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Life cycle environmental evaluation of kettles: Recommendations for the development of eco-design regulations in the European Union

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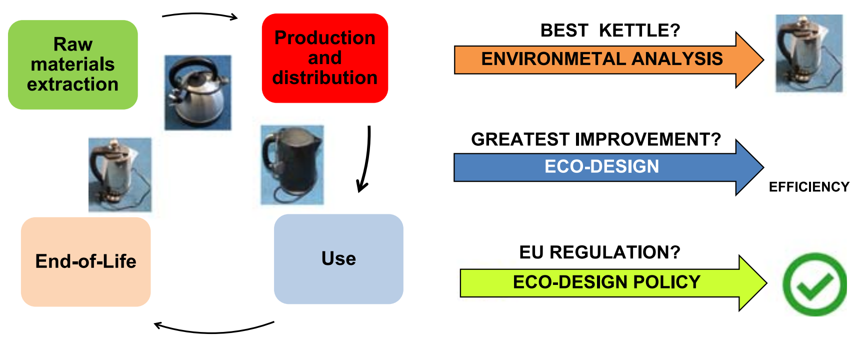
HIGHLIGHTS

- First comprehensive environmental evaluation of 145 million kettles used in the EU.
- Eco-kettles have over 30% lower impacts than conventional kettles.
- Eco-design water efficiency improvements would reduce impacts in the EU by 31%–33%.
- Higher durability and temperature control would result in <5% environmental savings.
- An EU eco-design regulation should be developed focusing on water efficiency.

GRAPHICAL ABSTRACT



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ABSTRACT

Between 117 and 200 million kettles are used in the European Union (EU) every year. However, the full environmental impacts of kettles remain largely unknown. This paper presents a comprehensive life cycle assessment of conventional plastic and metallic kettles in comparison with eco-kettles. The results show that the use stage contributes 80% to the impacts. For this reason, the eco-kettle has over 30% lower environmental impacts due to a greater water efficiency and related lower energy consumption. These results have been extrapolated to the EU level to consider the implications for proposed eco-design regulations. For these purposes, the effects on the impacts of durability of kettles and improvements in their energy and water efficiency have been assessed as they have been identified as two key parameters in the proposed regulations. The results suggest that increasing the current average durability from 4.4 to seven years would reduce the impacts by less than 5%. Thus, improving durability is not a key issue for improving the environmental performance of kettles and does not justify the need for an eco-design regulation based exclusively on it. However, improvements in water and energy efficiency through eco-design can bring relevant environmental savings. Boiling the exact amount of water needed would reduce the impacts by around a third and using water temperature control by further 2%–5%. The study has also considered the effects of reducing significantly the number of kettles in use after the UK (large user of kettles) leaves the EU and reducing the excess water typically boiled by the consumer. Even under these circumstances, the environmental savings justify the development of a specific EU eco-design regulation for kettles. However, consumer engagement will be key to the implementation and achievement of the expected environmental benefits.

1. Introduction

Electrical appliances and electronic products generate environmental impacts in all stages of their life cycle (Andrae, 2016), from

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extraction and production of raw materials, to manufacture and use, to end-of-life waste management. This has been demonstrated by many authors who have analysed different devices such as: televisions (Thomas et al., 2012), refrigerators (Monfared et al., 2014), laptops (Deng et al., 2011), mobile phones (Yu et al., 2010), digital cameras (Park et al., 2007), vacuum cleaners (Gallego-Schmid et al., 2016) and microwaves (Gallego-Schmid et al., 2018). Several life cycle assessment (LCA) studies have also been carried out for kettles, considering electricity and water consumption associated with their use when analysing environmental impacts of hot drinks. Examples include making tea (Azapagic et al., 2016; Cichorowski et al., 2015) or instant coffee (Humbert et al., 2009; Büsser and Jungbluth, 2009) which suggest that energy used by kettles is a key contributor to the impacts of the hot drinks. However, in these studies, other life cycle stages of kettles, such as their production, transport or end-of-life, were not considered. As far as we are aware, only four LCA studies are available in the literature that focused specifically on kettles, one of which was based in the UK (AEA Technology, 2008a, 2008b), one in the Netherlands (VHK, 2010) and the remaining two were carried out at the European Union (EU) level (Fischer et al., 2014; van Elburg et al., 2011). However, they also considered only the use stage, focusing on global warming potential or primary energy consumption. The rest of the life cycle was either omitted completely or aggregated data were used from the Methodology for Eco-design of Energy-related Products (MEErP) EcoReport tool (Kemna et al., 2011). The authors (Fischer et al., 2014) acknowledged in their study that the MEErP EcoReport tool could have under-estimated the impacts from the production of kettles. Similar was also demonstrated in LCA studies of some other devices, including computers (Hopkinson and James, 2011). However, inventory data for other life cycle stages of kettles are limited, incomplete or of insufficient quality (WRAP, 2010; Telenko and Seepersad, 2010). The above discussion suggests that a comprehensive LCA study of kettles considering a range of impacts across the life cycle is not available in the literature.

The environmental importance of kettles in the EU[1] is demonstrated by the fact that these devices have been included in the preparatory studies for establishing the Eco-design Working Plans for 2012–2014 (van Elburg et al., 2011) and 2015–2017 (Fischer et al., 2014). These studies provide background information and analysis to allow the European Commission to select an indicative list of energy-related product groups with high potential for environmental improvements. These devices will then be prioritised for the adoption of improvement measures through development of specific eco-design regulations over the next three years. In the preparatory study for 2012–2014 (van Elburg et al., 2011), kettles were ranked 13th out of the 36 energy-related product groups, but only eight groups were selected for the development of specific eco-design regulations (European Commission, 2012). Nevertheless, the EU preparatory study concluded that significant water and energy savings (up to 37 PJ/yr in 2030) could be achieved for kettles through eco-design measures. The study also concluded that electric kettles have received relatively limited interest as the subject of environmental studies and identified use of material to manufacture kettles as a relevant criterion from the environmental perspective.

In a subsequent preparatory study for the Working Plan 2015–2017 (Fischer et al., 2014), kettles were proposed to the European Commission as a priority for future development of a specific eco-design regulation, considering that there are between 117 and 200 million units with an estimated electricity consumption of 19.5–33.3 TWh/yr. This report suggested that the increase in the durability and the reduction of electricity consumption through eco-design could potentially reduce 42.8–73.2 PJ of primary energy demand, 5040 t of non-hazardous waste and 354 kg Ni eq. of heavy metals emission to air. But, the preparatory study acknowledged that the data on the durability of kettles in the EU were unreliable and highly uncertain as extensive independent data were not available. Therefore, it remains unclear whether the savings in resource consumption would be sufficient to justify an eco-design obligation on durability. For energy and water savings, according to the above-mentioned EU preparatory study (Fischer et al., 2014), the two major eco-design challenges are to reduce the switch-off time of the kettle when the water starts to boil and the excess amount of water used. The former remains under debate as it has been criticised by manufacturers (CECED, 2014), arguing that it is necessary for the water to boil long enough for water to reach 100 °C to kill the bacteria – while this is important in areas with less-stringent water treatment regulations, it is less relevant to the EU. On the other hand, all studies concur that overfilling the kettle is a critical issue from an environmental perspective (AEA Technology, 2008a, 2008b; VHK, 2010; van Elburg et al., 2011; Murray et al., 2015; Sauer and Rüttinger, 2004). Therefore, the environmental effects in the EU of changing the current durability of kettles and using eco-kettles, which enable dosing the exact amount of water needed, are assessed in the present study. This kind of eco-kettle, which is already available on the market, also allows water to be heated to different temperatures, in the range from 80 °C to 100 °C. Lower temperatures are also recommended for some common hot drinks, such as green tea or instant coffee, to preserve the taste (UK Tea and Infusion Association, 2016; Clear, 2016). The environmental benefits of regulating the water temperature, which were not included in the latest EU preparatory studies, have also been analysed here.

Therefore, to address the above-mentioned issues, the main objectives of the present study are:

- to provide a comprehensive life cycle inventory and compare the life cycle environmental impacts of plastic, metallic and eco-kettles and identify opportunities for improvements;
- to assess the environmental effects in the 28 EU countries (EU28) of the implementation of eco-design proposals for kettles, related to water and energy efficiency and their durability; and
- to assess the necessity of a future EU eco-design regulation for kettles.

To our knowledge, this is the first study of its kind internationally.

2. Methods

To achieve the study objectives, the life cycle environmental impacts have been estimated using LCA as tool. The study has been carried out in accordance with ISO 14040/44 guidelines (ISO, 2006a, 2006b), following the attributional approach. The inventory data and the assumptions are presented first individually for each of the three kettle types – plastic, metallic and eco-kettle - and then at the EU level, considering all the kettles in use in the EU28.

2.1. Reference kettles

2.1.1. System description and boundaries

Two main types of kettles are used in the EU: one with metallic (usually stainless steel) and another with plastic body (usually polypropylene), with a market split between the two of 40% and 60%, respectively (VHK, 2010). The European kettle market is homogeneous and characterised by 1.5–2.0 L cordless kettles with power rating of 2200–3000 W, mainly produced in China (Fischer et al., 2014; Murray et al., 2015). Therefore, this study focuses on the comparison of two 3000 W cordless kettles made in China: polypropylene (1.5 L) and stainless steel (1.7 L), which are representative of the European market. Recently, some manufacturers have started to produce new models with eco-design improvements allowing for boiling of the required amount of water and at different temperature settings for different types of drink (Bosch, 2016; Hickman, 2010). Thus, such an eco-kettle is also considered here, with a polypropylene body and power rating of 2200 W; as the other two kettles, it is also cordless and produced in

[1] If not stated otherwise in the text, the term 'EU' includes the UK.