

Due to the influence of the consumption on sustainability it is important to analyse commercially successful products. The iPhone belongs to the category of those successful products and because of its high prosperity it is very suitable as investigation object. Within this paper the focus laid on analysing the iPhone with regard to sustainability. For that reason in the first part of this paper sustainability with its three aspects economical, ecological and social was defined. In the second part the product life cycle is explained and information about the iPhone was given. Afterwards each stage of the defined product life cycle of the iPhone is analysed regarding the sustainability aspects. Table 1 shows the determined facts as a summary.

At production stage primary the used materials and the working conditions as well as the costs influence the sustainability aspects. At the usage stage sustainability is determined by the technical options and features of the smartphone but also by the activities and habits of the consumers. At the last stage the sustainability of the iPhone depends on the design connected with the used materials (e. g. recyclables and pollutants) and the recycling attempts of the manufacturers.

The ecological sustainability was positively influenced by a well-considered input, substitution possibilities which are given by the iPhone, more efficient components as well as a sophisticated recycling program. Both the pollution generated by the production and the high energy consumption compared with those of traditional mobile phones have to evaluated negatively. Apple reaches economical sustainability by outsourcing production in countries with low pay, typical life cycles as well as high product prices. In contrast to this the social sustainability has to be mentioned as bad. Compared with European standards the iPhone is produced under bad working conditions. Even though a lot of good approaches the iPhone is not absolutely sustainable, particularly with regard to ecological and social aspects.
<table>
<thead>
<tr>
<th>Stage / Aspect</th>
<th>Production</th>
<th>Usage</th>
<th>Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economy</td>
<td>* high profit per device</td>
<td>* high resale price and resale rate</td>
<td></td>
</tr>
<tr>
<td>Ecology</td>
<td>* high environmental pollution by suppliers, but promise by Apple to improve it</td>
<td>* usage period of original purchaser between several month and four years</td>
<td>* usage of completely recyclable packaging materials, arsenic-free glass, high-grade aluminium and polycarbonates</td>
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<tr>
<td></td>
<td>* no use of PVC plastic, brominated circuit boards, mercury and arsenic</td>
<td>* longer usage period by reselling instead of disposing it</td>
<td>* no use of PVC plastic, brominated circuit boards</td>
</tr>
<tr>
<td></td>
<td>* use of already recycled materials for packaging</td>
<td>* high energy consumption</td>
<td>* permanently installed accumulator</td>
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<td></td>
<td></td>
<td>* substitute for various other electronic devices</td>
<td>* recycling program initiated by Apple</td>
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<tr>
<td>Social</td>
<td>* bad labour conditions at suppliers, but nowadays regularly examined by independent inspectors</td>
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Table 1: Summary of the sustainability aspects

The ecological sustainability was positively influenced by a well-considered input, substitution possibilities which are given by the iPhone, more efficient components as well as a sophisticated recycling program. Both the pollution generated by the production and the high energy consumption compared with those of traditional mobile phones have to be evaluated negatively. Apple reaches economical sustainability by outsourcing production in countries with low pay, typical life cycles as well as high product prices. In contrast to this the social sustainability has to be mentioned as bad. Compared with European standards the iPhone is produced under bad working conditions. Even though a lot of good approaches the iPhone is not absolutely sustainable, particularly with regard to ecological and social aspects.

Within the wide field of sustainability topics sustainability analyses of competing products are an approach for future work. As a result the sustainability of the iPhone could be compared with its competitors in the smartphone market.

Bibliography


