Identification of water hotspots in the supply chain of a laptop – mitigation measures

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Available online:

https://www.researchgate.net/publication/280645966_Identification_of_water_hotspots_in_the_supply_chain_of_a_laptop_-_mitigation_measures

1. Introduction

Water is a vital resource; it is used for the irrigation of crops, the processing of fuels, in factories and for drinking supplies and other uses. The world population is projected to reach 11 billion in 2100, in comparison to current 7 billion (The Guardian, 2014). By 2030 water demand is expected to exceed current supply by 40% (Water resources group, 2009); consequently resulting in increased pressure on water resources around the world. Computers play a major role in our daily life. According to Gartner (2014), the worldwide personal computer users hit two billion, in 2014, during which approximately 180 million computers are expected to be replaced and 35 million are discarded into landfill. E-waste can contaminate groundwater resources which will contaminate the local ecosystems in the long-run (Deng, et al., 2009). The increasing number of computers is often viewed as a positive development, since computer availability improves access to information. Consequently, a problem arises; technology is rapidly changing at an alarming rate to the point that laptops become redundant after only a few years.

The assessment of the water footprint (WF) is important in supporting corporate water stewardship efforts by providing a decision making tool to measure and understand water use throughout its whole supply chain. Companies have traditionally focused on water use in their operations (i.e. operational WF), but not in their supply chain. However, in the majority of the cases the supply chain water footprint is much larger than the operational water footprint of a product (Hoekstra et al., 2013). As a result, it is more cost-effective for the companies to shift investments from efforts to reduce their operational water use to efforts to reduce their supply chain water footprint of their products and associated risks. Thus, the WF accounting should be based on an integrated approach. When a laptop is purchased by the user, a large quantity of water is already embedded into the product. Water is involved throughout the life cycle of a laptop, from the extraction and refinement of the materials, especially resources such as rare-earth metals (Gellert, 2014), to the transportation and packaging of the finished product, the usage of the laptop and the waste management strategy once the laptop reaches it end-of-life stage. What needs to be done is to examine each water footprint stage individually, highlight any highly intensive water hotspots and suggest ways of rectifying and reducing these hotspots. The goal of the study is to identify water hotspots along the supply chain of a laptop. Thus, the WF can be an efficient tool for companies producing laptops to understand their water use and for the consumers to give 'water value' to their personal computer. The communication of the WF assessment associated to the computer supply chain is of particular importance.

2. Methodology

To gain an understanding of whether water use is having an impact, the volume of water consumption must be considered with the cumulative effect of all uses of the shared water resources. According to Manhart & Grießhammer (2006), a laptop is made from more than 1,800–2,000 parts and is sourced from hundreds of different suppliers (EICC/BSR, 2010). As a result, the supply chain was simplified into a series of phases from 'cradle to grave' as illustrated in *Figure1*. The functional unit investigated is a laptop with generalised features, as proposed by Ekener-Perteren and Finnveden (2013). The Life Cycle Assessment (LCA) diagram (*Figure1*) gives an overview of the whole process; therefore it has been modified to include quantitative data, which precisely identifies the potential hotspots in the process. Different stages were considered and evaluated, in terms of water use, throughout the whole supply chain.

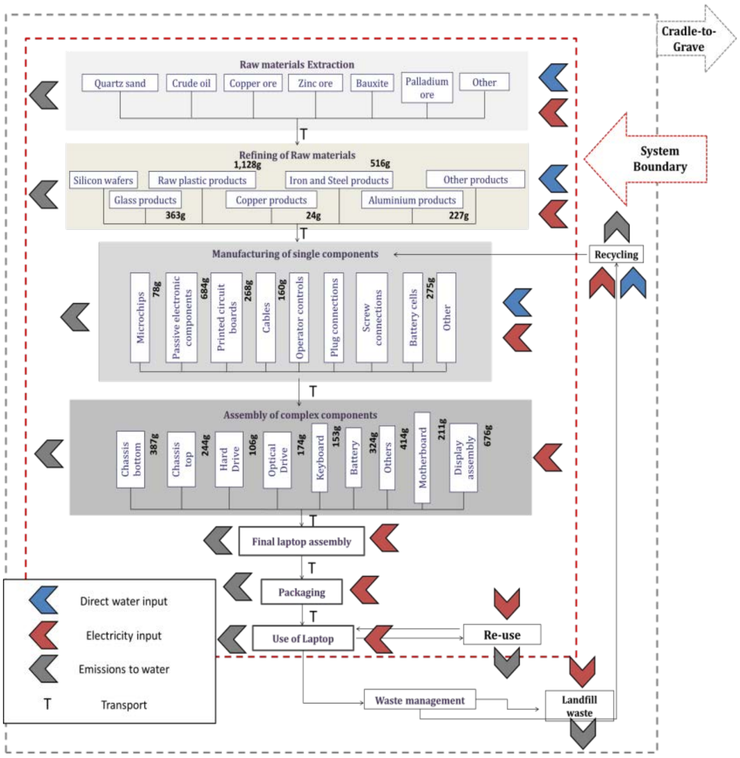

Figure 1. Stages involved in the supply chain (life cycle) of a laptop

Stage 1 - Resource extraction: Raw materials are extracted from over 100 countries around the world; however, the most characteristic materials are shown in *Figure 2*. The Engineering Bill of Materials (BOM) is required to identify the list of raw materials required for laptop production (Ekener-Perteren & Finnveden, 2013). The WF of the raw materials extraction is expressed as the volume of water per kg used, in order to extract and refine the primary materials.

Stage 2 - Refining and processing: At this stage of a laptop's lifecycle the primary materials are refined and processed; for instance, smelters and refineries for minerals and refineries and chemical plants for the fabrication of plastics from oil (Ekener-Perteren & Finnveden, 2013).

Stage 3 - Manufacturing and assembly: It the most difficult stage to analyse, since it requires multiple steps (single-complex components manufacturing, assembly etc.). However, according to Resolve (2010) and Manhart and Grießhammer (2006), the most representative regions are illustrated in *Figure 2*. Water footprint can be calculated by applying the stepwise accumulative approach introduced by Hoekstra et. al. (2011) and is incorporated in the Water Footprint Assessment Manual.

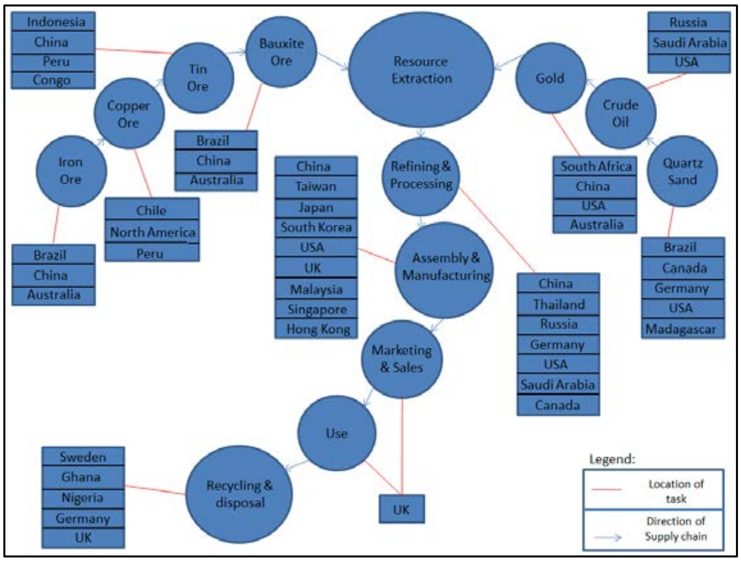

Figure 2. Life Cycle geographical distribution of a laptop

Stage 4 - Marketing and sales, use: This is the interaction between the consumers and the market in the UK, for this case. The laptops are transported from Origin Destination Matrix (ODMs) to the UK for distribution by sales. This entails water consumption by transportation. Use phase is considered to be 5 years, in which water consumed is correlated with energy use.

Stage 5 - Recycling and disposal: The exportation of e-waste is restricted by EU laws, unless it meets the Waste Electrical and Electronic Equipment Recycling Directive requirements (WEEE, Directive 2012/19/EU25). Furthermore there is a total ban in the exportation of e-waste to non-OECD countries after the Basel Convention held in 1989 (Ekener-Perteren & Finnveden, 2013). Subsequently, recycling and disposal is usually undertaken in the end-user country. On the contrary, despite the legalisation e-waste is illegally exported to developing countries, thus contaminating their ecosystem, moreover, resulting in a larger water footprint (UNDOC, 2009).

After assessing the water consumption in each phase of the life cycle of a laptop, the most water consuming procedures were connected with the water availability of the respective regions, and the hotspots are identified.

3. Results & Discussion

Hotspot identification through research following the LCA breakdown is essential as it allows for stakeholders to implement measures in order to reduce water consumption. Hotspots were identified along the laptop's supply chain (Table 1). Raw material extraction is a relatively water intensive stage and is responsible for serious contamination of water resources. It is calculated that 12% of the laptops total water consumption is required for the extraction of primary resources. The most significant portion of the industry's WF is associated with semiconductor and LCD manufacturing (Morrison et. al., 2009). The manufacturing process, in general, is the most water intensive accounting for 51% of water consumption, since this is the point where the final product is created. The following mitigation strategies are proposed to reduce the most water intensive stages:

- A comparison for consumers, so they can make an informed decision on what product to buy. For example, a label could be adapted for use, showing the consumer the most water intensive areas. This would pressurise companies to reduce their WF, in order to remain competitive.
- A recycling scheme with an incentive, so that consumers can get cash-back if they exchange their old laptop to buy a new one. A sort of scrappage scheme for laptops.
- Creating laptops with better specifications that do not become redundant quickly.
- Assuming the plastic parts are the most water intensive, bio-plastics which are less water intensive could be implemented instead. But care needs to be taken to use crops that require low amount of water to grow.
- Standardising the WF methodology, so that all companies follow the same guidelines. This will make it easier for consumers to compare different products fairly.
- Manufacture all parts required in one location to minimise WF that occurs during transportation. Localised factories should be created to serve different continents (e.g. one factory in Europe, one for the Americas, one for Africa etc).

Table 1. Water consumption and total WF throughout the whole supply chain of a laptop

Refining Raw Materials			
Material	Weight (g)	WF of 1 gram (L)	Total WF (L)
Glass	363	0.230	83.5
Raw Plastic	1,128	0.185	209
Copper	24	0.289	6.94
Iron & Steel	516	0.04	20.6
Aluminium	227	0.088	20.0
Water Cooling	-	-	249
Total	2258	0.832	589
Manufacturing of Components			
Material	Weight (g)	WF of 1 gram (L)	Total WF (L)
Electronic Components	762	212	161544
Circuit Boards	268	37	9895
Cables	160	16	2560
Battery Cells	275	23.3	6417
Water Cooling	-	-	41
Total	1465	288.3	180457
Assembly			
Product	Weight (g)	WF of 1 gram (L)	Total WF (L)
Laptop	5000	2.10	10345
Total WF of a Laptop			
Product	Total WF (L)	Total WF (m^3/kg)	
Laptop	191391	**38**	

4. Conclusions

The purpose of this study was to identify water hotspots along the supply chain of a generic laptop. In fact, multiple instances were found, which suggests that the reduction in water consumption during the laptop's life cycle is essential. Focusing on supply and operational water use, it is important to provide a complete picture of a product's full water consumption impact and to address the use of freshwater throughout the supply chain. The production of a personal laptop will consume approximately 38 m^3/kg of product. The average laptop is roughly around 5kg. Hence, a conclusion can be drawn that a laptop will consume approximately 190 m^3 of water. However, further study should take place to ensure all aspects are covered in terms of the raw material extraction processes, distribution of products from different countries, landfilling, disposal and recycling of the product after the end of the service life has been reached.

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