Preparatory study for Kettles implementing the Ecodesign Working Plan 2016-2019

Task 1: Scope

Final report

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Directorate-General for Energy
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LIST OF ABBREVIATIONS AND ACRONYMS

BAT	Best Available Technology
BNAT	Best not yet available technology
CEN	Comité Européen de Normalisation
CENELEC	European committee for electrotechnical standardization
EEE	electrical and electronic equipment
ERP	Energy-related Products
EN	European Standard
EP	European Parliament
EPBD	Energy Performance of Buildings Directive
EPD	Environmental Product Declaration
ESO	European Standardisation Organisation
EU	European Union
FU	functional unit
ISO	International Organization for Standardization
LCA	life cycle assessment
LLCC	Least Life Cycle Cost
MEErP	Methodology for Ecodesign of Energy-related Products
MEPS	Minimum Energy Performance Standard
MS	Member States
MTP	Market Transformation Programme
NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne (European Classification of Economic Activities)
NGO	Non-governmental organisation
PCR	Product Category Rule
RoHS	Restriction of Hazardous Substances
PRODCOM	Production Community
RC	Regulatory Committee *on the Ecodesign of Energy-related Products*
WEEE	Waste Electrical and Electronic Equipment
WTO	World Trade Organization

0. INTRODUCTION

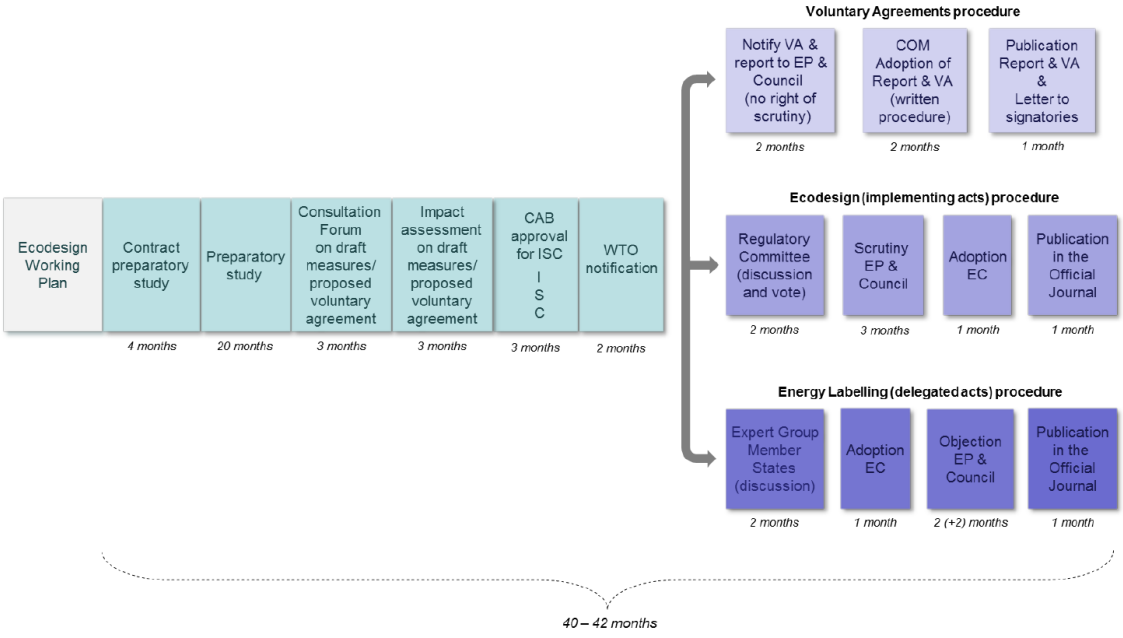
The Ecodesign Directive (Directive 2009/125/EC) establishes a framework for the setting of Community Ecodesign requirements for energy-related products with the aim of ensuring the free movement of such products within the internal market. This preparatory study has been carried out in the framework of this Directive. Its aim is to provide the European Commission with a technical, environmental and economic analysis of electrical kettles following the Methodology for ecodesign of energy-related products (MEErP 2011). According to Article 15 of the Ecodesign Directive, implementing measures can be proposed for products, which meet the following criteria:

- The product shall represent a significant volume of sales and trade, indicatively more than 200 000 units a year within the Community according to the most recently available figures;
- the product shall, considering the quantities placed on the market and/or put into service, have a significant environmental impact within the Community, as specified in the Community strategic priorities as set out in Decision No 1600/2002/EC;[1] and
- The product shall present significant potential for improvement in terms of its environmental impact without entailing excessive costs.

0.1. Legislative process

The process of making Ecodesign Regulations for specific product groups is represented in Figure 0-1.

Figure 0-1: Process of making Ecodesign Regulations (indicative timing, source: EC 2015)



Firstly, a preparatory study is conducted that gives recommendations on how to improve the environmental performance of the product. The study then serves as a basis for the decision as to whether, and if so which, Ecodesign requirements should be set out for that particular product. It provides the Commission with the necessary information to prepare for the next phases in the policy process (to be carried out by the Commission) and in particular the impact assessment, the Consultation Forum, and the possible draft implementing measures laying down Ecodesign requirements for products.

[1] See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32002D1600&from=EN

The scope of this study includes the technical properties of the product as well as its market data. This enables the determination of parameters such as for the Best Available Technology (BAT) and Least Life Cycle Cost (LLCC) of the product.

A working document is then prepared by the Commission based on the results of the preparatory study. Following the completion of the working document the Consultation Forum's first meeting is organised in which stakeholders are invited to give input on the working paper and the possible implementing measures presented in it. The Consultation Forum consists of representatives from Member States, industry and NGOs. An external impact assessment study is prepared in parallel to the meetings.

Afterwards, the final version of the proposed legislation is sent to the Regulatory Committee (RC) on the Ecodesign of Energy-related Products (ERP), which is made up of officials from all Member States. The committee is then allowed to adjust the proposal. It still has to reach a qualified majority for the Commission to present the proposal to the EP and the Council. After the RC has successfully voted for the proposal, the European Parliament (EP) and the Council have three months to apply scrutiny, in which they can review the final proposal and potentially still inhibit its introduction.

The World Trade Organization (WTO) is notified after 3 months and the implementing measure is officially legal after publication in the Official Journal of the European Union.

The result of the process can be a Commission Regulation implementing the Ecodesign Directive and/or the Energy Labelling Regulation. In some cases, the process can lead to a Voluntary Agreement with the industry or to no action, if the process is abandoned. In practice, the whole process typically takes 40 to 42 months, which is slightly longer than in Figure 0-1.

0.2. Ecodesign evaluation

The effectiveness of the Ecodesign Directive and its implementing measures were reviewed and assessed, according to Article 21 of the Directive. In order to prepare for the review and to examine the functioning of the Directive, an independent study[2] was conducted in 2012 to assess the appropriateness of extending the scope of the Ecodesign Directive beyond energy-related products.

The results of the study concluded that, in general, the Ecodesign Directive is effective in attaining its policy objectives (free movement of goods and environmental protection) and that no revision of the Directive is deemed appropriate at the moment or necessary to increase its effectiveness and of its implementing measures.

The study also indicated challenges faced at both the EU and Member State levels in the application of the Ecodesign Directive and its implementing measures, including:

- complex and lengthy preparatory procedure;
- unavailability of reliable data to inform policy decisions (e.g. market trends and technological changes, market data, performance data from market surveillance activities etc.);
- insufficient coordination of Ecodesign measures with other pieces of the EU legislation, such as WEEE, RoHS or EPBD Directives;
- lack of resources to deal with the increasing amount of the regulatory, communication and standardisation work;
- question on the level of ambition of requirements, and especially in Tier-1;
- remaining potential to further address non-energy related issues of energy related products (e.g. material efficiency, recyclability etc.);
- delays in the elaboration of suitable harmonised standards;

[2] CSES (2012)

- insufficient and ineffective market surveillance.

In 2015, the Energy Labelling and Ecodesign Directives were evaluated again.[3] The new Regulation (EU) 2017/1369, setting a framework for energy labelling and repealing Directive 2010/30/EU, is based on the analysis of the evaluation report. The major changes arising from this are the rescaling of the energy label – so that in the future the energy classes will range from A to G - and the establishment of a product database to improve market transparency for market surveillance purposes.

1. TASK 1: SCOPE

1.1. Objectives

The main objective of this task is to determine a clear scoping for electric kettles according to the needs of the Ecodesign process. For this definition, legal, normative and functional aspects related to the topic have been taken into account. These considerations will then serve as a basis for the whole study.

The product classification and definitions to be applied are developed in close agreement with the Commission following a stakeholder consultation process. These are subject to an on-going review throughout the course of the following tasks.

1.2. Product scope

1.2.1. General description and definition

In this task, the definition of the product group "electric kettles" will be clearly stated and will be limited to household appliances, even if such appliances can be used in the tertiary sector (e.g. in hotel rooms).

The Preparatory Study to establish the Ecodesign Working Plan 2015-2017 (BIO 2015) included the product group "electric kettles" and defined them as "kitchen appliances used to produce hot water using electrical heating for hot drinks and food".[4] However, the product group "electric kettles" had a rather heterogeneous scope, including various types of appliances:

Appliances for water, e.g. for making hot drinks other than hot water

This sub-group of appliances covers appliances preparing hot drinks based on hot water. Figure 1-1 presents common types of such appliances.

Figure 1-1: Main types of hot drinks appliances



Electric moka pot



Traditional filter coffee machines (coffee pot)

[3] See EC (2015)

[4] See BIO (2015)

1.2.1.1. Electric water kettles[5]

Electric water kettles are stand-alone appliances designed to boil water used for the production of food or hot drinks. Some water kettles can also heat water to a different pre-set temperature and/or maintain the water at the target temperature. A concealed element below a metal plate or an immersed heating element coil heats the water of the reservoir. Figure 1-2 shows different types of electric kettles.

Figure 1-2: Different types of electric water kettles



Traditional or dome shape kettle



Jug shape kettle



Kettle with temperature setting

There are different types of electric water kettles, which can be distinguished in particular by following characteristics:[6]

- corded or cordless;
- temperature setting (with pre-set temperature or adjustable temperature);
- capacity to keep the water at the target temperature (keep-warm);
- size (capacity of the water reservoir):
  - small portable kettles (also called travel kettles) below 1.0 litre
  - medium size kettles with about 1.5 – 2.0 litres (the most common size) or even 2.5 litres
  - large appliances: urns, which are usually designed with a tap to dispense hot water. The capacity ranges usually between 2.5 and 26 litres
- rated input power ranges typically between 1500 and 2400 W;
- material of the water reservoir. Some travel kettles can be folded.

1.2.1.2. Boiling water heaters

Boiling water heaters are products designed to supply boiling water instantly and directly from a tap. The water is boiled in a tank (usually 3 to 7 litres) by means of an immersed resistive element (power from 1600 to 2400 W).

There are two types of boiling water heaters depending on the location of the installed tank: either the tank is installed in the kitchen cupboard and linked to the boiling water tap on the worktop or it is visible and installed outside the kitchen cupboard.

---

5 These are to be distinguished from other types of kettles that heat water on a hob

6 More information is provided in 1.2.3.3 and in Task 4

Boiling water taps can provide boiled water much faster than kettles and are easier to handle. However they require to be permanently installed and are considerably more expensive than kettles, even if kettles have generally lower running costs.[7]

On the market, certain boiling water heaters can provide boiling water as well as domestic hot water. Only those boiling water heaters are covered by Commission Regulation (EU) No. 814/2013 (Ecodesign)[8] and Commission Delegated Regulation (EU) No. 812/2013 (Energy Label)[9] for water heaters. However, boiling water heaters designed for solely the production of food or hot drinks are excluded from the water heaters regulation.

1.2.1.3. Hot water dispensers

Hot water dispensers are stand-alone appliances which supply hot water on demand. The required quantity of water to be consumed is pumped from a reservoir and heated up through an integrated instantaneous water heater. The typical rated power is 3000W.
Compared to a kettle, a hot water dispenser has the advantage to quickly dispense a cup or a large mug of hot water. On the downside the water is hot but not boiling[10] and the quantity of water delivered is generally between 150 ml and 350 ml at once.

1.2.1.4. Urns

Urns boil and heat large quantities of water to a preset temperature and then maintain it at that temperature. Urns come in a variety of sizes and shapes. It should be noted that a particular variant of urns are samovars, which include a teapot placed on top. The teapot is filled manually with hot water from the urn in order to prepare the tea. Figure 1-3 shows a typical urn.

Figure 1-3: Urn



1.2.2. Preliminary scope of this study

While the Preparatory Study to establish the Ecodesign Working Plan 2015-2017 (BIO 2015) defined the product group "electric kettles" as "kitchen appliances used to produce hot water using electrical heating for hot drinks and food", it included a broad panel of products as presented in 1.2.1.

Therefore the project team suggests to exclude some types of products. Since the expected energy service of the product group is to produce hot water, which will then be used for the preparation of hot drinks and food, appliances producing only hot drinks instead of hot water[11] are excluded. Furthermore, stand-alone hot water dispensers are as well discarded, since they are restricted to supplying only one cup or mug of hot water and might be a niche product category and therefore

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7 Boiling one litre three times per day, according to Which? https://www.which.co.uk/reviews/kettles/article/quookers-and-boiling-water-taps-are-they-worth-it

8 See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013R0814

9 See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R0812

10 According to Which https://www.which.co.uk/reviews/kettles/article/hot-water-dispensers-how-to-buy-the-best

11 E.g. tea or coffee

deliver a different energy service. Regarding boiled water heaters, such products are technical systems, which require high investment costs and usually have be installed by a professional. The distribution channel is typically a kitchen planer, since a boiled water heater has to be integrated in a (new) kitchen. Consequently, they are hardly comparable to "simple" electrical water kettles. In other words, boiled water heaters are closer to a system than to a household appliance.

Based on this, a more restricted definition of the scope is proposed for the product group "electric kettles":

Definition of the scope of the preparatory study:

"Electric kettles" are stand-alone, unpressurized, electrically powered kitchen appliances primarily intended for boiling a batch of up to 10 litres of drinking water, potentially also including the possibility to heat water below boiling temperature and/or a warm-keeping function after heating.

This definition is a working basis, which may be adjusted in the light of the information provided in the Task 2 and 3 reports.

The 10 litres threshold for the water storage is set in accordance with the EN 60335-2-15.[12] Since the volume of urns is typically up to 26 litres, only small and medium urns will be included within the scope of this study. Based on this definition, the following appliances are clearly excluded from the scope of the study:

- appliances producing directly hot drinks (e.g. coffee machines and tea makers);
- egg boilers;
- feeding-bottle heaters;
- milk heaters;
- cooking pans;
- pressure cookers having a rated cooking pressure not exceeding 140 kPa and a rated capacity not exceeding 10 litres;
- slow cookers;
- steam cookers;
- wash boilers;
- yoghurt makers;
- rice cookers.

1.2.3. Product categories

In this section, product scoping should be discussed with regard to existing classifications. For this purpose, the corresponding classifications including PRODCOM classification will be briefly discussed.

1.2.3.1. PRODCOM categories

According to the MEErP methodology, the official European production statistics from the PRODCOM database should be used as a preferential data source for refining the scope of preparatory studies. PRODCOM consists of a survey of at least annual frequency, with the purpose of collecting and disseminating statistics on the production of various industrial (mostly manufactured) goods in the EU, mainly in terms of value and quantity. The word PRODCOM stands for the French "Production Communautaire". All products that are involved in the survey are listed in the PRODCOM lists and are given an eight-digit label. The first four digits refer to the equivalent class within the Statistical classification of economic activities in the European Community (NACE), and the subsequent two correspond to subcategories within the Statistical classification of products by activity. The

[12] "Household and similar electrical appliances. Safety. Particular requirements for appliances for heating liquids", see in 1.4.1

PRODCOM survey results can be accessed on the Eurostat website in an extensive database containing annual production and economic data partially dating back to 1995.

A recurring difficulty with PRODCOM data is that it does not provide details (e.g. category or size) on products. For kettles, the issue is that the current PRODCOM database does not even label electric kettles clearly.

Since 2011, water heaters operated electrically are labelled in two categories (see Table 1-1). A more detailed analysis on the PRODCOM database is conducted in Task 2.

Table 1-1: PRODCOM statistics for water heaters (source: Eurostat 2018)[13]

PRODCOM code	Description
27.51.25.30	Electric instantaneous water heaters
27.51.25.60	Electric water heaters and immersion heaters (excluding instantaneous water heaters)

Until 2010, Prodcom Eurostat Nace Rev 2 code had a slightly more detailed categorization (see Table 1-2).

Table 1-2: PRODCOM statistics for water heaters (source: Eurostat 2010)[14]

PRODCOM code	Description
27.51.25.30	Electric instantaneous water heaters
27.51.25.50	Electric water heaters (including storage water heaters) (excluding instantaneous)
27.51.25.70	Electric immersion heaters (including portable immersion heaters for liquids, usually with a handle or a hook)

According to the Working Plan study, 27.51.25.50 included electric kettles (until 2010). This category also covered boiling water heaters. Hot water dispensers are electric instantaneous water heaters and accordingly part of 27.51.25.30. However, the NACE categories are not precise enough to contribute to the definition of the scope of this study.

1.2.3.2. Categories according to EN- or ISO-standard

The standard IEC 60530;1975 "Methods for measuring the performance electric kettles and jugs for household and similar use" provides a brief definition of kettles or jugs: "A portable appliance for boiling water with means for pouring, either a lip or spout".

1.2.3.3. Categories according to technologies and features

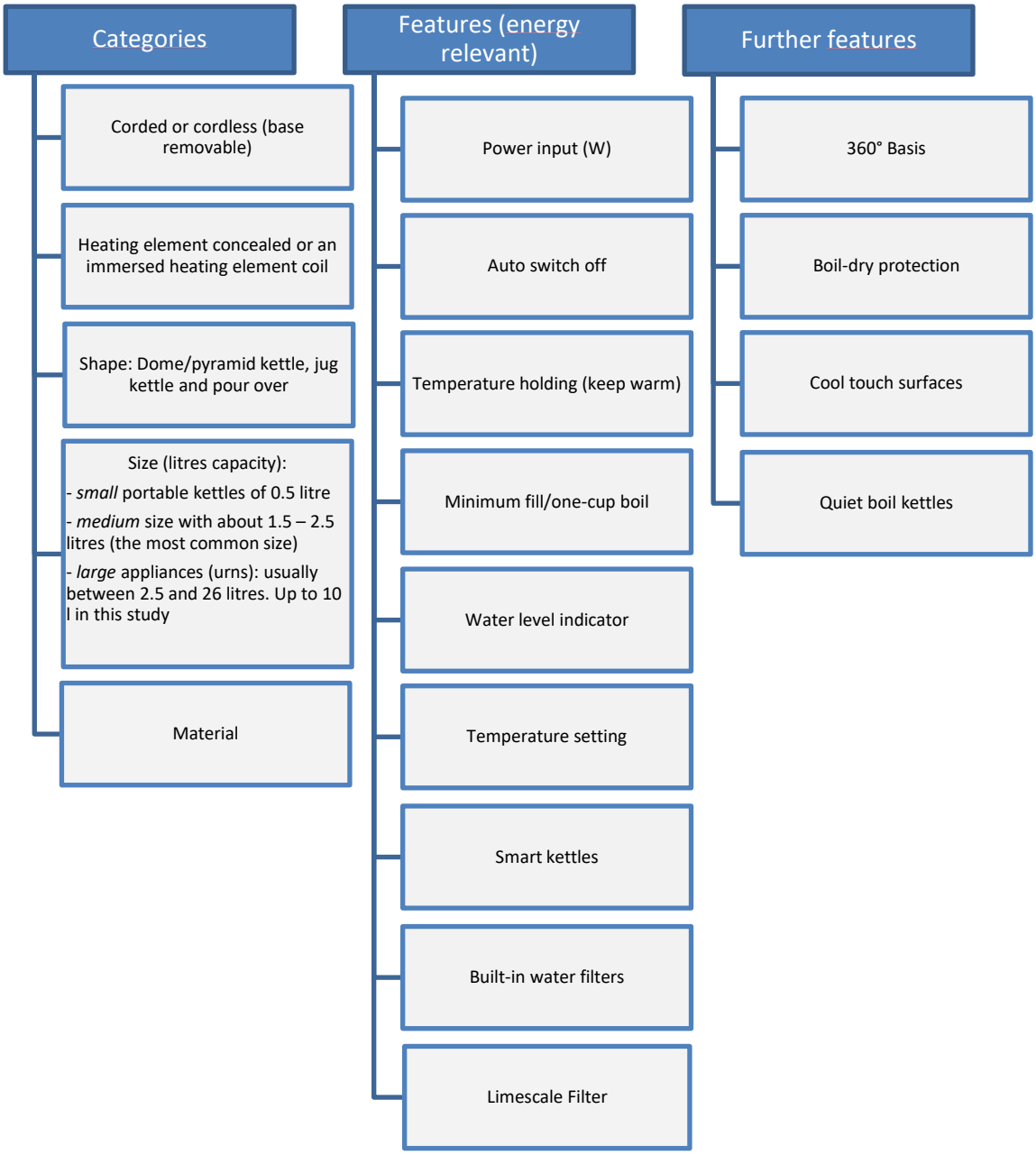
The U.K. consumers' association *Which?* has tested numerous electric kettles and provided an extensive overview of the categories and features of electric kettles on the market.[15] Based on this information, a categorisation by technologies and features of the product groups is proposed by the project team (see Figure 1-4). The categorisation covers categories, energy-relevant features and further features.

[13] See: https://ec.europa.eu/eurostat/documents/120432/10398214/Website_snapshot_2018_N2+%281%29.xlsx/3170ebc2-2ec4-b45b-3381-cd37449f308b

[14] See: https://ec.europa.eu/eurostat/documents/120432/10398214/Website_snapshot_2010_N2.xlsx/9a73ab26-e5be-a9c0-e484-a7050e9afd27

[15] See: https://www.which.co.uk/reviews/kettles/article/recommendations/which-best-buy-kettles

Figure 1-4: Overview of the different types of electric kettles (own representation partly based on Which?[16])



Short description of the main features:[17]

- auto switch-off: the kettle automatically switches off as soon as the water is heated and starts to boil;
- boil-dry protection: if there is not enough water in the kettle, it is automatically switched off;
- temperature setting: the temperature to which the water is to be heated can be set individually;
- keep-warm: keep the water at a pre-set temperature;

16 https://www.which.co.uk/reviews/kettles/article/how-to-buy-the-best-electric-kettle

17 Most of the descriptions are based on https://www.which.co.uk/reviews/kettles/article/kettle-features-explained

- smart Kettle: the kettle is connected to the smart home functions. It has various automatic features that can be remotely controlled;
- built-in water filter: no external water filter is required, as a filter is already installed in the upper part of the kettle and filters the water when pouring;
- limescale filter (or anti scale spout): mesh filter (typically located in the spout) that is especially important for hard water treatments;
- cool touch surface: the outside of the kettle remains cold due to the insulation, even when the water is boiling;
- quiet boil kettles: kettles are silently boiling the water;
- 360° base: the kettle can be placed on the base regardless its orientation.

1.3. Functional unit and performance parameters

1.3.1. Functional unit (FU)

The main function of an electric kettle is to heat water either to boiling or pre-set temperature. The functional unit is the amount of boiled water. So far, no standard covers the FU for electric kettles.

The net consumption of boiled water may vary substantially across European countries since the boiled water consumption is linked to drinking and cooking habits. However, based on the publications reviewed in Task 3, it is assumed that the Functional Unit corresponds to 800 litres of boiling water per year.

1.3.2. Primary Performance parameters

The following primary performance parameters have been identified for kettles:

- volume (litre) of the water container of the kettle (IEC 60530:1975)
- power input (W)

1.3.3. Secondary Performance parameters

Apart from the primary performance parameters mentioned in 1.3.2, secondary performance factors include:

- time to boil the water (s)
- time to automatic switch off (s), when boiling water
- noise (dB) even if this is generally not measured
- minimum amount of water to be heated (litre)
- pre-set temperature below boiling temperature (°C)
- shut-off temperature (°C), when boiling water
- temperature for keep warm (°C)

1.4. Test standards

The general objective of this task is to describe test standards related to the product categories described within the scope of this study. Standards are documents drawn up by consensus and approved by a recognised standardisation body. A test standard describes a method of testing in which no pre-given result is required when performing the test.

1.4.1. European Standards

The Comité Européen de Normalisation (CEN) states on their website that "A European Standard (EN) is a standard that has been adopted by one of the three recognised European Standardisation Organisations (ESOs): CEN, CENELEC or ETSI. It is produced by all interested parties through a transparent, open and consensus based process". These European Standards are seen as a vital element to the Single European market, as they serve as catalysts for greater social interaction

with technology as well as facilitating market exchange across industries. Regarding electric kettles, two technical bodies are relevant:

- CLC/TC 59X: Performance of household and similar electrical appliances
- CLC/TC 61: Safety of household and similar electrical appliances

The European standards available for electric kettles are given in Table 1-3. They were retrieved from the CEN website. So far, none of the EN standards addresses energy (efficiency) issues, only EN 50564 focuses on low power energy consumptions.[18]

Table 1-3: Main EN standards relevant for electric kettles

Reference	Title	Linked to regulation	Short title of the regulation
EN 50564[19]	Electrical and electronic household and office equipment - Measurement of low power consumption	1275/2008/EC	Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment
EN 55014-1[20]	Electromagnetic compatibility – Requirements for household appliances, electric tools, and similar apparatus: Emission	2014/30/EC	EMC Directive
EN 55014-2[21]	Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus: Immunity	2014/30/EC	EMC Directive
EN 62233[22]	Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure	2014/35/EC	LVD Directive

1.4.2. International Standards

For electrical appliances, the standards elaborated and published by the International Electrotechnical Commission (IEC)[23] are relevant. The Technical Committee TC 59[24] "Performance of household and similar electrical appliances" includes SC 59L, which is responsible for the standardisation of performance measurement of small household appliances and similar electrical appliances except surface cleaning appliances, it includes kettles.

Table 1-4 presents the most relevant IEC standards.

[18] Note that EN standards which are identical to ISO standards are not included in the analysis of this section but covered by the ISO section (see 1.4.2).

[19] EN 50564:2011-12: IEC 62301:2011, modified

[20] EN 55014-1:2017: CISPR 14-1:2016 + COR1:2016

[21] EN 55014-2:2015: CISPR 14-2:2015

[22] EN 62233:2008: IEC 62233:2005, modified

[23] https://www.iec.ch/

[24] https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1275,25

Table 1-4: Main IEC standards relevant for electric kettles

Reference	Title	Linked to regulation	Short title of the regulation
IEC 60335-1	IEC 60335-1 Household and similar electrical appliances – Safety: General requirements	2014/35/EC	Low Voltage Directive
IEC 60335-2-15	Specification for safety of household and similar electrical appliances. Particular requirements for appliances for heating liquids	2014/35/EC	Low Voltage Directive
IEC 61000-3-2	Electromagnetic compatibility (EMC). Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)	2014/30/EC	EMC Directive
IEC 61000-3-3	Electromagnetic compatibility (EMC). Limitations of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection	2014/30/EC	EMC Directive
IEC 60530:1975 IEC 60530:1975/AMD1:1992 IEC 60530:1975/AMD2:2004	Methods for measuring the performance of electric kettles and jugs for household and similar use		
IEC 60704-3:2019	Household and similar electrical appliances - Test code for the determination of airborne acoustical noise - Part 3: Procedure for determining and verifying declared noise emission values		

So far, most of the IEC standards deal with generic or safety issues. Only IEC 60530:1975 focuses on the performance of electric kettles:

- scope: Applies to electric kettles and jugs for household and similar use with a capacity up to 2.5 litres.
- purpose: The purpose of this standard is to state and to define the principal performance characteristics of electric kettles, which are of interest to the user and to describe the standard methods for measuring these characteristics.
- characteristics measured:
  - overall dimensions
  - mass
  - length of flexible cord
  - water capacity
  - time to boil 1 litre of water
  - time to boil water capacity
  - minimum quantity of water that can be boiled

- temperatures of supporting surface

The time to boil 1 litre of water is defined as the time to heat up 1 litre of cold water (15 °C) by 80°C, reaching a temperature of 95°C. Even if IEC 60530:1975 does not include the measurement of the electricity consumption, it describes clearly when boiling 1 litre of water is completed and could therefore be used for a possible ecodesign and/or energy efficiency regulation. The standard could be also easily upgraded to measure the electricity consumption required for boiling 1 litre of water and accordingly to rate the energy efficiency of an electric kettle.

1.4.3. Environmental Product Declaration

Electric kettles are not covered by Product Category Rules (PCRs), accordingly, no Environmental Product Declaration (EPD) has been elaborated.

1.4.4. Test standards in individual Member States

Non-harmonised standards of EU Member States applicable to electric kettles are listed in this section.

RAL-UZ 133 – Water kettles (Germany)

This standard is elaborated by RAL GmbH and is used to check if a water kettle fulfils the requirements of the voluntary Blue Angel eco-label (see Figure 1-5).[25] The scope of this standard is the electric water kettles for household use.

According to the Power Consumption Test Protocol:

- 1 litre of water is poured in the kettle (at an atmospheric pressure of 1 bar)
- Temperature difference compared to the boiling temperature of 100°C (at an atmospheric pressure of 1 bar) is measured (TM)
- power consumption until automatic switch-off of the kettle (water must boil before switch off) is measured (WM)
- finally, the power consumption is calculated as follows:[26]

$$W_{20} = W_M * 80 / T_M$$

The standard requires a Maximum Power Consumption of W_{20} = 0.115 kWh/litre of water.

The test standard is rather simple and lacks the specifications about:

- the room temperature, where the test is carried out
- how to deal with small water kettles (water reservoir <1 litre) or with large kettles

1.4.5. Other test standards

1.4.5.1. Stiftung Warentest (Germany)

Stiftung Wartentest[27] (German consumer organisation) assesses the performance of kettles. For this purpose, it measures the power consumption for heating up ¼, ½ and 1 litre of water until shutoff as well as the power consumption in standby.

[25] See basic award criteria (version 3 from September 2013) under: https://www.blauer-engel.de/en/products/electric-devices/water-boilers-electric-kettles

[26] In order to make it corresponding to temperature difference of 80°C

[27] https://www.test.de/

1.4.5.2. Topten (Switzerland)

Topten Switzerland has developed following Power Consumption Test Protocol for electric kettles:[28]

- measure the consumption to heat 1 litre of water from 15° to 100°C
- measure the power to keep the water warm
- measure the standby by power

Finally, the power consumption is calculated as follows:

$E_{kettle} = E_{boil} + E_{keep\ warm} + E_{stand\text{-}by}$

With:

$E_{boil} = 365 * E_{consumption}$ to heat 1 litre

if T-setting feature is available: -10%

$E_{keep\ warm} = P_{keep\ warm}$ x 0.5 x (max time keep-warm) x 365

if no measurement possible: 15 W x 1h x 365

$E_{stand\text{-}by}$: $P_{stand\text{-}by}$ x 8760 h

Kettles < 45 kWh/a fulfill the Topten criteria.

1.5. Existing legislation

According to the MEErP methodology, EU legislations, Member State legislations and third country legislations relevant to the product group have been screened and analysed.

1.5.1. European legislation

1.5.1.1. Overview

At the EU level, the main regulations relevant for electric kettles are listed in Table 1-5 and only one has a direct impact on energy consumption.

[28] https://storage.topten.ch/source/files/Technische-Kriterien-Wasserkocher-2017.pdf

Table 1-5: Overview of the main relevant regulations on EU level

Scope	Reference	Title (short)	Aim
Energy	2009/125/EC With 1275/2008 (and amendments)	Ecodesign Directive With: ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment	max 0.5 W in off mode max 0.5 W in standby mode max 1.0 W when providing only information networked equipment[29]: 2.0 W
Quality	93/68/EEC	CE Marking Directive	Conformity Marking and harmonisation of the market
Safety	2014/35/EC	Low Voltage Directive	Harmonisation of the laws related to safety issues of electrical equipment designed for use within certain voltage limits
Safety	2014/30/EC	Electromagnetic compatibility (EMC) Directive	Compatibility and safety issues
Safety	2011/65/EU	RoHS Directive	Restriction of the use of certain hazardous substances in electrical and electronic equipment
Safety	1935/2004/EC	Materials and articles intended to come into contact with food	
Environment	2012/19/EU	WEEE	Waste electrical and electronic equipment
Environment	2008/98/EC	Waste	Waste
Environment	2018/2005/EU	REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

Based on this overview, there is currently no European regulation specific to electric kettles. Even if there is no energy label for kettles in the EU, some sellers show confusing information for consumers (e.g. online website showing kettles with an A++++).

1.5.1.2. Details of the directive and regulations

This section provides details on the Directives and regulations listed in 1.5.1.1.

- Standby and off mode power consumption Regulation 1275/2008[30]

  Commission Regulation (EC) No 1275/2008 of 17 December 2008 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment (Text with EEA relevance)

  The regulation establishes ecodesign requirements related to standby and off mode electric power consumption. This Regulation applies to electrical and electronic household and office equipment, including kettles.[31]

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29 Equipment other than high network availability network equipment

30 See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R1275&from=EN

31 See Frequently Asked Questions (FAQ) on the Ecodesign Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products and its Implementing Regulations: "Annex II applies to any product falling under the Regulation, including kettles ("Other appliances for cooking and other processing of food", water is considered to be food.)", (EC 2019)

Annex I provides a list of energy-using products covered by this Regulation. "Other appliances for cooking and other processing of food, cleaning, and maintenance of clothes" are listed among the household appliances, and water is considered to be food.

Since 2013, the requirements both in standby mode and in off mode are 0.5 W.[32] (according to Annex II).

- Low Voltage Directive 2014/35/EC[33]

  Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits Text with EEA relevance

  Directive 2014/35/EU regarding Low Voltage electrical equipment (LVD) was issued in February 2014 and repeals the existing directive 2006/95/EC with effect from April 2016. The purpose of this Directive is to ensure that electrical equipment on the market fulfils the requirements providing for a high level of protection of health and safety of persons, and of domestic animals and property, while guaranteeing the functioning of the internal market. The Directive applies to electrical equipment designed for use with a voltage rating between 50 and 1000 V for alternating current and between 75 and 1500 V for direct current. These voltage ratings refer to the voltage of the electrical input or output, not to voltages that may appear inside the equipment. For electrical equipment within its scope, the directive covers all health and safety risks, thus ensuring that electrical equipment will be used safely and in applications for which it was made. For most electrical equipment (including kettles), the health aspects of emissions of electromagnetic fields are also under the domain of the Low Voltage Directive.

- Waste Electrical and Electronic Equipment Directive (WEEE) 2012/19/EC[34]

  Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) Text with EEA relevance

  The 2012/19EC Directive aims to avoid waste from electrical and electronic equipment (WEEE) and to reduce such waste by reuse, recycling and other forms of recovery. It lays down minimum standards for the treatment of WEEE in the EU, so as to preserve, protect and improve the quality of the environment and to use natural resources wise and cautiously.

  The categories of electrical and electronic equipment (EEE) covered by this Directive are:

  - large household appliances
  - small household appliances
  - IT and telecommunication equipment
  - consumer equipment and photovoltaic panels
  - lighting equipment
  - electrical and electronic tools (with the exception of large-scale stationary industrial tools)
  - toys, leisure and sports equipment
  - medical devices (with the exception of all implanted and infected products)

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32 See Annex II of the Regulation 1275/2008

33 See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0035&from=DE

34 See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0019&from=EN

- monitoring and control instruments
- automatic dispensers.

In the Directive, EEE is defined as:

- equipment which is dependent on electric currents or electromagnetic field in order to work properly
- equipment for the generation, transfer and measurement of such currents and fields
- equipment designed for use with a voltage rating not exceeding 1000 V for alternating current and 1500 V for direct current.

Equipment types excluded from the Directive are:

- equipment which is specially designed and installed as part of another type of equipment that is excluded from or does not fall within the scope of this Directive, which can fulfil its function only if it is part of the equipment
- large-scale fixed installations, except any equipment which is not specifically designed and installed as part of those installations
- means of transport for persons or goods, excluding electric two-wheel vehicles which are not type-approved.

Relevance for electric kettles: According to Annex IV of the WEEE directive, kettles are listed as "Small equipment" (category 5). From 15 August 2018[35], the minimum target applicable for kettles are:

- 75 % shall be recovered, and
- 55 % shall be prepared for re-use and recycled;

- RoHS Directive 2011/65/EC[36]

  Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment Text with EEA relevance

  Directive 2011/65/EU contributes to the protection of human health and the environment, including the environmentally sound recovery and disposal of waste EEE" by regulating their use and placing on the market. The aim is to eliminate hazardous components from electronic waste. It includes the replacing of leaded solderings and promotion of the introduction of equivalent replacement products where possible.

  Member states should ensure that new products do not contain any of the following substances:

  - mercury
  - cadmium
  - hexavalent chromium
  - polybrominated biphenyls (PBB)
  - polybrominated diphenyl ethers (PBDE).

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35 See Annex V

36 See https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:174:0088:0110:en:PDF

- The categories of EEE covered by this Directive are (Annex 1):
- large household appliances
- small household appliances
- IT and telecommunications equipment
- consumer equipment
- lighting equipment
- electrical and electronic tools
- toys, leisure and sports equipment
- medical devices
- monitoring and control instruments including industrial monitoring and control instruments
- automatic dispensers
- other EEE not covered by any of the categories above.

Relevance for electric kettles: at the time of the Preparatory Study, the use of 6 substances[37] was restricted by the RoHS directive

- Waste Framework Directive 2008/98/EC[38]

  Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance)

  This Directive of the European Parliament and of the Council of 19 November 2008 sets the basic waste management definitions for the EU. Furthermore, it provides a general framework of waste management requirements.

  Relevance for electric kettles: at the end of life, they should be treated and recycled according to the waste legislation.

  Since 15 August 2018, kettles (explicitly included in the non-exhaustive list of EEE covered by the directive) are subject to the requirements of the Directive 2008/98/EC.

- REACH 1907/2006[39]

  Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC

  REACH is a regulation of the European Union, adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals, while

[37] The Restricted substances are: Lead, Mercury, Cadmium, Hexavalent chromium, Polybrominated biphenyls (PBB), Polybrominated diphenyl ethers (PBDE) (see Directive 2011/65/EU ANNEX II)

[38] See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0098&from=DE

[39] See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006R1907-20140410&from=EN

enhancing the competitiveness of the EU chemicals industry. It also promotes alternative methods for the hazard assessment of substances in order to reduce the number of tests on animals. In principle, REACH applies to all chemical substances including those used in electrical appliances. To comply with the regulation, companies must identify and manage the risks linked to the substances they manufacture and market in the EU.

- Electromagnetic compatibility (EMC) Directive 2014/30/EU[40]

  Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility (recast) Text with EEA relevance

  The EMC directive limits electromagnetic emissions from equipment in order to ensure that, when used as intended, such equipment does not disturb radio and telecommunication, as well as other equipment. The directive also governs the immunity of such equipment to interference and seeks to ensure that this equipment is not disturbed by radio emissions, when used as intended. The main objectives of the directives are to regulate the compatibility of equipment regarding EMC:

  - equipment (apparatus and fixed installations) needs to comply with EMC requirements when it is placed on the market and/or taken into service,
  - the application of good engineering practice is required for fixed installations, with the possibility that competent authorities of EU countries may impose measures in instances of non-compliance.

- Materials and articles intended to come into contact with food – Directive 1935/2004/EC[41]

  Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC

  Commission Regulation (EC) No 1935/2004 provides a harmonised legal EU framework. It sets out the general principles of safety and inertness for all Food Contact Materials (FCMs). The principles set out in Regulation (EC) No 1935/2004 require that materials do not:

  - release their constituents into food at levels harmful to human health
  - change food composition, taste and odour in an unacceptable way
  - moreover, the framework provides:
  - for special rules on active and intelligent materials (they are by their design not inert)
  - powers to enact additional EU measures for specific materials (e.g. for plastics)
  - the procedure to perform safety assessments of substances used to manufacture FCMs involving the European Food Safety Authority
  - rules on labelling including an indication for use (e.g. as a coffee machine, a wine bottle, or a soup spoon) or by reproducing the appropriate symbol. For more information, please refer to the following document on Symbols for labelling food contact materials.

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40 See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0030&from=DE

41 See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004R1935&from=en

- for compliance documentation and traceability

Complementary, there are further legislations on specific substances.[42]

1.5.2. Member State legislation

In this section, a scoping of national laws and ordinances of Member States has been performed.

1.5.2.1. Germany: Blue Angel eco-label RAL-UZ 133

The Blue Angel eco-label (see Figure 1-5) for domestic electric kettles RAL-UZ 133 is a voluntary endorsement label.[43]

Figure 1-5: Blue Angel eco-label (source: Umweltbundesamt)



To be awarded, manufacturers must apply to the program with an electric kettle fulfilling specific environmental properties (see Table 1-6) covering among others: energy efficiency, water level and minimum warranty time.

[42] E.g. Commission Regulation (EU) 2018/213 - on the use of bisphenol A

[43] See basic award criteria (version 3 from September 2013) under: https://www.blauer-engel.de/en/products/electric-devices/water-boilers-electric-kettles

Table 1-6: Main requirements of Blue Angel eco-label RAL-UZ 133 (source: based on Umweltbundesamt)[44]

Characteristics	Requirements
Scope	Domestic cordless kettles
Minimum energy efficiency	20°C to auto-switch off <0.115kWh/litre 15°C to auto-switch off <0.122kWh/litre
Water level indicator	Must have marks that start at least at 0.5 litres with 0.25 litre increments and be visible from at least 0.3 litre
Manufacturer's warranty	Two years
Information	Information for users on energy efficient use such as not boiling more water than needed and providing descaling instructions
Material Requirements[45]	Several requirements regarding: Plastics used in water tank and base plate shall meet criteria set by different regulations (EC 1272/2008 and REACH). Halogenated polymers as well as halogenated organic compounds shall not be permitted. Flame retardants shall only be added if they are accordingly classified by the regulation EC 1272/2008. There are some exceptions that are excluded from the rule: – technically unavoidable impurities – fluor organic additives to improve the physical properties if their weight is less than 0.5 percent – plastic parts less than 25 grams in mass Plastic parts that may be touched shall contain less than 10 mg/kg of polycyclic aromatic hydrocarbons (PAHs) and less than 1 mg/kg benzo[a]pyrene. Components in contact with drinking Water: In accordance with the provisions of the German Food and Feed Code and with the relevant BfR recommendations for materials coming into contact with food. Bisphenol A is not to be released by plastic components or sealling material.
Safety Requirements	The electric kettle shall switch off within no more than 15 seconds if switched on without water

According to the Blue Angel website, only one kettle has been awarded the label.[46]

1.5.2.2. U.K.

The UK Energy Saving Trust covers electric kettles. The main requirements of "ESR003 Product Performance Requirements" were:

Products should demonstrate a 20% reduction in energy consumption compared to the consumption of an average kettle. Unfortunately, no detail on how to measure it has been published;
Products must consume ≤1W in passive standby (0.5W is now required by the EU standby Regulation);

[44] See the full version under: https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20133-201309-en%20Criteria-2020-01-07.pdf

[45] Summarized

[46] https://www.blauer-engel.de/en/products/electric-devices/water-boilers-electric-kettles/ritter-kettle-fontana-5

Applicants should demonstrate due diligence in considering design and usability of the product; and Products must conform to the relevant British Standards applicable to this class of product, including:

- BS EN 60335-1:2002 "Household and similar appliances. Safety. General requirements"
- BS EN 60335-2-15:2002 "Specification for safety of household and similar electrical appliances. Particular requirements for appliances for heating liquids."

1.5.3. Third country legislation

For this section, the policy database of CLASP[47] provides valuable information to identify relevant legislations.

1.5.3.1. China: GB/T 22089-2008

The **voluntary** standard GB/T 22089-2008 "Performance requirements and measuring methods for electric kettles" specifies performance requirements for household and electric kettle and test methods for similar purposes (Table 1-7). This standard applies to the rated voltage not exceeding 250V and the rated capacity of below 2.5 litres. The standard is based on IEC 60530.

The energy efficiency is defined as:

$$\eta = \frac{C*M*(T2-T1)}{E} * 100\%$$

Whereby:

- **η** is the thermal efficiency in %;
- **c** is the specific heat capacity of water, 4,187 J/(K.kg);
- **M** is the mass of water in kg;
- T_1 is the initial water temperature, expressed in °C;
- T_2 is the final water temperature, expressed in °C;
- ***E*** is the energy consumption, expressed in J.

[47] See https://clasp.ngo/policies

Table 1-7: Main requirements of GB/T 22089-2008 (source: Standardization Administration of the People's Republic of China)

Characteristics	Requirements
Scope	Electric kettles with a rated voltage not greater than 250 V AC and a rated capacity not greater than 2.5 L
Minimum energy efficiency	Thermal efficiency > 80% Measured with the rated capacity of water. The measure is stopped when the water temperature reaches 80 °C. Test condition: room temperature 20 +/- 5 °C, implicitly the same for the water temperature[48].
Material Requirements	No
Performance Requirements	The water temperature shall be not lower than 98 °C.
Service Life Requirements	The service life shall be not less than 3,000 working cycles (carried out with water rated volume).

The MEPS are complemented by an energy label, which differentiates three classes (Grade A to C, see Figure 1-6). Interestingly, the grades are not only based on thermal efficiency criteria but also on service lifetime (see Table 1-8).

Figure 1-6: China Energy Label[49] (source: CNIS)



Table 1-8: Main Performance Grading of Electric Kettles (source: GB/T 22089-2008)

Test	Unit	Grade A	Grade B	Grade C
Thermal efficiency	%	>= 93	>= 85	>= 80
Service Life (cycle)	Number of times	>= 8,000	>= 5,000	>= 3,000

1.5.3.2. Korea: Eco-Label Standard EL408:2013

The Korean Eco-Label (see Figure 1-7) is a state-certified eco-label, which provides environmental information to consumers. Eco-Labelling seeks to induce firms in developing and producing eco-

[48] The thermal efficiency test requires to make the initial water temperature as consistent with the ambient temperature as possible

[49] As example (no kettle presented here)

friendly products. It is a **voluntary** scheme developed and implemented by the Ministry of Environment. The Korean Eco-Label Standard EL408:2013 is dedicated to electric kettles and coffee makers. [50] The main requirements for electric kettles are provided in Table 1-9.

Figure 1-7: Korean Eco-Label logo (source: Ministry of Environment of Korea)



Table 1-9: Main requirements of EL408:2013 (source: Ministry of Environment of Korea)

Characteristics	Requirements
Scope	Electric kettle
Minimum energy efficiency	The consumption power when boiling the water shall be 120 Wh or less per 1 L of water. The temperature shall be 99°C or more right after the power is off. Test condition: room temperature 20 +/- 2 °C, water temperature 15 +/- 0.5°C.
Material Requirements	Several requirements regarding: Materials, accessories and components. Electric kettles may not contain: – lead, cadmium, mercury and their compounds – hexavalent chrome Cr^{6+} – polybrominated biphenyls (PBBs) – polybromodiphenyl ethers (PBDEs) More than 50% chlorine concentration SCCP
Safety Requirements	The power shall be automatically off when the water boils

1.5.3.3. Taiwan: Greenmark N126

Similar to the Blue Angel endorsement label in Germany, Taiwan has elaborated the Greenmark scheme, which covers electric kettles (see Figure 1-8).[51] The main requirements are summarized in Table 1-10.

[50] See http://el.keiti.re.kr/enservice/enpage.do?mMenu=2&sMenu=1

[51] See http://greenliving.epa.gov.tw/GreenLife/uploadfiles/Criteria/126/7ab784a7-239c-4e83-86c5-ca7331a47b72.pdf

Figure 1-8: Greenmark (source: Environmental Protection Administration)



Table 1-10: Main requirements of Greenmark N126 (source: based on Environmental Protection Administration)

Characteristics	Requirements
Scope	This standard is applicable to electric kettles, which meet the definition of CNS 15548.
Minimum energy efficiency	The product's water boiling energy consumption shall be less than 0.117 kWh/L, with an initial water temperature of 15 ℃. The water temperature at the end of the boiling cycle shall be above 99 ℃.
Water level indicator	The product shall have an easy to read and transparent water level indicator.
Disassemblability	The product shall be disassemble.
Information	The product shall have a clearly visible warning light to indicate that it is in use (power on).
Material Requirements	Several requirements regarding materials, accessories and components. There are regulatory limits for coating material (lead, cadmium, hexavalent chromium and mercury) as well as for plastics ((lead, cadmium, hexavalent chromium, mercury, PBBs, PBDEs, chloroparaffins with 10-13 carbon atoms per molecule, TPT, TBT and phthalate ester plasticizers).
Safety Requirements	The product shall power off automatically within 15 seconds when it is empty.

While the Blue Angel requires max 0.122 kWh/l for 85 °C temperature increase, Greenmark N126 requires max 0.117 kWh/l for 84°C and is therefore more stringent in terms of energy efficiency.

1.5.3.4. Thailand: Energy Efficiency Label No.5 for Electric Kettle

As a further Asiatic country covering electric kettles, Thailand has elaborated and implemented a **voluntary** comparative label in 2010 (see Figure 1-9).[52]

[52] See http://labelno5.egat.co.th/new58/wp-content/uploads/2016/form/mn/ele_kettle.pdf

Figure 1-9: Energy label in Thailand (source: Ministry of Energy, Thailand)



The energy efficiency is defined as:

$$\eta = \varrho * \frac{T_2 - T_1}{0{,}24\ P * t} * 100$$

Whereby:

- η is the energy efficiency in %
- ϱ is the volume of water used in the test, ml
- T_1 is the initial temperature of the water (30 °C)
- T_2 is the final temperature of the water (90 °C)[53]
- T is the time for heating the water from the water temperature of 30 °C to 90 °C in s
- P is the power input of the electric kettle from the water temperature of 30 °C to 90 °C in W

The energy efficiency classes are defined as follows:

Energy efficiency value (percent)		
Number 3	Number 4	Number 5
82.00-85.99	86.00-89.99	≥ 90

1.5.3.5. Iran- ISIRI 7875

The Islamic Republic of Iran has elaborated and implemented Minimum Energy Performance Standards (MEPS) as well as energy labelling[54] requirements for large electric kettles. The standard ISIRI 7875 covers the specifications and energy labelling of the electric kettles as well as the methods and indicators for measuring the energy consumption. The main characteristics of this standard are summarized in Table 1-11.

[53] In case the thermostat switches off at a temperature below 90 °C, short-circuit the thermostat so that the water in the electric kettle reaches the temperature of 90 °C

[54] See http://www.behsa.ir/index.php/booklibrary/standards/20-isiri-7875/file

Table 1-11: Characteristics of ISIRI 7875 (source: ISIRI 2005)

Characteristics	Requirements
Scope	Electric kettles with a rated volume between 4 and 30 L, and a rated voltage of up to 250 $V_{a.c.}$
Definition	Domestic electric kettle: rated volume max 10 L Commercial electric kettle: rated volume between 10 and 30 L
Performance	Time to heat the water from 20°C to 90°C is measured
Energy efficiency	Defined as the energy consumption per hour and per L to maintain the water at 90°C. Test is carried out over 2 hours, water reservoir is refilled with "cold water" every 30 min to compensate the volume of water evaporated.
Safety Requirements	The products shall comply with the safety standards of the electric kettles (INSO 1562-15)

The scope of the Iranian standard is large kettles (urns and samovar), the energy efficiency metric is focusing on the energy to maintain the temperature constant and not on the energy to heat up the water.

Table 1-12 presents the energy efficiency classes of the energy label (Figure 1-10).

Table 1-12: Energy efficiency classes of electric kettles (source: ISIRI 2005)

Energy Efficiency Class	EE in [Wh/L] for domestic kettle	EE in [Wh/L] for commercial kettle
A	$E_e < 108$	$E_e < 83$
B	$108 \leq E_e < 112$	$83 \leq E_e < 84$
C	$112 \leq E_e < 117$	$84 \leq E_e < 86$
D	$117 \leq E_e < 121$	$86 \leq E_e < 87$
E	$121 \leq E_e < 125$	$87 \leq E_e < 88$
F	$125 \leq E_e \leq 130$	$88 \leq E_e \leq 90$

The energy label for the electric kettles (Figure 1-10) indicates the energy efficiency class (A-F), boiling time (m), energy consumption (Wh/L), rated power (W) and rated volume (L). Only the products with the energy efficiency classes A and B are granted the permit to be imported into the country.

Figure 1-10: Energy label for electric kettles (source: ISIRI 2005)



1.5.4. Summary and conclusion on the review on legislations for electric kettles

A first assessment of the legislation regarding energy efficiency of electric kettles has revealed a lack of energy regulations in the EU. The majority of existing regulations directed to kettles predominantly cover safety aspects and no stringent requirements regarding energy efficiency could be found, except for stand-by requirements.

Outside the EU, a handful of countries in the world – which have a tea culture - have implemented energy efficiency regulations for electric kettles. However, most of these regulations are voluntary energy labelling schemes.

No test standard to measure the energy efficiency or the energy consumption of electric kettles could be identified. Yet, IEC 60530:1975 could be easily upgraded for this purpose.

1.6. Conclusions for product scoping

The work carried out under Task 1 suggests that the scope of the study could be exclusively limited to electric kettles with a volume of up to 10 litres. The proposed scope of the study for the Working Plan included products providing a different energy service than that of electric kettles. Analysis of Task 2 (market) and Task 3 (users) will be used to assess this preliminary scope. There is a lack of test standards to assess the energy consumption of kettles. Few voluntary programs (a majority in Asia) covering electric kettles have been identified. These programs have developed their own methodology to measure and assess the energy consumption or the energy efficiency of kettles.

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Task 2: Markets

Final report

Request for services N° ENER/C4/FV 2019-467/06/FWC 2015-619 LOT1/05 in the context of the Framework Contract N° ENER/C3/2015-619 Lot 1

Team:
Contract technical team leader: Antoine Durand (Fraunhofer ISI)
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May - 2021

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Preparatory study for Kettles implementing the Ecodesign Working Plan 2016-2019

Task 2: Markets

Final report

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2. TASK 2: MARKETS

2.1. *Task introduction*

General objective of Task 2:

The objective of Task 2 is to present an economic and market analysis of the products covered in Task 1. The aims are:

- to place kettles (according to the definition provided in 1.2.) within the context of EU industry and trade policy (subtask 2.1);
- to provide market size and cost inputs for the EU-wide environmental impact assessment of the product group (subtask 2.2);
- to provide insight into the latest market trends to help assess the impact of potential Ecodesign measures with regard to market structures and ongoing trends in product design (subtask 2.3, also relevant for the impact analyses in Task 3); and finally,
- to provide a practical data set of prices and rates to be used for Life Cycle Cost (LCC) calculations (subtask 2.4).

2.2. *Subtask 2.1- Generic economic data*

General objective of subtask 2.1:

In the MEErP[1] generic economic data refers to data that is available in official EU statistics (e.g. PRODCOM) and the aim of the subtask is to identify and report the 'EU apparent consumption' or 'sales' which is defined as 'EU production + EU import – EU export'. Also, the average value of each product is verified. The information required for this subtask should be derived from official EU statistics so as to be coherent with official data used in EU industry and trade policy.

Approach:

Data from PRODCOM relevant for the study can be found under the codes:[2]

- 27.51.25.60 - Electric water heaters and immersion heaters (excluding instantaneous water heaters), data from 2011[3].
  This category covers, among others, water kettles and boiling water heaters. A wide range of water heaters regulated by Commission Regulation (EU) No 814/2013[4] and Commission Delegated Regulation (EU) No 812/2013[5] are also included in this NACE category.
- 27.51.25.30 - Electric instantaneous water heaters.
  Here, statistics for hot water dispensers can be fund, but the NACE category includes further types of products.

The indicators available within the PRODCOM codes are displayed in Table 2-1. Besides these indicators, it is important to acquire data concerning the volume of imports and exports. Since such data is available in PRODCOM, one option would be to derive it from other related data sets.

---

1 see COWI and VHK (ed.) (2011)

2 see Task 1 report of this preparatory study

3 up to 2010: 27.51.25.50 - Electric water heaters (including storage water heaters) (excluding instantaneous)

4 see: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013R0814

5 see: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R0812

Table 2-1: Indicators available at PRODCOM

Data field	Definition
EXPQNT	Volume of exports in the unit indicated in UNIT, derived from the External Trade statistics
EXPVAL	Value of exports in Euro, derived from the External Trade statistics
IMPQNT	Volume of imports in the unit indicated in UNIT, derived from the External Trade statistics
IMPVAL	Value of imports in Euro, derived from the External Trade statistics
PRODQNT	Volume of production in the unit indicated in UNIT
PRODVAL	Value of production in Euro

Based on the indicators shown in Table 2-1, it is possible to calculate the sales or market, as following:

Equation 2-1 SALES = PROD + IMP - EXP

Table 2-2 provides an overview of the EU27 statistics for NACE 27.51.25.60 - Electric water heaters and immersion heaters (excluding instantaneous water heaters). The yearly sales have been calculated and they increased from 25 million units in 2011 to 35 million units in 2018, corresponding to an average of 6% increase per year over the same period. A large majority (90%) of the products placed on the EU market are imported.

Table 2-2: EU 27 PRODCOM for NACE 27.51.25.60 - Electric water heaters and immersion heaters (excluding instantaneous water heaters) (source: Eurostat 2020)

PERIOD/ INDICATORS	Exported quantity (million of units) EXPQNT	Value exports (M€) EXPVAL	Imported quantity (million of units) IMPQNT	Value imports (M€) IMPVAL	Produced quantity (million of units) PRODQNT	Value produced goods (M€) PRODVAL	*SALES QNT (million of units) calculated*	*SALES VAL (M€) calculated*
2011	6.05	142.09	22.02	226.83	9.04	901.92	*25.02*	*986.66*
2012	5.55	149.59	21.76	239.10	6.31	826.09	*22.52*	*915.60*
2013	7.30	203.17	25.39	262.36	7.88	925.68	*25.97*	*984.87*
2014	6.37	166.80	27.81	277.34	8.30	986.28	*29.73*	*1,096.83*
2015	5.71	171.46	28.12	321.50	10.38	1,117.34	*32.79*	*1,267.38*
2016	5.70	194.25	27.92	324.36	8.90	1,019.60	*31.12*	*1,149.72*
2017	6.49	223.21	29.23	351.89	8.97	1,098.81	*31.71*	*1,227.48*
2018	5.83	226.09	31.86	375.93	9.50	1,159.77	*35.53*	*1,309.61*

Statistics on Member States (see Table 2-3) for the year 2018 show some gaps and are difficult to explain, e.g. in Italy, the calculated sales are negative. However, based on these statistics, the four main countries manufacturing this type of products are: Italy (34%), Poland (18%), France (12%) and Bulgaria (11%).[6]

[6] Unfortunately, production statistics from some key countries, like Germany, are missing.

Table 2-3: EU 27 PRODCOM for NACE 27.51.25.60 - Electric water heaters and immersion heaters (excluding instantaneous water heaters), MS & U.K., 2018 (source: Eurostat 2020)

DECL/INDICATORS	Exported quantity (1,000 units) EXPQNT	Value exports (1,000 Euros) EXPVAL	Imported quantity (1,000 units) IMPQNT	Value imports (1,000 Euros) IMPVAL	Produced quantity (1,000 units) PRODQNT	Value produced goods (1,000 Euros) PRODVAL	*SALES QNT (1,000 units), calculated*	*SALES VAL (1,000 Euros), calculated*
Austria	493	9,004	1,133	20,263	:	*:*	-	-
Belgium	974	79,964	1,399	51,220	:	*:*	-	-
Bulgaria	797	50,828	260	4,859	1,054	*76,543*	*518*	*30,574*
Croatia	66	3,054	401	10,681	69	*4,594*	*403*	*12,221*
Cyprus	-	-	67	896	-	-	*67*	*896*
Czechia	2,600	48,709	4,028	49,698	:	*:*	-	-
Denmark	83	5,368	279	8,266	:	*:*	-	-
Estonia	4	336	132	4,957	0	*48*	*128*	*4,669*
EU27	5,826	226,090	31,861	375,930	9,496	*1,159,770*	*35,531*	*1,309,610*
Finland	21	1,757	115	7,522	:	*9,092*	-	-
France	287	41,514	1,787	114,660	1,132	*223,695*	*2,632*	*296,840*
Germany	7,712	115,125	14,822	153,717	:	*:*	-	-
Greece	17	794	517	9,828	80	*5,628*	*580*	*14,662*
Hungary	507	14,563	701	13,010	:	*:*	-	-
Ireland	23	1,071	482	7,520	:	*:*	-	-
Italy	8,436	189,649	2,471	43,324	3,185	*216,657*	*-2,780*	*70,332*
Latvia	35	915	221	5,083	-	-	*186*	*4,169*
Lithuania	151	3,512	533	9,561	-	-	*382*	*6,049*
Luxemburg	0	13	25	1,432	-	-	*25*	*1,420*
Malta	0	8	65	2,546	-	-	*65*	*2,538*
Netherlands	2,316	50,462	4,833	65,525	191	*124,897*	*2,707*	*139,961*
Poland	1,672	22,619	4,314	39,975	1,754	*37,752*	*4,396*	*55,107*
Portugal	206	19,720	471	14,212	:	*:*	-	-
Romania	19	1,065	736	20,602	:	*:*	-	-
Slovakia	215	8,448	766	8,587	:	*:*	-	-
Slovenia	226	2,749	1,532	12,207	-	-	*1,306*	*9,458*
Spain	421	13,942	2,814	71,952	:	*:*	-	-
Sweden	351	31,283	723	13,974	:	*:*	-	-
U.K.	*707*	*25,687*	*6,944*	*85,580*	*685*	*103,868*	*6,922*	*163,761*

Note: ":" means statistics not available

Table 2-4 provides an overview of the EU27 statistics for NACE 27512530 - Electric instantaneous water heaters. The yearly sales have been calculated and show large fluctuations, ranging between 1.74 million to 14.58 million of units depending on the year. No clear trend can be observed. The ratio between "imported quantity" and "sales quantity" varies largely, ranging between 35% and 117%, with an average of 84% over the last 11 years.

Table 2-4: EU 27 PRODCOM for NACE 27.51.25.30 - Electric instantaneous water heaters (source: Eurostat 2020)

PERIOD/ INDICATORS	Exported quantity (Mio. units) EXPQNT	Value exports (Mio. Euros) EXPVAL	Imported quantity (Mio. units) IMPQNT	Value imports (Mio. Euros) IMPVAL	Produced quantity (Mio. units) PRODQNT	Value produced goods (Mio. Euros) PRODVAL	*SALES QNT (Mio. units), calculated*	*SALES VAL (Mio. Euros), calculated*
2008	0.37	35.28	1.18	35.46	2.51	285.65	*3.33*	*285.84*
2009	0.36	30.72	0.93	35.14	1.94	223.44	*2.51*	*227.86*
2010	0.34	30.39	0.74	35.12	1.58	217.29	*1.97*	*222.02*
2011	1.48	98.15	1.69	42.21	1.53	215.52	*1.74*	*159.58*
2012	2.00	117.00	3.16	43.93	1.53	245.76	*2.70*	*172.69*
2013	0.91	66.11	3.83	43.74	1.67	264.67	*4.60*	*242.29*
2014	1.81	109.86	2.33	47.45	1.48	229.49	*2.00*	*167.08*
2015	1.69	113.60	5.28	56.64	1.45	204.46	*5.03*	*147.50*
2016	1.17	82.13	7.10	72.00	1.57	274.30	*7.50*	*264.17*
2017	0.68	60.07	13.72	72.04	1.55	225.06	*14.58*	*237.03*
2018	1.54	66.85	3.86	78.32	1.42	228.14	*3.75*	*239.61*

Statistics on Member States for the year 2018 (see Table 2-5) show also many gaps for the production. However, based on these statistics, Poland seems to be the main country manufacturing this type of products in the EU27 covering 31% of the EU27 production.

Table 2-5: EU 27 PRODCOM for NACE 27512530 - Electric instantaneous water heaters), ember States and U.K., 2018 (source: Eurostat 2020)

DECL/INDICATORS	Exported quantity (1,000 units) EXPQNT	Value exports (1,000 Euros) EXPVAL	Imported quantity (1,000 units) IMPQNT	Value imports (1,000 Euros) IMPVAL	Produced quantity (1,000 units) PRODQNT	Value produced goods (1,000 Euros) PRODVAL	*SALES QNT (1,000 units), calculated*	*SALES VAL (1,000 Euros), calculated*
Austria	3	273	114	3,838	-	-	*111*	*3,566*
Belgium	161	12,590	100	9,933	:	:	*:*	*:*
Bulgaria	13	348	146	1,915	22	727	*155*	*2,293*
Croatia	2	169	26	867	-	-	*23*	*697*
Cyprus	0	11	31	1,057	-	-	*30*	*1,045*
Czechia	234	3,616	264	4,735	:	:	*:*	*:*
Denmark	15	1,395	13	1,226	-	-	*-2*	*-169*
Estonia	1	132	14	793	-	-	*13*	*661*
EU27	1,535	66,847	3,861	78,321	1,421	228,138	*3,747*	*239,613*
Finland	1	88	23	604	-	-	*23*	*516*
France	395	8,542	279	10,772	:	:	*:*	*:*
Germany	5,514	72,267	1,389	41,219	:	:	*:*	*:*
Greece	12	196	146	1,090	9	824	*143*	*1,718*
Hungary	893	3,757	784	9,271	:	:	*:*	*:*
Ireland	212	10,743	352	18,989	:	:	*:*	*:*
Italy	52	1,941	1,307	12,430	-	-	*1,255*	*10,488*
Latvia	8	711	21	774	:	:	*:*	*:*
Lithuania	10	553	40	2,228	-	-	*30*	*1,675*
Luxemburg	2	285	27	1,259	-	-	*25*	*974*
Malta	0	34	3	195	-	-	*3*	*161*
Netherlands	68	4,092	59	5,427	:	:	*:*	*:*
Poland	770	12,067	930	11,805	434	17,139	*594*	*16,877*
Portugal	78	5,637	242	5,047	:	:	*:*	*:*
Romania	3	104	124	3,141	:	:	*:*	*:*
Slovakia	144	15,769	565	7,069	:	:	*:*	*:*
Slovenia	10	259	74	1,106	-	-	*64*	*847*
Spain	51	1,090	454	16,464	-	-	*403*	*15,374*
Sweden	109	2,402	13	1,789	:	:	*:*	*:*
U.K.	*480*	*30,226*	*2,176*	*50,685*	*:*	*113,806*	*:*	*134,265*

Note: ":" means statistics not available

Even if the PRODCOM statistics cover basically water kettles and similar boiling water products, they have a limited relevance for this study, thus alternative data sources will be used when possible. The main reasons are:

- the PRODCOM statistics are not specific enough:
  - 27.51.25.60 - Electric water heaters and immersion heaters (excluding instantaneous water heaters) covers a wide family of products. Therefore, it is not possible to estimate figures for "water kettles" and for "boiling water heaters", or even for both types of products together.
  - 27.51.25.30 - Electric instantaneous water heaters: Specific statistics for hot water dispensers cannot be found.
- some figures reported are so dynamic and instable that it is difficult to understand them or rely on them. This is specially the case for 27.51.2.5.30.

UNCOMTRADE reports detailed global trade data. UNCOMTRADE is a repository of official international trade statistics and relevant analytical tables. The dataset covers statistics on "Heaters; electric, instantaneous or storage water and immersion heaters" (Commodity Code 851610). This Commodity Code includes immersion water heaters and electric kettles (HS 85161019), hence including also the products other than the scope of this study. However, it could provide some indications on the possible export and import countries relevant for the EU in 2018 for electric kettles.

In 2018, 9 countries accounted for 67% of the exports of the EU (see Table 2-6) and two countries were responsible for 90% of the imports, of which China accounted for around 80% of the EU imports (see Table 2-7).

Table 2-6: Export from the EU of Heaters; electric, instantaneous or storage water and immersion heaters (Commodity Code 851610), in 2018 (source: UNCOMTRADE)

Export countries	Share of EU export [%]
Russian Federation	16.83%
Ukraine	16.65%
USA	8.27%
United Arab Emirates	5.92%
China, Hong Kong SAR	4.96%
Switzerland	4.94%
Serbia	3.54%
Morocco	3.31%
Saudi Arabia	2.67%

Table 2-7: Import in the EU of Heaters; electric, instantaneous or storage water and immersion heaters (Commodity Code 851610), in 2018 (source: UNCOMTRADE)

Import countries	Share of EU export [%]
China	79.45%
Turkey	11.20%
Tunisia	2.66%
Egypt	1.94%

2.3. *Subtask 2.2- Market and stock data*

General objective of subtask 2.2:

The objective is to compile market and stock data in physical units for the EU, for each of the product categories defined in Task 1.1 and for the stock, combined with a forecast. Therefore, the following parameters need to be identified:

- installed base ('stock');
- annual new product sales growth rate (% or physical units);
- average economic product life (in years), in service, and a rough indication of the spread (e.g. standard deviation);
- total new product sales / real EU-consumption;

Approach:

As mentioned in 2.2, PRODCOM statistics do not provide precise figures for the "electric kettles" market. No further data could be provided by manufacturers (APPLiA[7] and its members).
In order to be able to carry out this task, market data at EU level was purchased from GfK[8]. GfK is a well-known market research institute gathering market data which is considered in various Ecodesign preparatory studies. GfK portfolio covers also electric kettles[9] and gathered detailed information related to technical features.

2.3.1. Sales

Kettles

For this study, only aggregated EU data was purchased. EU data from GfK covers data gathered in 17 Member States [10] which, in total, corresponds to 91% of the EU households. Hence, the total sales were corrected to have an estimate of the EU 27 figures, by scaling up the GfKs figures on the total number of EU households.
As presented in Figure 2-1 and Table 2-8, the market is clearly dominated by water kettles, which make over 99.5% of the market. The other types of electric kettles – hot water dispensers, kettles and hot water dispensers, kettles and milk heaters, kettles and teapots as well as milk heaters –

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7 see section 2.4.2

8 see https://www.gfk.com/home

9 sub categories are: hot water dispenser, kettle and hot water dispenser, kettle and milk heater, kettle and tea pot, milk heater and water kettle

10 DE, AT, IT, FR, ES, PT, NL, BE, IE, SE, DK, FI, PL, CZ, HU, SK and GR

have an extremely marginal market importance. In other words, at EU level, the water kettle market is almost the same as the electric kettle market.

Figure 2-1: Overview of the EU27 kettle market (based on GfK 2020)

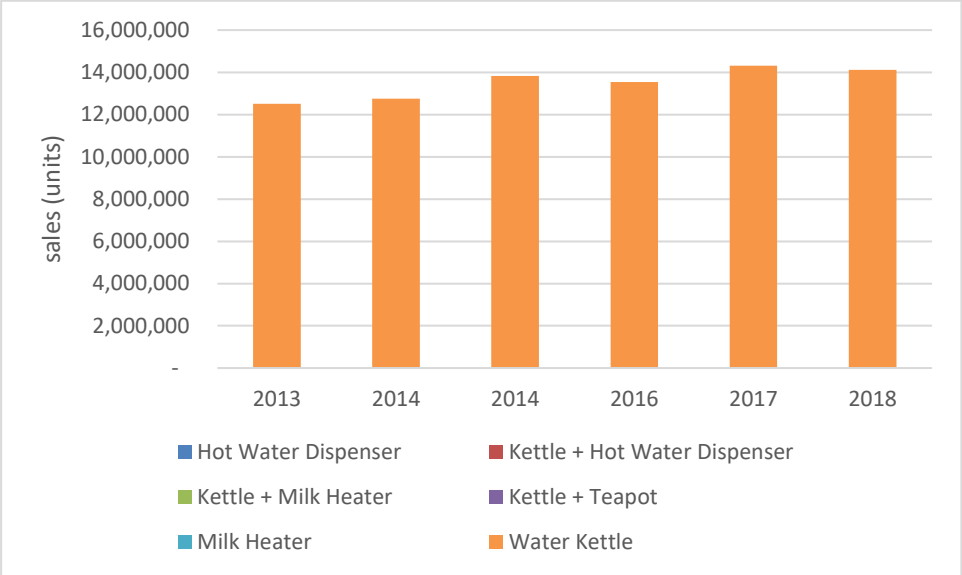
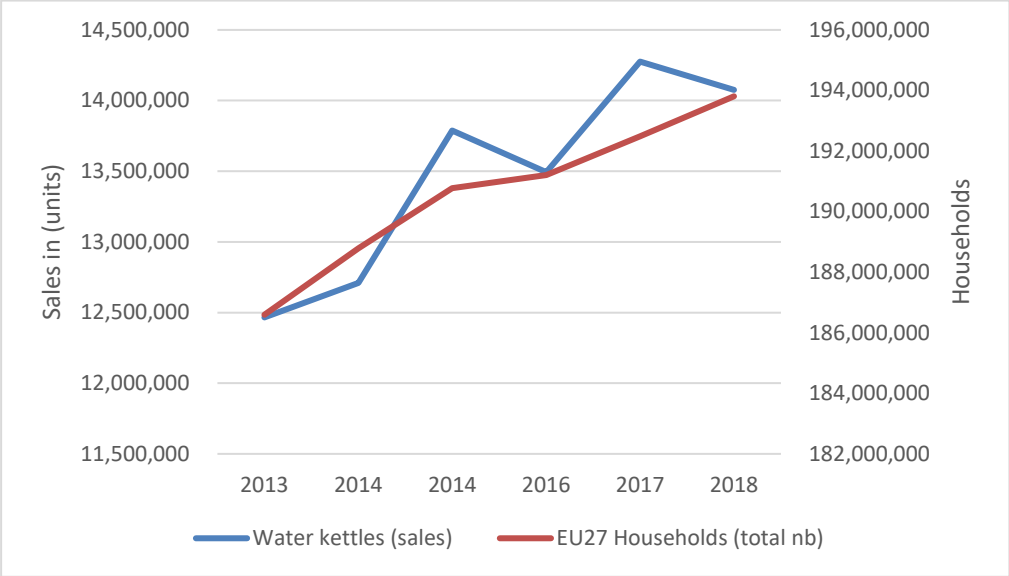


Table 2-8: Overview of the EU27 kettle market (based on GfK 2020)

Product category	2013	2014	2014	2016	2017	2018
Hot Water Dispenser	21,563	18,563	17,133	22,421	13,983	19,263
Kettle + Hot Water Dispenser	403	1,442	3,127	779	444	292
Kettle + Milk Heater	415	147	66	279	143	1,959
Kettle + Teapot	1,403	1,007	2,880	3,985	2,490	7,797
Milk Heater	17,692	15,324	17,459	16,520	14,512	14,859
Water Kettle	12,465,663	12,710,124	13,788,260	13,493,268	14,275,653	14,074,792

Between 2013 and 2018, the sales increased from 12.5 million of units/year to 14.1 million of units/year. Figure 2-7 shows that the sales seem to be driven by the number of households in the EU.

Figure 2-8: Number of water kettles and households in EU27 (source: GfK 2020 and Eurostat 2020)



Statista[11] provides also few statistics on the EU27 kettle market and covers all Member States. The EU27-sales amount to around 12 million of units / year (Table 2-9) which is in the range of the GfK figures.

Table 2-9: Overview of the kettles EU27-market (source: Statista 2020)

	2012	2013	2014	2015	2016	2017	2018
Turnover in million €	362.20	365.53	369.03	372.78	376.55	380.61	384.96
Sales in millions of units	11.46	11.60	11.73	11.88	12.02	12.17	12.32
Price per unit in €	31.60	31.52	31.45	31.39	31.32	31.27	31.24

The market shares of each Member State was estimated based on figures gathered by Statista. Table 2-10 presents the market shares according to the relevance of the national market to the EU27 market.

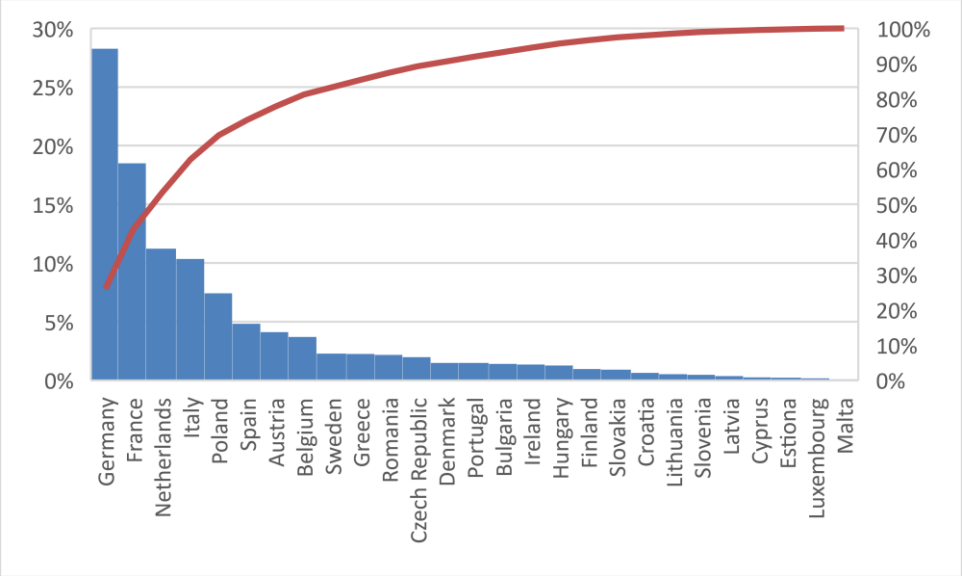
[11] https://www.statista.com/outlook/16021200/102/electric-kettles/europe

Table 2-10: EU27 market shares according to Member States[12] in year 2019 (source: Statista 2020)

Country	Market share (sales)	Country	Market share (sales)	Country	Market share (sales)
Austria	4%	France	18%[13]	Malta	0%
Belgium	4%	Germany	28%	Netherlands	11%
Bulgaria	1%	Greece	2%	Poland	7%
Croatia	1%	Hungary	1%	Portugal	1%
Cyprus	0%	Ireland	1%	Romania	2%
Czech Republic	2%	Italy	10%	Slovakia	1%
Denmark	2%	Latvia	0%	Slovenia	0%
Estonia	0%	Lithuania	1%	Spain	5%
Finland	1%	Luxembourg	0%	Sweden	2%
				U.K.	*Equivalent to 24%*

Four countries (Germany, France, Netherlands and Italy) account together for 68% of the EU27 market (see Figure 2-2).

Figure 2-2: EU27 market shares according to countries in year 2019 (source: Statista 2020)



[12] U.K. is shown just as comparison but is not accounted in the EU27 market

[13] this roughly matches to 1.9 Mio of water kettles sold in France in 2019, according to GfK, see https://www.gifam.fr/wp-content/uploads/2020/03/Bouilloire.pdf

Prior to the Brexit, U.K. was the largest market in the EU. The current sales represent 24% of the EU27 market.

Urns

Specific statistics on urns are scarce or almost non-existent. Assuming that urns are kettles with a rated volume > 2.2 litres, the market share in 2018 is 0.2 % of the water kettles (see Table 2-14).

Boiling water heaters

This kind of product is not sold via the same channels as kettles or other stand-alone appliances, instead, it is sold within a package for a new or retrofitted kitchen. GfK has not systematically covered this product, and Statista has no information on it. Therefore it is very difficult to estimate sales figures.

The manufacturer Quooker reports for 2019 a production of 130.000 Quookers per year.[14] However, it is unclear how many are sold on the EU market or how many products deliver only boiled water.[15]

The project team assumes that the share of boiling water heaters is 50% and that Quooker – as historical market leader –accounts for around 50% of the EU27 market. Based on these assumptions, around 130.000 boiling water heaters are sold in EU27 in 2019.

For all product groups, future sales will be estimated through a stock model (see next section 2.3.2) and based on future stock figures.

2.3.2. Stock

In the recent literature, all the figures refer to the estimates from the study on the Ecodesign Working Plan 2015-2017 (BIO 2015), which are presented in Table 2-11.

Table 2-11: EU28 stock (BIO 2015)

Product group	EU Stock (millions of units)			
	2010	Today (2015)	2020	2030
Kettles	117–200	117–200	119–204	122–208
Instantaneous hot water heaters and dispensers	Not known, no data available			
Commercial urns		2.8-3.0		

As U.K. accounted for 19% of the EU28 sales, the estimate of the stock for EU27 has to be corrected accordingly. After correction, the EU27 stock is assumed to range between 96 Mio and 165 Mio kettles in 2020 (see Table 2-12).

[14] interview with Quooker Germany

[15] See remark in 2.2

Table 2-12: Estimated EU27 stock (based on BIO 2015)

Product group	EU Stock (millions of units)			
	2010	Today (2015)	2020	2030
Kettles	95–162	95–162	96-165	99-168
Instantaneous hot water heaters and dispensers	Not known, no data available			
Commercial urns		2		

Estimate of the stock with a stock model

In a stock model, the stock is assumed as equal to the cumulated sales over a period corresponding to the technical lifetime of a product and is calculated in each year *y* as follows:

Equation 2-2

$$stock_y = \sum_{j=y-lifetime+1}^{y} sales_j$$

Technical lifetime of kettles

Based on the review carried out in Task 3, a technical lifetime of 6 years is assumed for kettles. The same technical lifetime is assumed for other stand-alone products in this study.

Boiled water heaters

According to the study carried out by VHK 2010 on the boiled water heaters from Quooker, the lifetime of such products is 13.2 years.

TRENDS FOR STOCK IN THE FUTURE

The stock in the base year (2018) is calculated based on the historical sales (see Equation 2-2).[16] The equipment rate is calculated over the time and the trend is extrapolated until 2030. The future stock for each product is then calculated on the basis of the equipment rate[17] and number of households (see Figure 2-3 and Table 2-13).

Based on the data gathered and assumptions previously made, the stock of water kettles will increase from 83 million units in 2020 to 89 million units by 2030, as a result of the combined effect of the changing number of households in the EU and an increasing equipment rate.

The stock figures in 2020 reported in Table 2-12 (96-165 million units, based on BIOS 2015) are 16% to 96% higher than those estimated with the stock model (83 million units) of this study. The BIOS figures were not specific to the household sector while the GfK figures don't cover the B2B channel, and therefore underestimate the sales of in the commercial sector. It is therefore

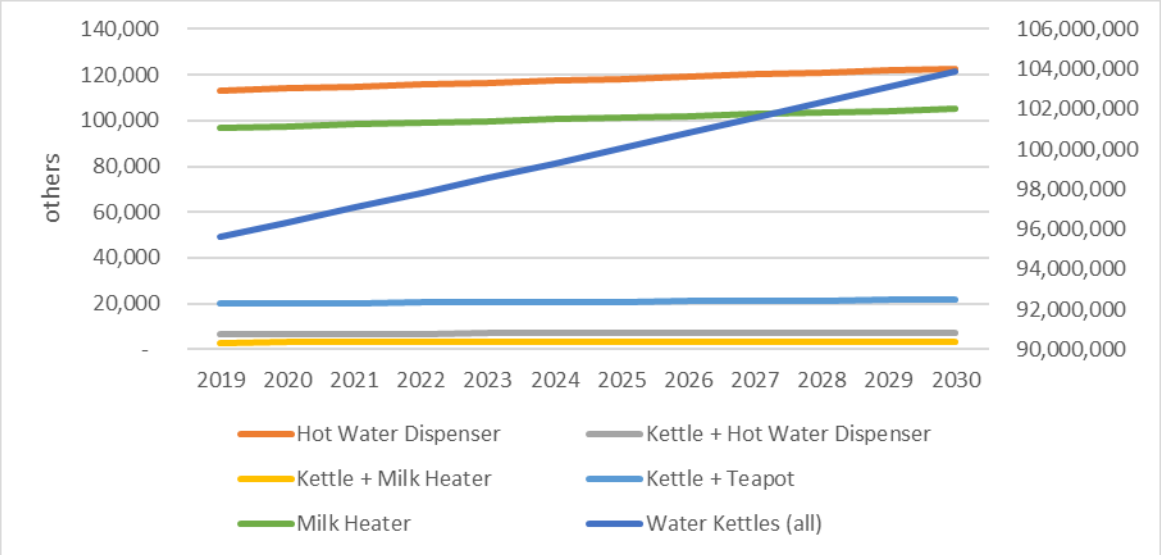
[16] As a stock model is used, the stock of one year is always equal to the cumulated sales over the product lifetime.

[17] historical trend is extrapolated

assumed that EU27 sales (for all sectors) were 16% higher than the sales reported by GfK in Table 2-8.[18]

The water kettles will represent over 99% of the electric kettle stock in the future. Among water kettles, 0.2% are urns (see Figure 2-5), accordingly, the stock of urns is around 192,000 units. This figure is considerably lower than the 2 million units mentioned in the study on the Ecodesign Working Plan 2015-2017 (BIO 2015). This gap might lie in the definition of the products: BIO reported the stock of commercial urns, while the estimate in the present report considered large kettles reported by GfK, sold through channels for non-professional customers. The number of urns sold for domestic uses are assumed to be much less than commercial urns purchased by hotels, offices, etc.

Figure 2-3: Estimated EU27 stock of electric kettles (own calculation)



[18] a "high sales" scenario corresponding to 165 Mio. of products in 2020 will be considered in Task 7 for the sensitivity analysis.

Table 2-13: Estimated EU27 sales and stock of electric kettles (own calculation)

		2020	2025	2030
Sales [units]	Hot Water Dispenser	19,417	22,614	21,064
	Kettle + Hot Water Dispenser	1,493	681	399
	Kettle + Milk Heater	169	375	2,006
	Kettle + Teapot	1,158	1,933	8,114
	Milk Heater	16,055	18,859	16,400
	Water Kettle[19],[20]	15,465,579	17,102,074	17,848,846
Stock [units]	Hot Water Dispenser	113,945	118,311	122,844
	Kettle + Hot Water Dispenser	6,763	7,022	7,291
	Kettle + Milk Heater	2,968	3,082	3,200
	Kettle + Teapot	20,086	20,856	21,655
	Milk Heater	97,506	101,242	105,121
	Water Kettle[21]	96,351,249	100,042,983	103,876,167
Equipment rate [%]	Hot Water Dispenser	0.06%	0.06%	0.05%
	Kettle + Hot Water Dispenser	0.00%	0.00%	0.00%
	Kettle + Milk Heater	0.00%	0.00%	0.00%
	Kettle + Teapot	0.01%	0.01%	0.01%
	Milk Heater	0.05%	0.05%	0.05%
	Water Kettle[22]	49.71%	53.25%	57.04%

2.4. *Subtask 2.3- Market trends*

General objective of subtask 2.3:

The purpose of this task is to identify market trends such as:

[19] figures are 16% higher than in Table 2-8 to include sales not covered by GfK.

[20] of which 0.2% are urns

[21] of which 0.2% are urns

[22] of which 0.2% are urns

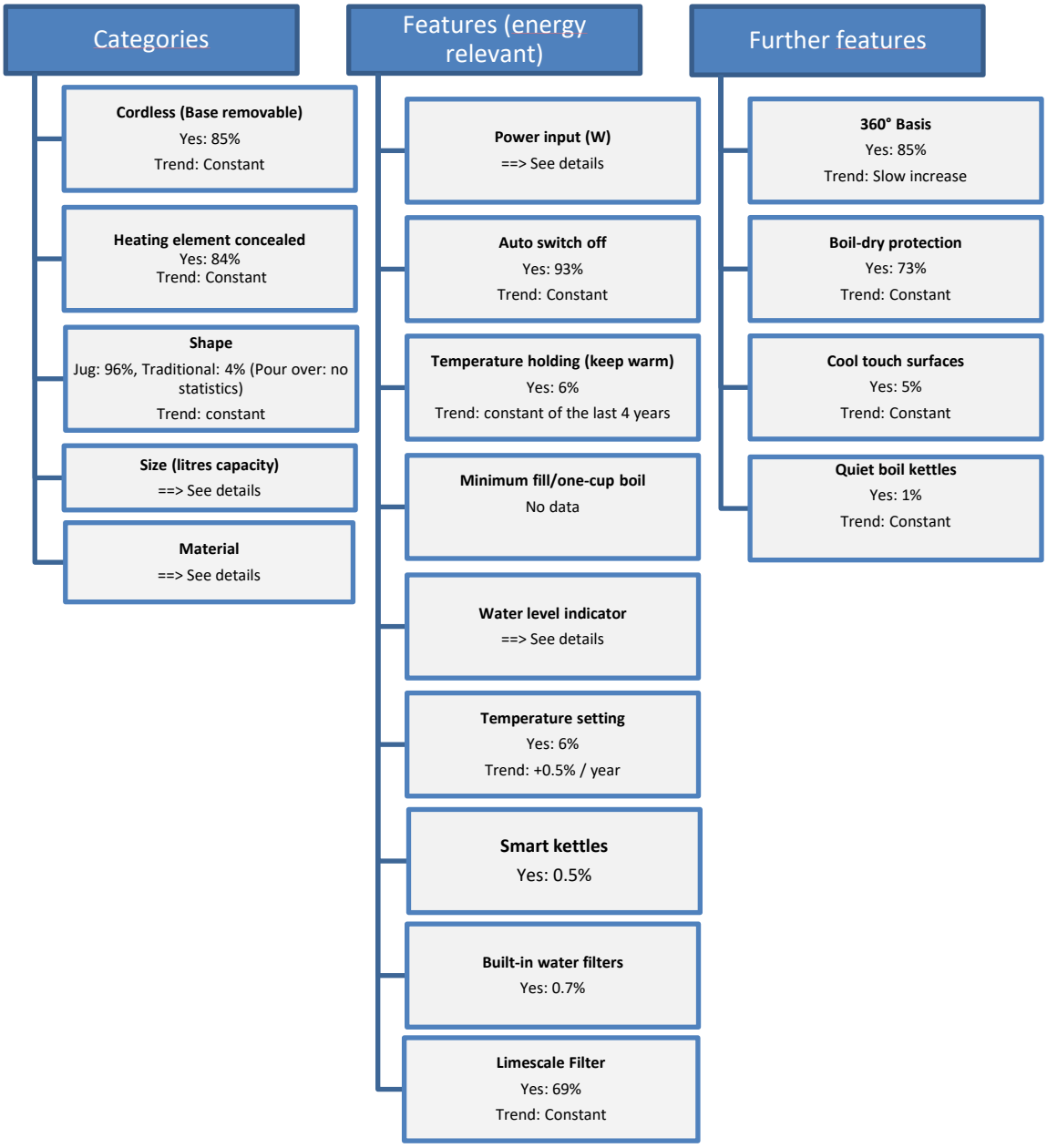
- general market trends (growth/ decline, if applicable per segment), trends in product-design and product-features;
- market channels and production structure; identification of the major players (associations, large companies, share SMEs, employment);
- trends in product design/ features, illustrated by recent consumer association tests (valuable, but not necessarily fully representative of the diversity of products put on the market).

2.4.1. Market trends

2.4.1.1. *Water kettles*

For most of the features (see Figure 2-4), the market shares are stable over time.

Figure 2-4: Market shares according to water kettle characteristics (source: based on GfK 2020)



Based on the statistics in Figure 2-5, the product team assumes that:

- kettles with the option "temperature setting" have also the option "temperature holding". The market shares (6%) are the same and the required technologies for both features are quite similar.
- "360° basis" kettles might have "concealed element". Here, the required technologies are not linked, but the market shares are similar. However low-priced kettles are rather those having none of these features.

In the following, some key features or characteristics are analysed and presented more in details.

Rated volume

Figure 2-5 and Table 2-14 present the distribution of the sales in the EU27 according to the rated volume. Over 50% of the water kettles have a volume of around 1.7 litres. Water kettles with a volume of around 1l or 1.5l are the next favourite ones in the EU, with each covering 14% of the market share. Large kettles / urns have less than 1% of the market share, but this kind of appliances might be purchased on non-household consumer market places, which were not covered by GfK.

Figure 2-5: EU27-sales of water kettles according to rated volume (source: GfK 2020)

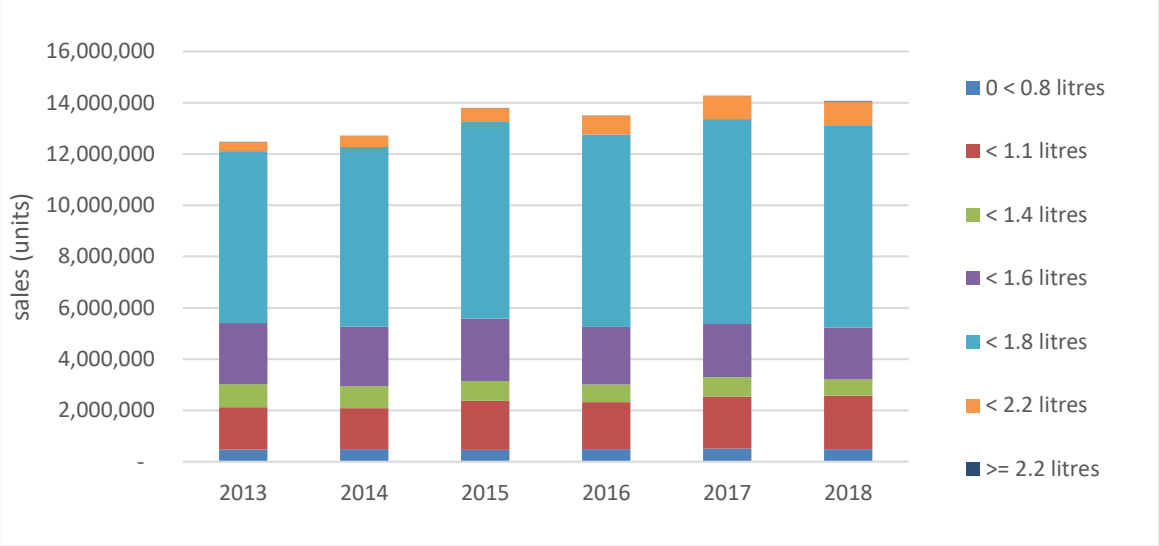


Table 2-14: EU27 market shares of kettles according to rated volume (source: GfK 2020)

Volume [litre]	2013	2014	2015	2016	2017	2018
< 0.8	3.77%	3.85%	3.31%	3.62%	3.61%	3.51%
< 1.1	13.31%	12.53%	13.88%	13.64%	14.20%	14.77%
< 1.4	7.14%	6.77%	5.67%	5.07%	5.30%	4.48%
< 1.6	19.15%	18.35%	17.63%	16.61%	14.55%	14.43%
< 1.8	53.83%	55.11%	55.56%	55.61%	55.95%	56.05%
< 2.2	2.73%	3.35%	3.90%	5.40%	6.29%	6.56%
>= 2.2	0.08%	0.04%	0.05%	0.06%	0.11%	0.20%

Material of the housing

Figure 2-6 and Table 2-15 provide an overview of the EU market in terms of material of the water kettle housing. In 2018, plastic was the most common material with a 46% market share, although the trend is decreasing. At present, metal is almost on a par (44%) and glass represents 9% of the market with a steady growth since 2013 (1% of the market at that time).

Figure 2-6: EU27 sales of water kettles according to the material of the housing (source: GfK 2020)

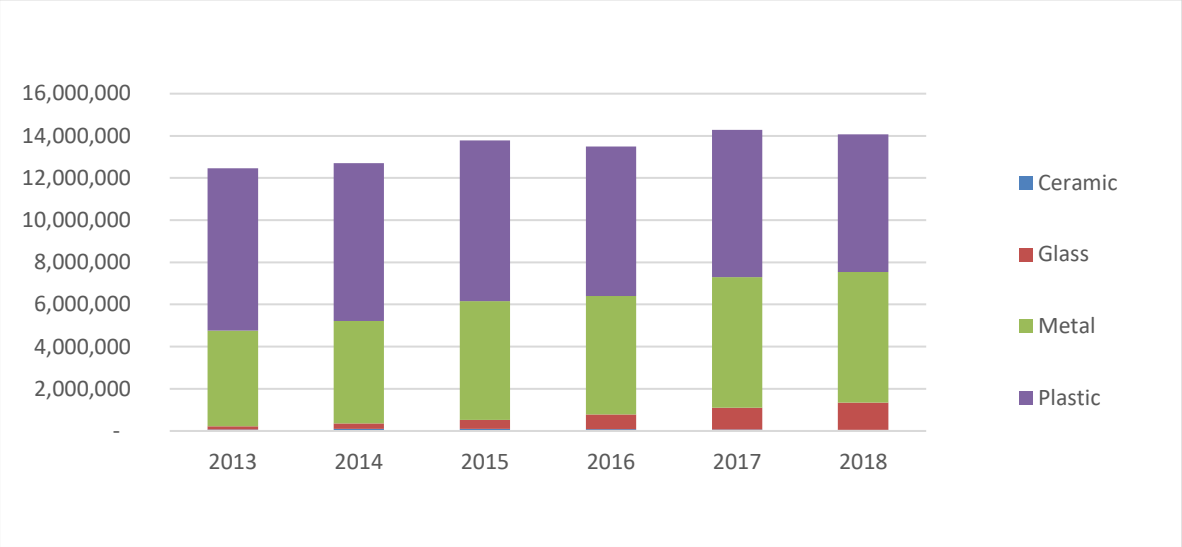


Table 2-15: EU27 market shares of water kettles according to the material of the housing (source: GfK 2020)

Material	2013	2014	2015	2016	2017	2018
Ceramic	0.52%	0.73%	0.72%	0.67%	0.49%	0.39%
Glass	1.28%	2.05%	3.04%	5.18%	7.18%	9.16%
Metal	36.39%	38.26%	40.90%	41.64%	43.46%	44.05%
Plastic	61.80%	58.96%	55.34%	52.51%	48.86%	46.40%

Rated power

As shown in Figure 2-7 and Table 2-16, the power range of 2,200 W -2,400 W is the most popular among water kettles, with 44% of market share in 2018. Kettles with 2,400 W-2,800 W rated power represent 20% of the market. According to GfK, almost no appliance on the EU27 market has more than 3,200 W rated power.[23]

[23] Even large kettles (urns) have a power level below 3,200 W. This is due to the fact that urns have a large volume but their main function is to maintain the water at the desired temperature, the performance is less focused on the time required to heat the water.

Figure 2-7: EU27-sales of water kettles according to the rated power (source: GfK 2020)

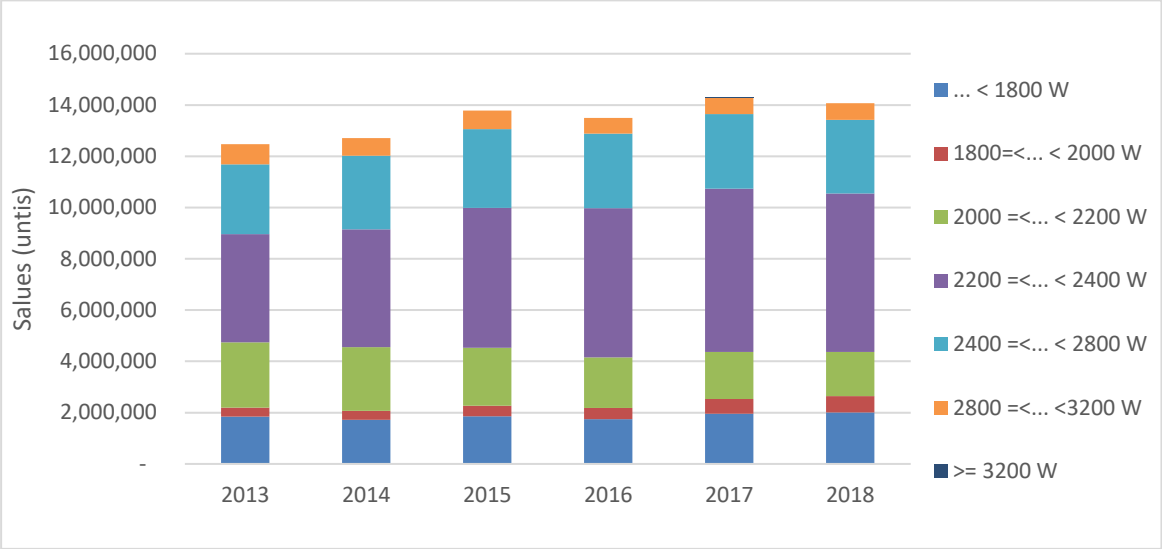


Table 2-16: EU27 market shares of water kettles according to the rated power of the housing (source: GfK 2020)

Rated power [W]	2013	2014	2015	2016	2017	2018
< 1,800	14.82%	13.52%	13.43%	12.95%	13.68%	14.24%
< 2,000	2.82%	2.77%	3.05%	3.26%	4.08%	4.55%
< 2,200	20.42%	19.58%	16.39%	14.58%	12.81%	12.21%
< 2,400	33.88%	36.09%	39.53%	43.15%	44.65%	43.93%
< 2,800	21.81%	22.63%	22.27%	21.54%	20.33%	20.42%
< 3,200	6.25%	5.40%	5.33%	4.52%	4.44%	4.66%
>= 3,200	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Water level

Only few water kettles (6%) do not provide any information regarding the water level. This figure was only 3% in 2013 (see Figure 2-8 and Table 2-17).

Figure 2-8: EU27-sales of water kettles according to the water level indication (source: GfK 2020)

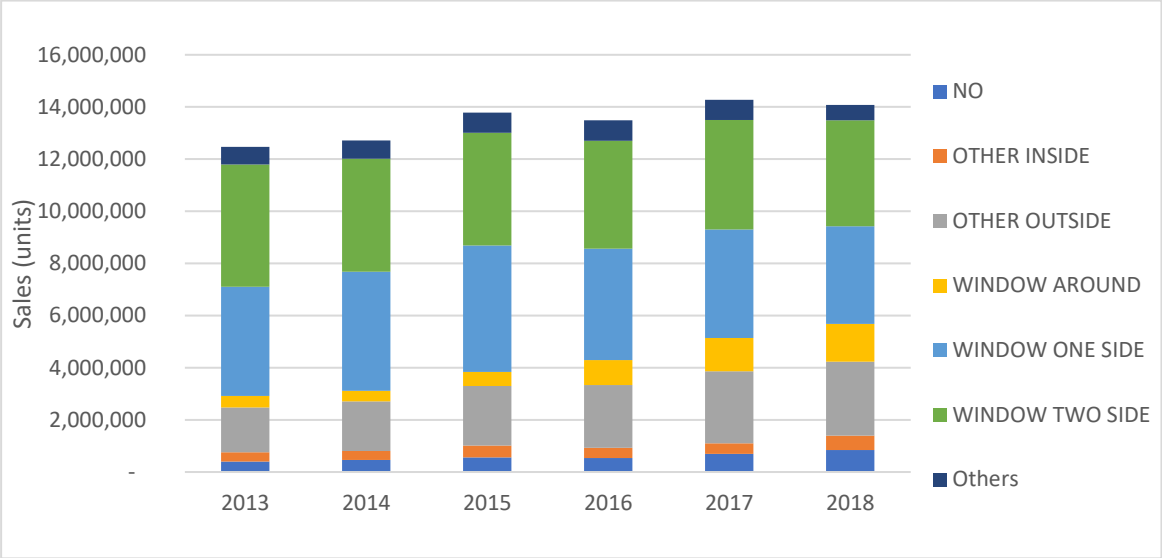


Table 2-17: EU27 market shares of water kettles according to the water level indication (source: GfK 2020)

Water level indication	2013	2014	2015	2016	2017	2018
no	3.22%	3.64%	4.10%	3.99%	4.84%	6.03%
other inside	2.85%	2.75%	3.23%	2.91%	2.91%	3.93%
other outside	13.84%	14.95%	16.55%	17.81%	19.28%	20.09%
window around	3.47%	3.16%	3.96%	7.09%	8.93%	10.31%
window one side	33.63%	35.93%	35.21%	31.68%	29.16%	26.56%
window two side	37.60%	34.11%	31.33%	30.65%	29.47%	28.91%
others	5.39%	5.47%	5.63%	5.86%	5.41%	4.17%

2.4.1.2. *Hot water dispensers*

Rated Volume

Figure 2-9 and Table 2-18 present the distribution of the sales in the EU27 according to the rated volume. The minimum volume of water dispenser is 1.4 l. The 1.4-1.6 l range represents roughly 20% of the market. Currently, over 2/3 of the hot water dispensers have a rated volume of 1.8 l or more, however, a clear shift from the 1.8-2.2 l range to larger appliances has occurred after 2016.

Figure 2-9: EU27 sales of hot water dispensers according to rated volume (source: GfK 2020)

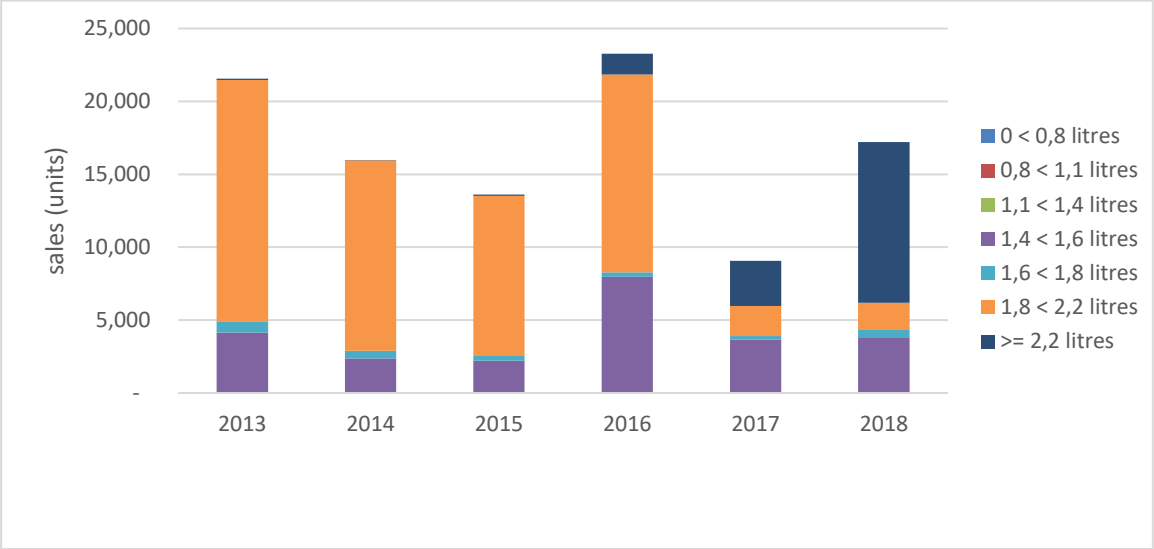


Table 2-18: EU27 market shares of hot water dispensers according to rated volume (source: GfK 2020)

Volume [litre]	2013	2014	2015	2016	2017	2018
< 0.8	0%	0%	0%	0%	0%	0%
< 1.1	0%	0%	0%	0%	0%	0%
< 1.4	0%	0%	0%	0%	0%	0%
< 1.6	19%	13%	13%	35%	26%	20%
< 1.8	4%	3%	2%	1%	2%	3%
< 2.2	77%	70%	64%	61%	15%	10%
>= 2.2	0%	0%	1%	6%	22%	57%

Rated power

As hot water dispensers are a specific type of instantaneous water heaters, the rated power is relatively high. Since 2017, 85% of the hot water dispensers had a typical power of 2,400 W or even higher, as shown in Figure 2-10 and Table 2-19.

Figure 2-10: EU27 sales of hot water dispensers according to the rated power (source: GfK 2020)

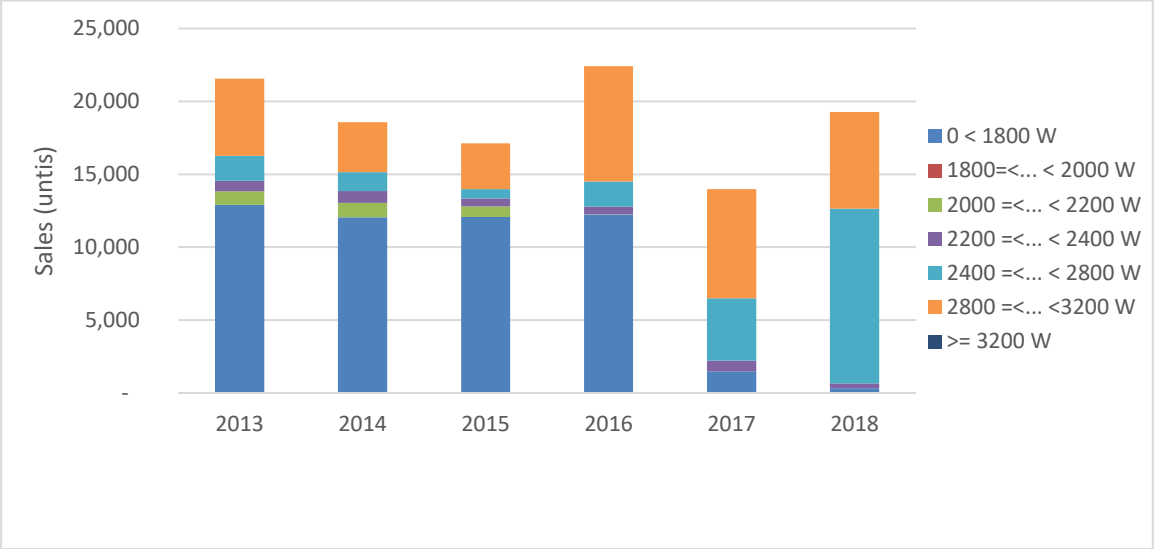


Table 2-19: EU27 market shares of hot water dispensers according to the rated power (source: GfK 2020)

Rated power [W]	2013	2014	2015	2016	2017	2018
< 1,800	60%	65%	70%	54%	11%	2%
< 2,000	0%	0%	0%	0%	0%	0%
< 2,200	4%	5%	4%	0%	0%	0%
< 2,400	3%	4%	3%	2%	5%	2%
< 2,800	8%	7%	4%	8%	31%	62%
<3,200	25%	18%	18%	35%	54%	34%
>= 3,200	0%	0%	0%	0%	0%	0%

2.4.1.3. *Urns*

Water kettles with a maximum capacity of over 2.2 litres are considered as urns in this study. According to GfK figures:

- 71% of the urns sold on the EU27 market have a volume between 2.2 and 5 litres, 29% between 5 and 10 litres
- the typical wattage is between 2,200 W and 2,400 W
- almost all urns have concealed heat elements

2.4.1.4. *Boiling water heaters*

No detailed information on this type of products.

2.4.2. *Manufacturers and trade associations*

Since there is no dedicated association representing water kettle manufacturers, the European home appliance industry association APPLiA[24] is the main representative. Some APPLiA members[25] produce small appliances, including water kettles.

Many kettle manufacturers are competing on the EU market. Most of them are large enterprises even if there are also small manufacturers in the competition. Since the differentiation of kettles is rather limited, the product group can be considered as homogeneous. Competition in this product category is fierce.

According to some EU manufacturers, most of the kettles are developed[26] and produced by only a few Chinese kettle manufacturers. Regarding kettle controls - one of the main components of a kettle - two suppliers (OTTER and STRIX) have a predominant position in the market.

Table 2-20 presents key figures of some APPLiA members, which among other produce electric kettles. The annual report of companies was analysed. On average, the net margin is 5% and the turnover per employee is 223,212 €.

Table 2-20: Key figures of some large manufacturers (source: manufacturers)

Manufacturer	Turnover [M€]	Profit (gross) [M€]	Profit (net) [M€]	Employees	Profit (net) / Turnover [%]	Turnover / employee [€]
Arcelik[27]	5,032	1,616	150	31,534	3%	159,574
Electrolux[28]	11,184	214	171	48,652	2%	229,882
Philips[29]	19,482	1,644	1,173	80,495	6%	242,027
Groupe SEB[30]	7,354	740	380	34,000	5%	216,294
De'Longhi[31]	2,106	280	162	7,850	8%	268,280
Average	9,032	899	407	40,506	5%	223,212

In addition, APPLiA provides an overview of the home appliance industry in Europe (Table 2-21). The turnover per employee is close to the figures provided in Table 2-20. APPLiA reported that for each direct employee, are 3.4 indirect employees involved. We assume that this last figure might

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24 https://www.applia-europe.eu/

25 e.g. BSH, Arcelik, Electrolux, Philips, Groupe SEB and De'Longhi

26 based on the specifications of the EU brands

27 http://www.arcelikas.com/UserFiles/file/Annual%20Report_2019_23.03.2020_compressed.pdf

28 https://www.electroluxgroup.com/annualreports/2019/files/AR_2019/PDF/Electrolux_AnnualReport_2019.pdf

29 https://www.results.philips.com/publications/ar19#highlights

30 https://www.groupeseb.com/en/groupe-seb-brief

31 https://www.delonghigroup.com/sites/default/files/Annual%20Report%202019_2.pdf

apply rather for space heating products than for kettles, as maintenance and inspection aspects are not comparable.

Table 2-21: Home appliance industry in Europe, in 2017 (source: APPLiA 2019)

Category	Value
Turnover in the EU [Mio. €]	50,000
Number of enterprises in the EU	3,453
Number of direct employees	200,960
Number of indirect employees	683,264
Wages & salaries [€]	31,628
Turnover / employee [€]	248,806

2.4.3. Market actors and the role of installers, maintenance companies and inspection

Kettles are stand-alone appliances, purchased in physical or online shops which need neither maintenance nor an inspection by a professional.

The situation is more complex for boiling water heaters. The main distribution channel is the kitchen studio, as these systems are purchased when a new (high end) kitchen or a thorough retrofit of the existing kitchen is planned. After the planning of the kitchen, the boiled water heater has to be installed. Regular descaling can be done by customers but every few years, a maintenance is necessary. This is usually carried out by the maintenance service or the trained staff of the manufacturer.

2.5. *Subtask 2.4- Consumer expenditure base data*

General objective of subtask 2.4:

This task will define:

- average EU consumer prices, incl. VAT (for consumer prices)/ excl. VAT (for B2B products), in euros;
- consumer prices of consumables;
- repair and maintenance costs (euro/product life);
- installation costs (for installed appliances only);
- indicative disposal tariffs/ taxes (euro/product).

For electricity, fossil fuel, water, interest, inflation and discount rates this task will use values from the MEErP methodology, including the average annual price increases mentioned therein. Also an approach will be elaborated for regional differentiation of consumer prices that can be used in a sensitivity analysis in Task 7.

Data

Here again, the main data sources regarding price information are the figures provided by GfK as well as Statista. In addition and for products not covered by the previous sources, a desk research was carried out to get a rough overview of the market.

2.5.1. Average EU consumer prices

2.5.1.1. *Water kettles*

Based on the GfK data, the average EU consumer prices for a water kettle was 26 EUR in 2018. Statista reports an average price which is slightly higher: 31 EUR in 2019. However, the price depends on some characteristics (see Table 2-22) and features of the products.

Table 2-22: Average EU price of water kettles according to the max. volume (source: GfK 2020)

Volume max [litres]	Price [EUR]
< 0.8	17
< 1.1	23
< 1.4	31
< 1.6	29
< 1.8	28
< 2.2	17
>= 2.2	22

2.5.1.2. *Hot water dispensers*

In 2018, the price for a typical hot water dispenser sold on the EU market was 73 EUR (GfK 2020). However, the price depended on the volume of the tank (see Table 2-23).

Table 2-23: Average EU price of hot water dispensers according to the max. volume (source: GfK 2020)

Volume max	Price [EUR]
0 < 0,8 litres	n.a.
0,8 < 1,1 litres	n.a.
1,1 < 1,4 litres	n.a.
1,4 < 1,6 litres	42
1,6 < 1,8 litres	52
1,8 < 2,2 litres	67
>= 2,2 litres	86

2.5.1.3. *Urns*

Based on a small sample of 13 urns,[32] the average price of an urn was estimated to be 58 EUR.

[32] own desk research

2.5.1.4. *Boiling water heaters*

Modell of two manufacturers of boiling water heaters could be fund. On average, the purchase price for the system – providing boiled water only – which includes the tank and the tap is about 1,500 € / system (Table 2-24).

Table 2-24: Price of boiling water heaters (incl. tap)

Product	Price [EUR]
Quooker Pro 3[33]	1,120 – 2,290
Grohe Red MONO[34]	1,505

2.5.2. Consumer prices of consumables

All appliances consume water and electricity, for which the specific costs are presented in the next section. The yearly costs for water and electricity will depend then on the usage and the performance of each product or base case.

2.5.2.1. *General data*

- Energy costs (electricity)

The most accepted source currently available for such projections is the 'EU Reference Scenario 2016 Energy, transport and GHG emissions Trends to 2050'[35] elaborated by the European Commission. This study explains how today's electricity price is composed of several components, see Figure 2-11. Not all components can be taken into account, especially fixed costs that cannot be avoided by energy savings, because there will be a rebound effect in the cost per kWh when the costs have to be distributed across fewer kWh sales. In this model the grid and sales costs increase over time due to the increasing share of RES, and particularly variable distributed RES. Hence it is reasonable to take part of the grid cost into account due to the cost avoidance effect that more efficient transformers will produce.

Therefore further tasks can use the PRIMES forecasted average end user prices for households and the service sector as indicated in Table 2-25.

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33 tank and tap: https://www.quooker.de/preisliste

34 https://www.reuter.de/kueche.html/filter/hersteller/grohe/serie/red?adword=google%2FGrohe%20DE%2FGrohe%20Serien%20Kueche%2F%2Bgrohe%20%2Bred

35 EU Reference Scenario 2016 Energy, transport and GHG emissions Trends to 2050, Main results (2016), available at: https://ec.europa.eu/energy/sites/ener/files/documents/20160712_Summary_Ref_scenario_MAIN_RESULTS%20%282%29-web.pdf

Figure 2-11: Decomposition of electricity generation costs and prices (€ per MWh) historical and forecast values (source: PRIMES)

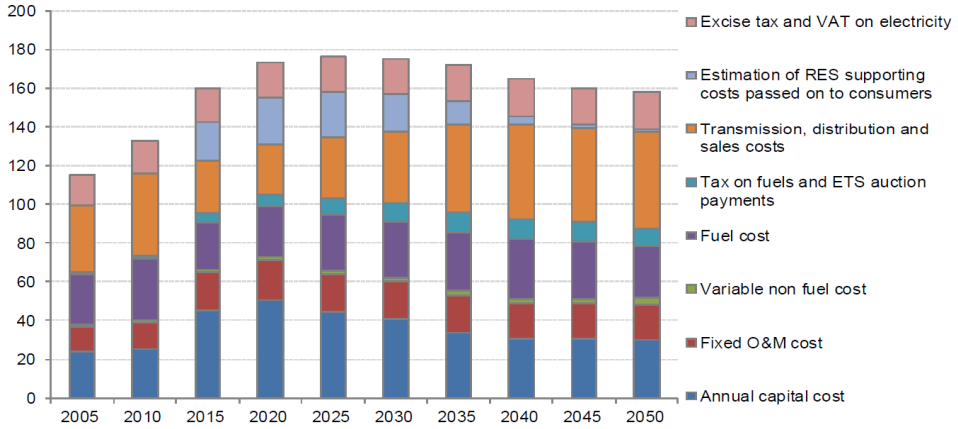


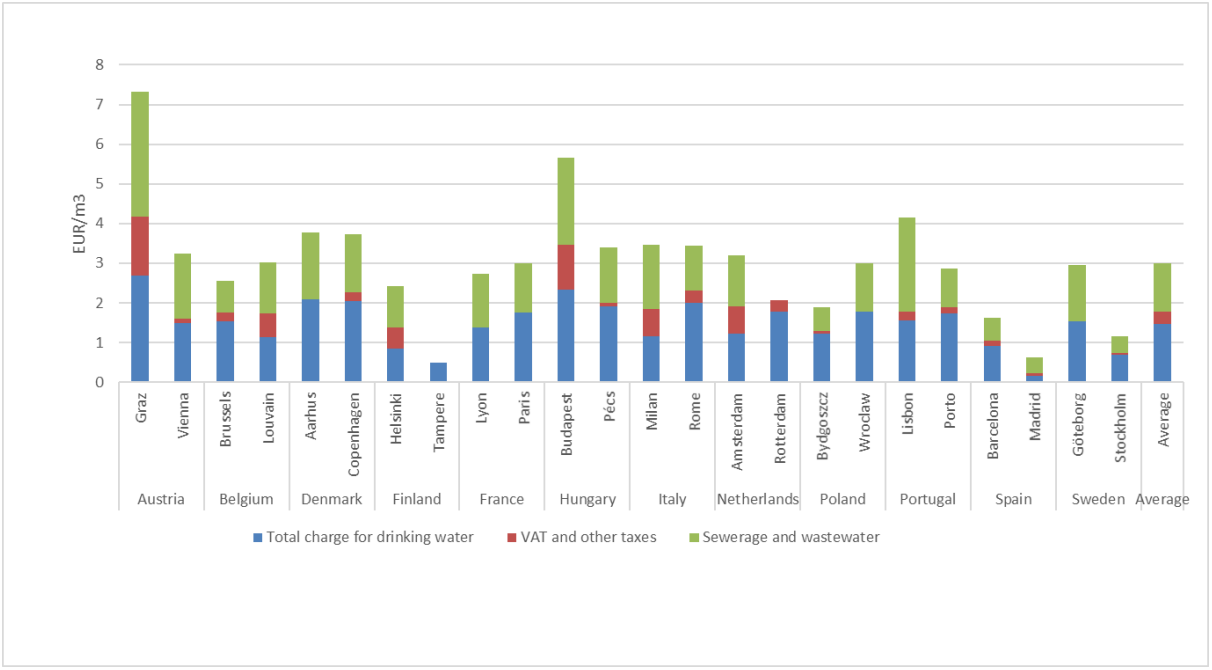
Table 2-25: Decomposition of electricity generation costs and prices (€ per kWh) historical and forecast values (source: based in PRIMES with data supplied by the EC services)

€/kWh	2020	2025	2030	2035	2040
Average price	0.1532	0.1575	0.1609	0.1654	0.1651
Industry	0.0977	0.0988	0.0999	0.1014	0.1016
Households	0.2032	0.2092	0.2123	0.2171	0.2152
Services	0.1709	0.1760	0.1791	0.1837	0.1824

- Water

EUROSTAT does not gather statistics on water prices but OECD provides some figures (OECD 2015). The prices in selected major EU cities for the year 2013 are shown in Figure 2-12.

Figure 2-12: Water prices in selected major EU cities, 2013 (source: OECD 2015)



On average on the data shown in Figure 2-12, households paid 2.99 €/m3 incl. costs for sewerage/wastewater and VAT in 2013. An escalation rate of 2.5% will be applied.[36]

2.5.2.2. *Water kettles*

Water kettles are simple appliances. Apart from the electricity and water costs, the running costs consist of decalcifying/cleaning and filters, for the kettles with built-in water filters.

- Descaling/cleaning

Regular descaling prolongs the life of the kettle and limits the risks of premature breakdown.[37] According to Stiftung Warentest (2013), in regions with hard water, a kettle has to be descaled every 100 l. Manufacturers advice to descale between once every 3 months (soft water) and once every month (hard water). For this purpose, white vinegar or a commercial descaling agent (citric acid based) has to be used.

Manufacturers (e.g. Grundig[38]) recommend following descaling procedure (using white vinegar):

1. Fill the kettle with water, up to three quarters of the maximum level.
2. Add white vinegar or lemon acid in the kettle up to the maximum level.
3. Boil the solution (refer to Operation section).
4. After the kettle has switched off, unplug the appliance.
5. Leave the solution in the kettle for a few hours.

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36 see (COWI and VHK, 2011)

37 according to Which?, 'Limescale problems' accounted for 13% of all faults in the Which! survey (and this doesn't account for all problems that may be related to a limescale build-up, such as a faulty lid).

38 https://grundig-manuals-live.nureg.de/fileadmin/Export/Manuals/WK/WK_7680_BDA.pdf

6. Pour out the solution and rinse the inside thoroughly.

7. Fill the kettle with clean water and boil the water.

8. Empty the kettle and rinse it with water again.

The price of 1 litre of white vinegar is: 0.40 €

The yearly cost related to the cleaning of a water kettle will be:

- white vinegar

Assuming that 1 l of white vinegar costs 0.40 €[39], the yearly white vinegar costs are:

1/4 x (4 + 12) / 2 x 0.4 = 2 x 0.4 = 0.8 € / litre of rated volume of the kettle

- electricity

In addition to white vinegar, electricity costs have to be taken into account for descaling. Following the instructions of manufacturers, boiling twice the total max volume of the kettle is necessary every time the kettle will be descaled. Assuming the kettle will be descaled 8 times a year, the yearly energy costs for descaling will be 16 times the energy consumption of a boiling cycle.

- water

The yearly amount of water used for descaling will be:

(3/4 + 1) x (4 + 12) / 2 = 14 l / litre of rated volume of the kettle

- Built-in water filter

Some of the water kettles have a limescale filter or cartridge, which is built in the reservoir of the kettle. According to some manufacturers, cartridges have to be replaced every four weeks or 100 - 150 litre.[40] The price is around 3 € per cartridge.

Accordingly, the annual costs for built-in water filters are 36 €.

2.5.3. Repair and maintenance costs

In 2019, Which? carried out a survey among its 4,800 members asking them about their satisfaction regarding their water kettle,[41] and reported three major faults:[42]

- faulty lid: 15%
- broken limescale filter: 14%
- leaking: 12 %

While leaking is almost impossible to be fixed, faulty lid and broken limescale filter can be easily replaced by end-users, assuming the corresponding spare parts are available.

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[39] average price based on a sample of 4 countries (France, Germany, Hungary and Spain), own desk research

[40] see https://www.brita.com.au/filters-cartridges and https://www.warenvergleich.de/wasserfilter/?tr_source=google&tr_medium=cpc&gid=EAIaIQobChMIjf6orIfC6QIVCLp3Ch1Llg6LEAAYAyAAEgLSTvD_BwE&v=p

[41] Which? (2020)

[42] Other faults can be auto cut-off failing (7% of the reported faults)

Table 2-26 provides an overview of the price of some spare parts in relation to the price of new kettles:

Table 2-26: Indicative price[43] of spare parts

Product	Purchase Price [EUR]	Filter Price [EUR]	Price Share %	Lid Price [EUR]	Price Share %	Other
Bosch TWK6003V01	119.00	3.80	3%	6.00	5%	Base: 11.60
Bosch TWK6004N01	47.00	3.80	8%	4.90	10%	Base: 17.90
Siemens TW86103P	65.00	3.05	5%	n.a.	n.a.	Base: 10.15
Bosch TWK8611P	64.00	3.05	5%	n.a.	n.a.	Base: 31.90
Ritter Fontana 5	125.99	6.00	5%	21.61	17%	Base: 69.00 Water tank: 73.00
Clatronic WK 3445	13.99	3.00	21%	n.a.	n.a.	
Severin WK 3644	15.00	2.00	13%	2.00	13%	
ProfiCook-WKS 1167	51.99	n.a.	n.a.	n.a.	n.a.	
Russell Hobbs 21600-57	36.99	15.00	41%	n.a.	n.a.	
Emerio WD-118981	57.99	n.a.	n.a.	n.a.	n.a.	
WMF Stelio 1,7l	35.41	6.00	17%	n.a.	n.a.	
Russel Hobbs Buckingham 20460-56	49.49	15.00	30%	n.a.	n.a.	
Average			15%		11%	

However, reparations are carried out only if the costs are low compared to the purchase price.

The reparation costs are assumed to be:

Equation 2-3

$$\%P_{reparation} = \sum_{faults} \left(\%P_{\_part} \times \%Occurency\_part\right)$$

$$\%P_{reparation} = 15\% \times 11\% + 14\% \times 15\% = 4\%$$

[43] including VAT but excluding shipping costs

In this preparatory study, it is assumed, that reparation costs will correspond to 4% of the purchase costs over the lifetime of the product. This figure seems realistic and reasonable. For simple products, it is accepted that up to around 1/3 of the purchase price is acceptable.[44]

As the customers can carry out the reparation, no labour costs are assumed.

The short desk research of spare part prices showed that:

- water tanks are usually not available as spare parts, even for kettles with glass tanks. The Ritter Fontana 5[45] was the only kettle for which a new water tank can be purchased (58% of the kettle purchase price)
- bases are available. The price for simple bases is much lower than for bases integrating temperature controls (15% vs. 50% of the kettle purchase price)
- shipping prices might be higher than the cost of the spare parts. This might limit the chance for the consumer to decide to purchase a spare part

2.5.4. Installation costs

Not applicable for kettles, hot water dispensers and urns as they are light stand-alone appliances.

Boiling water heaters

In the case of boiling water heaters, an installation is necessary in order to place and connect the system under the countertop / sink unit. According to manufacturers, the installation costs are between 100 € and 200 €, therefore 150 € are assumed.

2.5.5. Disposal tariffs/ taxes

Water kettles and hot water dispensers

Water kettles as well as hot water dispensers belong to the WEEE[46] Category 5 "Small equipment (no external dimension more than 50 cm)". According to Annex V of the WEEE directive:

> *Minimum targets applicable by category from 15 August 2018 for WEEE falling within category 5 or 6 of Annex III,*
>
> *— 75 % shall be recovered, and*
>
> *— 55 % shall be prepared for re-use and recycled;*

Table 2-27 provides the EEE fees for a kettle. When the fees are not calculated per unit but per kg, a 1.5 kg water kettle was considered.

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[44] see Task 2 of BIO 2011

[45] the only electric kettle awarded by Blue Angel

[46] Directive on waste electrical and electronic equipment, see https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0019

Table 2-27: Disposal fee for kettles

Country	Disposal fee[47]
France[48]	0.30 EUR / unit
Germany[49]	0.12 EUR / unit
EU[50]	0.30 EUR / unit[51]

For this study, 0.30 EUR disposal fee for a water kettle or hot water dispenser will be considered

Boiling water heaters

According to the figures found in France[52], the disposal fee for boiling water heaters are 3 EUR/unit.

2.6. *Subtask 2.5- Recommendations*

General objective of subtask 2.5:

This task makes recommendations with regard to a refined product scope from an economical/ commercial perspective (e.g. excluding niche markets) and identifies barriers and opportunities for Ecodesign from the economical/ commercial perspective.

General conclusion

This task could provide detailed information on the EU27 market for following products: electric water kettles, hot water dispensers, kettles + hot water dispensers, kettles + teapots. In this task report, urns were assumed to be large electric water kettles between 2.2 litres and 10 litres. A brief insight in the boiling water heater market was also provided.

Sales of electric water kettles are in 2020 around 15.5 million units/year and are assumed to grow slowly, reaching 17.8 million units/year by 2030. The stock is assumed to be 96.3 Mio million units/year in 2020. Other product groups are clearly niche markets, representing together 1% of the sales of the electric water kettles.

The data gathered by GfK was very detailed in terms of technical details and provided a clear picture of the market and of the trends. Among electric water kettles, 15% have immersed heating elements and 6% pre-set temperatures.

Subtask 2.4 shows that the purchase costs for an electric water kettle are low: 26 EUR in the EU27, which is much lower than the costs for a boiling water heater (almost 60 times more expensive).

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47 based on the assumption that a kettle weighs 1.5 kg

48 Eco Participation tariffs: https://www.popai.fr/docs/Bareme_detaille_01032017.pdf

49 85 € / t for category 5 , see: https://www.elektrogesetz.de/umsetzung/kosten/

50 Table 2 in Sousa et al. 2018

51 Average of the EU MS covered by the study: 0.20 EUR/kg.

52 Eco Participation tariffs: https://www.popai.fr/docs/Bareme_detaille_01032017.pdf

Task 2 figures would support the preliminary conclusions of Task 1, stressing that this preparatory study should focus on electric water kettles only.

The task 2 market data is already structured and segmented according to the user data in Task 3 and in line with Task 1.

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ANNEX A

TableAnnex 2-1: Yearly sales and stock figures for kettles in the EU27 (source: own calculation based on GfK 2020)

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	EU27 Households	182,264,200	183,843,800	185,164,400	186,594,300	188,787,000	190,772,200	191,210,900	192,489,900	193,807,100	195,021,100	196,493,170	197,976,351	199,470,727	200,976,384	202,493,406	204,021,878
sales	Hot Water Dispenser	18,821	18,821	18,821	21,563	18,563	17,133	22,421	13,983	19,263	21,727	19,417	17,993	23,287	14,856	20,143	22,614
	Kettle + Hot Water Dispenser	1,081	1,081	1,081	403	1,442	3,127	779	444	292	628	1,493	3,178	830	496	344	681
	Kettle + Milk Heater	501	501	501	415	147	66	279	143	1,959	352	169	88	302	166	1,982	375
	Kettle + Teapot	3,260	3,260	3,260	1,403	1,007	2,880	3,985	2,490	7,797	1,777	1,158	3,031	4,138	2,644	7,952	1,933
	Milk Heater	16,061	16,061	16,061	17,692	15,324	17,459	16,520	14,512	14,859	18,101	16,055	18,195	17,262	15,259	15,612	18,859
	Water kettles (Gfk)	*11,398,757*	*11,754,393*	*12,110,028*	*12,465,663*	*12,710,134*	*13,788,260*	*13,493,968*	*14,275,653*	*14,074,792*	*14,097,053*	*13,332,396*	*14,415,229*	*14,124,970*	*14,912,123*	*14,716,066*	*14,743,167*
	Water Kettles (not B2C: +16%)	*1,823,801*	*1,880,703*	*1,937,604*	*1,994,506*	*2,033,620*	*2,206,122*	*2,158,923*	*2,284,105*	*2,251,967*	*2,255,528*	*2,133,183*	*2,306,437*	*2,259,995*	*2,385,940*	*2,354,570*	*2,358,907*
	Water Kettles (all)	13,222,559	13,635,096	14,047,633	14,460,170	14,743,744	15,994,381	15,652,191	16,559,758	16,326,758	16,352,581	15,465,579	16,721,665	16,384,965	17,298,063	17,070,636	17,102,074
stock	Hot Water Dispenser	112,927	112,927	112,927	115,669	115,411	113,723	117,323	112,485	112,927	113,091	113,945	114,805	115,672	116,545	117,424	118,311
	Kettle + Hot Water Dispenser	6,488	6,488	6,488	5,810	6,171	8,216	7,914	7,277	6,488	6,712	6,763	6,814	6,865	6,917	6,969	7,022
	Kettle + Milk Heater	3,009	3,009	3,009	2,922	2,567	2,132	1,910	1,551	3,009	2,946	2,968	2,991	3,013	3,036	3,059	3,082
	Kettle + Teapot	19,562	19,562	19,562	17,705	15,452	15,071	15,796	15,026	19,562	19,936	20,086	20,238	20,391	20,545	20,700	20,856
	Milk Heater	96,367	96,367	96,367	97,997	97,260	98,658	99,118	97,568	96,367	96,776	97,506	98,242	98,984	99,731	100,484	101,242
	Water kettles (Gfk)	*63,058,015*	*65,191,827*	*67,325,639*	*69,459,451*	*71,482,088*	*74,227,226*	*76,321,736*	*78,842,997*	*80,807,760*	*82,439,150*	*83,061,422*	*83,688,391*	*84,320,092*	*84,956,562*	*85,597,836*	*86,243,951*
	Water Kettles (not B2C: +16%)	*10,089,282*	*10,430,692*	*10,772,102*	*11,113,512*	*11,437,134*	*11,876,356*	*12,211,478*	*12,614,880*	*12,929,242*	*13,190,264*	*13,289,827*	*13,390,143*	*13,491,215*	*13,593,050*	*13,695,654*	*13,799,032*
	Water Kettles (all)	73,147,297	75,622,519	78,097,741	80,572,963	82,919,222	86,103,582	88,533,214	91,457,876	93,737,002	95,629,414	96,351,249	97,078,533	97,811,307	98,549,612	99,293,490	100,042,983
equipment rate	Hot Water Dispenser	0.0583%	0.0583%	0.0583%	0.0597%	0.0595%	0.0587%	0.0605%	0.0580%	0.0583%	0.0580%	0.0577%	0.0574%	0.0572%	0.0569%	0.0566%	0.0563%
	Kettle + Hot Water Dispenser	0.0033%	0.0033%	0.0033%	0.0030%	0.0032%	0.0042%	0.0041%	0.0038%	0.0033%	0.0034%	0.0035%	0.0036%	0.0037%	0.0038%	0.0039%	0.0040%
	Kettle + Milk Heater	0.0016%	0.0016%	0.0016%	0.0015%	0.0013%	0.0011%	0.0010%	0.0008%	0.0016%	0.0015%	0.0015%	0.0014%	0.0014%	0.0013%	0.0013%	0.0013%
	Kettle + Teapot	0.0101%	0.0101%	0.0101%	0.0091%	0.0080%	0.0078%	0.0082%	0.0078%	0.0101%	0.0102%	0.0104%	0.0105%	0.0106%	0.0107%	0.0109%	0.0110%
	Milk Heater	0.0487%	0.0487%	0.0487%	0.0506%	0.0502%	0.0509%	0.0511%	0.0503%	0.0487%	0.0496%	0.0495%	0.0494%	0.0493%	0.0492%	0.0491%	0.0490%
	Water Kettles (all)	37.7423%	39.0195%	40.2966%	41.5738%	42.7844%	44.4275%	45.6811%	47.1902%	48.3661%	49.0354%	49.7140%	50.4019%	51.0994%	51.8065%	52.5234%	53.2502%

		2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	EU27 Households	205,561,888	207,113,522	208,676,868	210,252,015	211,839,052	213,438,068	215,049,153	216,672,400	218,307,899	219,955,743	221,616,026	223,288,841	224,974,283	226,672,447	228,383,429
sales	Hot Water Dispenser	20,310	18,893	24,194	15,770	21,064	23,541	21,244	19,834	25,142	16,725	22,026	24,511	22,222	20,819	26,135
	Kettle + Hot Water Dispenser	1,546	3,231	884	550	399	736	1,601	3,287	940	607	456	793	1,659	3,346	999
	Kettle + Milk Heater	192	111	326	189	2,006	399	216	136	350	214	2,031	425	242	162	376
	Kettle + Teapot	1,315	3,190	4,298	2,805	8,114	2,096	1,480	3,356	4,465	2,974	8,284	2,267	1,652	3,529	4,640
	Milk Heater	16,819	18,965	18,038	16,041	16,400	19,653	17,618	19,771	18,849	16,858	17,223	20,483	18,455	20,613	19,698
	Water kettles (Gfk)	*13,983,388*	*15,071,134*	*14,785,826*	*15,577,968*	*15,386,936*	*15,419,102*	*14,664,424*	*15,757,312*	*15,477,183*	*16,274,543*	*16,088,770*	*16,126,233*	*15,376,893*	*16,475,158*	*16,200,448*
	Water Kettles (not B2C: +16%)	*2,237,342*	*2,411,381*	*2,365,732*	*2,492,475*	*2,461,910*	*2,467,056*	*2,346,308*	*2,521,170*	*2,476,349*	*2,603,927*	*2,574,203*	*2,580,197*	*2,460,303*	*2,636,025*	*2,592,072*
	Water Kettles (all)	16,220,730	17,482,516	17,151,558	18,070,443	17,848,846	17,886,158	17,010,732	18,278,482	17,953,532	18,878,470	18,662,973	18,706,430	17,837,196	19,111,183	18,792,520
stock	Hot Water Dispenser	119,204	120,104	121,010	121,924	122,844	123,771	124,705	125,647	126,595	127,551	128,513	129,483	130,461	131,446	132,438
	Kettle + Hot Water Dispenser	7,075	7,128	7,182	7,237	7,291	7,346	7,402	7,457	7,514	7,570	7,628	7,685	7,743	7,802	7,861
	Kettle + Milk Heater	3,105	3,129	3,152	3,176	3,200	3,224	3,249	3,273	3,298	3,323	3,348	3,373	3,399	3,424	3,450
	Kettle + Teapot	21,013	21,172	21,332	21,493	21,655	21,819	21,983	22,149	22,316	22,485	22,655	22,826	22,998	23,171	23,346
	Milk Heater	102,006	102,776	103,552	104,334	105,121	105,915	106,714	107,520	108,331	109,149	109,973	110,803	111,639	112,482	113,331
	Water kettles (Gfk)	*86,894,942*	*87,550,848*	*88,211,704*	*88,877,549*	*89,548,420*	*90,224,354*	*90,905,391*	*91,591,568*	*92,282,925*	*92,979,500*	*93,681,334*	*94,388,465*	*95,100,933*	*95,818,779*	*96,542,044*
	Water Kettles (not B2C: +16%)	*13,903,191*	*14,008,136*	*14,113,873*	*14,220,408*	*14,327,747*	*14,435,897*	*14,544,863*	*14,654,651*	*14,765,268*	*14,876,720*	*14,989,013*	*15,102,154*	*15,216,149*	*15,331,005*	*15,446,727*
	Water Kettles (all)	100,798,133	101,558,983	102,325,577	103,097,957	103,876,167	104,660,251	105,450,253	106,246,219	107,048,193	107,856,220	108,670,347	109,490,619	110,317,082	111,149,784	111,988,771
equipment rate	Hot Water Dispenser	0.0560%	0.0558%	0.0555%	0.0552%	0.0549%	0.0546%	0.0544%	0.0541%	0.0538%	0.0535%	0.0533%	0.0530%	0.0527%	0.0524%	0.0521%
	Kettle + Hot Water Dispenser	0.0041%	0.0042%	0.0043%	0.0044%	0.0045%	0.0046%	0.0047%	0.0048%	0.0049%	0.0050%	0.0050%	0.0051%	0.0052%	0.0053%	0.0054%
	Kettle + Milk Heater	0.0012%	0.0012%	0.0011%	0.0011%	0.0011%	0.0010%	0.0010%	0.0009%	0.0009%	0.0008%	0.0008%	0.0008%	0.0007%	0.0007%	0.0006%
	Kettle + Teapot	0.0111%	0.0113%	0.0114%	0.0115%	0.0116%	0.0118%	0.0119%	0.0120%	0.0122%	0.0123%	0.0124%	0.0125%	0.0127%	0.0128%	0.0129%
	Milk Heater	0.0489%	0.0488%	0.0487%	0.0486%	0.0485%	0.0484%	0.0483%	0.0482%	0.0481%	0.0480%	0.0479%	0.0478%	0.0477%	0.0476%	0.0475%
	Water Kettles (all)	53.9870%	54.7341%	55.4915%	56.2594%	57.0379%	57.8272%	58.6274%	59.4387%	60.2612%	61.0951%	61.9405%	62.7976%	63.6666%	64.5476%	65.4408%

Green: Data from GfK scaled up for EU27

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Task 3: Users

Final report

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Directorate-General for Energy
Directorate C - Renewables, Research and Innovation, Energy Efficiency
Unit C4: Energy Efficiency: Buildings and Products

European Commission
B-1049 Brussels

EUROPEAN COMMISSION

Preparatory study for Kettles implementing the Ecodesign Working Plan 2016-2019

Task 3: Users

Final report

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LIST OF ABBREVIATIONS AND ACRONYMS

IEC	International Electrotechnical Commission
MEErP	Methodology for Ecodesign of Energy-related Products
UK	United Kingdom

3. TASK 3: USERS

Users affect the environmental impact of electric kettles especially during the use phase. In line with the MEErP methodology [Kemna 2011], their influence on the life-cycle performance of kettles is analysed within this Task 3 across five subtasks. These subtasks cover the direct energy consumption (Subtask 3.1) as well as indirect energy consumption effects (Subtask 3.2) of the kettles during the use phase, user influence on end-of-life behaviour (Subtask 3.3), the relevance of local infrastructure (Subtask 3.4) and a set of conclusions (Subtask 3.5) for the following steps within this preparatory study.

3.1. Subtask 3.1: System aspects affecting direct energy consumption during the use phase

The aim of Subtask 3.1 is to detail the influence of users on the **direct impact** of kettles on the environment and resources during the use phase. Direct impact means any impact that is directly linked to the operation of the kettle. This analysis has different levels of scoping, starting from a "strict product approach", followed by an "extended product approach", passing to a "technical system approach" and finally concluding in a "functional system approach". These different scoping levels can summarized as follows:

- **Strict product approach:** In the strict product approach, the system boundary is limited to the electric kettle itself. Its operating conditions are nominal as defined in traditional standards.

- **Extended product approach:** In the extended product approach, the influence of the kettle usage and real-life deviations from test standards are covered.

- **Technical system approach:** When viewed from the technical system perspective, the kettle is embedded in its surrounding system.

- **Functional approach:** In the functional system approach, the basic service of a kettle to provide boiled water is maintained, yet other ways to satisfy this need are reviewed, as well.

3.1.1. Strict product/component scope

The strict product approach is the most restrictive point of view with regard to user influence on product performance, as it is based on nominal operating conditions as defined in energy-related standards.

As per the results of Task 1, there is no established standard dealing with the energy efficiency of electric kettles. Yet the standard IEC 60530:1975 ('Methods for measuring the performance of electric kettles and jugs for household and similar use') (including amendments) [IEC 1975] has been pointed out as an approach that could be extended towards energy-related aspects. In lack of another specific standard or methodology, IEC 60530:1975 will therefore be used as a proxy to discuss kettles from a strict product scope. Though the standard is not designed for energy-related measurements, it underlines basic requirements/assumptions that a standard or a methodology on energy consumption/efficiency will also require. Based on the following discussion of user behaviour on the environmental performance of kettles, suggestion for extending the current methodological approach will be provided in the final section of this task.

IEC 60530:1975, followed by two amendments, describes a set of measurements for kettles and related conditions for measurement. While some measurements focus on physical properties of the kettles (e.g. its cord length), other aspects like the 'time to boil 1 litre of water' and the 'time to boil water capacity' seem very relevant for a potential extension towards energy consumption. Combined with additional measurements on electricity consumption, the standard or a derived methodology might serve as a reference for energy performance indications.

As the focus of the existing measurements foreseen by the standard is on boiling time, some requirements particularly deal with time-related aspects of use. The main standardized operating conditions for measuring the time for boiling 1 litre of water for kettles with a water capacity above this value are the following:

- The kettle should be preconditioned at a temperature of 23 ± 2°C.

- The kettle is to be filled with 1 litre of cold water at 15 ± 1°C.

- All controls should be set to a maximum position[1] and the kettle is to be switched on directly after filling. The time to raise the temperature 80°C above its initial value is to be determined and rounded to the nearest 10 seconds.

- For temperature measurements, there are specific requirements to the position and type of the required sensor.

The time to boil to capacity is determined in the same way, but based on the stated capacity or, in lack of this, a capacity measurement of the kettle as further detailed in the standard.

Another measurement of potential relevance for the environmental performance within the standard is the determination of the minimum quantity of boiled water for kettles with an immersed heating element. This value reflects how much water must be boiled at a minimum when operating the kettle.

It should be noted that assumptions as made for the measurements of boiling time are a regular element in standards to ensure a harmonized and objectively repeatable result on the one hand and to simplify the complex reality on the other hand. Here, they serve as a basis to structure the subsequent discussion of user influence on direct consumption of kettles in real-life. In view of this, some of the aspects mentioned in IEC 60530:1975 (e.g. the position of the sensor for measuring temperature) are irrelevant to a common user while there are others that a kettle user can actually influence, including the:

- Amount of water for boiling

- Settings of controls including a target temperature

- Cold water temperature

- Starting temperature of the empty kettle

3.1.2. Extended product approach

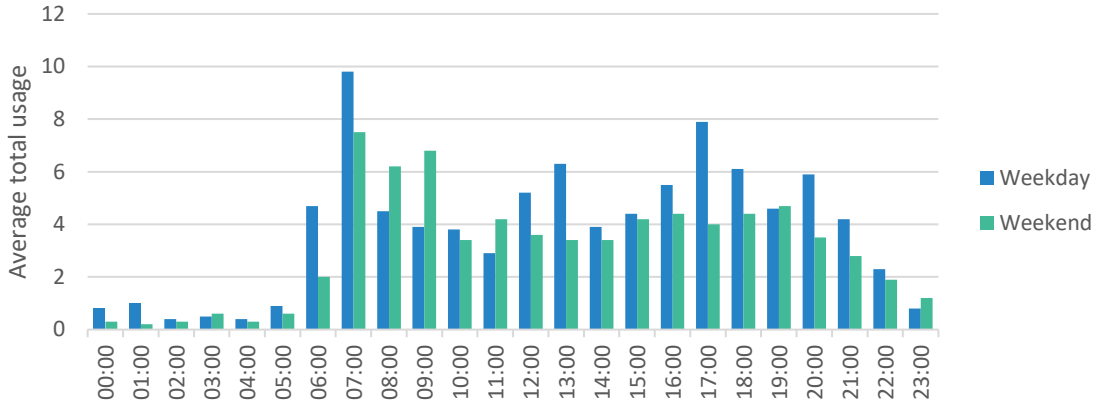
The aim of viewing the product from an 'extended product approach' in this section is to point out where real-life behaviour may deviate from the 'ideal' conditions as given in default calculations, in this case IEC 60530:1975. This discussion follows the items mentioned in the previous section and aims to contrast the assumptions with evidence on real-life usage.

Amount of water for boiling

The standard focuses on the time for boiling a pre-defined amount of water, i.e. 1 litre or nominal capacity. Yet usage patterns of kettles in general may vary. In an in-depth investigation of kettle usage in 14 houses in the United Kingdom [Murray et al. 2016], a seasonal shift of kettle usage was observed for example. Monitoring data on kettle utilization across one year suggests a slight increase during winter and holiday periods. Further investigations by hours of day suggests differences between working days and weekends (Figure 3-1). Among others, a general shift towards later hours in the morning and less evident peaks at certain hours later in the day have been observed during the weekend as compared to weekdays [Murray et al. 2016]. Since the study is limited to the sample households, there is no evidence on whether the changes are mirrored for example in boiled water consumption at offices where the inhabitants might alternately consume it during working days instead. Yet the data underlines a general variation in boiled water consumption.

[1] Due to the focus of the standard on boiling time, the reason for this setting is likely derived from the aim of indicating the minimum time for boiling.

Figure 3-1: Distribution of kettle usage across 14 houses in October 2014 by hour and type of day (Data source: Murray et al. 2016)



Further information on kettles use is available is available from surveys in Germany and the United Kingdom. The data for Germany [Prakash et al. 2020] is based on responses to a consumer survey on obsolescence covering five types of domestic appliances including electric kettles. In this survey from 2013/2014, 692 participants answered questions relating to electric kettles. The data for the United Kingdom [EST 2013] contains self-reported information of consumers using an online tool. This survey also included a question on kettle utilization. While no specific indications on the number of answers to this question are yielded in the source, the report points out a high number of responses (86 171 participants) obtained for the report in general.

Figure 3-2 shows the data from the German study, indicating that about 64% of the users use the kettle as least once per day. The values in Figure 3-3 from the United Kingdom point to a higher share of 84%[2] with at least one use per day. Data presented in [Murray et al. 2016] suggests an average 6 kettles uses per house and day.

In sum, the data suggests that kettles are used considerably more often than once per day, at least in the United Kingdom. While this data does not provide indications on the actual amount of water used for boiling for each utilization, it underlines the variation in kettle utilization in real-life.

Figure 3-2: Use of kettles according to a consumer survey in Germany (Data: [Prakash et al. 2020]; Question: 'How often did you use this kettle as a rule? If you do not know, please estimate a value.', n=688)

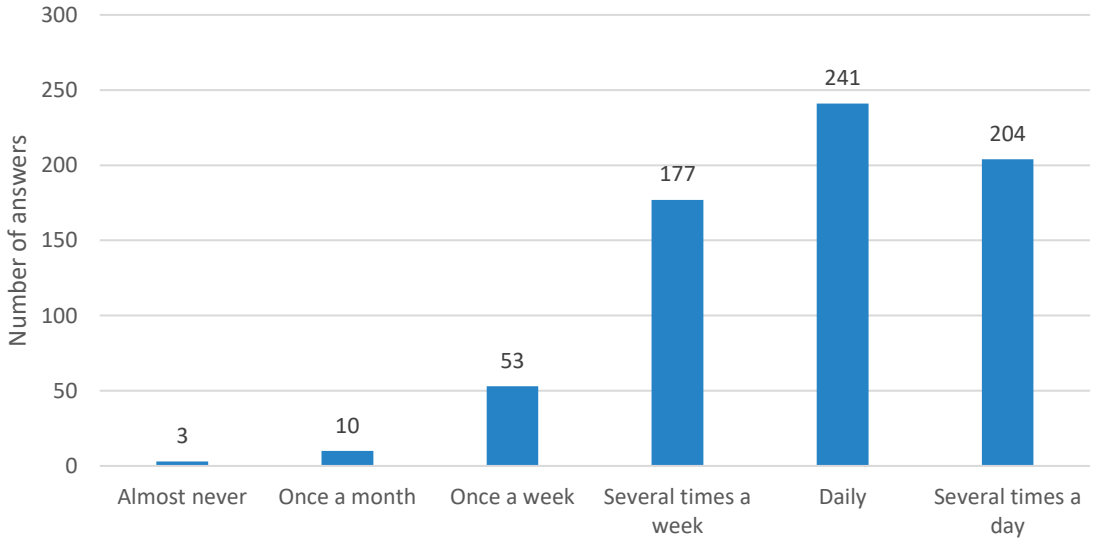
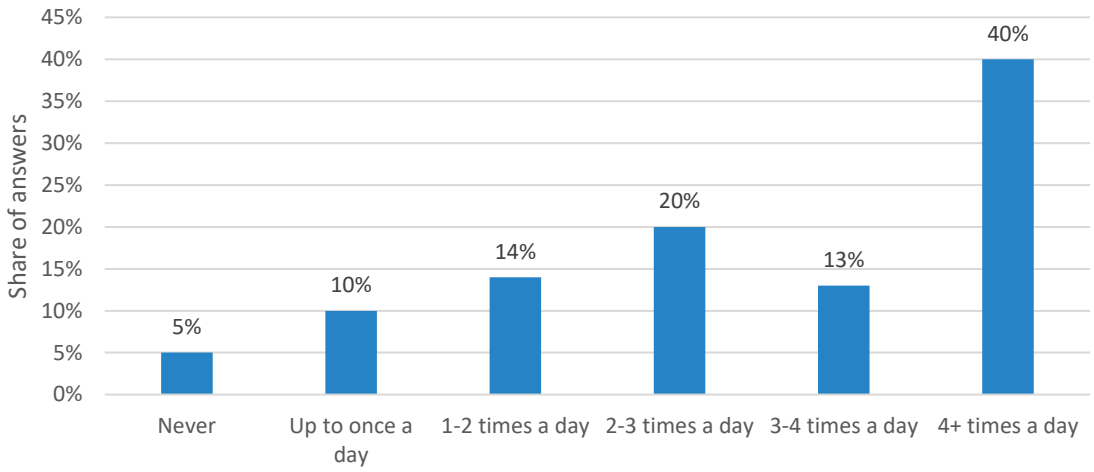


Figure 3-3: Number of kettles uses per household and day according to a household survey in the United Kingdom[2] (Data: [EST 2013]; Question: 'How many times does your household use the kettle each week?'; n: not specified)



The considerable variation in the number of uses per day has also been pointed out elsewhere [bio et al. 2015].

A crucial parameter for the determination of the environmental performance of electric kettles is their annual usage. Both literature and comments from the stakeholder consultation show some variation in the actual usage data. One of the concern of stakeholders is that a simple transfer of figures from specific regions like the United Kingdom on usage patterns to the rest of Europe might lead to an overestimation of kettle use. For this reason, the available indications on the average consumption of electric kettles from various source have been put together here in a structured manner. These indications differ in quality, some being based on survey and statistics, others simple assumptions used in other contexts, yet they provide some insights on expected kettle usage.

In total, 15 such indications on boiled water consumption from electric kettles have been collected (Figure 3-4). It should be noted that most of these values specify gross consumption, i.e. the amount of water heated in a kettle. One source refer to net consumption, i.e. the amount actually used as boiled water by consumers. The difference between gross and net is due to 'overboiling' (see below). One of the sources did not provide sufficient details to conclude on whether the indication is gross or net. The individual indications are:

- **Case 1:** According to [bio et al. 2015], the UK Energy Saving Trust determined the annual electricity consumption of electric kettles based on measurements in 412 households. The average resulting consumption is 167 kWh/year. Assuming an average consumption for boiling in an electric kettle of 0.12 kWh/l translates into an overall consumption per kettle and year of 1392 litres.
- **Case 2**: Also according to [bio et al. 2015], the UK Market Transformation Programme assumes a gross volume of 1542 litres per year and household. Under the assumption that 'overboiling' causes about one third of total boiled water consumption, a net value of 1000 litres per year and household is identified a proxy value.
- **Case 3**: [bio et al. 2015] also refers to another study on 250 households in the UK and provides a value of 168 kWh/year per kettle. With the same assumption on specific consumption of 0.12 kWh/l, this yields 1400 litres per year.
- **Case 4**:_Another investigation [Gallego Schmid et al. 2018] assumes a functional unit of 1542 litres of gross boiled water, referring to the figures also mentioned in case 2.
- **Case 5**: During the stakeholder consultation for this study, the UK test magazine 'Which?' indicated that data by their members points to six uses per day. With 1 litre per fill, this

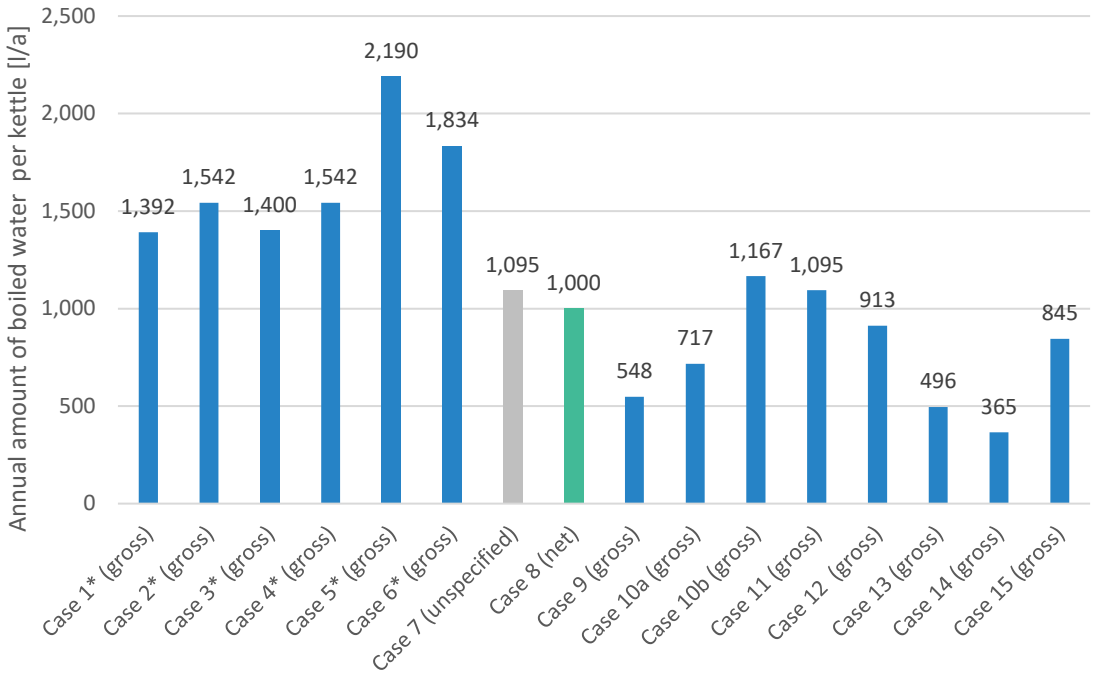
[2] Please note that figures in the publication add up to 102%.

translates to 2190 litres gross consumption per year. Yet the authors also point out that this might not be representative nor might it reflect lower usage patterns in Europe.

- **Case 6**: Based on the previously shown user surveys and additional assumptions, some estimates on gross consumption can also be derived. Using the UK survey data (Figure 3-3) and further assumptions ("up to once a day" is chosen as 0.5 uses per day, "4+ uses" is considered as 4.5 uses per day and for the remaining ones, the middle is chosen; consumption is 0.12 kWh/l again), an annual (gross) consumption of 1834 litres per year can be derived.
- **Case 7**: An investigation on the environmental labelling on kettles [Schüler; Grießhammer 2009] assumes an average demand of 3 litres of boiled water per two-person-household, translating into 1095 litres per year. In this investigation, the value is considered as a conservative, i.e. low estimate.
- **Case 8**: Another source referenced in [bio et al. 2015] indicates a net consumption of 1000 litres for boiling water with 650 litres for hot drinking and 350 litres for cooking. Yet there is no clear indication of whether this consumption is to be covered by electric kettles only.
- **Case 9**: In a comparison between electric kettles and stovetop kettles [Ayoub, Irusta 2014], a functional unit of boiling 0.5 litres water 3 times a day on each weekday is assumed. This translates into a gross consumption of 548 litres per year.
- **Case 10**: For illustrating the overall impact of kettles, a Swedish study [Energimyndigheten 2018] uses the example of two fully filled vessels per day between 1 and 1.7 litres. With the previous specific consumption (0.12 kWh/l), this translates into a gross consumption of 717 respectively 1167 litres per year.
- **Case 11**: In a screening life cycle assessment investigation [Grzesik; Guca 2011], a kettle for operation in Poland is assumed to operate three times a day for boiling 1 litre of water. This translates into 1095 litres of gross consumption per year.
- **Case 12**: In its test of electric kettles, the German magazine test [test 2013] uses a proxy value of 2.5 litres per day for illustrating energy demand and costs of various types of water heating options. On an annual basis, this translates into an annual gross demand of 913 litres.
- **Case 13**: Another input from the stakeholder consultation was received by the European association APPLiA who sees a realistic estimate in 1.7 uses per day with an average gross filling of 0.8 litres. This translates into 496 litres per year and kettle.
- **Case 14**: Within the methodology by topten [topten.ch 2017], the assumption for determining the overall demand of an electric kettle is based on assuming boiling 1 litre per day, resulting in an annual gross consumption of 365 litres.
- **Case 15**: Assuming for the German survey data (Figure 3-2) that "several times" means 3 times (resulting in 1.36 uses per day) and assuming further that a kettle with a capacity of 1.7 litres filled completely (resulting in 2.31 litres/day), this leads to an annual (gross) consumption of 845 litres.

The indications of cases 1 to 6 in Figure 3-4 were given in context with the UK, while the cases 7 to 15 are provided for other geographical areas. Despite the mentioned limits, the data seems to support the statement that the consumption in the UK is higher than in the other regions. The simple average for the remaining regions is about 800 litres of gross consumption per day. This roughly corresponds to about two uses of a 1.7 litre kettles per day filled to 2/3 of its capacity. In conclusions based on available data, a functional unit of 800 litres per electric kettle and year is considered as a suitable proxy. For the sake of completeness, it should be noted that the consumption varies by individual kettle. Some might not be regularly used while other might be under intensive regular use, e.g. in office kitchen or hotel lobbies.

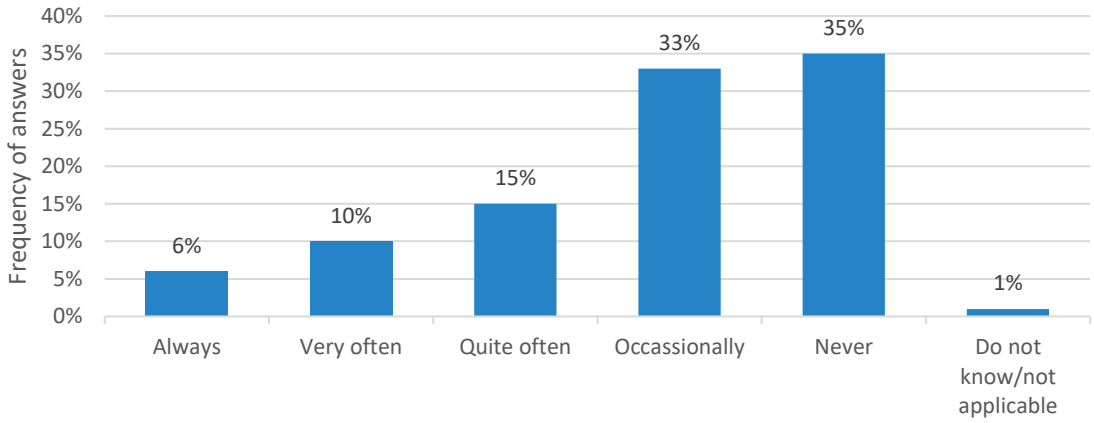
Figure 3-4: Indications on annual amount of boiled water according to various sources (Data sources and assumptions: see text; blue: gross values; green: net value; grey: unspecified; *: in context of UK values)



Another aspect related to kettle usage and user influence is descaling. Descaling of kettles is needed in case of hard water in the local water supply. Descaling is usually performed by cleaning the kettle with a cleaning agent at elevated temperatures, i.e. the kettle is turned on. Thereafter, the kettle needs rinsing, usually boiling the kettle with clean water several times before re-using it for drinking water. This will lead to an additional direct energy and water consumption. In terms of the frequency for descaling, a recommended frequency of descaling in case of normal kettles use up to 5 times a day ranges from a monthly to a quarterly basis depending on water hardness. Following the assumptions from Task 1, the overall consumption for descaling lies in the area of 1 to 2% of overall energy consumption.

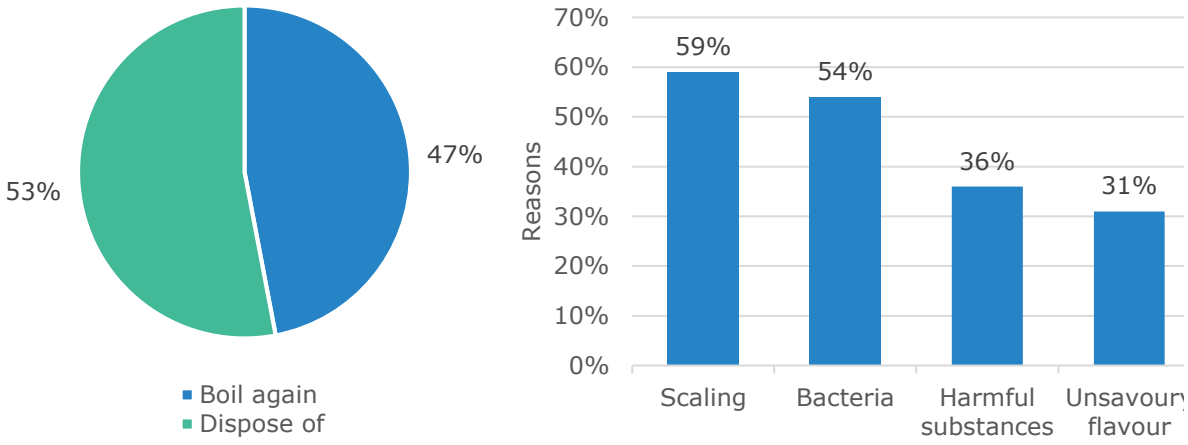
There is evidence for a considerable impact on direct energy due to 'overboiling'. 'Overboiling' is caused by a behaviour where the actually needed amount of boiled water is smaller than the amount of water filled and heated up in the kettle. Evidence on the occurrence of this phenomenon can be found in a survey in the United Kingdom by the British Department for Business, Energy & Industrial Strategy [BEIS 2020]. Its 'Public Attitudes Tracker' is a survey that is carried out four times a year. In the most recent wave of the survey, a representative sample of 1,851 adults were asked, among others, about energy-related behaviour including a specific question on their use of kettles. Figure 3-5 shows the results for boiling water in a kettle. The results underline that nearly two-thirds (65%) of the participants at least occasionally boil too much water in a kettle (result of preceding survey in March 2019: 61%). With regard to an extension to the standard or establishing an energy-related methodology for kettles, the approach could indicate whether any design features to minimize overboiling have been put into place.

Figure 3-5: Share of overboiling according to a household survey in the UK (Data: [BEIS 2020]; Question: 'How often, if at all, do you personally do any of the following … Boil the kettle with more water than you are going to use?', n=1851)



Next to the resulting direct impact on energy consumption due to heating more water than needed, this behaviour also entails an increase in water consumption if water is not 'reboiled'. Some indication on the relevance of 'reboiling' can be found in a press release by SGS Institut Fresenius [SGS group 2017]. According to a survey among 500 persons in Germany, the majority (53%) disposes of remaining water after boiling it. Various reasons are provided for this behaviour, including scaling in the kettle (59% of answers), fear of bacteria growing the water (54% of answers), a fear of accumulating harmful substances from the inner kettle in the water (36% of answers) and an unsavoury taste of the water (31% of answers).

Figure 3-6: Use of 'overboiled' water according to a survey in Germany (Data: [SGS group 2017]; Question: 'Do you boil water from the kettle again?', n=500)



This suggests that a considerable share of the boiled water is disposed of and that some energy might be "lost" in case of reheating if the water was still warmer than ambient temperature. With regard to potential design options as discussed later in Task 6, this could imply that an improved insulation of kettles to reduce energy losses might benefit from accompanying information on issues related to re-using boiled water. Yet it should also be noted that still nearly half of the users indicated that they re-boil water anyways.

This discussion of aspects related to the amount of boiled water shows that the standard is making a simplification of reality when focusing on a particular amount of water for boiling only.

Settings of controls including a target temperature

With regard to the setup of the standard, a rather narrow behaviour is chosen with a maximisation of control settings and the specified increase in temperature of 80°C.

This is a simplification for energy demand measurement. Water kettles generally allow users to interrupt the heating process at any given moment, e.g. to avoid an excessive release of vapour

or to reduce noise close to the boiling point or simply as a manual mean to adjust temperature levels. Information on such behaviour, however, is limited and likely also difficult to integrate in a standard. No data seems to be available on manual switch-off by users, but it was pointed out during the stakeholder consultation, that this behaviour is considered as unlikely because of the automatic switch as a main feature of a kettle.

More advanced kettles also allow for setting desired target temperatures instead of fixed temperature levels (see also Tasks 2.4.1 and 4.1.2.5). If a lower or higher temperature than 95°C is chosen (as a result from the basic 15°C default temperature and the 80°C increase in the standard), this will have a direct impact on energy consumption. In a study on the environmental performance of kettles [Gallego Schmid et al. 2018], a distribution of 73% of consumption at 100°C, 22% at 90°C and 5% at 80°C has been used. The market analysis in Task 2 has yet shown that sales for kettles with temperature control are still limited and no published quantitative data on actual temperature setting have been found and no data on this seems available from stakeholders during the consultation either.

However, with a general trend towards smarter and IT-enabled products, there could be an increasing number of kettles offering this functionality. An energy-related standard or methodology for electric kettles might consider different target temperature levels for the calculation of energy demand (e.g. a weighted target temperature collective).

Another aspect related to temperature levels is the warm keeping function in some kettles. This allows the user to select a mode of operation where the water temperature is maintained at a specified level after regular boiling stops, i.e. the kettle will reheat the water when it drops below a specified temperature. No data on the utilization of the warm keeping function could be identified, but the same principle might apply as for 'overboiling': If the water kept warm is not used, the warm keeping function leads to excessive resource consumption. For a limited sample of kettles, the duration for warm keeping function has been identified as between 15 and 40 minutes (Energimyndigheten 2018).

Considering all aspects with a regard to a future methodology for determining the performance of kettles, it seems advisable to foresee a more differentiated view in a standard to come with regard to target temperatures and warm keeping to enhance capturing real-word behaviour.

User impact on the starting temperature of the empty kettle

The assumed "starting temperature of the empty kettle" is also a simplifying assumption. In real-world behaviour, a kettle might still be filled with remaining water from the last boiling (see also Figure 3-5). Furthermore, the assumed temperature of the kettle might deviate from reality since many factors affect this temperature.

- In case water the kettle was recently used, the kettle might still have a higher temperature as the assumed 23°C plus tolerance.

- Based on the location of use, the user might place the kettle in a particular warm location (e.g. close to an oven, heat outlet of a fridge, radiator or in the sunlight) or cold location (e.g. close to an air conditioner vent, near an open window in winter). This could affect the assumed starting temperature.

While all these issues related to user behaviour can lead to deviations from the standard, the benefits from considering varied starting temperatures of empty kettles seem limited.

User impact on cold water temperature

With regard to the "cold water temperature", the actual temperature can vary in different ways based on user behaviour:

- Water temperature varying with intensity of use: Independently of a particular intervention by a user, water temperature may vary. In a summer with previous little water use, water may have adopted elevated temperatures of the building after staying in a rather warm pipe heated by the general warmer ambient temperature for some time. In another case, much water might have been consumed recently, thus leading to water that passed an underground and thus rather cool pipe network for some time, thus leading to a lower consumption.

- Water temperature consciously changed by user: A user might also fill a kettle by selecting a hot water position at a tab, expecting for example a shorter heating time or a decrease in electricity use if the tab water is heated by other means.

- Composite temperature of water: Finally, the kettle might not have been emptied entirely. Thus, some water with an elevated temperature from the last use might remain in the kettle, thus affecting the resulting temperature in the kettle when new water is added.

While these points affect energy consumption in real-life, they also seem difficult to capture and quantify. Thus, an average assumption on cold water temperature seems justified for simplifying reality.

Other aspects related to applying the standard

There are also circumstances when applying the standard that do not necessarily meet the reality of users:

- First, there is no specification on the status of the lid. For minimizing boiling time and ensuring proper operation (e.g. the proper working of the automatic switch-off), it is likely closed during the test. A closed lid is also needed to prevent scalding hazards due to hot water spitting. In practice, however, kettles could also be switched on with an open lid.

- Second, it seems likely that the test will be operated on new kettles. In practice, real-world kettles may not be regularly cleaned by the user, leading to scaling of the kettle. Scaling can affect the thermal conductivity of an "empty" vessel and thus affect the energy consumption of a kettle. However, no information on the magnitude of this effect could be identified.

- Third, a keeping warm function as available for some kettles is not covered by the standard. Maintaining the high water temperature may entail addition energy consumption for re-boiling over a specific interval of time. A similar situation as for "overboiling" can occur, i.e. the water is kept warm but not used by the user in the end.

3.1.3. Technical systems approach

The technical system approach extends the scope of the analysis further and aims to consider kettles as a part of a larger system. Since electric kettles are stand-alone devices, there seems no particular aspects relevant to this product group. A first aspect is the aforementioned water temperature from the tap, which can affect direct energy consumption. A second aspect it the "thermal load" character of the kettle which might affect indirect energy consumption of a building (see section 3.2). If the kettle is combined with a water filter, the filter might need regular replacement, also depending on the local water properties. In sum, the project teams could not identify any user-related aspects on direct energy consumption from the technical system approach.

3.1.4. Functional systems approach

The functional systems approach shall cover other ways to provide the same services as an electric kettle. According to Task 1, the "main function of an electric kettle is to heat water either to boiling or pre-set temperature. The functional unit is the amount of boiled water." Furthermore, the kettle might offer the possibility to keep boiled water warm for some time.

In general, boiled water is used for many purposes in food preparation. Accordingly, there are many products for specific purposes that may also deliver boiled water as a core feature ("boiled water essential feature for the product"), as additional feature to another core feature ("boiled water accompanying addition") or also as a non-design feature ("product requires boiled water, but boiled water is only a 'side-effect'") (see also product scoping in Task 1.2):

Core features:

- Stove-top kettles

- Mounted electric water heaters

- Hot water dispensers
- Urns and similar vessels

Additional feature:

- Electric tea or coffee machines including derivate products
- Microwave ovens

Non-design feature:

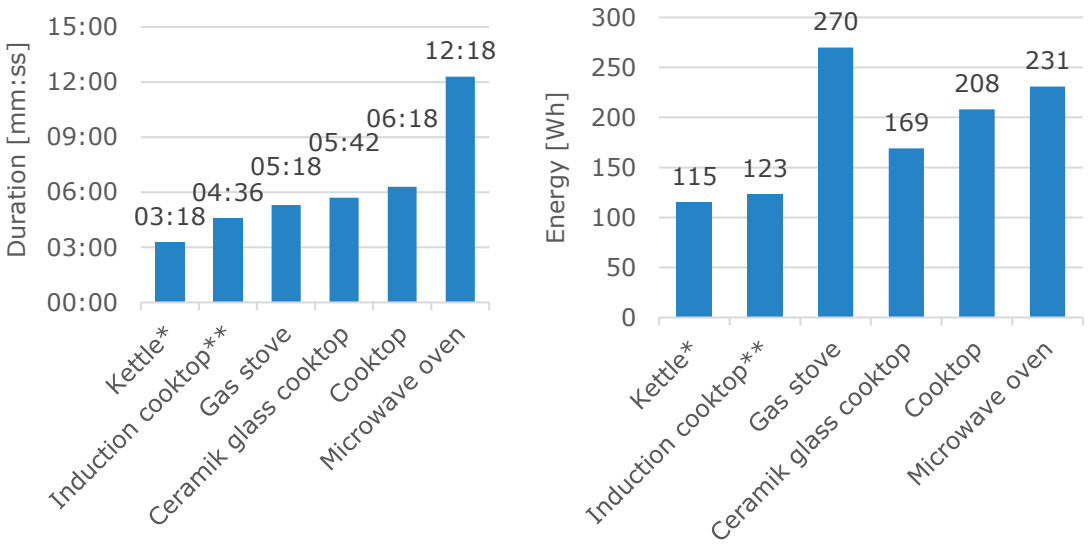
- Other stove-top kettles (e.g. cooking pans; pressure cookers; slow cookers; steam cookers)
- Products with other core usages that might heat water (e.g. egg boilers; rice cookers; milk heaters)

Even though 'non-design feature' products could yield boiled water, it seems rather unlikely that users would use these broadly as a regular substitute for electric kettles. In case of products with 'additional features', using them as a substitute is more likely than for the previous group. Yet, depending on the product, some aspects might limit their use, e.g. the achievable temperature, the available maximum volume per use, the boiling time and depending on the product, the boiled water might also adopt the flavour of the 'core' product (e.g. hot water from coffee machines).

The products with the same basic core features as the electric kettles are most likely used as a substitute for electric kettles. According to the market estimates for urns (Task 2), their relevance as a substitute for kettles seems negligible for consumers, also due to the expected larger storage vessels. Household hot water dispensers might serve as a substitute for electric boilers. Yet their current sales volume has been identified as negligible compared to electric kettles (Task 2). Indications on the performance of other ways for boiling water is given in a general comparison of the German consumer magazine 'test' [test 2013]. There, different ways of boiling water are compared which includes the duration and energy demand to boil water (Figure 3-7). In terms of boiling time, the electric kettle is attributed with the shortest time, followed by the induction cooktop (without boosting function). Other options for boiling water (e.g. other types of cooktops, microwave ovens) follow, but take longer and use more final energy according to the provided data.

In sum, when concluding on electric kettles from a functional perspective, users might most likely use traditional cooktop kettles as an alternative to operating electric kettles. However, stand-alone plug-in hot water dispensers might serve as substitutes only for some usages (especially limited amount of hot water needed) and they are currently not sold broadly.

Figure 3-7: Comparison for boiling water for 1 litre of water using different products Warentest (Data: [test 2013]: *: average of tested products; **: without booster function)



3.2. Subtask 3.2 - System aspects affecting indirect energy consumption during the use phase with indirect energy consumption effect

The aim of this subtask is to report on any **indirect** consumption effects during the use phase that affect the environment and resources. The operation of particular products (e.g. windows) might affect the energy consumption of other systems, thus causing an indirect consumption in these systems.

In general, the operation of electric kettles causes an energy transfer from the electrical grid to water with the result of obtaining boiled water. Due to losses, some of this energy is dissipated to the environment, e.g. through the vessel of the kettle and by steam emanating from the boiling process. Depending on the local operating conditions and the use of the water, this might affect the energy needed for heating (in winter) and cooling/air conditioning (in summer). Yet the magnitude of the impact does not only depend on the local environment, but also on the actual use of the water. A few example for illustration: A user might drink some hot water and then move to another location, thus dislocating also part of the energy used for boiling. In another scenario, the boiled water might be poured down an outlet. These examples hint at the difficulty in tracking where the thermal energy taken actually ends up. Furthermore, the additional net effect on any heating/cooling systems seems difficult to quantify in a generalized manner. The effects might even themselves out depending on the actual location and heating/cooling requirements.

With regard to the order of magnitude of the thermal impact, a rough estimate can be provided. Assuming:

- an average energy demand for boiling 1 litre of water of about 0,12 kWh (warm keeping function not considered),
- the previously mentioned consumption of 1500 litres per year and household (including overboiling) and
- further that the energy does not leave the location where the kettle is located,

the thermal impact would be about 180 kWh/year. For comparison: this value is in the area of the specific heating demand for heating 1 m²/year in an average building.

Due to the thus relatively limited impact, the considerable heterogeneity with regard to the need for heating and cooling buildings, the multitude of different heating and cooling technologies and especially the aforementioned uncertainties, it is suggested not to further consider the indirect energy consumption of electric kettles on heating/cooling of the building.

3.3. Subtask 3.3 - End-of-Life behaviour

The aim of this subtask is to identify, retrieve and analyse data and to report on consumer behaviour regarding end-of-life aspects from an average European perspective.

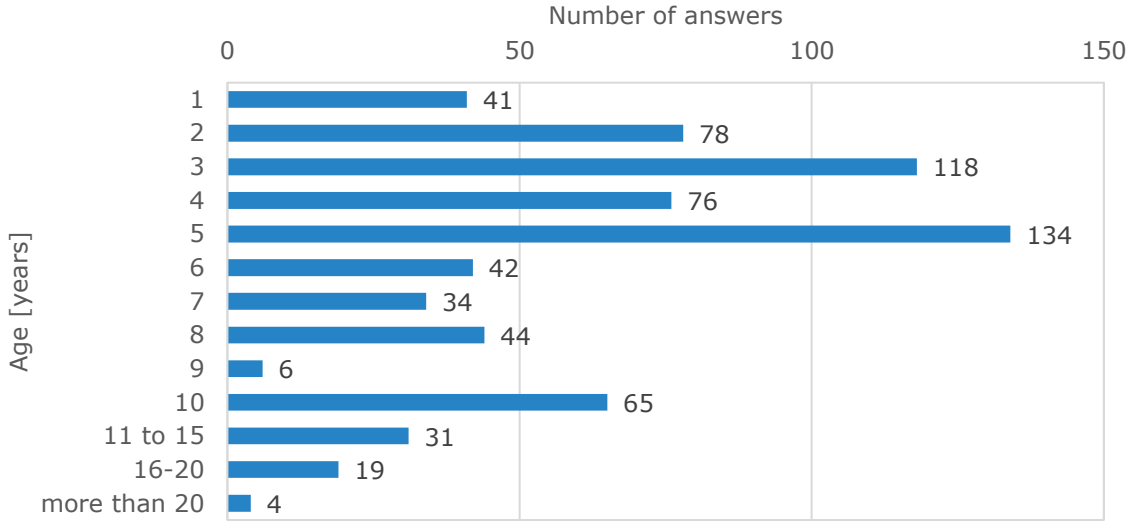
3.3.1. Product use & stock life

With regard to the lifetime of electric kettles, the corresponding analysis of the Ecodesign Working Plan study [bio et al. 2015] points out that the electric kettle market is very competitive and that price is more important than durability despite an effort by reputable brands to provide reliable products. Difference in product quality by brands were also pointed out by the UK-based test magazine 'Which?' [Williams 2020]. Based on a survey of its members, the analysis points out that well above 90% of the products of the top brand do not show any faults after three years of operation while the least reliable brand had about 70% of products still in operation after the same time.

Manufacturers of elevated quality kettles with concealed heating elements are reported to design their products for up to 20,000 uses [bio et al. 2015]. This corresponds to seven years of operation assuming eight uses per day according to the cited study. Lower priced models are reported to have a lifetime of 3 years, yet an average aggregate lifetime of 5 years have been assumed in the Working Plan study [bio et al. 2015]. Further evidence on kettle lifetime is available based on consumer survey data for the Netherlands. For hot water and coffee making products, a median lifespan of 7.0 years in the year 2000 and a value of 6.4 for the year 2005 is referred to [Bakker et al. 2014]. A survey for the German Environment Agency [Prakash et a. 2020] points in a similar direction. Figure 3-8 shows the age distribution of replaced kettles as indicated by survey participants. The results illustrate well the heterogeneity in kettle lifetimes; the average replacement cycle was determined at 5.7 years in the study with a standard deviation of 4.2 years.

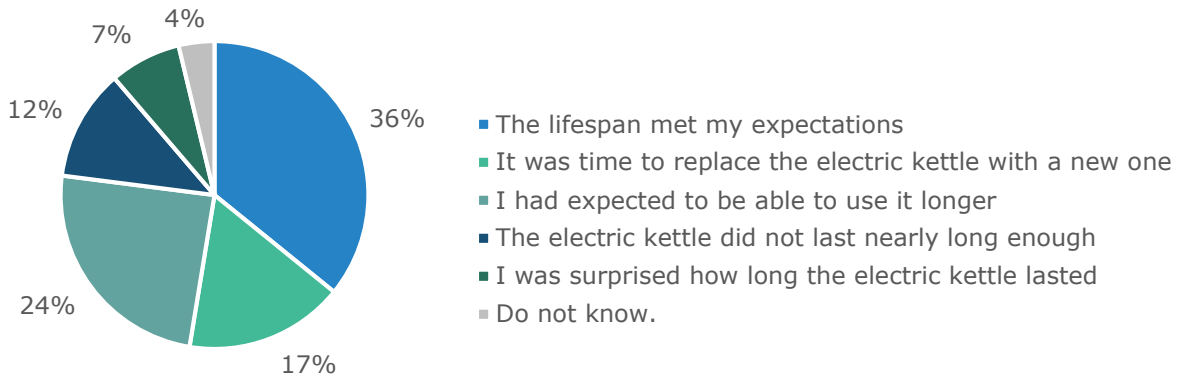
To conclude, an average lifetime assumption of 6 years seems to be a suitable order of magnitude to capture the average real-life usage of electric kettles for the study. In the individual case, considerably shorter or longer observed lifetimes are possible.

Figure 3-8: Age distribution of kettles according to a consumer survey in Germany (Data: [Prakash et a. 2020]; Question: 'How old was the kettle? If you do not know, please estimate a value [in years].', n=692)



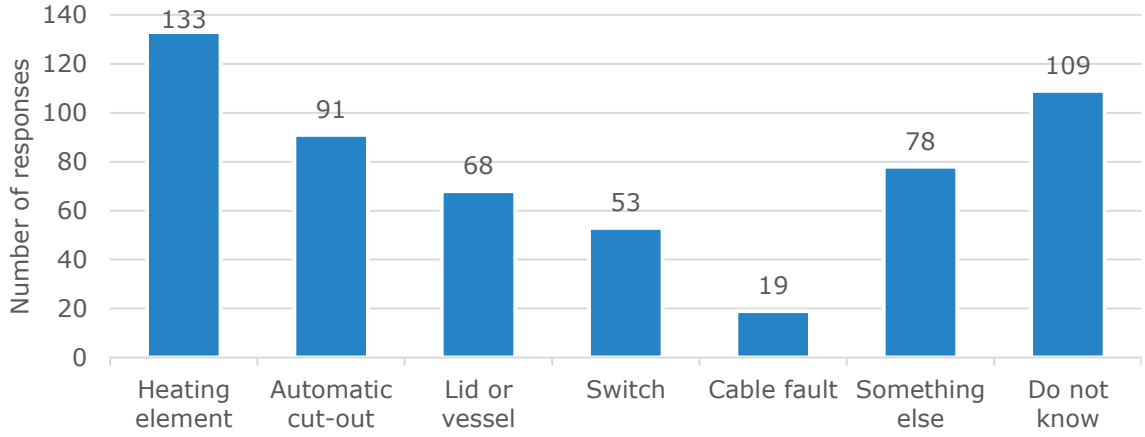
Further interesting results with regard to user behaviour is given in the German study [Prakash et al. 2020]. This study also investigates on the perception of the achieved lifetimes. Specifically, the survey participants were asked about their satisfaction with the lifespan of the kettle. More than half of the participants indicated that their lifetime expectations were met (36%) or that they saw the need to replace the existing kettle (17%). More than one third pointed out that they expected a longer lifetime (24%) or that the lifetime was well below expectations (12%). About 7% of the participants, on the contrary, were surprised on the long lifetime. This seems to suggest that consumers are generally satisfied with the lifetime of current kettles, though there might be a tendency for preferring longer lifetimes.

Figure 3-9: Satisfaction with kettle lifetime according to a consumer survey in Germany (Data: [Prakash et al. 2020]; Question: 'How satisfied were you with the lifespan of this electric kettle?'; n=692)



An investigation into the reasons for disposing of the kettle [Prakash et al. 2020] points to defects in various areas. Problems with the heating element of the automatic switching off were the most often mentioned answers (Figure 3-10). In the survey by the UK test magazine 'Which?' [Williams 2020], a broken lid was the most commonly reported error mentioned by the participants (problem in 15% of cases). Yet it should be noted that while the German study focuses on disposed kettles, the UK survey does not necessitate a prior disposal.

Figure 3-10: Defects of kettles according to a consumer survey in Germany (Data: [Prakash et al. 2020]; Question: "What exactly was wrong with the electric kettle?"; n=473, multiple answers possible)

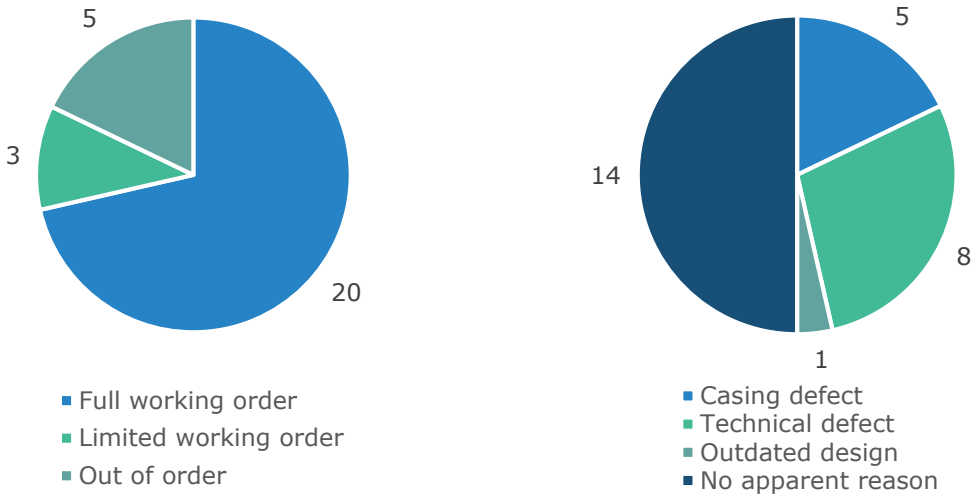


Further information on the end-of-life of kettles from a user perspective can be derived from another set of information mentioned in the German study [Prakash et al. 2020]. It reports on an analysis of 28 electric kettles collected at a local waste collection point close to Bonn, Germany, in 2013/2014. These kettles were further investigated at the local University. Figure 3-11 shows the result of this investigation: Most of the kettles (20) did not show any obvious faults that affected their utilization/function; a few (3) were classified as operating with limits (e.g. due to a broken switch that had to be manually held down/released) and the remaining kettles (5) were identified as broken. Based on these results combined with a review of external design and appearance as well as an internal inspection, the study concluded on probable reasons for disposal. The analysis of the sample concludes that for half (14) of the kettles, no apparent reason for disposal could be identified, yet 9 of them showed heaving scaling. Technical defects were identified as probable reason of disposal for 8 further kettles, defects of the casing for 5 kettles[3] and for 1 kettle, an

[3] The study mentioned that it could only be ensured for two kettles that the external damage did not originate from rough handling at the waste collection/recycling centre.

outdated design was pointed out. It has furthermore been pointed out that no connection between disposal and the nature of the product as branded or non-branded product was found [Prakash et al. 2020].

Figure 3-11: Working order test results (left) and the probable cause for disposal (right) of a sample of disposed electric kettles collected from a local waste collection point in Germany (Data: [Prakash et al. 2020])

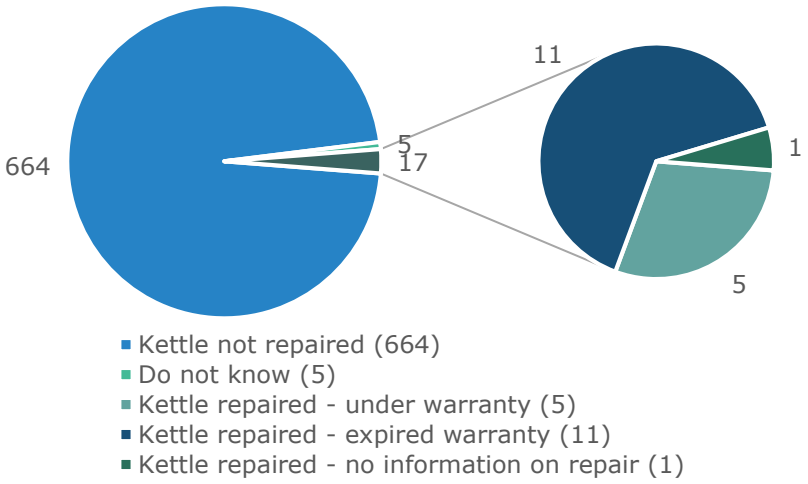


Stakeholders pointed out during the consultation that at least in the United Kingdom and Germany, manufacturers offer breakfast sets of filter coffee machines, toasters and electric water kettles in the same design. This might lead to early replacements of the devices in case consumers change all of them at the same time.

3.3.2. Repair and maintenance practice

With regard to maintenance and repair practice, the price of appliances will be a very important criterion since any repair will likely compete with the purchase of a new product. According to available data, repairs of kettles are carried out rather seldom. According to the German survey [Prakash et a. 2020], less than 3% of all kettles undergo repair and less than 1% were repaired under the warranty period. In conclusion, repairs of electric kettle are rather uncommon.

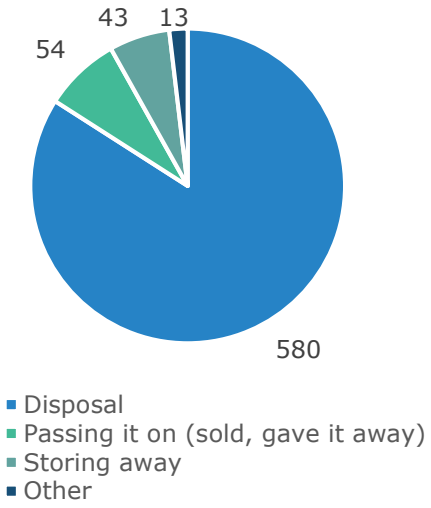
Figure 3-12 : Repair of electric kettles according to a consumer survey in Germany (Data: [Prakash et al. 2020]; Questions: 'Was the electric kettle ever repaired? ', 'Was the repair carried out during the warranty period?'; n=686 (first question), 17 (second question))



3.3.3. *Collection rates*

Generally, information on collection rates for electric kettles seem limited. Again, the survey results of the German study [Prakash et al. 2020] provide some indications on the disposal respectively second hand utilization of electric kettles. Offered a set of choices, most of the participants indicated that their kettles were directly disposed of (84%).

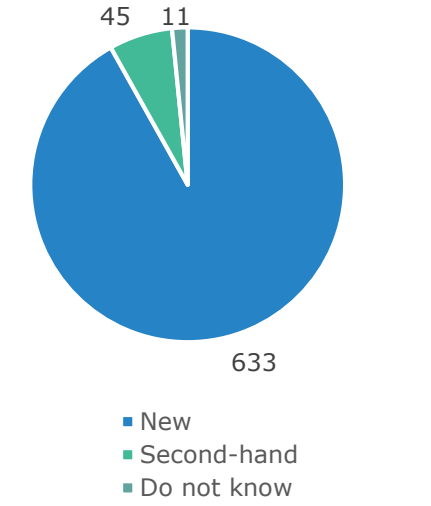
Figure 3-13 : Behaviour in case of putting kettle out of commission according to a consumer survey in Germany (Data: [Prakash et al. 2020]; Question: 'What did you do with the old kettle?', n=690)



3.3.4. *Estimated second hand use*

Due to the relatively low price of basic kettles, the hypothesis by the project team is that the second hand market for electric kettles is limited. The survey for the German Environmental Agency [Prakash et al. 2020] shows that nearly 92% of the respondents bought the kettle new while less than 7% bought the kettle second hand (Figure 3-14). This seems to support the initial hypothesis of a low passing on of kettles.

Figure 3-14 : Acquisition of the most recently acquired kettle according to a consumer survey in Germany (Source: [Prakash et al. 2020]; Question: 'Was the kettle bought new or second-hand?', n=689)



3.3.5. *Best practice in sustainable product use, amongst other regarding the items above*

Based on the previously discussed items, a summary of best practices by manufacturers to support a sustainable user behaviour with regard to electric kettles can be given.

- Since overboiling is a major source for energy and water waste, it is of particular relevance for user behaviour. Strategies therefore aim at optimizing the filling levels of the kettle that

the uses chooses. Technical means to do so are for example water indicators or integrated displays.

- In case of kettles with warm-keeping functions, alarms and automatic turn-off functions after a set duration could improve the environmental performance in this mode of operation.
- Other conceivable strategies are related to smart functions provide users with feedback on kettle utilization (see Section 4.1.4.1/Task 4).
- In view of avoiding a shift from electric to stove-top kettles, a suggestion by stakeholders is to point out the time to boil a particular amount of water (e.g. 1 cup, 1 litre) as compared to a typical stove. This could support the use of kettles as fast and environmentally well-performing mean for cooking water.
- Another factor that appears relevant for kettle lifetimes is scaling. As indicated by the cited studies, scaling appears to be a relevant factor for an early disposal of electric kettles. Best practice therefore supports the user in descaling the kettle. Shipping a descaler has been mentioned by stakeholders as a suggestion in the context of encouraging users for regular descaling.

3.4. Subtask 3.4 - Local infrastructure

The aim of this subtask is to identify, retrieve and analyse data and thereby to report on barriers and opportunities relating to any local infrastructure needed for the operation of kettles.

3.4.1. Energy infrastructure

Kettles as defined in Task 1 are devices connected to the electrical grid via a plug. There is no particular influence of kettles users on the energy infrastructure.

3.4.2. Water infrastructure

Kettles are commonly used to boil water from a tap. As mentioned earlier, users might affect the direct energy consumption of kettles if they fill them with warm water from the tap.

Depending on the local setup for heating tap water (e.g. via decentralized boiler vs. a centralized without circulation; operation by electricity or other energy carrier), obtaining hot water from the tap might require opening the tap for some time, thus leading to increases in water consumption and energy losses.

With regard to the role of the water infrastructure and local water supply, it should also be mentioned that harder water might increase scaling and the need for descaling. It might influence energy demand (see also section 3.1.2) and the use of scale filters.

3.4.3. Telecom infrastructure

Recent "smart kettles" may require wireless connections (e.g. bluetooth, wifi), e.g. for linking them to a smartphone app. These models offer services as traditional kettles via additional manual controls, e.g. for selecting certain temperature levels or a warm keeping function.

In general, this additional functionality and its impact on IT infrastructure/energy consumption of mobiles is in general similar to other "smart home devices" and it thus not seem to be of particular relevance.

3.4.4. Installation

As the electrical kettles as defined in Task 1 only need to be connected to a plug socket, no physical installation (e.g. wall mounting, piping) is relevant for this product group. Smart devices might yet need to undergo a setup procedure (e.g. pairing with smartphone).

3.4.5. Physical environment

Within the aspect entitled "physical environment", the MEErP points out to analyse sharing opportunities for the products. No particular data on sharing opportunities of kettles could be identified. Yet there are several aspects mentioned earlier that give an indication on the likelihood

of sharing: Kettles are relatively low-priced products. This is underlined by the observation that a substantial share of kettles still operational is disposed of. Few users buy second-hand kettles and kettles are often used several times a day.

While it is technically conceivable to share kettles, the combination of the previous aspects suggest that few users will tend to share the product outside of their household. In an office kitchen or similar location, kettles might be run a shared equipment. This should not be perceived as additional or new sharing opportunity but a long-established characteristic of shared kitchens.

3.5. Subtask 3.5 - Recommendations

The aim of this subtask is to provide recommendations on a refined product scope and on barriers and opportunities for Ecodesign considering user behaviour.

3.5.1. Recommendations on the refined product scope

Based on the analysis of user behaviour, the following recommendations for the refined product scoping are made:

- The analysis of user behaviour has shown a considerable variety in kettle utilization. The subsequent analysis should therefore take into consideration different usage intensities of kettles in Task 4/5.
- Overboiling has been identified as an important aspect. If available, measures to reduce overboiling should be considered in the design options developed in Tasks 6 of this study.
- Some indications on short-lifed products were found. Impact of short(er) lifetimes might also be included as a sensitivity in the scenario analysis in Task 7.
- While at the current state, there is little evidence on the actual boiling temperature selected by users, different temperature profiles for kettles with a temperature selection function/indicator could be included in Tasks 6/7, also including the consideration of a warm keeping function.

3.5.2. Recommendations on Ecodesign

Based on the discussion on the role of users, some more general recommendations for the subsequent Ecodesign process should be made:

- Overboiling is a related to user behaviour. Measures for reducing overboiling could in general be considered as well as heating water not beyond required temperature levels.
- Care should be taken that measures taken within Ecodesign do not cause a substantial shift of users towards using cooktop operation.
- Measures addressing the lifetime of the products might be included in the scenario analysis in Task 7.

Other recommendations concern a potential development of a method to assess energy consumption/energy efficiency measurements based of the basic concepts of standard IEC 60530:1975:

- The standard currently focuses on boiling time as a key result. For determining energy demand, the measurements should be extended to include power measurements. If energy consumption is to be considered, a warm keeping should also be considered in the standard.
- The temperature setup in the standard is limited to a fixed increase of 80 K to a temperature of about 95°C. More advanced modern kettles also allow selecting other target temperatures. The inclusion of a representative target temperature profile (where relevant) should be considered.
- The fixed increase by 80 K should be reconsidered. In practice, a kettle will not stop heating at a fixed temperature, but at the temperature specified by the controller. This temperature should be used, also for a target temperature profile. Combined with that, the standard should also determine this automatic shut-off temperature.
- Overboiling has been identified as a major source of energy losses. Measures to prevent overboiling should also be noted as a requirement in the standard when analysing a kettle.

- As mentioned, the methodology does not explicitly specify the status of the lid and on scaling. This should be added to avoid ambiguity.

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Task 4: Technologies

Final report

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Team:
Contract technical team leader: Antoine Durand (Fraunhofer ISI)
Contractors: VITO (Belgium) and Fraunhofer ISI (Germany)
May - 2021

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Unit C4: Energy Efficiency: Buildings and Products

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Preparatory study for Kettles implementing the Ecodesign Working Plan 2016-2019

Task 4: Technologies

Final report

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LIST OF ABBREVIATIONS AND ACRONYMS

BAT	Best Available Technology
BC	Base case
BNAT	Best not yet available technology
BOM	Bill of material
CEN	Comité Européen de Normalisation
CENELEC	European committee for electrotechnical standardization
ErP	Energy-related Products
EN	European Standard
EP	European Parliament
EU	European Union
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
LCA	life cycle assessment
MEErP	Methodology for Ecodesign of Energy-related Products
MEPS	Minimum Energy Performance Standard
MS	Member States
NTC	Negative Temperature Coefficient
PTC	Positive Temperature Coefficient

4. TASK 4: TECHNOLOGIES

This task, which is structured in accordance with the MEErP Task 4, presents the processes involved in the functional performance of electric water kettles via a technological description and analysis. This is conducted for technologies that are already on the market and that will become the basis for the base cases, but also for Best Available Technologies (BAT) and state-of-the-art Best Not-yet Available Technologies (BNAT). The analysis addresses both the product level and the component level and briefly assesses improvement potentials.

The aim of this task is also to collect a comprehensive dataset across the whole product life cycle on which to undertake the analysis of the life cycle environmental impact and economics in the subsequent tasks of this preparatory study.

4.1. Technical product description

In this task a comprehensive technical analysis of the products, present in the market, is carried out. Besides the base case technologies, which are intended to represent the average product entering the market today, BAT and BNAT (in terms of environmental improvement potential) are assessed. The assessment of the BAT and BNAT provides the input for the identification of the improvement potentials reported in Task 6.

4.1.1. Different types of kettles (working towards definition of Base Cases)

The work carried out under Task 1 suggested that the scope of the study could be exclusively limited to electric kettles with a volume of up to 10 litres. In order to provide a full information, info, a brief description of hot water dispensers and boiled water heaters is also provided in this document.

4.1.1.1. Electric Water Kettles

When it comes to heating and boiling water (e.g. for cooking, tea or coffee) electric water kettles are the products used the most in households, gastronomy and hotels.

Similar to hot water dispenser, there are multiple types of electric water kettles existing. They vary in terms of

- capacity of the container
- material of the container
- rated input power
- heating element
- base
- features like temperature setting and temperature holding

All these parameters are going to be introduced and analysed within this preparatory study at the component descriptions (see 4.1.2).

Working principle

Despite all variables, there are components all electric water kettles need, to be able to operate in the first place:

- container
- heating element[1]

The working principle of an electric kettle itself is relatively simple. Although it changes slightly depending on the features an electric kettle has (e.g. the kettle with feature of temperature setting requires more electronic parts than other kettles). The water heating/ boiling process can be divided into three steps:

- Step 1: Start of heating/ boiling process

[1] see https://www.wasserkocher.net/aufbau-funktion/#gref (last call 15.06.2020)

After filling the container with some water and placing it on the base, dropping a pulser mechanically closes a circuit. The component in charge of the heating is the heating element. A current starts flowing through the element: the boiling process starts.[2]

- Step 2: Heating/ boiling process

  The working principle of the heating element is a resistive principle. This means a current flows through an element converting electricity to heat energy due to the components electrical resistance, the resistive heating element heats up.3 As a result, heat flows from heating element to the heating plate. The water temperature rises continuously and reaches the boiling temperature eventually.4

- Step 3: Automatic switch off

  All modern electric water kettles possess the feature of an automatic switch-off. One principle behind this feature is that evaporating water generates steam, which heats a bi-metallic thermostat. A kettle switches off, as the bi-metallic element reaches a certain temperature (depending on the metals used in the element) and the element changes its position. As a result, the electric circuit is interrupted and the heating and boiling process stops. Other principles are using thermistors as Negative Temperature Coefficient (NTC) or Positive Temperature Coefficient (PTC).

To summarize there are different types of technologies and kettles, which can fulfil the task to heat and to boil water. For the further input of this preparatory study, the definition of "electric water kettles" used in Task 1 - Scope is used:

"Electric kettles" are stand-alone, unpressurized, electrically powered domestic appliances primarily intended for boiling a batch of up to 10 litres of drinking water, potentially also including a warm-keeping function after heating."[5]

4.1.1.2. Hot water dispenser

Hot water dispensers are known as products to dispense water. There are several types existing, a typical model is an instant hot water dispenser.

Working principle

Hot water dispenser consists of a tank, usually metal, with rubber tanks also being found in lower-end models, and an electrical coil that is attached to the pipe, quickly and efficiently heating up cold water that goes through the pipe (see Figure 4-1).

The working principle is quite simple. After activated, the required amount of cold water is pumped from the water tank and heated up to the desired water temperature (max. 94°C). Concerning the heating process, most hot water dispensers have an instantaneous water heater for heating the water (see Figure 4-1). For this purpose, cold water is pumped from a tank through a pipe to the outlet. While going through the pipe, it is heated by an instantaneous water heater to the temperature needed.[6]

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[2] see https://de.techinfus.com/dlya-kuxni/elektrochajnik/remont-chajnika-svoimi-rukami.html (last call: 15.06.2020)

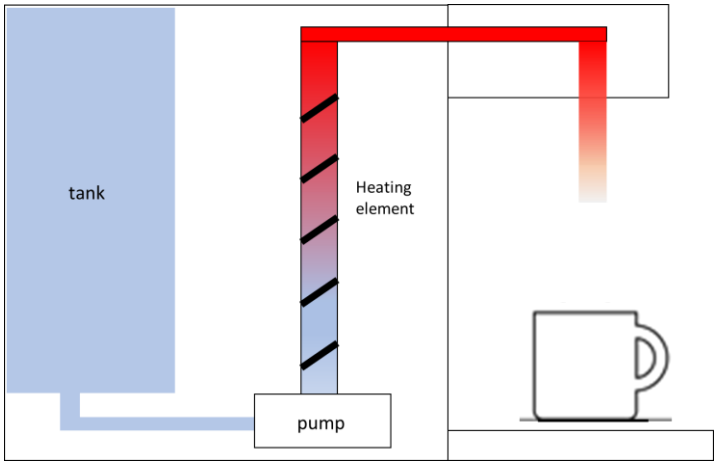
[3] see https://www.explainthatstuff.com/heating-elements.html last call 23.06.2020

[4] see https://kettleheatingelements.weebly.com/functionality-and-materials.html last call 22.06.2020

[5] see Task 1

[6] See https://de.wikipedia.org/wiki/Wasserkocher (last call 15.06.2020)

Figure 4-1: Working principle of hot water dispenser



Characteristically for hot water dispenser is that they just boil the amount of water, which is actually needed. Hot water dispenser also copes with the underlying prerequisite to heat water.

4.1.1.3. Boiling water heaters

In comparison to most of hot water dispensers and electric water kettles a Quooker is directly connected with the cold water supply. Boiling water heater systems consist of a vacuum-isolated tank, tap, inlet valve and some minor installation parts (e.g. screws, thread rings, other rings). The system most relevant for this preparatory study is the Quooker PRO3 that provides hot/ boiling water only.[7]

The tank in the kitchen cupboard is connected to the boiling water tap on the worktop, where - depending on the product -a certain amount of hot water is stored at overpressure conditions and 110°C temperatures. The tank itself can be seen as a vacuum flask connected to the cold water supply. The air in the insulated wall is so thin that the heat is unable to escape. It therefore takes very little energy[8] to keep the water at 110°C.

Working principle

As soon as the tap is turned on, the outflowing water starts to boil. Simultaneously, the temperature of the water drops to 100°C. At the same time that the water is flowing out of the tap, cold fresh water is refilling the tank.

Quooker fulfils the underlying prerequisite to heat water and due to its insulation, it is relatively efficient. According to Quooker, the stand-by-mode consumes 10W[9] and therefore generates costs up to 0.05 ct€/day.[10]

4.1.2. Components of electric water kettles

Despite all differences, electric water kettles are, generally speaking, simple products with manageable number of component-groups. In the next few chapters, these groups -also

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[7] see https://www.quooker.de/media/wysiwyg/i/n/installationsanleitung_pro3_de_2.pdf (last call 15.06.2020)

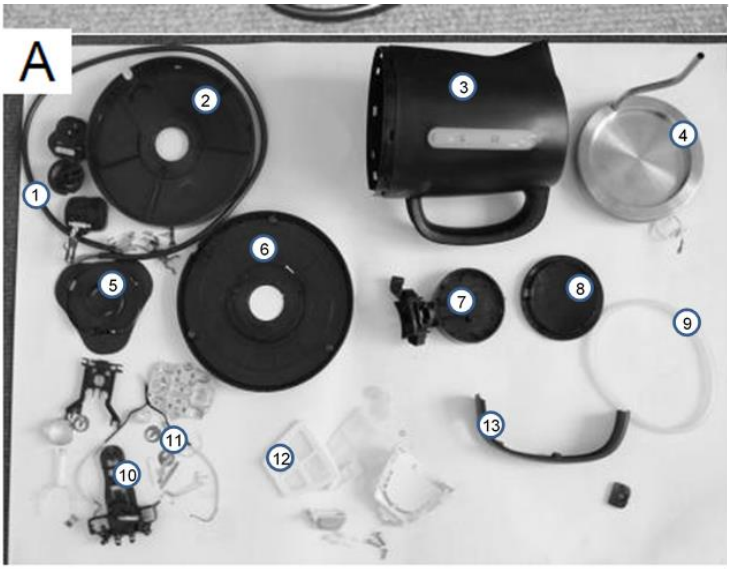
[8] According to Quooker just 10 watts (https://www.quooker.co.uk/how-a-quooker-works (last call: 15.06.2020))

[9] see https://www.quooker.co.uk/media/wysiwyg/i/n/installation_guide_vaq_e_uk.pdf (last call 10.11.2020)

[10] see https://www.quooker.de/media/wysiwyg/Endkundenbrosch_re_DE.pdf (last call 15.06.2020)

considering potential alternative variants or materials- are introduced. Figure 4-2 provides a good overview of built-in components of an electric water kettle.

Figure 4-2: Dismantled electric water kettle [Source: Alejandro Gallego-Schmid et al. (2018)]



1: Power cable
2: Base moulding
3: Water reservoir
4: Heating plate
5: Wire housing
6: Bottom cover of reservoir
7: Lid release mechanism
8: Lid cover
9: Rubber seal
10: Control unit
11: Bi-metal disk
12: Removable filter
13: Handle cover

4.1.2.1. Power cord and plug

Every electric water kettle has a power cord, connecting mains power with the kettle. The power cord can be mounted on the kettle directly or on a base

Every electric water kettle has a power cord, connecting mains power with the kettle. The power cord can be mounted on the kettle directly or on a base, a differentiation between cordless and corded can be made.

Cordless

Contradicting to the first understanding of the word "cordless" it does not mean that an electric kettle has no power cord at all. In connection with kettles, "cordless" means that the power cord connects the mains power with the base. The container of the kettle itself is not connected to the mains power and therefore is portable. The product offers a two-piece approach.

Corded

Next to cordless products with a two-piece approach, there are one-piece gadgets without a base. The power cord is mounted on the electric kettle directly. This means when filling with fresh water and pouring boiling water the plug should be withdrawn for safety reasons.

There is no causal relation between the way a kettle is connected with the mains power and a certain use of heating element. A cordless product can have either a concealed, underfloor or an immersed heating element.[11]

4.1.2.2. Base

In addition to the differentiation between "cordless" and "corded" explained in the previous subchapter, "cordless" kettles usually have bases, whereas corded models do not.

The component "base" is directly linked with the power cord and is of pivotal meaning for the whole function and operating mode of an electric water kettle. The base can be seen as the control centre where most of the sensors, thermostats, control units and other safety mechanisms are situated,

[11] see https://de.wikipedia.org/wiki/Wasserkocher (last call: 15.06.2020)

providing the technology basis for all features a modern kettle offers. For some kettles the hardware for pre-set temperature and temperature holding is also placed on the base.

Besides its importance from a technological point of view, the connector on top of the base ensures -as a preliminary step- the closing of the power circuit through placing the container of the kettle on the base (which is initiated through pushing the pulser at a later stage). Vice versa, removing/ lifting the container from the base interrupts the power circuit and therefore the boiling process. Some but not all kettles offer a feature that prevents the kettle from re-starting the boiling process after the kettle is placed on the base again.[12]

Another distinction can be made in terms of handling the kettle. For cordless kettles, there are bases available which allow

- 360° radius: kettles operate independently of the position on the base
- fixed base: kettles can just be placed in one certain position and therefore solely operate in this position

4.1.2.3. Container

The component in which water kettles vary the most is the container of the kettle. The container comprises the location the actual heating and boiling process takes place, as well as the handle, the lid and the space between these areas (partly used for placing sensors, thermostats and control units, depending on the kettle). A container can differ in following parameters:

- construction
- design
- lid
- material
- capacity
- other components (e.g. water filling indicator, filters)

To give a short and comprehensive overview these parameters are specified in the turn.

Construction

Kettles are constructed in various ways. Some products have a double wall characteristic, which can lead to different qualities of a kettle:

- Cool touch / Insulation

  In its effect, the easiest variation is using two different or one special material(s) for building the wall(s) of the kettle. This double wall measure is aiming for a higher safety standard in handling the kettle (scalding protection).

  Normally, such products go hand in hand with an insulation. Build-in materials provide a certain amount of thermal insulation like a thermos flask. Due to the high price sensitivity of the market, nowadays there is just air, instead of special filling material, between the two layers. A product with the feature cool touch does not necessarily have an insulation, whereas it is most likely that a product with insulation has automatically cool touch feature.

- Vacuum

  Some water kettles go even further and have special approach of insulation. So-called vacuum kettles are vacuum-isolated with a reduced amount of air between two walls of the kettle to prevent heat losses through materials.

Next to the special construction option of the wall, there are products where their hardware for the features pre-set temperature and/or temperature holding are not integrated in the base but in the handle of the container. Therefore, not for every water kettle, all sensors, thermostats and control units are located in the base. Depending on the product, some of those components are built in the spare place in the container, e.g. there are gadgets having the thermostat for providing an auto-

[12] see https://de.wikipedia.org/wiki/Wasserkocher (last call: 15.06.2020)

switch-off between the tank where the actual heating and boiling process takes place and the handle.

Design

Electric water kettles are sold in different styles and shapes. Most of the kettles are jug-like kettles. However, there are also some products with a traditional -dome/ pyramid- design. Form is not dictated by energy efficiency considerations but by design issues. However, form and design could influence energy consumption of a product. Since kettles are appliances used in households and a visible part of the daily life, they are not just tools to boil water but also products fulfilling special design requirements. As a result, sometimes a higher amount of material is used as it would be actually needed to solely serve the task of heating and boiling water. This has effects on bill of material and the life cycle assessment dealt with at a later stage in this preparatory study.

Lid

Lids of kettles have multiple functions. On the one hand, a closed lid prevents boiling water from spilling out of the container and functions as a scalding protection. On the other hand, it contains - in some cases- sensors, e.g. boiling temperature sensor that is responsible for the auto-off-feature.

Normally lids can be opened via pushing a button, located on the handle. However, the degree to which a lid opens varies from kettle to kettle. For some kettles, the lid can be removed completely, which makes for example cleaning and descaling process easier. Concerning the material: lids of water kettles do not necessarily have the same material as the container of the kettle.[13]

Capacity

In context with this preparatory study, the expression capacity stands for the capacity of the container of the kettle. The volume of water that can be heated and boiled safely.

Looking at the numbers of stock and sales from Task 1, the spectrum of models with different capacities is very broad. To provide a comprehensive overview, three ranges can be made, which comprises the different use-cases the best:

- small kettles

  Small gadgets with a volume up to 1.2l. Mostly used as travel kettles or in hotel rooms. They have the least sophisticated approach and their primarily function is boiling water.

- medium-sized/ standard kettles

  The vast majority of kettles in stock and sales within the European Union concerns medium-sized models with a capacity between 1.5l and 1.7l. This product category exists in all variations with a broad range of features.

- large kettles

  Large kettles are also known under the name "urn". Urns show the widest range of capacity. There are gadgets between 2.5 and 26l. In this study and for a more comprehensive approach, the maximum capacity is limited to 10l.

Material

The material can vary depending on the component of the kettle. The material of the container can differ from the material of the lid, or from the material used for the base. In terms of the material, one can distinguish between materials used for the container, for the lid, for the base. Except for the electrical parts, most kettle components consist of three materials:

- Plastic
- Stainless steel

[13] see https://de.wikipedia.org/wiki/Wasserkocher (last call: 15.06.2020)

- Glass

There are products made out of solely one material. Normally, most of the kettles can be stated to have been preliminary made out of one material with components out of other material. Currently in Europe, plastic or stainless steel are the most used materials for manufacturing kettles. However, as Task 2 shows, the share of plastic kettles decreased continuously since 2013, while glass kettles account now for around 10% of the market. Trends show that consumers are getting more sensitive in terms of health and environmental issues.

Other components

- Water level indicator

  For electric water kettles, another distinction can be made in terms of water level indicator. Traditionally the indicator gives information about the amount of water in the kettle in litre. However, alternative systems are existing. Especially regarding energy efficiency, an indicator showing the amount of water needed to be boiled for a number of cups (instead of the amount of water in litres) is a potential energy saver. The so-called minimum fill or one-cup-boil information on the scale informs the user of the kettle about the water level that is required to be boiled for just one cup of tea or coffee[14].

- Limescale filter & other protection elements (vapour etc.)

  Modern water kettles obtain components to prevent limescale deposits from flowing into cups and/or teapots. Such permanent filters are demountable and cleanable.[15]

4.1.2.4. Heating element

Heating elements of water kettles differ regarding their rated input power and the integration of their heating element.

Rated input power

Similar to the capacity of electric water kettles there are multiple ranges of rated input power existing. Looking at the stock and sales data for Europe and in order to get a first overview about the current product distribution, it is possible to divide the kettles into certain clusters of rated input power. Smaller shares concern the low rated input power (lower 1,800W) and high rated input power (above 2,800W). Most of operating kettles are in the range of 2,200W to 2,800W.

As for the heating element, water kettles normally offer two types of built-in heating elements, though both are conventional, tubular electric heater:

Immersed heating element

An immersed heating element is directly integrated in the container of a kettle and stands in immediate and direct heat exchange with the liquid. Due to the unconcealed montage, they are more difficult to clean and descale compared to the concealed versions. They are often built-in less expensive water kettles though.

Their shapes vary from horizontal and flat to a vertical approach.[16] To operate a kettle with such a heating element a minimum amount of water needs to cover the heating element completely on grounds of safety issues. This has an impact on the aspect of over-boiling (vs. heating/ boiling the amount of water that is actually required) and can be mentioned as energy efficiency potential.

Underfloor heating element

Conventional, underfloor, heating elements are not directly integrated in the container. They are concealed and attached under a metallic plate, which builds the bottom of the container. The heat

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[14] e.g.: Philips Kettle HD4644/00 with 1 cup indicator

[15] see https://de.wikipedia.org/wiki/Wasserkocher (last call: 15.06.2020)

[16] see examples: https://thermoer.com/products/kettle-heating-element-supplier/ (last call 16.06.2020)

exchange works indirectly. In comparison to immersed heating elements, concealed heating elements are easier to clean and to descale. They also can be designed to be able to operate with a relatively low minimum water level (e.g. one-cup-indicator, boiling approx. 200-300 ml water), resulting in the potential to operate more application-specific.

Both immersed and conventional underfloor heating elements vary within their cross-section area according to their rated power input; the higher the wattage the larger the cross-sectional area.

Composition - conventional, tubular

To be precise, a standard heating element can be divided into several sub-components.[17] A central function has the heating wire (as the original resistance heating element), often comprising a nickel-based, nichrome heating element (NiCr), magnesium oxide powder and an outer casing. The heating wire itself is coiled. Forming a ring increases the resistance value, enhances the durability and improves heat generation speed and efficiency.

The most common mixture of nichrome heating element consists of 80 percent nickel and 20 percent chromium. Its benefits are high melting point, no oxidization, no significant expansion and relatively stable resistance qualities in terms of increasing temperatures.[18] The magnesium powder filled around the coiled wire guarantees electrical insulation and good heat transfer (thermal conductivity) within the heating element. Whereas the outer casing (often stainless steel alloys) is heat-resistant and conducting and provides both protection and form.[19]

Thick film heating element

Besides the common tubular heating elements mentioned above there are also thick film heating elements.

Thick film heating elements follow another approach and composition.[20] They generally consist of a metal core. The core is coated with a glass-ceramic lining, which ensures electrical insulation and carries conductive, screen printed heater tracks.

Currently, thick film heating elements are more expensive than conventional, tubular one. These elements are able to transfer a higher amount of energy/ heat per surface (average over the printed area 50 W/cm²)[21]. Additionally, such elements offer a lower thermal mass, therefore heat losses to the surrounding material are lower.

4.1.2.5. Other mechanical & electrical parts, sensors and control units

Hand in hand with the heating elements, go mechanical and electrical parts as sensors/thermostats and control units, that enable features like auto-switch-off, pre-set temperature, temperature keeping and boil-dry protection.

Basic definition

To be able to bring features of a modern water kettle in line with the underlying technology, some basic definitions and understandings have to be made. The expression of temperature sensors is misleading, since these sensors do not measure the actual temperature themselves. Elements providing a certain water temperature are either mechanical bi-metal switches or thermistors. Therefore, an auto-switch-off feature bases always on the same technology as pre-set temperature features. How and with which technology these features are guaranteed are dealt with within the next subchapters.

Bi-metal switch (mechanical)

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17 see example: https://thermoer.com/how-to-make-a-heating-element/ (last call 23.06.2020)

18 see https://www.explainthatstuff.com/heating-elements.html (last call 23.06.2020)

19 see http://www.ottercontrols.co.uk/x6-series.html#gsc.tab=0 (last call 26.06.2020)

20 see example: http://www.ferrotechniek.com/thick_film_heaters/technology.aspx (last call 24.06.2020)

21 see http://www.ferrotechniek.com/thick_film_heaters/technology.aspx (last call 24.06.2020)

Boiling water creates steam. Continuous generated steam is led to a mechanical sensor, a bi-metallic disk. This sensor can be placed on various locations (base, handle, lid). The working principle though does not change: once water boils long enough, steam hits the bi-metallic sensor and heats it up. Reaching a certain temperature (e.g. 100°C) the bi-metallic disk snaps its position and cuts off the power circuit. Such a bi-metal switch can be mounted in several ways. Integrated in the control unit or remote in other areas in base or product (e.g. lid or handle). Bi-metal switches are working with tolerances of +/- 5 to 7 K.[22]

Additional to the auto-switch-off feature, the working principle of a bi-metal switch can provide boil-dry protection. When the temperature soars beyond what would be expected in presence of water, a second bi-metal switch would open, cut off the circuit and not reset until the disk is close to room temperature as an infinite on-off-cycle.[23]

Thermistor (electrical)

The word thermistor is the short form of thermally-sensitive resistor. Thermistors are elements that change their electrical resistance in response to a change in their body temperature. For electric water kettles two different types of thermistors are used: PTC (Positive Temperature Coefficient) and NTC (Negative Temperature Coefficient).

- PTC

  PTC thermistor's resistance increases as temperature rises.[24] Inversely when temperature decreases, so does the resistance. As a result, the conductivity is higher as temperatures stay low. PTCs often have a transition temperature and reaching this temperature leads to an abrupt rise of resistance. They are often used in self-regulating heating elements or commonly installed in series with a circuit and used to protect against overcurrent conditions as resettable fuses.[25]

  As for water kettles, PTCs are for example beneficial for products with several pre-set temperatures (step-approach). To realize this feature different PTCs have to be mounted on the same spot. In combination with a step switch and depending on the pre-set temperature, circuits are closed or cut off.[26]

- NTC

  NTC thermistor's resistance decreases as temperature rises.[27] Whereas resistance increases as temperature decreases,[28] resulting in a better conductivity at higher temperatures, which means the higher the temperature, the higher the current. In comparison to PTCs, NTCs do not have transition temperatures and their resistance decreases linear with temperature.[29] NTCs are commonly used as a temperature sensor, or in series with a circuit as an inrush current limiter.[30]

  As for water kettles, NTCs are beneficials of different approaches (step, stepless). In combination with a control unit the kettle continuously detects the resistance and therefore the water temperature, resulting in either close or cut off the circuit. To illustrate this on an example (keep warm feature):

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22 based on Expert interview BSH (19.06.2020)

23 based on Expert interview BSH (19.06.2020)

24 see https://en.wikipedia.org/wiki/Thermistor (last call 24.06.2020)

25 see https://www.teamwavelength.com/thermistor-basics/ (last call 24.06.2020)

26 see http://wasserkocher-test24.de/woher-weiss-der-wasserkocher-wann-das-wasser-kocht/ (last call 24.06.2020)

27 see https://en.wikipedia.org/wiki/Thermistor (last call 24.06.2020)

28 see https://www.teamwavelength.com/thermistor-basics/ (last call 24.06.2020)

29 see http://wasserkocher-test24.de/woher-weiss-der-wasserkocher-wann-das-wasser-kocht/ (last call 24.06.2020)

30 see https://en.wikipedia.org/wiki/Thermistor (last call 24.06.2020)

After switching on the keep warm feature, the control unit will detect the water temperature via NTC. If the temperature is lower than the pre-set temperature, the heating element will switch on to heat the water to the pre-set temperature again. Especially for the keep warm feature, it is worth mentioning that there is no special additional sensor used. Already existing devices are supplemented by a timer, which runs for maximum 30 minutes.

Depending on price sensitivity, aspired price segment and product group, target group and corresponding control unit, both NTCs and PTCs can provide features like auto-switch-off, boil-dry (PTC), pre-set temperature, temperature keeping and work with an accuracy of +/- 2 to 5 K.[31]

Control unit & Connector

A control unit is the "brain" of each kettle, where individual elements as bi-metal disk(s), PTCs and NTCs run together. The product portfolio ranges from rather basic control units to high-end products -including all safety and steering functions as e.g. sensors and switches. Therefore, control units play a pivotal role in the daily operation of electric water kettles, especially in combination with thermistors, where the unit permanently detects and controls the resistance and therefore the temperature of the kettle. This results in starting and stopping the heating and boiling process.

However, control units do not only differ in terms of the grounds of the sensors built in a kettle, but also on the type of kettle itself

- Corded - immersed heating element

  In terms of control unit there is -theoretically- just one difference between corded and cordless kettles; the area one can carry the kettle without unplugging it: the base. However, corded kettles do not need one component that the cordless kettles need: a connector that acts as an extended arm of the control unit, establishing a connection between heating element (container) and control unit (base). Depending on the heating element there are different connectors built. As for a immersed heating element the heating element is physically integrated inside the container

- Corded - underfloor heating element

  In comparison to the corded immersed heating element, an underfloor heating element is built in directly under the bottom of the container.

- Cordless – immersed heating element

  Since an immersed heating element is mounted on the container wall, the connector cannot be placed directly under the container. This is also the reason why such kettles mostly require a fixed base and the connectors look different. They partly offer the possibility to place the steam detector integrated in the control unit or remote (e.g. in the lid of the container, or the handle)

- Cordless – underfloor heating element

  Control units of underfloor heating elements are in most cases leaner than the immersed ones and offer usually 360° movable use of the kettle.

  Noteworthy, that there are two world-market suppliers for (micro) control units- Otter Controls LTD and Strix Ltd- which play a pivotal role not just in producing and supplying control units but also in developing, constructing and other services.32

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[31] based on Expert interview BSH (19.06.2020)

[32] see http://www.ottercontrols.co.uk/kettleservices.html#gsc.tab=0 (last call 24.06.2020)

4.1.2.6. Other small parts

As in every other product there are also other small parts built in electric water kettles. Screws, buttons (rubber, protective), a rubber seal of the central switch "ON/OFF", its corresponding lamp (LED) various fixed rings.

In comparison to the other components mentioned above, those parts play an underlying role.

4.1.3. Products with standard improvement (design options)

Environmental impact of electrical products -as electrical products in households- has been intensifying over the last few years, recognizable on various ecodesign preparatory studies and regulations on these subjects. As one field of environmental impact, the energy consumption can be named. On the basis of analysing components of an electric water kettle, potential for improvements can be identified as so called design options, which are going to be specified within Task 6.

Besides energy efficiency measures, there are other potentials that have influence on real life energy consumption. As showed in Task 3, user behaviour is one of them. Prevention of over-boiling and an easy to clean and descale container have an impact. The package of potential improvements (see Table 4-1) also includes solutions to support a change in behaviour of users. *Considering the scope of the preparatory study, only water kettles are going to analysed further*

Table 4-1: Summary of potential standard improvements (design options)

Topic	Option	Component	Measure
Thermal optimization	1	Material	Material substitution
Thermal optimization	2	Design	Energy efficient design
Thermal optimization	3	Construction	Insulation
Technical optimization	4	Rated input power	Seizing
Technical optimization	5	Heating element	Immersed heating element
Technical optimization	6	Heating element	Heating element substitution
Technical optimization	7	Other mechanical & electrical parts, sensors and control units	Temperature control
Technical optimization	8	Other mechanical & electrical parts, sensors and control units	Sensors
Technical optimization	9	Other mechanical & electrical parts, sensors and control units	Boil-dry protection
Usage behaviour	10	Construction	Double chamber A double chamber approach means that there are two chambers in one kettle. One for containing the cold water, one where the actual boiling process takes place.
Usage behaviour	11	Water level indicator	Water usage
Usage behaviour	12	Heating element	Cleaning /Limescale

4.1.4. Best Available Technology – BAT (e.g. the best products on the market)

Concerning electric water kettles there is no single technology, which pushes energy efficiency of the products. Characteristically for the European market of electrical water kettles is a major intersection of features offered by each kettle. However, this intersection comprises not only technology- or energy-related topics but also user behaviour. Therefore, it is hard to say from which point, a technology can be considered as Best Available Technology (BAT). Significant distinguishing features are for example pre-set temperature and keep warm. An additional differentiation cannot be made by features or technologies themselves but by the quality of the single components. Hence, best products on the market are also considered.

4.1.4.1. Water dosing

Over-boiling is the most significant reason for energy waste during the use phase of electric water kettles. Reducing the excess of boiled water, decreases the waste of energy by more than 30 %.[33] There are two BATs dealing with this issue, initiating not just a reduction of energy waste but also a potential change in user behaviour.

Two-chamber water kettles

Products following a two-chamber approach help to heat and boil just the amount of water that is actually needed. For this purpose, water is poured in a smaller separate tank inside the actual container of the kettle where the heating/ boiling process takes place. Pushing a button, a valve opens and water enters the actual container of the kettle, where the heating/ boiling process takes place. Large windows allow easy checking of the current water level, resulting in a rather well scalable filling process, enabling to heat/ boil just the amount of water that is actually needed.

Despite being logical from an energy efficiency perspective, there are no such products on the market currently.

Downsize water level indicator

Based on the same reason, but with a different approach, this feature aims to reduce the excess energy resulting from boiling too much water.

Most water level indicators start at 0.5l. Especially, for single cups of coffee or tea, a smaller amount would be sufficient. This feature is aiming for both enhancing the usability and influencing the behaviour of users. Therefore, the water level indicator is enlarged both by scale (smaller numbers) and by window surface. The users shall be enabled to just fill to the amount of water they need. Particularly interesting are alternative scales, e.g. indicators not solely with numbers, but with corresponding numbers of cups.

Figure 4-3: Example of an alternative scale indicating the volume in number of cups

That fact that alone a water level indicator with up to one cup can save up to 18 % has been demonstrated in a study commissioned from Philips and conducted in 2008. For this study over a four-week period, 70 consumers were asked to use their own electric kettle. After that period a second period of four-weeks started, where the consumers were asked to use a kettle with a one-cup indicator. The selected consumers represented broadly typical English and Welsh households.

4.1.4.2. Monitoring temperature

Another feature is a digital display of temperature on the surface of the container of the kettle. The possibility to monitor the temperature potentially saves re-boiling procedures (see **Fehler! V erweisquelle konnte nicht gefunden werden.**). For example, if the person who wants to boil water, leaves and returns after the kettle finished the boiling process, not knowing if the temperature is still sufficient, he will start the boiling process again.

4.1.4.3. Thick film heating elements

Currently, and in comparison with resistance heating elements, thick film heating elements are more expensive. However, their benefits are obvious.

Having high power density in combination with a low thermal mass[34], they are able to heat direct and efficient, with lower amount of energy "wasted" to heat the surrounding mass of kettles.

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[33] see Gallego Schmid, A, et al., Life cycle environmental evaluation of kettles: Recommendations for the development of eco-design regulations in the European Union, DOI: 10.1016/j.scitotenv.2017.12.262

[34] see http://www.ferrotechniek.com/thick_film_heaters/technology.aspx (last call 26.06.2020)

Particularly interesting is to observe the development of stand-by mode for kettles -either in relation with WiFi-connected gadgets or kettles with keep warm feature, since the energy use of thick film heating elements for providing such a mode is rather low.[35]

4.1.4.4. Permanent cut off power circuit

There are different technologies used in electric water kettles to provide boil-dry-protection. No matter if the feature is implemented mechanically via a bi-metallic switch or electronically via a thermistor, both solutions can result in a permanent switch-on, switch-off cycle after detection of lack of water.

Both solutions fulfil the requirements of the relevant safety standard. However, there are technologies that avoid endless on/off triggering and cut off the power circuit permanently, which can lead to additional energy savings (in case of occurrence).

4.1.4.5. Electric kettles with WiFi-connection

Electric kettles with WiFi-connection are already on the market. However, studies show that their handling and steering via App is not working smoothly yet.[36] Regarding increasing level of digitalization and smart home concepts of other product groups and appliances (heating system, ventilations system, fridge, etc.) it is most likely that electric water kettles are going to be integrated in such systems at some point.

The question about the energy demand for a permanent operation in stand-by mode to be accessible for Apps is a question, which needs to be further investigated.

4.1.4.6. Sensors and Control Units

Sensors used in water kettles can be divided into mechanical and electrical sensors. However, both possess a certain tolerance in determining the actual temperature of the water. Mechanical sensors as bi-metallic switches tend to have a higher inaccuracy than for instance thermistors. However, technology is evolving, and sensors offer a lower tolerance. A close interaction between sensors and control unit enables narrower detecting and checking schemes and potentially leads to an earlier cut of the circuit and therefore to a reduction in energy consumption.

4.1.5. Best Not yet Available Technology (BNAT)

After reviewing patents for heating liquids, heating technologies and control mechanisms in relation with heating and boiling liquids, it appears that electric water kettles are rather mature products. Characteristically for kettles are not their innovation potential but the intensive price sensitivity of customers and the pressure of low production and distribution costs of producers.

Also worth of mentioning, not just for the BNAT chapter of this preparatory study but also for implementing measures or potential regulation, is that there is a high market concentration in the supplying segment of control units of two major producers. These producers cannot be seen as conventional suppliers but as full-service providers from planning and developing to the realisation of the steering and controlling unit (incl. sensors and safety applications). This circumstance could influence further activities and measures according to Article 15, 5(e) related to "Implementing measures"[37] of the Ecodesign Directive 2009/125/EC, which should be considered carefully. However, there are two trends worth mentioning on this stage.

4.1.5.1. Induction heating

Repeatedly, alternative heating principles occur. So does the principle of induction. Induction is seen as the heating technology of the 21st century for more than one product area.

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[35] see http://www.ferrotechniek.com/thick_film_heaters.aspx (last call 26.06.2020)

[36] see https://www.techstage.de/ratgeber/Wasserkocher-mit-App-Optimale-Temperatur-ab-35-Euro-4686998.html?hg=2&hgi=2&hgf=false (last call 26.06.2020)

[37] see Articel 15, 5, (e): implementing measures shall meet all the following criteria: in principle, the setting of an ecodesign requirement shall not have the consequence of imposing proprietary technology on manufacturers;

However, there has always been a lack of additional "user benefit" or "more convenience" for induction technology as criteria for generating customer needs. Addressing this issue, one innovative product entering the market was a heating application with two components, an induction plate and a metal rod / a disk-like ending.[38]

Induction is an electric heating method. Usually, a planar copper coil is supplied by electrical power via a frequency inverter (~20 to 200 kHz). Alternating current induces eddy current in nearby metallic objects such as the disk-like ending of the metal rod.[39]

Therefore, in order to heat or boil water, a cup filled with water is placed on the induction plate. The metal rod will be immersed in the liquid and the plate will be switched on. Since the liquid is directly heated in its vessel, the topic of over-boiling is not present with this technology. Such technology does not just heat or boil water but various other liquids, e.g. milk and soups.[40] Despite all advantages, the product lacks technological maturity and has not succeeded on the market yet.

4.1.5.2. Kippit Water kettles

Another potential BNAT can be identified not in developing or using new technology but in improving the reparability and durability of electric water kettles. The product follows the approach, that every part of the kettle can be changed easily and is available for life. Stressing that repairing is not just financially advantageous but also from a circular economy point of view.[41]

There are products entering the market, which not just aim to boil water but broaden the application portfolio. Such kettle-like appliances do not just heat or boil water but do offer several different inlets that can be used to heat soup, cook noodles.[42]

4.2. Production, distribution and end of life

Following the MEERP methodology, this study requires an analysis by using base cases (BC). Base cases represent standard electric water kettles, reflecting the average product of the market. As a result of the tasks carried out so far, three base cases can be defined. The values are derived from stakeholder input, product catalogues and product data from GfK (see Task 2), existing environmental product declarations and other LCA studies for electric water kettles components or products.

4.2.1. Definition of Base Cases

Analysing the European market in stock and sale as well as using other relevant data, the project team suggest defining three Base Cases (BC), as follows:

- Base Case 1: simple plastic kettle with no special specifications such as temperature setting and temperature holding. The rated input power as well as the capacity of the container is relatively low. The base itself is fixed and the container has an immersed heating element. Those kinds of kettles are typically used as travel kettles.
- Base Case 2: simple plastic kettle. In terms of both capacity of the container and rated input power, this Base Case represents the average electric water kettle -highest number of kettles in stock and sale- used in Europe. The kettle has a concealed, underfloor heating element and 360° moveable base.

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[38] see https://www.gruenderszene.de/allgemein/miito-kickstarter-insolvenz?interstitial (last call 26.06.2020)

[39] see Lot 23, Domestic and commercial hobs and grills included when incorporated in cookers, Task 4: Technical analysis of existing products, Preparatory Studies for Ecodesign Requirements of EuPs (III) [Contract N° TREN/D3/91-2007-Lot 23-SI2.521661]

[40] see https://www.kickstarter.com/projects/747044530/miito-the-sustainable-alternative-to-the-electric (last call 26.06.2020)

[41] see https://www.kippit.fr/pourquoi-kippit/ (last call 26.06.2020)

[42] see https://www.kippit.fr/boutique/ (last call last call: 23.06.2020)

– Base Case 3: plastic as container material. In comparison to BC 2 special specifications, namely temperature setting and temperature holding, are considered.

Table 4-2 shows all main characteristics and basic parameters of the base cases:

Table 4-2: Overview - Base Cases

Base Case	Heating element	Material of the container	Capacity of the container[l]	Rated power input [W]	Features	Shape	Base & 360°
1	Non-concealed	Plastic	1.0	1,000-1,400	-	Jug	No
2	Concealed	Plastic	1.7	2,200 – 2,400	-	Jug	Yes
3	Concealed	Plastic	1.7	2,200 – 2,400	Temperature-setting, keep warm	Jug	Yes

4.2.2. Bill of materials

Since the three BCs are intended to represent the average products on the current market, the bill of materials allow a scaling up of materials used and required for electric water kettles within Europe. The three BOMs were elaborated based on data provided in the valuable work of Alejandro Gallego-Schmid et al. (2018). Within this paper kettles have been dismantled and BOMs have been generated. One BOM represents a kettle out of plastic with similar features like the BCs.

Further remarks:

- If a material is occurring just once in the list of materials as well as in the list of components, no scaling and calculations have been undertaken, since it can be assumed that this material is necessary for operating the kettle.
- In comparison to BC2, BC3 has the features of pre-set temperature and temperature keeping. Therefore, BC2 acts as a reference model in terms of components and material. However further electronic components have been added. Information about the additional components are derived from a BOM of an Eco-Kettle listed in Alejandro Gallego-Schmid et al. (2018)

Table 4-3 shows a summary of the BOM of the three base cases. Further detailed explanations about the proceeding about these calculations are attached in Appendix.

Table 4-3: Summary of bill of materials

Name	BC 1	BC 2	BC 3
Description	Simple plastic kettle, low capacity, no special specifications, medium power	Simple plastic kettle, medium capacity, no special specifications, higher power	Simple plastic kettle, medium capacity, no special specifications, higher power
Capacity of the container [litre]	1.0	1.7	1.7
Material of the container	Plastic	Plastic	Plastic
Rated input power [W]	1,000 - 1,400	2,200 - 2,400	2,200 - 2,400
Temperature setting	no	no	yes
Keep warm	no	no	yes
Weight [g]	723.00	1,166.00	1,195.47
Weight incl. packaging [g]	860.80	1,433.00	1,462.47

The aggregated BOMs representing the BCs are shown in the following tables. For each BC a detailed BOM is attached in the Appendix. Whereas the BOM is presented according to the EcoReport template in Task 5.

Table 4-4: Bill of material - Overview

Name	Base Case 1	Base Case 2	Base Case 3
Description	Simple plastic kettle, low capacity, no special specifications, medium power	Simple plastic kettle, medium capacity, no special specifications, higher power	Simple plastic kettle, medium capacity, no special specifications, higher power
Stainless steel (g)	186,00	299,97	306,93
Brass (g)	20,25	32,66	32,66
Copper (g)	15,00	24,19	26,73
Aluminium (g)	-	-	0,82
Tin (g)	-	-	0,08
Silver (g)	-	-	-
Polypropylene (PP) (g)	350,25	564,86	575,32
Polyvinyl chloride (g)	43,50	70,15	72,49
Nylon (g)	49,50	79,83	79,83
Polyoxymethylene (POM) (g)	9,75	15,72	15,72
Polycarbonate (g)	6,75	10,89	10,89
Acrylonitrile butadiene styrene (g)	30,00	48,38	48,38
High density polyethylene (g)	-	-	4,88
Silicone (g)	12,00	19,35	20,75
Ag (g)			0,00
Sum	723,00	1,166.00	1,195.47

Table 4-5: Bill of material - Power Supply Base

		Base Case 1	Base Case 2	Base Case 3
BC-Component	Material	Weight	Weight	Weight
POWER SUPPLY BASE				
Plug + Cord	Polypropylene (PP) (g)	33.75	54.43	54.43
	Copper (g)	10.33	16.67	16.67
	Brass (g)	15.75	25.40	25.40
	Polyvinyl chloride (g)	42.98	69.31	69.31
Screws	Stainless steel (g)	2.25	3.63	3.63
Base	Polypropylene (PP) (g)	56.25	90.72	90.72
base centerpiece	Copper (g)	2.21	3.57	3.57
	Nylon (g)	12.75	20.56	20.56
Electronic switch (elements on the top)	Stainless steel (g)			6.96
	HDPE			4.88
	Copper (g)			0.07
	Polyvinyl chloride (g)			0.69
Electronic switch (base)	Polypropylene (PP) (g)			2.26
	Copper (g)			0.29
	Tin (g)			0.03
	Ag (g)			0.00
Keypad (cables)	Copper (g)			0.72
	Polyvinyl chloride (g)			0.71
Keypad (itself)	Polypropylene (PP) (g)			3.96
	Copper (g)			0.51
	Tin (g)			0.05
	Ag (g)			0.00
Interior cables	Copper (g)			0.96
	Polyvinyl chloride (g)			0.94
Bottons control temperature	Al (g)			0.82
Protective buttons	Polypropylene (PP) (g)			4.25
Rubber bottons	Silicone (g)			1.39

Table 4-6: Bill of material - Electronic Base-Container Kettle

		Base Case 1	Base Case 2	Base Case 3
BC-Component	Material	Weight	Weight	Weight
ELECTRONIC BASE-CONTAINER KETTLE				
connections	Brass (g)	3.00	4.84	4.84
Spiked base	Brass (g)	1.50	2.42	2.42
	Stainless steel (g)	4.50	7.26	7.26
basic electronic support	Copper (g)	1.48	2.38	2.38
	Nylon (g)	15.75	25.40	25.40
Additional element supporting base electronics	Nylon (g)	5.25	8.47	8.47
Transparent element	Polycarbonate (g)	6.75	10.89	10.89
Base extraible	Acrylonitrile butadiene styrene (g)	26.25	42.33	42.33
Base cover	Polypropylene (PP) (g)	11.25	18.14	18.14
Discs	Stainless steel (g)	0.75	1.21	1.21
Lamp cables	Polyvinyl chloride (g)	0.52	0.84	0.84
	Copper (g)	0.97	1.57	1.57
Screws + washers	Stainless steel (g)	2.25	3.63	3.63
Spring	Stainless steel (g)	0.75	1.21	1.21
Supports	Stainless steel (g)	0.75	1.21	1.21
Fixed ring	Nylon (g) (PA)	15.75	25.40	25.40
POM Parts	Polyoxymethylene (POM) (g)	2.25	3.63	3.63

Table 4-7: Bill of material - Container

		Base Case 1	Base Case 2	Base Case 3
BC-Component	Material	Weight	Weight	Weight
CONTAINER				
Handle, accessories and container				
	Polypropylene (PP) (g)	153.00	271.43	271.43
Handle	Polypropylene (PP) (g)	40.00	60.00	60.00
Accessories	Polypropylene (PP) (g)	41.75	47.15	47.17
Base metal body	Stainless steel (g)	173.25	279.40	279.40
Base target coverage	Silicone (g)	12.00	19.35	19.35
Pulser	Acrylonitrile butadiene styrene (g)	3.75	6.05	6.05
Filter and housing	Polypropylene (PP) (g)	14.25	22.98	22.98
POM Parts	Polyoxymethylene (POM) (g)	7.50	12.10	12.10
Screws	Stainless steel (g)	1.50	2.42	2.42

Table 4-8: Bill of material - Packaging

		Base Case 1	Base Case 2	Base Case 3
BC-Component	Material	Weight	Weight	Weight
Packaging				
Packaging foil	Low density polyethylene (g)	6.30	11.90	11.90
Cardboard boxes	paper (g)	131.50	255.10	255.10

4.3. Recommendations

In this task, three base cases for electric water kettles were suggested. Table 4-9 shows some design options for components and areas of the BCs where improvements would be applicable. Within Task 6 further relevant combinations are going to be investigated.

Table 4-9: Potential standard Improvements – suggestions for Task 6

Topic	Component		BC1	BC2	BC3
Thermal optimization	Material	Material substitution	X	X	X
Thermal optimization	Design	Energy efficient design	X	X	X
Thermal optimization	Construction	Insulation	X	X	X
Technical optimization	Rated input power	Seizing	X	X	X
Technical optimization	Heating element	Immersed heating element	X	n/a	n/a
Technical optimization	Heating element	Heating element substitution	X	X	X
Technical optimization	Other mechanical & electrical parts, sensors and control units	Temperature control	X	X	n/a
Technical optimization	Other mechanical & electrical parts, sensors and control units	Sensors	X	X	X
Technical optimization	Other mechanical & electrical parts, sensors and control units	boil-dry protection	X	X	X
Usage behaviour	Construction	Double chamber	X (x)	X	X
Usage behaviour	Water level indicator	Water usage	X	X	X
Usage behaviour	Heating element	Cleaning	X	n/a	n/a

Legend:
X = yes
(x) = yes, desirable but with restrictions

References for Task 4

BIO Intelligence Services (2011): Preparatory Studies for Ecodesign Requirements of EuPs (III) [Contract N° TREN/D3/91-2007-Lot 23-SI2.521661] Lot 23, Domestic and commercial hobs and grills included when incorporated in cookers, Task 4: Technical analysis of existing products,

Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products

Gallego Schmid, A., Jeswani, H., Fernandez Mendoza, J. M., & Azapagic, A. (2018). Life cycle environmental evaluation of kettles: Recommendations for the development of eco-design regulations in the European Union. Science of the Total Environment, 625. https://doi.org/10.1016/j.scitotenv.2017.12.262

Appendix - BOM

Since the three BCs are intended to represent the average products on the market nowadays, the bill of materials allow a scaling up of materials used and required for electric water kettles within Europe. For generating the three BOMs (see Table 4-10) following approach has been chosen:

Basic input is delivered from a paper by Alejandro Gallego-Schmid et al. (2018). Within this paper kettles have been dismantled and BOMs have been generated. One BOM represents a kettle out of plastic with similar features of the BCs. Based on this paper some calculations can be made:

- relations of materials to the total weight of the kettle
- relations of materials per component to total weight of one material

In a second step, three kettles have been identified representing the characteristics of each BC. Knowing the total weight of each of three kettles, the results of the calculations can be scaled on the total weight of the three BC-representative kettles.

For this calculation, the same approach as for calculating the relations is applied, but vice versa. In a first step, relations of materials to total weight of the BC-kettles are used to calculate the share of materials per BC.

Second step, relations of materials per component to total weight of one material are used to calculate the materials per component.

Further remarks:

- If a material is occurring just once in the list of materials as well as in the list of components, no scaling and calculations have been undertaken, since it can be assumed that this material is necessary for operating the kettle.
- Alejandro Gallego-Schmid et. al (2018) dealing with casing, handle and lid of the container of the kettle as one component. With regard to task 6, a sub-calculation has been carried out calculating the amount of the casing. On the share of handle and lid assumptions have been made.
- In comparison to BC2, BC 3 has the features of pre-set temperature and temperature keeping. Therefore, BC2 acts as a reference model in terms of components and material. However further electronic components have been added. Information about the additional components are derived from a BOM of an Eco-Kettle listed in Alejandro Gallego-Schmid et al. (2018).

Table 4-10: Overview of the BoM

		BC 1	BC 2	BC 3
BC-Component	Material	Weight	Weight	Weight
POWER SUPPLY BASE				
Plug + Cord	Polypropylene (PP) (g)	33.75	54.43	54.43
	Copper (g)	10.33	16.67	16.67
	Brass (g)	15.75	25.40	25.40
	Polyvinyl chloride (g)	42.98	69.31	69.31
Screws	Stainless steel (g)	2.25	3.63	3.63
Base	Polypropylene (PP) (g)	56.25	90.72	90.72
base centerpiece	Copper (g)	2.21	3.57	3.57
	Nylon (g)	12.75	20.56	20.56
Electronic switch (elements on the top)	Stainless steel (g)			6.96
	HDPE			4.88
	Copper (g)			0.07
	Polyvinyl chloride (g)			0.69
Electronic switch (base)	Polypropylene (PP) (g)			2.26
	Copper (g)			0.29
	Tin (g)			0.03
	Ag (g)			0.00
Keypad (cables)	Copper (g)			0.72
	Polyvinyl chloride (g)			0.71
Keypad (itself)	Polypropylene (PP) (g)			3.96
	Copper (g)			0.51
	Tin (g)			0.05
	Ag (g)			0.00
Interior cables	Copper (g)			0.96
	Polyvinyl chloride (g)			0.94
Bottons control temperature	Al (g)			0.82
Protective buttons	Polypropylene (PP) (g)			4.25
Rubber bottons	Silicone (g)			1.39
ELECTRONIC BASE-CONTAINER KETTLE				
connections	Brass (g)	3.00	4.84	4.84
Spiked base	Brass (g)	1.50	2.42	2.42
	Stainless steel (g)	4.50	7.26	7.26
basic electronic support	Copper (g)	1.48	2.38	2.38
	Nylon (g)	15.75	25.40	25.40
Additional element supporting base electronics	Nylon (g)	5.25	8.47	8.47
Transparent element	Polycarbonate (g)	6.75	10.89	10.89
Base extraible	Acrylonitrile butadiene styrene (g)	26.25	42.33	42.33
Base cover	Polypropylene (PP) (g)	11.25	18.14	18.14
Discs	Stainless steel (g)	0.75	1.21	1.21
Lamp cables	Polyvinyl chloride (g)	0.52	0.84	0.84
	Copper (g)	0.97	1.57	1.57
Screws + washers	Stainless steel (g)	2.25	3.63	3.63
Spring	Stainless steel (g)	0.75	1.21	1.21
Supports	Stainless steel (g)	0.75	1.21	1.21
Fixed ring	Nylon (g) (PA)	15.75	25.40	25.40
POM Parts	Polyoxymethylene (POM) (g)	2.25	3.63	3.63
CONTAINER				
Handle, accessories and containe	234.75			
Container	Polypropylene (PP) (g)	153.00	271.43	271.43
Handle	Polypropylene (PP) (g)	40.00	60.00	60.00
Accessories	Polypropylene (PP) (g)	41.75	47.15	47.15
Base metal body	Stainless steel (g)	173.25	279.40	279.40
Base target coverage	Silicone (g)	12.00	19.35	19.35
Pulser	Acrylonitrile butadiene styrene (g)	3.75	6.05	6.05
Filter and housing	Polypropylene (PP) (g)	14.25	22.98	22.98
POM Parts	Polyoxymethylene (POM) (g)	7.50	12.10	12.10
Screws	Stainless steel (g)	1.50	2.42	2.42
SUM		723.00	1,166.00	1,195.47

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Preparatory study for Kettles implementing the Ecodesign Working Plan 2016-2019

Task 5: Environment & Economics

Final report

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Team:
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EUROPEAN COMMISSION

Preparatory study for Kettles implementing the Ecodesign Working Plan 2016-2019

Task 5: Environment & Economics

Final report

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LIST OF ABBREVIATIONS AND ACRONYMS

BC	Base-Case
BOM	Bill-of-Materials
EU	European Union
EU27	27 Member States of the European Union
GHG	Greenhous Gases
GWP	Global Warming Potential
LCA	Life Cycle Analysis
LCC	Life Cycle Costs
MEErP	Methodology for Ecodesign of Energy-related Products
NPV	Net Present Value
PAH	Polycyclic Aromatic Hydrocarbons
PAM	Particulate Matter
POP	Persistent Organic Pollutants
VAT	Value Added Tax
VOC	Volatile Organic Compounds

5. TASK 5: ENVIRONMENT AND ECONOMICS

General objective of Task 5:

The objective of Task 5 is to define EU product(s) or to choose a representative product category as the "Base Case" for all EU-27 Members States. Throughout the rest of the study, most of the environmental and Life Cycle Cost analyses will be built upon this Base Case. The Base Case is a conscious abstraction of reality, necessary for practical reasons (budget, time). The question of whether this abstraction may lead to inadmissible conclusions for certain market segments will be addressed in the impact- and sensitivity analysis. The description of the Base Case is the synthesis of the results of Tasks 1 to 4 and the point-of-reference for Tasks 6 (improvement potential) and 7 (impact analysis).

The different subtasks are:

- Subtask 5.1 - Product specific inputs
- Subtask 5.2 - Base Case Environmental Impact Assessment (using EcoReport 2014)
- Subtask 5.3 - Base Case Life Cycle Cost for consumer
- Subtask 5.4 - Base Case Life Cycle Costs for society
- Subtask 5.5 - EU totals.

For each of the Base Cases, Task 5 collects the most appropriate information from the previous tasks. Using the EcoReport tool and the above inputs, the emission/resources categories in MEErP format are calculated for the different life cycle stages of an electric kettle and for the different Base Cases. In addition, the Life Cycle Costs for consumers are calculated. Subsequently, the Base Case environmental impact data and the Life Cycle Cost data will be aggregated to EU-27 level, using stock and market data from Task 2.

5.1. Subtask 5.1- Product specific inputs

This section collects all the relevant quantitative Base Case information from previous tasks, which are needed for the life cycle assessment and life cycle costing.

5.1.1. Selection of Base Cases

In total, three Bases Cases have been selected, which almost cover the entire market. An overview of the three Base Cases is available in Table 5-1.

Table 5-1: Overview of selected Base Cases

Description		BC 1	BC 2	BC 3
Capacity of the container [litre]		1.0	1.7	1.7
Material of the container		Plastic	Plastic	Plastic
Rated input power [W]		1,000 - 1,400	2,200 - 2,400	2,200 - 2,400
Real input power [W]		1,000	2,200	2,200
Temperature setting		no	no	yes
Temperature holding		no	no	yes
Weight[1] [g]		723	1,166	1,195
Heating element		Non-concealed	Concealed	Concealed
Form		Jug	Jug	Jug
Base 360 °C		No	Yes	Yes
Lifetime	[a]	6	6	6
Water boiled	[litre/a]	800	800	800
Vmax	[litre]	1.0	1.7	1.7
Vmin	[litre]	0.50	0.50	0.50
keep warm : max time	[min]	n.a.	n.a.	60.0

The next sub-sections present the Base Cases. An aggregated BoM of all Base Cases is displayed in Appendix D.

5.1.2. Base Case 1

Base Case 1 represents a basic and small water kettle with immersed heating element. This type of water kettle is usually called "travel kettle" and has a plastic container. The detailed BoM for this water kettle is presented in Appendix A and Table 5-2 shows the aggregated BoM for this Base Case according to various material categories.

[1] without packaging

Table 5-2: Base Case 1 – BoM Summary

	Life Cycle Phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	BUTION		Disposal	Recycl.	**Stock**	
	Materials	**unit**									
1	Bulk Plastics	g			**383**		**4**	213	174	0	**0**
2	TecPlastics	g			**50**		**1**	28	23	0	**0**
3	Ferro	g			**186**		**2**	9	178	0	**0**
4	Non-ferro	g			**35**		**0**	2	34	0	**0**
5	Coating	g			**0**		**0**	0	0	0	**0**
6	Electronics	g			**0**		**0**	0	0	0	**0**
7	Misc.	g			**132**		**1**	45	88	0	**0**
8	Extra	g			**75**		**0**	30	46	0	**-1**
9	Auxiliaries	g			**0**		**12,000**	6,600	5,400	0	**0**
10	Refrigerant	g			**0**		**0**	0	0	0	**0**
	Total weight	g			**861**		**12,008**	6,926	5,943	0	**-1**

5.1.3. Base Case 2

Base Case 2 represents a typical 1.7 litre water kettle. It is a cordless kettle, which has a plastic container and a concealed heating element but no special feature.[2] The detailed BoM for this water kettle is presented in Appendix B and Table 5-3 shows the aggregated BoM for this Base-Case according to various material categories.

Table 5-3: Base Case 2 – BoM Summary

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	BUTION		Disposal	Recycl.	**Stock**	
	Materials	**unit**									
1	Bulk Plastics	g			**619**		**6**	344	281	0	**0**
2	TecPlastics	g			**81**		**1**	45	37	0	**0**
3	Ferro	g			**300**		**3**	15	288	0	**0**
4	Non-ferro	g			**57**		**1**	3	55	0	**0**
5	Coating	g			**0**		**0**	0	0	0	**0**
6	Electronics	g			**0**		**0**	0	0	0	**0**
7	Misc.	g			**255**		**3**	88	170	0	**0**
8	Extra	g			**121**		**0**	48	75	0	**-1**
9	Auxiliaries	g			**0**		**20,400**	11,220	9,180	0	**0**
10	Refrigerant	g			**0**		**0**	0	0	0	**0**
	Total weight	g			**1,433**		**20,413**	11,762	10,085	0	**-1**

5.1.4. Base Case 3

Base Case 3 represents an advanced kettle. It is similar to Base Case 2 (cordless, plastic container, concealed heating element) but has two major features: temperature pre-setting and keep-warm functions, which are relevant for both comfort and energy consumption. The BC3 BoM is based on the BC2 BoM but includes different sensor[3] and controller, and it has also more buttons and electronic (e.g. display). The detailed BoM for this water kettle is presented in

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[2] Annex G delivers information on the choice of container material

[3] one NTC sensor

Appendix C and Table 5-4 shows the aggregated BoM for this Base-Case according to various material categories.

Table 5-4: Base Case 3 – BoM Summary

	Life Cycle Phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	BUTION		Disposal	Recycl.	**Stock**	
	Materials	**unit**									
1	Bulk Plastics	g			**634**		**6**	352	288	0	**0**
2	TecPlastics	g			**83**		**1**	46	38	0	**0**
3	Ferro	g			**307**		**3**	16	295	0	**0**
4	Non-ferro	g			**60**		**1**	3	58	0	**0**
5	Coating	g			**0**		**0**	0	0	0	**0**
6	Electronics	g			**0**		**0**	0	0	0	**0**
7	Misc.	g			**255**		**3**	88	170	0	**0**
8	Extra	g			**122**		**0**	48	75	0	**-1**
9	Auxiliaries	g			**0**		**20,400**	11,220	9,180	0	**0**
10	Refrigerant	g			**0**		**0**	0	0	0	**0**
	Total weight	g			**1,462**		**20,413**	11,773	10,104	0	**-1**

5.1.5. Economic parameters and product service life from Task 2

5.1.5.1. Market and economic assumptions of the three Base Cases

Table 5-5 presents an overview of the assumptions regarding the following parameters:

- sales (market volume)
- stock
- technical lifetime
- economic data (consumable, reparation & maintenance as well as disposal costs)

The assumptions are based on the work carried out in Task 2 and Task 3.

Table 5-5: Market and economic assumptions of the three Base Cases

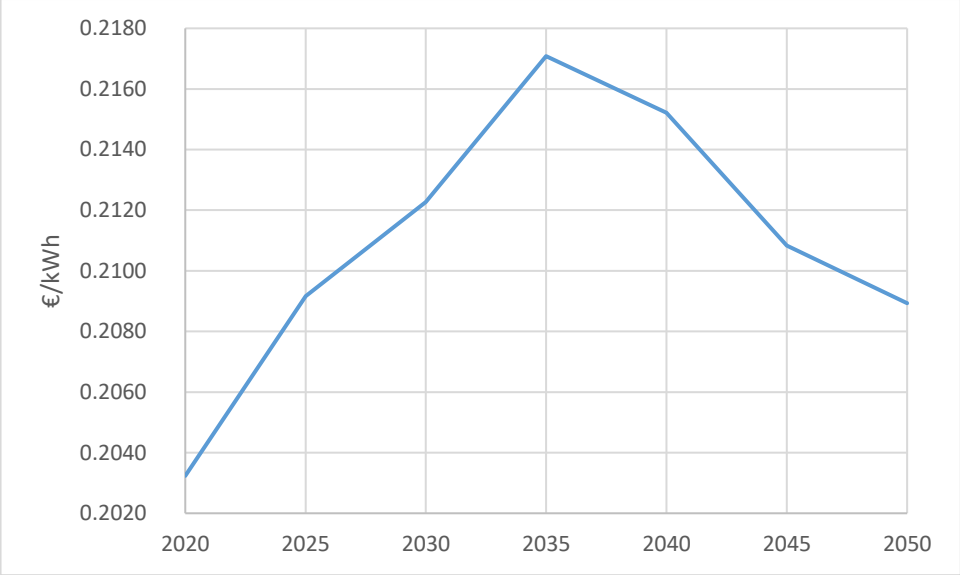
	Description		BC 1	BC 2	BC 3
Market	Sales in 2020	[-]	2,301,402	12,120,719	920,561
	Stock in 2020	[-]	14,536,872	76,560,861	5,814,749
	Lifetime	[a]	6.0	6.0	6.0
Economic data	Price	[€]	16.00	26.00	62.00
	water (for boiling)	[€/a]	2.39	2.39	2.39
	water (for descaling)	[€/a]	0.04	0.07	0.07
	installation	[€/unit]	-	-	-
	consumable - vinegar (for descaling)	[€/a]	0.80	1.36	1.36
	electricity (for boiling)	[€/a]	17.96	19.08	28.43
	electricity (for descaling)	[€/a]	0.36	0.62	0.62
	reparation and maintenance	[€/unit]	0.64	1.04	2.48
	Disposal	[€/unit]	0.30	0.30	0.30

5.1.5.2. Other economic parameters

The electricity prices applied in the analysis are based on PRIMES (see Task 2, paragraph 2.5.).

The PRIMES series of electricity prices since 2020 are provided in Figure 5-1.

Figure 5-1: PRIMES electricity prices for households



The **discount rate is set at 4%,** following the rules for EU impact assessments.

5.1.6. Product life cycle information

5.1.6.1. Production and manufacturing phase

The EcoReport tool contains fixed impacts on weight basis for the manufacturing of components. These data have been used in this study. The only variable that can be edited in this section is the percentage of sheet metal scrap. The default value given by the EcoReport tool is 25%.

5.1.6.2. Distribution phase

For the distribution phase, the EcoReport tool requires the volume of the final packaged product to be entered as an input. Based on this volume, the impact of transport of the product to the site of installation is calculated. The packaging volume of Base Case 1 is 0.0045 m^3 [4] for 2 and 3, the considered volume is 0.00765 m^3.[5]

5.1.6.3. Use phase

The main input for this phase is the electricity use during the six years of technical lifetime of a kettle. The estimated electrical energy consumption is provided in Table 5-6.

MEErP assumes that the impact of spare parts equals 1% of the impact of production of the materials and manufacturing of the components. This default assumption has not been changed for the current study.

[4] 15 x 15 x 20 cm

[5] 15 x 15 x 34 cm

Table 5-6: Assumptions regarding the use phase of the product[6]

	Description		BC 1	BC 2	BC 3
Description	Capacity of the container [litre]		1.0	1.7	1.7
	Real input power [W]		1,000	2,200	2,200
	Temperature setting		no	no	yes
	Temperature holding		no	no	yes
Technical data Performance	Lifetime	[a]	6	6	6
	Water boiled (net)	[litre/a]	800	800	800
	Water boiled	[litre/a]	800	800	800
	Standby power	[W]	-	-	0.250
	Vmax	[litre]	1.0	1.7	1.7
	Vmin	[litre]	0.50	0.50	0.50
	heat 1l from 15°C to 98°C (T_switchoff)	time to heat [s]	390	189	189
		[kWh/l]	0.108	0.115	0.115
		efficiency [%]	89.0%	83.8%	83.8%
	heat Vmax from 15°C to 98°C (T_switchoff)	time to heat [s]	390	306	306
		[kWh/l]	0.108	0.110	0.110
		efficiency [%]	89.0%	87.7%	87.7%
	heat Vmin from 15°C to 98°C (T_switchoff)	time to heat [s]	213	103	103
		[kWh/l]	0.119	0.125	0.125
		efficiency [%]	81.4%	77.0%	77.0%
	heat 1l from 15°C to 80°C	time to heat [s]	n.a.	n.a.	148
		[kWh/l]	n.a.	n.a.	0.090
		efficiency [%]			83.8%
	Vmax from 15°C to 80°C	time to heat [s]	n.a.	n.a.	240
		[kWh/l]	n.a.	n.a.	0.086
		efficiency [%]			87.7%
	keep warm : max time	[min]	n.a.	n.a.	60.0
	keep warm 1l @ 98°C	[kW/l]	n.a.	n.a.	0.127
	keep warm 1l @ 90°C	[kW/l]	n.a.	n.a.	0.115
	keep warm 1l @ 80°C	[kW/l]	n.a.	n.a.	0.099
Yearly energy consumption	*heating (assuming 1l @ Tmax each time) -- indicative*	*[kWh/a]*	86.75	92.19	92.19
	heating (assuming 1l filled in and 73%@98°C, 22% @90°C and 5% @80°C)	[kWh/a]	86.75	92.19	88.99
	keep warm (assuming 1l @98°C over 60 min every day)	[kWh/a]	-	-	46.25
	Standby	[kWh/a]	-	-	2.09
	Total energy consumption [kWh]	**[kWh/a]**	**86.75**	**92.19**	**137.33**

[6] Energy consumption: assessed based on data provided by the Swedish Energy Agency, tests carried out by Fraunhofer ISI and by one manufacturer. Heating time: calculated based on the energy consumption and volume. Efficiency: calculated based on the energy consumed/energy required to heat the same volume of water under the same conditions

5.1.6.4. End-of-life

The default values from the MEErP EcoReport tool have been used for end-of-life modelling as well as for the fractions going to re-use, recycling, heat recovery, non-recoverable incineration and landfill.

5.2. Subtask 5.2 – Base Case Environmental Impact Assessment (using EcoReport 2014)

5.2.1. Cradle-to-grave life cycle assessment

Life cycle environmental impacts have been calculated for the three Base Cases using the EcoReport tool 2014. The data used are listed in the previous section (section 5.1). Five materials (Tin, Ag, Silicone, Nylon and POM) could not be modelled with the standard materials provided in the EcoReport tool and have now been added to it. The life cycle inventory data used to model these materials are described in Annex E.

Emission and resource use have been expressed in the impact categories which are required by the MEErP methodology for the life cycle stages:

- raw Materials Use and Manufacturing;
- distribution;
- use phase;
- end-of-life phase.

In the sub-sections below, the results are expressed first as absolute figures and subsequently as relative values (contribution of the life cycle phase to the total environmental impact).

The graphs in the sub-sections below show the environmental impact profile of the different Base Cases. On the X-axis of the graphs the environmental impact categories to be considered in MEErP studies are given. The environmental impact categories have different units, so it is not possible to show the absolute values in one graph per Base Case. In the graphs, the total environmental impact is set at 100% (production, distribution, use and end-of-life) per impact category. The bar is then split into the different life cycle stages and shows the importance of the life cycle stages per environmental indicator.

In this kind of graph, all impact categories look equally important to the product group, while this might not be the case in reality.

5.2.1.1. Results for Base Case 1

The total environmental impacts over the life cycle for Base Case 1 according to EcoReport calculations are listed in Table 5-7, and the contribution of each life cycle stage is presented in Figure 5-2. These figures are based on 800 litre water boiled per year for six years.

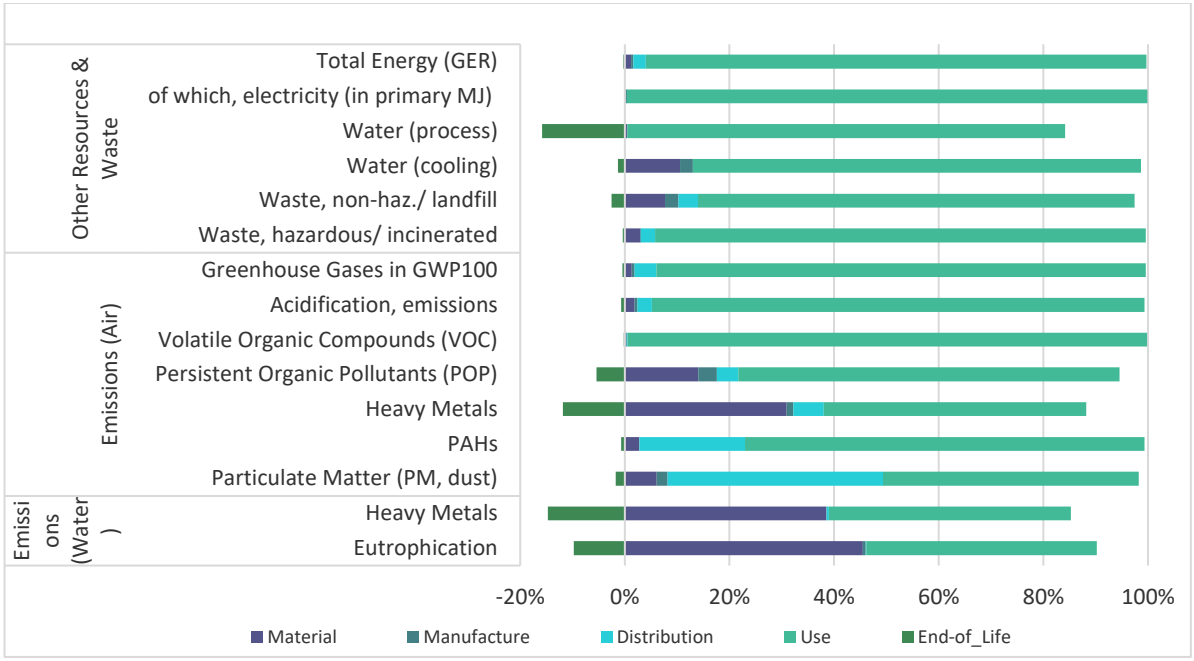
Table 5-7: Base Case 1 – Lifetime impact

	Life Cycle Phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	BUTION		Disposal	Recycl.	**Stock**	
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	MJ	59	21	**81**	**116**	**4,715**	3	-17		**4,898**
12	of which, electricity (in primary MJ)	MJ	6	13	**18**	**0**	**4,715**	0	-7		**4,726**
13	Water (process)	ltr	34	0	**34**	**0**	**6,663**	0	-1,259		**5,438**
14	Water (cooling)	ltr	26	6	**32**	**0**	**210**	0	-3		**238**
15	Waste, non-haz./ landfill	g	224	74	**298**	**109**	**2,432**	6	-81		**2,764**
16	Waste, hazardous/ incinerated	g	2	0	**2**	**2**	**74**	0	0		**79**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	kg CO2 eq.	3	1	**4**	**9**	**201**	0	-1		**213**
18	Acidification, emissions	g SO2 eq.	18	5	**23**	**26**	**891**	0	-7		**933**
19	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**105**	0	0		**106**
20	Persistent Organic Pollutants (POP)	ng i-Teq	2	1	**3**	**1**	**11**	0	-1		**13**
21	Heavy Metals	mg Ni eq.	30	1	**31**	**6**	**48**	0	-11		**73**
22	PAHs	mg Ni eq.	0	0	**0**	**3**	**11**	0	0		**14**
23	Particulate Matter (PM, dust)	g	2	1	**3**	**16**	**19**	0	-1		**37**
	Emissions (Water)										
24	Heavy Metals	mg Hg/20	17	0	**17**	**0**	**20**	0	-7		**31**
25	Eutrophication	g PO4	1	0	**1**	**0**	**1**	0	0		**2**

Figure 5-2 shows the environmental impact profile of the Base Case 1:

The use phase is the most important life cycle stage in all impact categories - in particular 'Total energy', 'water' and 'waste' – with the exception of 'Eutrophication'. The production phase (including material and manufacture) is the most important life cycle phase for the impact category 'Eutrophication'. The distribution phase is a relevant life cycle stage in the impact category 'Particulate matter'. The impact in the distribution phase comes from transport of the packaged product. Due to the recyclability of some components, the end-of-life phase has a positive contribution to the environmental profile.

Figure 5-2: Environmental profile of Base Case 1



5.2.1.2. Results for Base Case 2

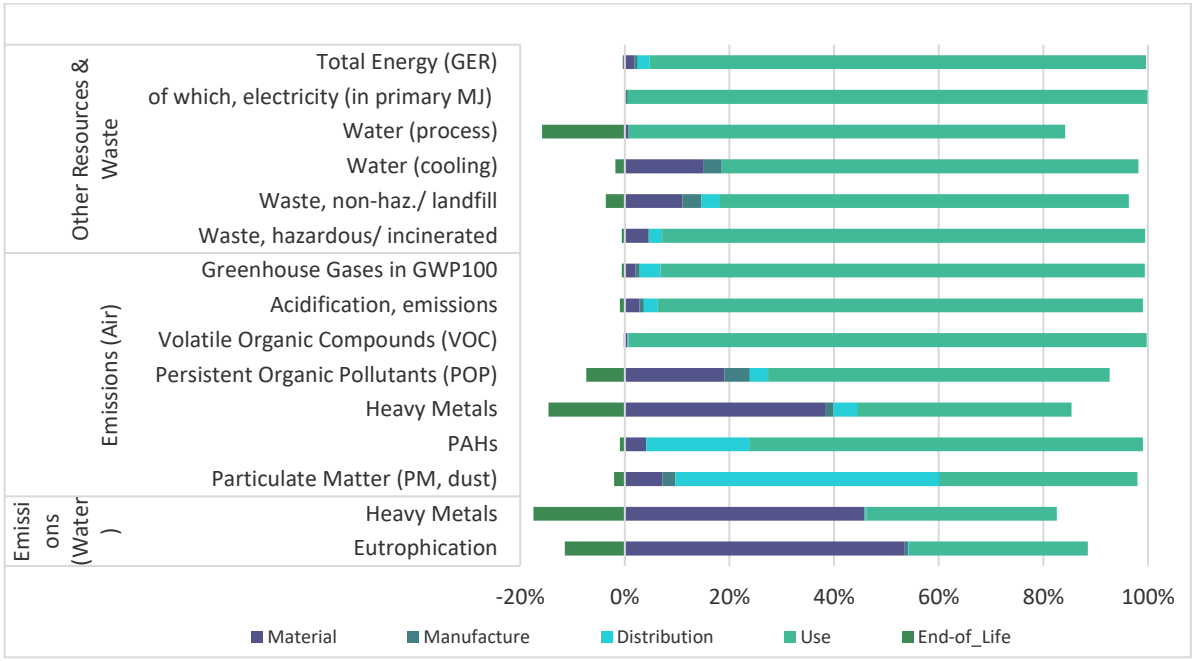
The total environmental impacts over the life cycle for the Base Case 2 according to EcoReport calculations are listed in Table 5-8, and the contribution of each life cycle stage is presented in Figure 5-3. These figures are based on 800 litre water boiled per year for six years.

Table 5-8: Base Case 2 – Lifetime impact

	Life Cycle Phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	BUTION		Disposal	Recycl.	**Stock**	
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	MJ	97	35	**131**	**120**	**5,009**	4	-24		**5,240**
12	of which, electricity (in primary MJ)	MJ	9	21	**30**	**0**	**5,009**	0	-7		**5,031**
13	Water (process)	ltr	54	0	**55**	**0**	**6,663**	0	-1,265		**5,453**
14	Water (cooling)	ltr	42	10	**51**	**0**	**223**	0	-5		**269**
15	Waste, non-haz./ landfill	g	363	120	**483**	**111**	**2,585**	9	-130		**3,058**
16	Waste, hazardous/ incinerated	g	4	0	**4**	**2**	**79**	0	0		**85**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	kg CO2 eq.	5	2	**7**	**9**	**214**	0	-1		**228**
18	Acidification, emissions	g SO2 eq.	29	8	**37**	**27**	**946**	0	-10		**1,000**
19	Volatile Organic Compounds (VOC)	g	1	0	**1**	**0**	**112**	0	0		**112**
20	Persistent Organic Pollutants (POP)	ng i-Teq	3	1	**4**	**1**	**12**	0	-1		**15**
21	Heavy Metals	mg Ni eq.	48	2	**50**	**6**	**51**	0	-18		**88**
22	PAHs	mg Ni eq.	1	0	**1**	**3**	**12**	0	0		**15**
23	Particulate Matter (PM, dust)	g	4	1	**5**	**27**	**20**	0	-1		**51**
	Emissions (Water)										
24	Heavy Metals	mg Hg/20	27	0	**28**	**0**	**22**	0	-10		**39**
25	Eutrophication	g PO4	2	0	**2**	**0**	**1**	0	0		**2**

Figure 5-3 shows the environmental impact profile of the Base Case 2. The use phase is the most important life cycle stage in all impact categories - in particular 'Total energy', 'water' and 'waste' – with the exception of 'Eutrophication', 'Heavy metals' and 'Particulate Matter'. The production phase (including material and manufacture) is the most important life cycle phase for the impact category 'Eutrophication' and 'Heavy metals'. The distribution phase is a relevant life cycle stage in the impact category 'Particulate matter'. The impact in the distribution phase comes from transport of the packaged product. Due to the recyclability of some components, the end-of-life phase has a positive contribution to the environmental profile.

Figure 5-3: Environmental profile of Base Case 2



5.2.1.3. Results for Base Case 3

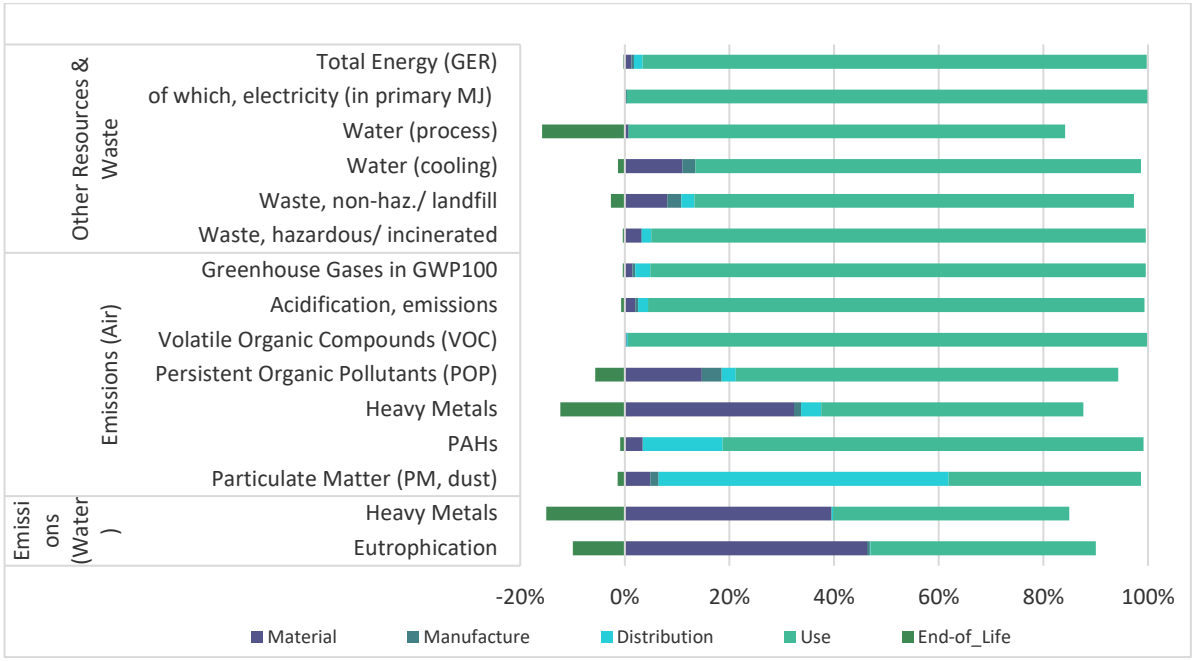
The total environmental impacts over the life cycle for the Base Case 3 according to EcoReport calculations are listed in Table 5-9, and the contribution of each life cycle stage is presented in Figure 5-4. These figures are based on 800 litre water boiled per year for six years.

Table 5-9: Base-Case 3 – Lifetime impact

	Life Cycle Phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	BUTION		Disposal	Recycl.	**Stock**	
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	MJ	99	35	**134**	**126**	**7,447**	4	-25		**7,687**
12	of which, electricity (in primary MJ)	MJ	9	21	**30**	**0**	**7,446**	0	-8		**7,469**
13	Water (process)	ltr	55	0	**55**	**0**	**6,663**	0	-1,265		**5,453**
14	Water (cooling)	ltr	43	10	**53**	**0**	**331**	0	-5		**379**
15	Waste, non-haz./ landfill	g	372	123	**495**	**114**	**3,841**	10	-133		**4,327**
16	Waste, hazardous/ incinerated	g	4	0	**4**	**2**	**118**	0	0		**123**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	kg CO2 eq.	5	2	**7**	**10**	**318**	0	-1		**333**
18	Acidification, emissions	g SO2 eq.	29	9	**38**	**28**	**1,407**	0	-10		**1,462**
19	Volatile Organic Compounds (VOC)	g	1	0	**1**	**0**	**166**	0	0		**167**
20	Persistent Organic Pollutants (POP)	ng i-Teq	4	1	**4**	**1**	**17**	0	-1		**21**
21	Heavy Metals	mg Ni eq.	49	2	**51**	**6**	**76**	0	-19		**114**
22	PAHs	mg Ni eq.	1	0	**1**	**3**	**17**	0	0		**21**
23	Particulate Matter (PM, dust)	g	4	1	**5**	**45**	**30**	0	-1		**79**
	Emissions (Water)										
24	Heavy Metals	mg Hg/20	28	0	**28**	**0**	**32**	0	-11		**50**
25	Eutrophication	g PO4	2	0	**2**	**0**	**1**	0	0		**3**

Figure 5-4 shows the environmental impact profile of the Base Case 3. The use phase is the most important life cycle stage in all impact categories - in particular 'Total energy', 'water' and 'waste' – with the exception of 'Eutrophication' and 'Particulate Matter'. The production phase (including material and manufacture) is the most important life cycle phase for the impact category 'Eutrophication'. The distribution phase is a relevant life cycle stage in the impact category 'Particulate matter'. The impact in the distribution phase comes from transport of the packaged product. Due to the recyclability of some components, the end-of-life phase has a positive contribution to the environmental profile.

Figure 5-4: Environmental profile of Base Case 3



5.2.1.4. Summary

Table 5-10 presents the results of the environmental assessment for the three Base Cases, based on the impacts presented for each Base Case. The aim is not to compare the products but to provide an overview of the impacts.

Table 5-10: Summary of the results for the three Base Cases

			Base Case 1			Base Case 2			Base Case 3	
			TOTAL	USE		TOTAL	USE		TOTAL	USE
	Other Resources & Waste									
11	Total Energy (GER)	MJ	4,898	4,715		5,240	5,009		7,687	7,447
12	of which, electricity (in primary MJ)	MJ	4,726	4,715		5,031	5,009		7,469	7,446
13	Water (process)	ltr	5,438	6,663		5,453	6,663		5,453	6,663
14	Water (cooling)	ltr	238	210		269	223		379	331
15	Waste, non-haz./ landfill	g	2,764	2,432		3,058	2,585		4,327	3,841
16	Waste, hazardous/ incinerated	g	79	74		85	79		123	118
			0	0		0	0		0	0
	Emissions (Air)		0	0		0	0		0	0
17	Greenhouse Gases in GWP100	kg CO2 eq.	213	201		228	214		333	318
18	Acidification, emissions	g SO2 eq.	933	891		1,000	946		1,462	1,407
19	Volatile Organic Compounds (VOC)	g	106	105		112	112		167	166
20	Persistent Organic Pollutants (POP)	ng i-Teq	13	11		15	12		21	17
21	Heavy Metals	mg Ni eq.	73	48		88	51		114	76
22	PAHs	mg Ni eq.	14	11		15	12		21	17
23	Particulate Matter (PM, dust)	g	37	19		51	20		79	30
			0	0		0	0		0	0
	Emissions (Water)		0	0		0	0		0	0
24	Heavy Metals	mg Hg/20	31	20		39	22		50	32
25	Eutrophication	g PO4	2	1		2	1		3	1

Gallego-Schmid et al. (2017) analysed the environmental impacts of kettles in detail (covering 3 kettles). The paper shows that the use stage is also important (Annex F), as they find it to be the main hotspot for all the environmental impact categories.[7] Only for three categories, which are "depletion of elements", "human toxicity" and "terrestrial ecotoxicity", the material used to produce the kettles was impacted.[8]

5.2.2. Aspects related to the circular economy

In the communication from the Commission from 30th of November 2016 on the Ecodesign Working Plan 2016-2019, it is emphasized that Ecodesign should make a more significant contribution to the circular economy, for example by more systematically tackling material efficiency issues, such as durability and recyclability.

This study makes use of the EcoReport tool version 2014, which considers the results of the project "Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products (MEErP) (BIO Intelligence, 2013 a and b)". This project identifies the

[7] The use stage contributed to over 90% of the impact categories for the plastic kettle and to 80% for the metallic eco-kettles.

[8] Around 8% for plastic kettles and 12%-16% for other

most significant parameters from available evidence regarding material efficiency that may be used in MEErP. The parameters selected as most suitable are:

- recyclability benefit rates (describing the "potential output" for future recycling);
- recycled content (describing the "input" of materials with origin on waste);
- lifetime (a mechanism to display impacts not only as a total over the entire lifespan, but also per year of use, allowing an easier comparison of products with different lifetimes or analysing the effect of lifetime extension); and
- Critical Raw Material Index.

The following paragraphs discuss these parameters for the product group 'electric kettles'.

5.2.2.1. Recyclability benefit rates

Within the EcoReport tool the recyclability benefit rate is calculated only for bulk and technical plastics. To avoid double counting, the recyclability of metals is not considered in the EcoReport tool.

5.2.2.2. Recycled content

This parameter is focused on the manufacturing phase of the life cycle, defining the origin of materials used for a product (different than the recyclability benefit rate which depends on the end-of-life treatment). Assumptions for recycled content of metals are incorporated in the EcoReport tool 2014 and have been used within the scope of this study. They differ per material category.

5.2.2.3. Lifetime

Kettles have a typical lifetime of six years (see Task 3). As revealed by the LCA analyses, the production stage is an important life cycle stage in the categories 'Eutrophication' and emissions liked to 'Heavy Metals". Extending the lifetime of a kettle will thus decrease environmental impacts (calculated per year). Some aspects potentially leading to a longer lifetime include the quality of the products and the reparability of some parts[9].

JRC currently works on the development of a scoring system for repair and upgrade of products (JRC, 2018). The examples used to test the scoring system are smaller consumer products with a shorter lifetime than lifts (laptops, vacuum cleaners and washing machines).

5.2.2.4. Critical Raw Material Index

MEErP also uses a CRM (Critical Raw Material) indicator to quantify the use of CRM in the product. The CRM indicator is not an environmental indicator as such. It describes the scarcity of a material from an economic perspective. It is part of the MEErP because also there might be improvement options for certain product groups in this field. MEErP provides characterization factors for 14 critical raw materials. The characterization factors are based on the following aspects (Kemna, 2011b):

- high import dependency (ratio of EU imports vs. consumption)
- limited possibilities to find substitutes for the same or similar performance ("substitutability")
- no or very small recycling rate (ratio of recycled old scrap vs. production)

The electric water kettles components include no significant amounts of critical raw materials.

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[9] based on a survey carried out by Which? (see Task 2), it seems that faulty lids and broken limescale filters are the two major reported faults.

5.3. Subtask 5.3: Base Case life cycle cost for the consumer and society

The lifecycle costs for consumers have been calculated using the MEErP EcoReport tool.

The inputs used to calculate the Life Cycle Costs are:

- the prices for hardware, installation and maintenance and repair mentioned in Table 5-5;
- the considered electricity price is 0.206 euro/kWh (average price over six years based on PRIMES);
- a lifetime of six years.

The tables below present the life cycle costs (LCC) per Base Case. Furthermore, to compare the discounted net present value (NPV) of the running costs --which is the specific viewpoint of Life Cycle Costing-- with the actual expenditure today, the second column also gives the total consumer expenditure in the EU-27 per year.

5.3.1. LCC results for Base Case 1

As Table 5-11 shows, every year all EU consumers are spending € 344 million in the purchase and operation of their Products. And each time a consumer makes a buying decision, the decision is not just on a purchase price of € 16 but on the total Life Cycle Costs (LCC) of the product -- including running costs discounted to their net present value of on average € 143.

With the LCC, the product acquisition is responsible for 11% and the running costs of energy and other consumables for around 88 %. Repairs & maintenance make up the rest of the total. In terms of annual expenditure, the EU-27 running costs amount to 0.3 billion Euro and the purchase and installation costs make up around 2 million Euro.

Table 5-11: Base Case 1 – Life cycle costs for consumer and society

	Item	LCC new product		total annual consumer expenditure in EU27	
D	Product price	16	€	**37**	mln.€
E	Installation/ acquisition costs (if any)	0	€	**0**	mln.€
F	Fuel (gas, oil, wood)	0	€	**0**	mln.€
F	Electricity	107	€	**260**	mln.€
G	Water	14	€	**35**	mln.€
H	Aux. 1: None	5	€	**12**	mln.€
I	Aux. 2 :None	0	€	**0**	mln.€
J	Aux. 3: None	0	€	**0**	mln.€
K	Repair & maintenance costs	1	€	**2**	mln.€
L	**External damages total, of which**	12		**28**	mln.€
	- production PPext	1		**2**	
	- lifetime operating expense N*OEext	11		**26**	
	- end-of-life OELext	0		**0**	
	Total	**155**	€	**373**	mln.€

Societal costs, i.e. external damage, is 12 Euros per product, or 28 million Euros for all products covered by this Base Case.

5.3.2. LCC results for Base Case 2

As Table 5-12 shows, every year all EU consumers are spending € 2 billion in the purchase and operation of their Electric water kettles: Base Case 2. And each time a consumer makes a buying decision, the decision is not just on a purchase price of € 26. but on the total Life Cycle Costs (LCC) of the product --including running costs discounted to their net present value-- of on average € 163.

With the LCC, the product acquisition is responsible for 15% and the running costs of energy and other consumables for around 83 %. Repairs & maintenance make up the rest of the total. In terms of annual expenditure, the EU-27 running costs amount to 1.8 billion Euro and the purchase and installation costs make up around 0.3 billion Euro.

Table 5-12: Base Case 2 – Life cycle cost for consumer and society

	Item	LCC new product		total annual consumer expenditure in EU27	
D	Product price	26	€	**315**	mln.€
E	Installation/ acquisition costs (if any)	0	€	**0**	mln.€
F	Fuel (gas, oil, wood)	0	€	**0**	mln.€
F	Electricity	114	€	**1,455**	mln.€
G	Water	14	€	**183**	mln.€
H	Aux. 1: None	8	€	**104**	mln.€
I	Aux. 2 :None	0	€	**0**	mln.€
J	Aux. 3: None	0	€	**0**	mln.€
K	Repair & maintenance costs	1	€	**13**	mln.€
L	**External damages total, of which**	13		**163**	mln.€
	- production PPext	1		**15**	
	- lifetime operating expense N*OEext	11		**146**	
	- end-of-life OELext	0		**2**	
	Total	**176**	€	**2,234**	mln.€

Societal costs, i.e. external damage is 13 Euros per product, or 163 million Euros for all products covered by this Base Case.

5.3.3. LCC results for Base Case 3

As Table 5-13 shows, every year all EU consumers are spending € 246 million in the purchase and operation of their Electric water kettles: Base Case 3. And each time a consumer makes a buying decision, the decision is not just on a purchase price of € 62. but on the total Life Cycle Costs (LCC) of the product --including running costs discounted to their net present value-- of on average € 256.

With the LCC the product acquisition is responsible for 24% and the running costs of energy and other consumables for around 74 %. Repairs & maintenance make up the rest of the total. In terms of annual expenditure, the EU-27 running costs amount to 0.2 billion Euro and the purchase and installation costs make up around 0.1 billion Euro.

Table 5-13: Base Case 2 – Life cycle cost for consumer and society

	Item	LCC new product		total annual consumer expenditure in EU27	
D	Product price	62	€	**57**	mln.€
E	Installation/ acquisition costs (if any)	0	€	**0**	mln.€
F	Fuel (gas, oil, wood)	0	€	**0**	mln.€
F	Electricity	170	€	**165**	mln.€
G	Water	14	€	**14**	mln.€
H	Aux. 1: None	8	€	**8**	mln.€
I	Aux. 2 :None	0	€	**0**	mln.€
J	Aux. 3: None	0	€	**0**	mln.€
K	Repair & maintenance costs	2	€	**2**	mln.€
L	**External damages total, of which**	19		**18**	mln.€
	- production PPext	2		**1**	
	- lifetime operating expense N*OEext	17		**17**	
	- end-of-life OELext	0		**0**	
	Total	**276**	€	**264**	mln.€

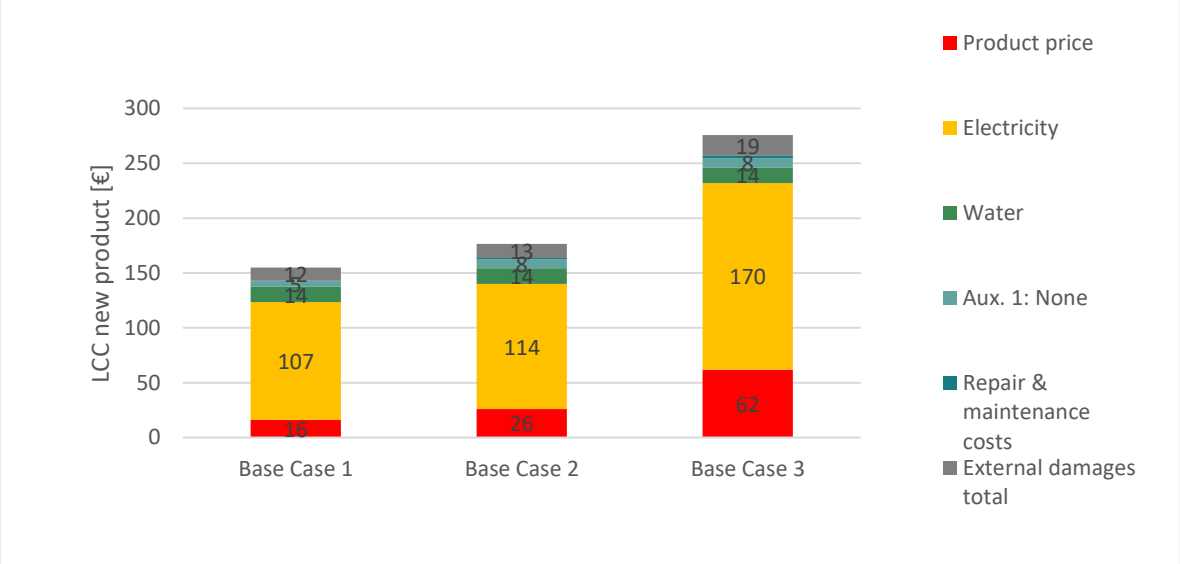
Societal costs, i.e. external damage is 19 Euros per product, or 18 million Euros for all products covered by this Base Case.

5.3.4. Summary

Figure 5-5 provides an overview of the Life Cycle Costs (LCC) of the product for the three Base Cases. The LCC range between 143 € and 276 €, or 155 € and 276 € if the societal costs are included.[10] The electricity costs are responsible for around 70% of the LCC without externalities.

[10] external damages account for around 8% of the LLC without externalities

Figure 5-5: Life Cycle Costs per product in the EU-27



5.4. Subtask 5.5: EU totals

This section provides the environmental assessment of the Base Cases at the EU-27 level using stock and market data from Task 2 for the year 2020.

5.4.1. Life cycle environmental impacts

Table 5-14 shows the total environmental impacts of all products in operation in EU-27 in 2020, based on the extrapolation of the Base Cases impacts (assuming that all electric kettles have the same impacts as the Base Case of their category). These figures come from the EcoReport tool by multiplying the individual environmental impacts of a Base Case with the stock of this Base Case in 2020. The total electricity consumption of the stock of kettles corresponds to about 9 TWh.

Table 5-14: Environmental impacts of the EU-27 stock in 2020 for all Base Cases

			Base Case 1		Base Case 2		Base Case 3		Total	
			TOTAL	USE	TOTAL	USE	TOTAL	USE	TOTAL	USE
11	Total Energy (GER)	PJ	71.20	68.55	401.18	383.53	44.71	43.30	517.07	495.38
12	of which, electricity (in primary MJ)	PJ	68.71	68.54	385.16	383.46	43.43	43.30	497.30	495.30
	of which, electricity (in final energy)	**TWh**		**1.26**		**7.06**		**0.80**		**9.12**
13	Water (process)	mio. m^3	79.05	96.86	417.45	510.12	31.71	38.74	528.21	645.72
14	Water (cooling)	mio. m^3	3.46	3.05	20.61	17.07	2.21	1.93	26.28	22.05
15	Waste, non-haz./ landfill	kt	40.18	35.35	234.12	197.88	25.20	22.33	299.46	255.57
16	Waste, hazardous/ incinerated	kt	1.14	1.08	6.48	6.05	0.72	0.68	8.34	7.82
	Emissions (Air)									
17	Greenhouse Gases in GWP100	Mt CO2 eq.	3.10	2.93	17.47	16.37	1.94	1.85	22.50	21.15
18	Acidification, emissions	kt SO2 eq.	13.56	12.95	76.56	72.45	8.51	8.18	98.63	93.58
19	Volatile Organic Compounds (VOC)	kt	1.54	1.53	8.60	8.56	0.97	0.97	11.11	11.06
20	Persistent Organic Pollutants (POP)	g i-Teq	0.20	0.16	1.17	0.90	0.12	0.10	1.49	1.16
21	Heavy Metals	t Ni eq.	1.06	0.70	6.76	3.91	0.67	0.44	8.48	5.05
22	PAHs	t Ni eq.	0.21	0.16	1.17	0.90	0.12	0.10	1.50	1.16
23	Particulate Matter (PM, dust)	kt	0.54	0.27	3.89	1.54	0.46	0.17	4.89	1.98
	Emissions (Water)									
24	Heavy Metals	t Hg/20	0.45	0.30	2.99	1.67	0.29	0.19	3.73	2.16
25	Eutrophication	t PO4	0.02	0.01	0.17	0.07	0.02	0.01	0.20	0.09

Base Case 2 kettles contribute to the largest share in all the indicators calculated by EcoReport as they represented 79% of the total stock of electric kettles in 2020.

5.4.2. Life cycle costs

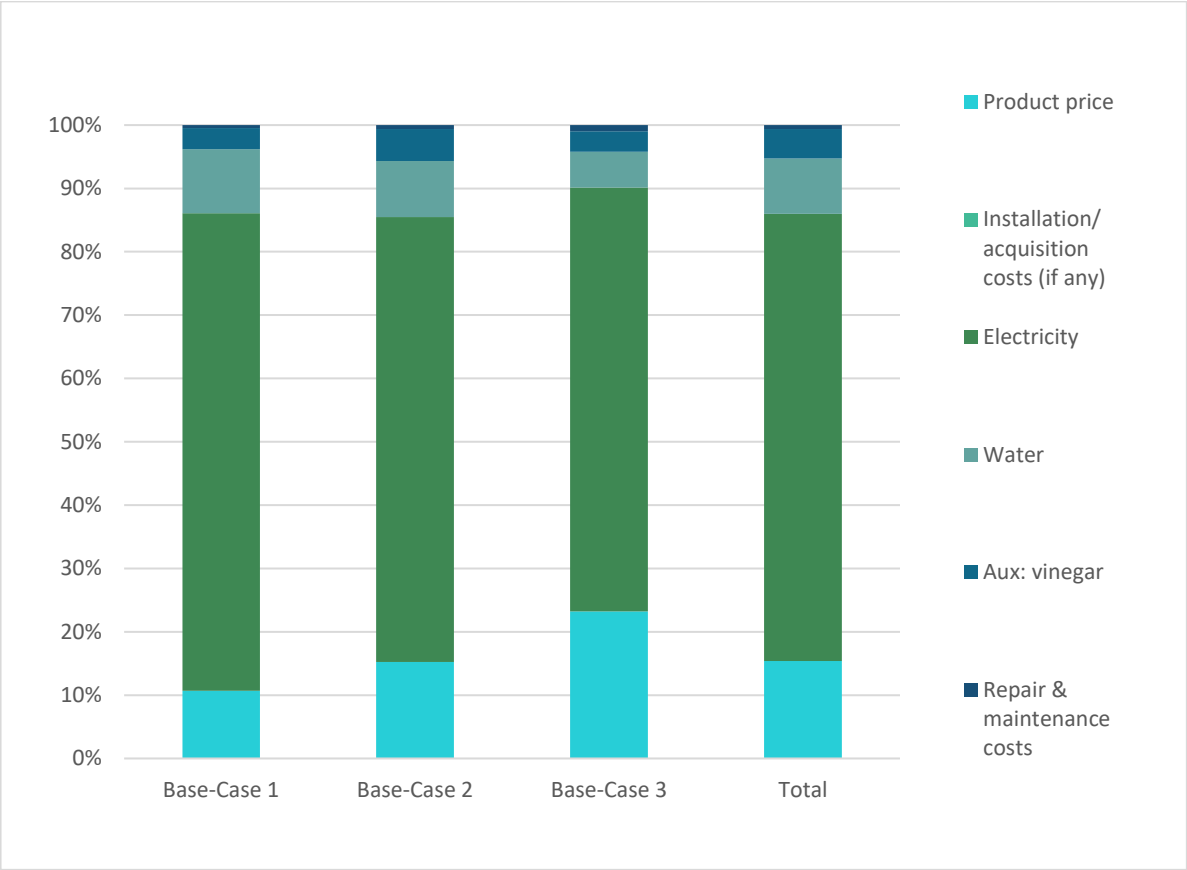
Details on consumer expenditure are provided in Table 5-15. These results come from the EcoReport tool which takes into account the various costs per machine and then extrapolates them for the year 2020 by using the sales and stock data.

Table 5-15: Total annual consumer expenditure in EU-27, 2020

		Base Case 1	Base Case 2	Base Case 3	Total
Stock	mio units	14.54	76.56	5.81	96.91
Sales	mio units	2.30	12.12	0.92	15.34
Product price	mln.€	36.82	315.14	57.07	409.04
Installation/ acquisition costs (if any)	mln.€	0.00	0.00	0.00	0.00
Electricity	mln.€	260.03	1,455.36	164.66	1,880.05
Water	mln.€	34.77	183.13	13.91	231.81
Other costs: vinegar	mln.€	11.63	104.12	7.91	123.66
Repair & maintenance costs	mln.€	1.55	13.27	2.40	17.22
Total	**mln.€**	**344.81**	**2,071.03**	**245.95**	**2,661.79**

As shown in Figure 5-6, electricity costs correspond to around 70% of the total consumer expenditure in 2020.

Figure 5-6: Breakdown of the total annual consumer expenditure in EU-27, 2020



5.5. Conclusion

The environmental impact assessments of all three Base Cases were carried out with the EcoReport tool. The results among the Base Cases are similar: the use phase is by far the most impacting stage of the life cycle in terms of energy consumption, GHG, water, waste (hazardous/ incinerated as well as non-haz./ landfill), acidification, VOC, POP, PAHs, and heavy metals emissions to air.

The production phase has a significant contribution to the eutrophication and heavy metals emissions to water. Finally, the distribution is dominating only one category: Particulate Matter (PM, dust).

A Life Cycle Costs analysis was also carried out with the EcoReport tool for all Base Cases. The electricity costs accounts for 70% of the total consumer expenditure.

In the next Task, Design Options that reduce the energy consumption and the environmental impacts will be investigated and analysed (LCA and LCC).

References for Task 5

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5.6. Annex A: Base Case 1 - Detailed Bill of Materials and MEErP eco-indicator

Version 3.06 VHK for European Commission 2011,
modified by IZM for european commission 2014

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ECO-DESIGN OF ENERGY RELATED/USING PRODUCTS

EcoReport 2014: INPUTS

Assessment of Environmental Impact

Nr	Electric water kettles	Date	Author
	Base Case 1	15.10.2020	Fraunhofer ISI

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
1	**POWER SUPPLY BASE**				
2	***Plug + Cord***				
3	Polypropylene (PP) (g)	33.75	1-BlkPlastics	4 - PP	Yes
4	Copper (g)	10.33	4-Non-ferro	31-Cu tube/sheet	Yes
5	Brass (g)	15.75	4-Non-ferro	32 - CuZn38 cast	Yes
6	Polyvinyl chloride (g)	42.98	2-TecPlastics	13 - PC	Yes
7					
8	***Screws***				
9	Stainless steel (g)	2.25	3-Ferro	26 - Stainless 18/8 coil	Yes
10					
11	***Base***				
12	Polypropylene (PP) (g)	56.25	1-BlkPlastics	4 - PP	Yes
13					
14	***Base centerpiece***				
15	Copper (g)	2.21	4-Non-ferro	31-Cu tube/sheet	Yes
16	Nylon (g)	12.75	8-Extra	103-Nylon	Yes
17					
18	***Electronic switch (elements on the top)***				
19	Stainless steel (g)	0.00	3-Ferro	26 - Stainless 18/8 coil	Yes
20	HDPE	0.00	1-BlkPlastics	2 - HDPE	No
21	Copper (g)	0.00	4-Non-ferro	31-Cu tube/sheet	Yes
22	Polyvinyl chloride (g)	0.00	2-TecPlastics	13 - PC	Yes
23					
24	***Electronic switch (base)***				
25	Polypropylene (PP) (g)	0.00	1-BlkPlastics	4 - PP	Yes
26	Copper (g)	0.00	4-Non-ferro	31-Cu tube/sheet	Yes
27	Tin (g)	0.00	4-Non-ferro	33 - ZnAl4 cast	Yes
28	Ag (g)	0.00	8-Extra	101-Ag	Yes
29					
30	***Keypad (cables)***				
31	Copper (g)	0.00	4-Non-ferro	31-Cu tube/sheet	Yes
32	Polyvinyl chloride (g)	0.00	2-TecPlastics	13 - PC	Yes
33					
34	***Keypad (itself)***				
35	Polypropylene (PP) (g)	0.00	1-BlkPlastics	4 - PP	Yes
36	Copper (g)	0.00	4-Non-ferro	31-Cu tube/sheet	Yes
37	Tin (g)	0.00	8-Extra	100-Tin	Yes
38	Ag (g)	0.00	8-Extra	101-Ag	Yes
39					
40					

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
41	***Interior cables***				
42	Copper (g)	0.00	4-Non-ferro	31 -Cu tube/sheet	Yes
43	Polyvinyl chloride (g)	0.00	2-TecPlastics	13 -PC	Yes
44					
45	***Bottons control temperature***				
46	Al (g)	0.00	4-Non-ferro	27 -Al sheet/extrusion	Yes
47					
48	***Protective buttons***				
49	Polypropylene (PP) (g)	0.00	1-BlkPlastics	4 -PP	Yes
50					
51	***Rubber bottons***				
52	Silicone (g)	0.00	8-Extra	102-Silicone	No
53					
54	**ELECTRONIC BASE- CONTAINER KETTLE**				
55	***Connections***				
56	Brass (g)	3.00	4-Non-ferro	32 -CuZn38 cast	Yes
57					
58	***Spiked base***				
59	Brass (g)	1.50	4-Non-ferro	32 -CuZn38 cast	Yes
60	Stainless steel (g)	4.50	3-Ferro	26 -Stainless 18/8 coil	Yes
61					
62	***Basic electronic support***				
63	Copper (g)	1.48	4-Non-ferro	31 -Cu tube/sheet	Yes
64	Nylon (g)	15.75	8-Extra	103-Nylon	Yes
65					
66	***Additional element supporting Base electronics***				
67	Nylon (g)	5.25	8-Extra	103-Nylon	Yes
68					
69	***Transparent element***				
70	Polycarbonate (g)	6.75	2-TecPlastics	13 -PC	Yes
71					
72	***Base extraible***				
73	Acrylonitrile butadiene styrene (g)	26.25	1-BlkPlastics	11 -ABS	Yes
74					
75	***Base cover***				
76	Polypropylene (PP) (g)	11.25	1-BlkPlastics	4 -PP	Yes
77					
78	***Discs***				
79	Stainless steel (g)	0.75	3-Ferro	26 -Stainless 18/8 coil	Yes
80					
81	***Lamp cables***				
82	Polyvinyl chloride (g)	0.52	2-TecPlastics	13 -PC	Yes
83	Copper (g)	0.97	4-Non-ferro	31 -Cu tube/sheet	Yes
84					
85	***Screws + washers***				
86	Stainless steel (g)	2.25	3-Ferro	26 -Stainless 18/8 coil	Yes
87					

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
88	***Spring***				
89	Stainless steel (g)	0.75	3-Ferro	26 -Stainless 18/8 coil	Yes
90					
91	***Supports***				
92	Stainless steel (g)	0.75	3-Ferro	26 -Stainless 18/8 coil	Yes
93					
94	Fixed ring				
95	Nylon (g) (PA)	15.75	8-Extra	103-Nylon	Yes
96					
97	POM Parts				
98	Polyoxymethylene (POM) (g)	2.25	8-Extra	104-POM	Yes
99					
100	**CONTAINER**				
101	***Container***				
102	Polypropylene (PP) (g)	153.00	1-BlkPlastics	4 -PP	Yes
103					
104	***Handle***				
105	Polypropylene (PP) (g)	40.00	1-BlkPlastics	4 -PP	Yes
106					
107	***Accessories***				
108	Polypropylene (PP) (g)	41.75	1-BlkPlastics	4 -PP	Yes
109					
110	***Base metal body***				
111	Stainless steel (g)	173.25	3-Ferro	26 -Stainless 18/8 coil	Yes
112					
113	***Base target coverage***				
114	Silicone (g)	12.00	8-Extra	102-Silicone	No
115					
116	***Pulser***				
117	Acrylonitrile butadiene styrene (g)	3.75	8-Extra		No
118					
119	***Filter and housing***				
120	Polypropylene (PP) (g)	14.25	1-BlkPlastics	4 -PP	Yes
121					
122	***POM Parts***				
123	Polyoxymethylene (POM) (g)	7.50	8-Extra	104-POM	Yes
124					
125	***Screws***				
126	Stainless steel (g)	1.50	3-Ferro	26 -Stainless 18/8 coil	Yes
127					
128	**PACKAGING**				
129	***Packaging foil***				
130	Low density polyethylene (g)	6.30	1-BlkPlastics	4 -PP	Yes
131					
132	***Cardboard boxes***				
133	paper (g)	131.50	7-Misc.	57 -Cardboard	Yes
134					

5.7. Annex B: Base Case 2 - Detailed Bill of Materials and MEErP eco-indicator

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ECO-DESIGN OF ENERGY RELATED/USING PRODUCTS

EcoReport 2014: INPUTS Assessment of Environmental Impact

Nr	Electric water kettles	Date	Author
	Base Case 2	15.10.2020	Fraunhofer ISI

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
1	**POWER SUPPLY BASE**				
2	***Plug + Cord***				
3	Polypropylene (PP) (g)	54.43	1-BlkPlastics	4 - PP	Yes
4	Copper (g)	16.67	4-Non-ferro	31-Cu tube/sheet	Yes
5	Brass (g)	25.40	4-Non-ferro	32 - CuZn38 cast	Yes
6	Polyvinyl chloride (g)	69.31	2-TecPlastics	13 - PC	Yes
7					
8	***Screws***				
9	Stainless steel (g)	3.63	3-Ferro	26 - Stainless 18/8 coil	Yes
10					
11	***Base***				
12	Polypropylene (PP) (g)	90.72	1-BlkPlastics	4 - PP	Yes
13					
14	***Base centerpiece***				
15	Copper (g)	3.57	4-Non-ferro	31-Cu tube/sheet	Yes
16	Nylon (g)	20.56	8-Extra	103-Nylon	Yes
17					
18	***Electronic switch (elements on the top)***				
19	Stainless steel (g)	0.00	3-Ferro	26 - Stainless 18/8 coil	Yes
20	HDPE	0.00	1-BlkPlastics	2 - HDPE	No
21	Copper (g)	0.00	4-Non-ferro	31-Cu tube/sheet	Yes
22	Polyvinyl chloride (g)	0.00	2-TecPlastics	13 - PC	Yes
23					
24	***Electronic switch (base)***				
25	Polypropylene (PP) (g)	0.00	1-BlkPlastics	4 - PP	Yes
26	Copper (g)	0.00	4-Non-ferro	31-Cu tube/sheet	Yes
27	Tin (g)	0.00	4-Non-ferro	33 - ZnAl4 cast	Yes
28	Ag (g)	0.00	8-Extra	101-Ag	Yes
29					
30	***Keypad (cables)***				
31	Copper (g)	0.00	4-Non-ferro	31-Cu tube/sheet	Yes
32	Polyvinyl chloride (g)	0.00	2-TecPlastics	13 - PC	Yes
33					
34	***Keypad (itself)***				
35	Polypropylene (PP) (g)	0.00	1-BlkPlastics	4 - PP	Yes
36	Copper (g)	0.00	4-Non-ferro	31-Cu tube/sheet	Yes
37	Tin (g)	0.00	8-Extra	100-Tin	Yes
38	Ag (g)	0.00	8-Extra	101-Ag	Yes
39					
40					

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
41	***Interior cables***				
42	Copper (g)	0.00	4-Non-ferro	31 -Cu tube/sheet	Yes
43	Polyvinyl chloride (g)	0.00	2-TecPlastics	13 -PC	Yes
44					
45	***Bottons control temperature***				
46	Al (g)	0.00	4-Non-ferro	27 -Al sheet/extrusion	Yes
47					
48	***Protective buttons***				
49	Polypropylene (PP) (g)	0.00	1-BlkPlastics	4 -PP	Yes
50					
51	***Rubber bottons***				
52	Silicone (g)	0.00	8-Extra	102-Silicone	No
53					
54	**ELECTRONIC BASE- CONTAINER KETTLE**				
55	***Connections***				
56	Brass (g)	4.84	4-Non-ferro	32 -CuZn38 cast	Yes
57					
58	***Spiked base***				
59	Brass (g)	2.42	4-Non-ferro	32 -CuZn38 cast	Yes
60	Stainless steel (g)	7.26	3-Ferro	26 -Stainless 18/8 coil	Yes
61					
62	***Basic electronic support***				
63	Copper (g)	2.38	4-Non-ferro	31 -Cu tube/sheet	Yes
64	Nylon (g)	25.40	8-Extra	103-Nylon	Yes
65					
66	***Additional element supporting Base electronics***				
67	Nylon (g)	8.47	8-Extra	103-Nylon	Yes
68					
69	***Transparent element***				
70	Polycarbonate (g)	10.89	2-TecPlastics	13 -PC	Yes
71					
72	***Base extraible***				
73	Acrylonitrile butadiene styrene (g)	42.33	1-BlkPlastics	11 -ABS	Yes
74					
75	***Base cover***				
76	Polypropylene (PP) (g)	18.14	1-BlkPlastics	4 -PP	Yes
77					
78	***Discs***				
79	Stainless steel (g)	1.21	3-Ferro	26 -Stainless 18/8 coil	Yes
80					
81	***Lamp cables***				
82	Polyvinyl chloride (g)	0.84	2-TecPlastics	13 -PC	Yes
83	Copper (g)	1.57	4-Non-ferro	31 -Cu tube/sheet	Yes
84					
85	***Screws + washers***				
86	Stainless steel (g)	3.63	3-Ferro	26 -Stainless 18/8 coil	Yes
87					

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
88	***Spring***				
89	Stainless steel (g)	1.21	3-Ferro	26 -Stainless 18/8 coil	Yes
90					
91	***Supports***				
92	Stainless steel (g)	1.21	3-Ferro	26 -Stainless 18/8 coil	Yes
93					
94	Fixed ring				
95	Nylon (g) (PA)	25.40	8-Extra	103-Nylon	Yes
96					
97	POM Parts				
98	Polyoxymethylene (POM) (g)	3.63	8-Extra	104-POM	Yes
99					
100	**CONTAINER**				
101	***Container***				
102	Polypropylene (PP) (g)	271.43	1-BlkPlastics	4 -PP	Yes
103					
104	***Handle***				
105	Polypropylene (PP) (g)	70.00	1-BlkPlastics	4 -PP	Yes
106					
107	***Accessories***				
108	Polypropylene (PP) (g)	37.15	1-BlkPlastics	4 -PP	Yes
109					
110	***Base metal body***				
111	Stainless steel (g)	279.40	3-Ferro	26 -Stainless 18/8 coil	Yes
112					
113	***Base target coverage***				
114	Silicone (g)	19.35	8-Extra	102-Silicone	No
115					
116	***Pulser***				
117	Acrylonitrile butadiene styrene (g)	6.05	8-Extra		No
118					
119	***Filter and housing***				
120	Polypropylene (PP) (g)	22.98	1-BlkPlastics	4 -PP	Yes
121					
122	***POM Parts***				
123	Polyoxymethylene (POM) (g)	12.10	8-Extra	104-POM	Yes
124					
125	***Screws***				
126	Stainless steel (g)	2.42	3-Ferro	26 -Stainless 18/8 coil	Yes
127					
128	**PACKAGING**				
129	***Packaging foil***				
130	Low density polyethylene (g)	11.90	1-BlkPlastics	4 -PP	Yes
131					
132	***Cardboard boxes***				
133	paper (g)	255.10	7-Misc.	57 -Cardboard	Yes
134					

5.8. Annex C: Base Case 3 - Detailed Bill of Materials and MEErP eco-indicator

Version 3.06 VHK for European Commission 2011,
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ECO-DESIGN OF ENERGY RELATED/USING PRODUCTS

EcoReport 2014: INPUTS Assessment of Environmental Impact

Nr	Electric water kettles	Date	Author
	Base Case 3	15.10.2020	Fraunhofer ISI

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
1	**POWER SUPPLY BASE**				
2	***Plug + Cord***				
3	Polypropylene (PP) (g)	54.43	1-BlkPlastics	4 - PP	Yes
4	Copper (g)	16.67	4-Non-ferro	31-Cu tube/sheet	Yes
5	Brass (g)	25.40	4-Non-ferro	32 - CuZn38 cast	Yes
6	Polyvinyl chloride (g)	69.31	2-TecPlastics	13 - PC	Yes
7					
8	***Screws***				
9	Stainless steel (g)	3.63	3-Ferro	26 - Stainless 18/8 coil	Yes
10					
11	***Base***				
12	Polypropylene (PP) (g)	90.72	1-BlkPlastics	4 - PP	Yes
13					
14	***Base centerpiece***				
15	Copper (g)	3.57	4-Non-ferro	31-Cu tube/sheet	Yes
16	Nylon (g)	20.56	8-Extra	103-Nylon	Yes
17					
18	***Electronic switch (elements on the top)***				
19	Stainless steel (g)	6.96	3-Ferro	26 - Stainless 18/8 coil	Yes
20	HDPE	4.88	1-BlkPlastics	2 - HDPE	No
21	Copper (g)	0.07	4-Non-ferro	31-Cu tube/sheet	Yes
22	Polyvinyl chloride (g)	0.69	2-TecPlastics	13 - PC	Yes
23					
24	***Electronic switch (base)***				
25	Polypropylene (PP) (g)	2.26	1-BlkPlastics	4 - PP	Yes
26	Copper (g)	0.29	4-Non-ferro	31-Cu tube/sheet	Yes
27	Tin (g)	0.03	4-Non-ferro	33 - ZnAl4 cast	Yes
28	Ag (g)	0.00	8-Extra	101-Ag	Yes
29					
30	***Keypad (cables)***				
31	Copper (g)	0.72	4-Non-ferro	31-Cu tube/sheet	Yes
32	Polyvinyl chloride (g)	0.71	2-TecPlastics	13 - PC	Yes
33					
34	***Keypad (itself)***				
35	Polypropylene (PP) (g)	3.96	1-BlkPlastics	4 - PP	Yes
36	Copper (g)	0.51	4-Non-ferro	31-Cu tube/sheet	Yes
37	Tin (g)	0.05	8-Extra	100-Tin	Yes
38	Ag (g)	0.00	8-Extra	101-Ag	Yes
39					
40					

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
41	***Interior cables***				
42	Copper (g)	0.96	4-Non-ferro	31 -Cu tube/sheet	Yes
43	Polyvinyl chloride (g)	0.94	2-TecPlastics	13 -PC	Yes
44					
45	***Bottons control temperature***				
46	Al (g)	0.82	4-Non-ferro	27 -Al sheet/extrusion	Yes
47					
48	***Protective buttons***				
49	Polypropylene (PP) (g)	4.25	1-BlkPlastics	4 -PP	Yes
50					
51	***Rubber bottons***				
52	Silicone (g)	1.39	8-Extra	102-Silicone	No
53					
54	**ELECTRONIC BASE- CONTAINER KETTLE**				
55	***Connections***				
56	Brass (g)	4.84	4-Non-ferro	32 -CuZn38 cast	Yes
57					
58	***Spiked base***				
59	Brass (g)	2.42	4-Non-ferro	32 -CuZn38 cast	Yes
60	Stainless steel (g)	7.26	3-Ferro	26 -Stainless 18/8 coil	Yes
61					
62	***Basic electronic support***				
63	Copper (g)	2.38	4-Non-ferro	31 -Cu tube/sheet	Yes
64	Nylon (g)	25.40	8-Extra	103-Nylon	Yes
65					
66	***Additional element supporting Base electronics***				
67	Nylon (g)	8.47	8-Extra	103-Nylon	Yes
68					
69	***Transparent element***				
70	Polycarbonate (g)	10.89	2-TecPlastics	13 -PC	Yes
71					
72	***Base extraible***				
73	Acrylonitrile butadiene styrene (g)	42.33	1-BlkPlastics	11 -ABS	Yes
74					
75	***Base cover***				
76	Polypropylene (PP) (g)	18.14	1-BlkPlastics	4 -PP	Yes
77					
78	***Discs***				
79	Stainless steel (g)	1.21	3-Ferro	26 -Stainless 18/8 coil	Yes
80					
81	***Lamp cables***				
82	Polyvinyl chloride (g)	0.84	2-TecPlastics	13 -PC	Yes
83	Copper (g)	1.57	4-Non-ferro	31 -Cu tube/sheet	Yes
84					
85	***Screws + washers***				
86	Stainless steel (g)	3.63	3-Ferro	26 -Stainless 18/8 coil	Yes
87					

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !	Recyclable?
88	***Spring***				
89	Stainless steel (g)	1.21	3-Ferro	26 -Stainless 18/8 coil	Yes
90					
91	***Supports***				
92	Stainless steel (g)	1.21	3-Ferro	26 -Stainless 18/8 coil	Yes
93					
94	Fixed ring				
95	Nylon (g) (PA)	25.40	8-Extra	103-Nylon	Yes
96					
97	POM Parts				
98	Polyoxymethylene (POM) (g)	3.63	8-Extra	104-POM	Yes
99					
100	**CONTAINER**				
101	***Container***				
102	Polypropylene (PP) (g)	271.43	1-BlkPlastics	4 -PP	Yes
103					
104	***Handle***				
105	Polypropylene (PP) (g)	70.00	1-BlkPlastics	4 -PP	Yes
106					
107	***Accessories***				
108	Polypropylene (PP) (g)	37.15	1-BlkPlastics	4 -PP	Yes
109					
110	***Base metal body***				
111	Stainless steel (g)	279.40	3-Ferro	26 -Stainless 18/8 coil	Yes
112					
113	***Base target coverage***				
114	Silicone (g)	19.35	8-Extra	102-Silicone	No
115					
116	***Pulser***				
117	Acrylonitrile butadiene styrene (g)	6.05	8-Extra		No
118					
119	***Filter and housing***				
120	Polypropylene (PP) (g)	22.98	1-BlkPlastics	4 -PP	Yes
121					
122	***POM Parts***				
123	Polyoxymethylene (POM) (g)	12.10	8-Extra	104-POM	Yes
124					
125	***Screws***				
126	Stainless steel (g)	2.42	3-Ferro	26 -Stainless 18/8 coil	Yes
127					
128	**PACKAGING**				
129	***Packaging foil***				
130	Low density polyethylene (g)	11.90	1-BlkPlastics	4 -PP	Yes
131					
132	***Cardboard boxes***				
133	paper (g)	255.10	7-Misc.	57 -Cardboard	Yes
134					

5.9. Annex D: Aggregated Bill of Materials of the Base Cases

Name	BC 1	BC 2	BC 3
Description	Simple plastic kettle, low capacity, no special specifications, medium power	Simple plastic kettle, medium capacity, no special specifications, higher power	Simple plastic kettle, medium capacity, no special specifications, higher power
Stainless steel (g)	186.00	299.97	306.93
Brass (g)	20.25	32.66	32.66
Copper (g)	15.00	24.19	26.73
Aluminium (g)	-	-	0.82
Tin (g)	-	-	0.08
Silver (g)	-	-	-
Polypropylene (PP) (g)	350.25	564.86	575.32
Polyvinyl chloride (g)	43.50	70.15	72.49
Nylon (g)	49.50	79.83	79.83
Polyoxymethylene (POM) (g)	9.75	15.72	15.72
Polycarbonate (g)	6.75	10.89	10.89
Acrylonitrile butadiene styrene (g)	30.00	48.38	48.38
High density polyethylene (g)	-	-	4.88
Silicone (g)	12.00	19.35	20.75
Ag (g)			0.00
Sum	**723.00**	**1,166.00**	**1,195.46**
Packaging			
Low density polyethylene (g)	6.30	11.90	11.90
Paper (g)	131.50	255.10	255.10
Sum	**137.80**	**267.00**	**267.00**

5.10. Annex E: Materials added to the MEErP EcoReport tool

Five materials have been added to the MEErP EcoReport tool: Tin, Ag, Silicone, Nylon and POM. The background data (life cycle inventory) used to model the first four materials is "ecoinvent v3.6 allocation, cut-off by classification". Industry data 2.0 was used for POM.

The calculated environmental impact per kg of material is given in Table 5-16.

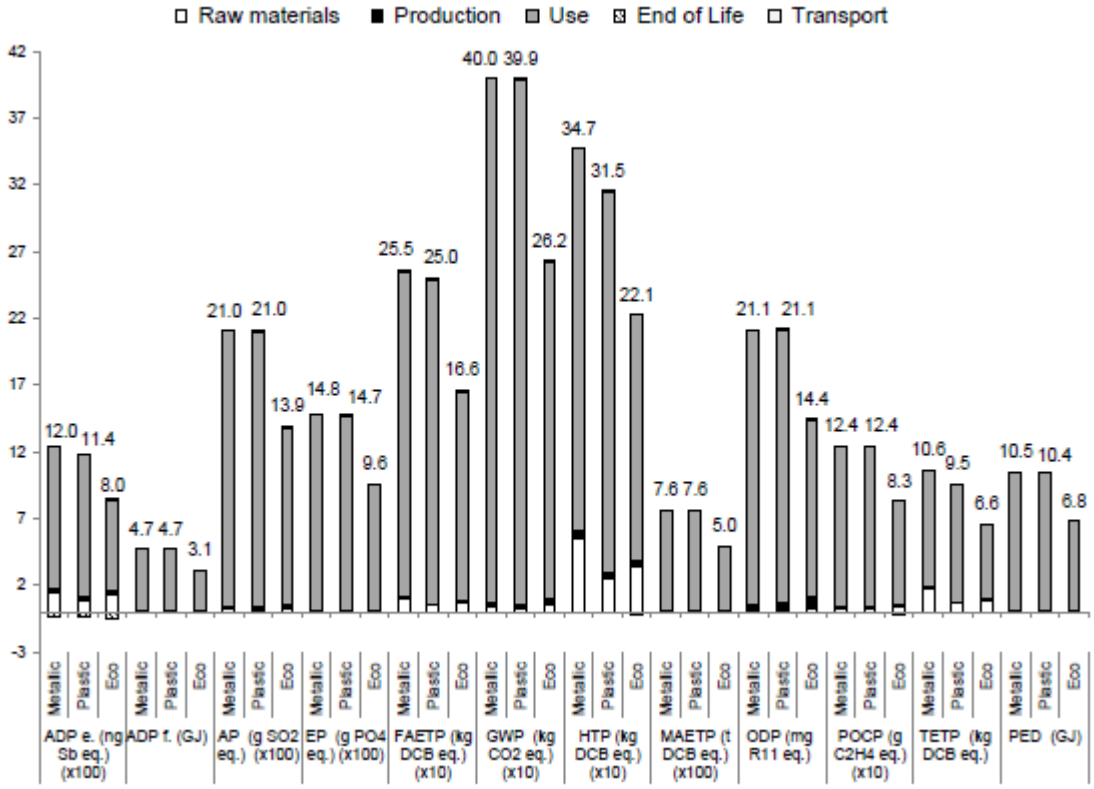
Table 5-16: Environmental impact of extra materials

nr	Name material	Recycle %*	Primairy Energy	Electr energy	feedstock	water proces	Water cool	waste haz	waste non	GWP	AD	VOC	POP	Hma	PAH	PM	HMw	EUP
unit	New Materials production phase (category '**Extra**')	%	MJ	MJ	MJ	L	L	g	g	kg CO2 eq.	g SO2 eq.	mg	ng i-Teq	mg Ni eq.	mg Ni eq.	g	mg Hg/20	mg PO4
100	**Tin**		159.28			223.44		0.14	1949.69	11.00	110.85	11.62	5.75	112.51	4.85	330.51	342.63	8447.63
101	**Ag**		7819.92			3880.59		106.84	36517.48	506.55	5247.41	528.32	520.52	4608.61	152.81	1487.21	20905.43	726809.48
102	**Silicone**		87.73			45.09		0.05	276.62	2.66	13.56	5.32	0.93	12.80	2.30	4.29	0.95	2388.85
103	**Nylon**		141.07			226.21		0.00	102.17	8.06	30.35	4.60	0.06	3.19	0.07	2.03	0.61	6910.98
104	**POM**		7.54			541.67		0.00	0.01	3.22	5.54	0.63	0.13	2.32	0.20	0.34	10.82	1222.26

5.11. Annex F: LCA of kettle in the literature

Few papers deal with the LCA of kettles. While they all compare different technologies to boil water (incl. kettles), only Gallego-Schmid et al (2017) focus on electric kettles and covered three ones. The main environmental impacts are shown in Figure 5-7.

Figure 5-7: Life cycle environmental impacts of plastic, metallic and eco-kettles over their average useful lifetime (4.4 years) (source: Gallego-Schmid et al (2017))



5.12. Annex G: Comparison of Materials for the container

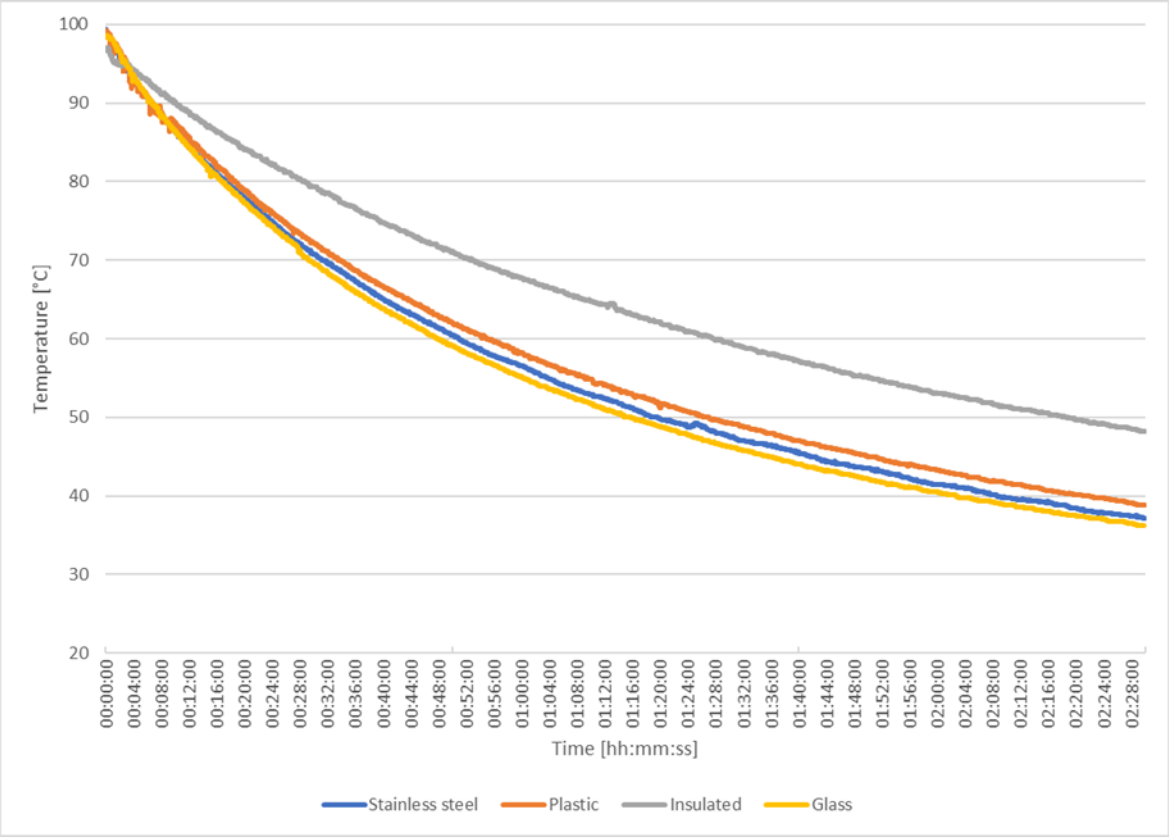
For single-wall kettles, there are three main container materials (see also Task 2 report):

- plastic
- glass
- stainless steel

Performance

Measurements carried out by Fraunhofer ISI on kettles having different containers materials showed no relevant difference in terms of energy efficiency (see Figure 5-8).

Figure 5-8: Cool down measurement of kettles with different containers (Fraunhofer ISI with 1 l of water heated at T_{max})



BoM

For the glass and stainless steel variants, the Base Case 2 BoM shows the following differences compared to the "plastic" Base Case 2 version (see Table 5-17).

Table 5-17: Base Case 2: Deviations in terms of BOM according to the container material

	Plastic (Ref)	Glass		Stainless steel	
Stainless steel	299.97	299.97	-	**574.97**	**275.00**
Brass	32.66	32.66	-	32.66	-
Copper	24.19	24.19	-	24.19	-
Aluminium	-	-	-	-	-
Tin	-	-	-	-	-
Silver	-	-	-	-	-
Polypropylene (PP)	564.86	**315.86**	**- 249.00**	**315.86**	**- 249.00**
Polyvinyl chloride	70.15	70.15	-	70.15	-
Nylon	79.83	79.83	-	79.83	-
Polyoxymethylene (POM)	15.72	15.72	-	15.72	-
Polycarbonate	10.89	10.89	-	10.89	-
Acrylonitrile butadiene styrene	48.38	48.38	-	48.38	-
High density polyethylene	-	-	-	-	-
Silicone	19.35	19.35	-	19.35	-
Ag	-	-	-	-	-
Borosilicate Glass	0	**677.00**	**677.00**	-	-
Total (without packaging)	1,166.00	1,594.00	428.00	1,192.00	26.00
Low density polyethylene	11.90	11.90	-	11.90	-
Paper	255.10	255.10	-	255.10	-
Total (with packaging)	1,433.00	1,861.00	428.00	1,459.00	26.00

Life Cycle Impact (per unit)

In terms of environmental impacts, Table 5-18 shows the main differences among the tree variants.

Table 5-18: Base Case 2: Life Cycle Impact (per unit) of Electric water kettles, depending on the material

	Life Cycle Phases -->		Plastic	Glass		Stainless steel	
	Resources Use and Emissions		TOTAL	TOTAL	Glas. vs. Plastic	TOTAL	Steel vs. Plastic
	Other Resources & Waste						
11	Total Energy (GER)	MJ	5,239	5,220	-0.3%	5,227	-0.2%
12	of which, electricity (in primary MJ)	MJ	5,030	5,029	0.0%	5,027	-0.1%
13	Water (process)	ltr	5,453	5,455	0.1%	5,464	0.2%
14	Water (cooling)	ltr	269	257	-3.2%	259	-3.6%
15	Waste, non-haz./ landfill	g	3,056	3,025	-0.7%	3,218	5.3%
16	Waste, hazardous/ incinerated	g	85	84	-0.7%	84	-1.2%
	Emissions (Air)						
17	Greenhouse Gases in GWP100	kg CO2 eq.	228	227	-0.2%	228	0.1%
18	Acidification, emissions	g SO2 eq.	1,000	998	-0.2%	1,007	0.7%
19	Volatile Organic Compounds (VOC)	g	112	112	0.0%	112	0.0%
20	Persistent Organic Pollutants (POP)	ng i-Teq	15	15	0.2%	17	13.5%
21	Heavy Metals	mg Ni eq.	88	88	0.1%	116	31.0%
22	PAHs	mg Ni eq.	15	15	-0.4%	15	-0.6%
23	Particulate Matter (PM, dust)	g	51	50	-0.7%	52	2.0%
	Emissions (Water)						
24	Heavy Metals	mg Hg/20	39	39	0.0%	54	38.3%
25	Eutrophication	g PO4	2	2	-1.9%	3	16.8%

In general, the deviations are relatively limited. However, stainless steel kettles have the highest environmental impact (with around 35% higher heavy metals emissions than for the plastic kettle). Kettles with glass container and with plastic container have a very close environmental impact, whereby 'eutrophication' (-1.9 %) and 'water cooling' (-3.2 %) are slightly better for glass kettles.

Due to these facts, polypropylene (PP) was considered as the container material of the Base Cases of this study.

[Catalogue number]



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Preparatory study for Kettles implementing the Ecodesign Working Plan 2016-2019

Task 6: Design options

Final report

Request for services N° ENER/C4/FV 2019-467/06/FWC 2015-619 LOT1/05 in the context of the Framework Contract N° ENER/C3/2015-619 Lot 1

Team:
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Preparatory study for Kettles implementing the Ecodesign Working Plan 2016-2019

Task 6: Design option

Final report

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LIST OF ABBREVIATIONS AND ACRONYMS

BAT	Best available technologies
BNAT	Best not-yet available technologies
CO_2	Carbon dioxide
DD	Discount rate
EE	Compound growth rate
EOL	End of life
kWh	kilowatt hour
kWh/a	kilowatt hour per year
LCC	Life cycle costs
LLCC	Least life cycle costs
LED	Light emitting diode
MEErP	Methodology for Ecodesign of Energy-related Products
NPV	Net present value
NN	Product lifetime
OE	Operating expense
PM	Particulate matter
PP	Purchase price
PWF	Present worth factor
SO_2	Sulfur dioxide
VOC	Volatile organic compounds

6. TASK 6: DESIGN OPTIONS

The base cases described in the previous tasks serve as baselines for the assessment of improvement potentials from the use of Best Available Technologies (BAT) or Best Not-yet Available Technologies (BNAT). These potentials are to be analysed using so-called "design options", i.e. (aggregated clusters of) design measures to increase the performance of electric kettles.

The aim of this task is to identify and describe these options, to assess their quantitative impact on the environmental performance of kettles, to analyse their economic performance and to determine Least Life Cycle Costs (LLCC). For this purpose, this task relies on the calculation models established in the preceding tasks, in particular Task 5, and complements them, where necessary.

6.1. Subtask 6.1 - Design options

The aim of this subtask is to identify and describe the design options that can improve the environmental performance of kettles. According to the underlying methodology[1], typically 4 to 8 design options are considered as a manageable number of design options for Ecodesign preparatory studies. The impact of these individual design options may vary depending on previously implemented ones. An improved sensor, for example, that precisely stops boiling at a selected target temperature may reduce the electricity consumption for boiling the water on the one hand. On the other hand, a water level indicator may cause a user to reduce the amount of excessive water boiled in the kettle. Simply adding up the individual impact of both options will lead to an overestimation of their impact. In this first part of the report, a perspective is taken that considers the design options individually, i.e. independent of each other. In the second part starting from section 6.4, the interaction of the design options is then taken into account.

Table 6-1 provides an overview of the six design options applied to the three base cases of kettles in this study. Not all design options are relevant for all of the base cases. Whether a design option is relevant for a particular base case is indicated in the table by an 'X'. The design options are based on the technological analysis carried out in the previous tasks, especially Tasks 4 and 5. They can be described as follows:

1. **Water level indicator**: This design options deals with two different measures concerning water level indicators of electric water kettles. Both of them aim to reduce "over boiling", i.e. a situation where the user boils more water that is actually needed for consumption (see also Task 3). The option includes an enlarged of the water level indicator down to a lower minimum volume (e.g. 0.25 litres). In addition to the information in litres, alternative scales for highly intuitive use are covered by this design options, e.g. indicating the filling level in cups.

2. **Heating element**: By this design option, conventional heating elements like immersed or underfloor heating elements are replaced by thick film heating elements. Thick film heating elements operate with a higher efficiency since the have a higher energy density and lower thermal losses, which particularly affects performance in case of low filling levels.

3. **Sensor and controller**: According to the testing procedure described within IEC 60530:1975, electric water kettles shall increase temperature by 80K to a target temperature of 95°C. However, measurements and data from stakeholders show an "over heating" of kettles, i.e. a situation where kettles keep on boiling water beyond 95°C, thus causing additional electricity demand. This design option aims to reduce the time between reaching 95°C (fulfilling standard) and the automatic shut off the kettle. To do so, this design option uses sensor and controller units with higher accuracy.

4. **Insulation of the container**: This design option addresses the container insulation of electric water kettles. According to this design option, containers are equipped with a double shell and a layer of air in between. The focus of this design option is neither on the heating phase nor material substitution (dealt within Task 5), but if reduces heat losses during the cooling phase, i.e. after boiling, and therefore reduces energy consumption, in particular but not limited to keep warm features.

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[1] Kemna R. (2011): Methodology for Ecodesign of Energy-related Products, MEErP 2011, 704 Methodology report, Part 1, methods.

5. **Pre-set temperature**: In some usage scenarios, e.g. brewing teas, temperatures of 95°C are not required. This design option allows users to select temperature levels below 95°C, which results in energy savings.

6. **Keep-warm function:** There is currently no standard or regulation that limits the use of the keep warm function. By setting a maximum duration for keep-warm to 30 minutes, kettles, extensive re-heating of boiled water is avoided.

These design options can be viewed with regard to their impact on heating water, i.e. the boiling phase, and by their effect during the keep warm phase, where relevant. The right part of Table 6-1 shows the upper limits for the expected savings in both phases. These values are based on available documents, additional assumptions and following discussions with stakeholders during the second stakeholder meeting. The specific impact of the design options on energy demand of the specific base cases is provided in Table 6-2 in the next section.

Table 6-1: Overview of the design options and their relevance for the base cases.

		Applies to			**Changes energy consumption during**	
		Base case 1	**Base case 2**	**Base case 3**	**boiling by up to**	**keep warm by up to**
1	Water level indicator	X	X	X	-10 %	-10 %
2	Heating element	X	X	X	-8 %	-8 %
3	Sensor and controller	X	X	X	-5 %	-5 %
4	Insulation of the container	X	X	X	-1,5 %	-50 %
5	Pre-set temperature		X		-3,5 %	0 %
6	Keep-warm function			X	0 %	-50 %

6.2. Subtask 6.2 - Impacts of the design options

The aim of this subtask is to describe the impacts of the six design options on the environmental performance of the base cases. It should be noted that this analysis is done from a perspective where the design options are directly integrated into new kettles, not from an add-on perspective to existing ones.

6.2.1. Impact on Energy demand

To determine the impact of the design options on energy demand and costs, information on their environmental impact and costs is needed. Table 6-2 gives an overview on the annual electricity consumption of the base cases and the assumed relative impact of the various design options on it.

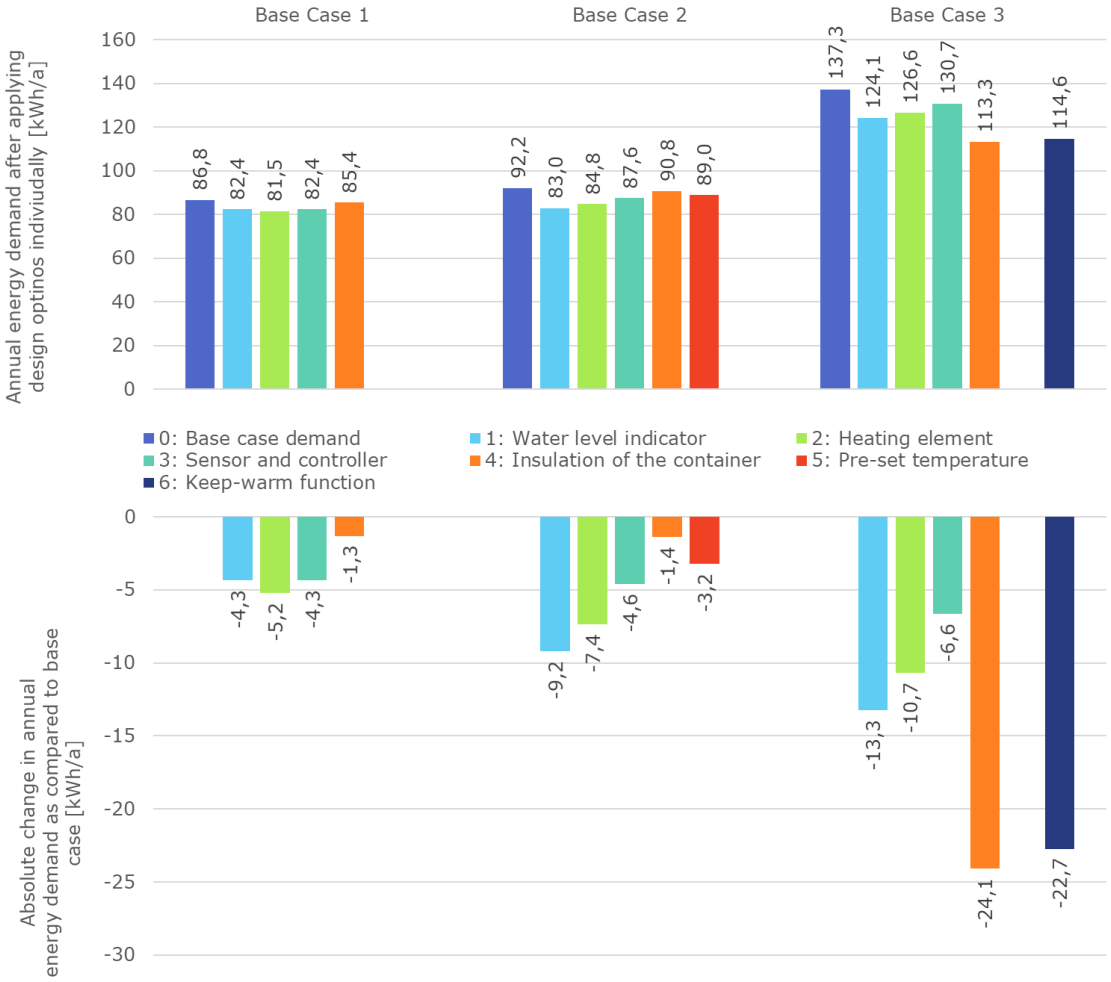
Table 6-2: Annual direct energy demand of the base case kettles based on Task 5 and assumptions on relative changes due to the implementation of individual design options

		Base case 1	**Base case 2**	**Base case 3**
0	Base case demand	86,8 kWh/a	92,2 kWh/a	137,3 kWh/a
1	Water level indicator	-5,0%*	-10,0%	-9,7%
2	Heating element	-6,0%	-8,0%	-7,8%
3	Sensor and controller	-5,0%	-5,0%	-4,8%
4	Insulation of the container	-1,5%	-1,5%	-17,5%
5	Pre-set temperature		-3,5%	
6	Keep-warm function			-16,5%

*Conservative assumption considering higher minimum water level in kettles with immersed heating elements.

Figure 6-1 visualizes the impact on the annual overall electricity demand of the base cases (upper part) and the savings in absolute terms as compared to the base case (lower part).

Figure 6-1: Impact on annual energy demand when applying the design options individually (upper part: annual energy consumption; lower part: difference as compared to the respective base case).



6.2.2. Impact on other environmental parameters

Next to the assessment on energy demand, the MEErP methodology also requires an analysis of the impact of the design options on other environmental impact parameters. Changes should be reported if substantial impacts occur due to the design options.

Since some of the design options change the physical setup of the kettles, they affect the input to the bill of materials. Table 6-3 shows the changes associated with the implementation of the design options within this study. As shown in Task 5, the material input only plays a rather small role for most of the environmental indicators. A detailed overview of the combined impact of the changes in the bill of materials combined with the impact of reduced energy consumption can be found in the Annex A (section 6.6) of this report. Across all indicators, the performance values remain unchanged or they are improved, i.e. the environmental impact of the kettles is regularly reduced. This means that any potentially worse performance by using additional material is overcompensated by the additional improvements due to reduced electricity demand.

Table 6-3: Modification to the bill of materials due to the design options (minus indicates a reduction in usage; plus signs indicate an increase)

		Base case 1	Base case 2	Base case 3
1	Water level indicator	None	None	None
2	Heating element	-47g stainless steel	-105g stainless steel	-105g stainless steel
3	Sensor and controller	None	None	None
4	Insulation of the container	+90g plastic	+129g plastic	+129g plastic
5	Pre-set temperature		+7g stainless steel +2.5g cooper +0.8g aluminium +0.08g tin +10.5g polypropylene +2.3g polyvinyl chloride +4.9g high density poly ethylene +1.4g silicone +0.0022g Silver	
6	Keep-warm function			None

6.3. Subtask 6.3 - Costs

The aim of this subtask is to estimate the price increase due to the implementation of the options and to derive conclusions on their impact on the life cycle costs of kettles. According to the MEErP methodology, this analysis should either be carried out based on an assessment of the market prices of the products, i.e. kettles, and/or by applying a production cost model with sector-specific margins. Here, the market price approach has been chosen since it allows a more direct analysis on the life cycle costs from a user perspective.

To enhance the accessibility of the underlying calculation and their results, an overview of the life cycle model is given first which is underlying the calculations in Task 5, as well. This model from the MEErP distinguishes two different perspective for the life cycle costs: the user and the societal perspective. Preparatory studies are required to assess both types.

The basic equation to determine the life cycle costs from the user perspective (LCC in Euro) covers the following elements: the purchase price (PP in Euro), the annual operating expense (OE in Euro), the dimensionless present worth factor (PWF) and the end-of-life costs (disposal, recycling) or benefits (resale) (EOL in Euro) as follows:

$$\mathrm{LCC} = \mathrm{PP} + \mathrm{PWF} \cdot \mathrm{OE} + \mathrm{EOL}$$

Note, that while the annual operating expense is discounted to the present year, the end-of-life costs are not. This is explained by the experience that disposal costs for many products are already covered during acquisition. The present worth factor, in turn, is calculated using the product lifetime (NN in years) and the discount rate (DD). Furthermore, price increases in operating expenses can be taken into account by DD as an escalation rate expressed as a percentage. Based on this, the calculation of the present worth factor can be written as:

$$\mathrm{PWF} = 1 - \frac{(1+\mathrm{EE})}{(1+\mathrm{DD})} \cdot \left(1 - \left(\frac{1+\mathrm{EE}}{1+\mathrm{DD}}\right)^{\mathrm{NN}}\right)$$

If several different price increases are to be assessed together (e.g. one rate for external damage, one rate for energy costs and one rate for maintenance), they should be aggregated into one compound growth rate (EE) by considering their respective shares in the overall annual costs. In case the discount rate and the overall annual price increases are identical, the previous equation simplifies to the lifetime of the product:

$$\mathrm{PWF} = \mathrm{NN}$$

In the MEErP methodology, it has been argued that the discount rate, the external damage escalation rate and the energy growth rate were all of the order of 3 to 4 % at the time of preparing the MEErP

methodology. **We considered a unique rate of 4 %** for the analysis of life cycle costs, allowing for the previous simplification.

Beyond the life cycle costs from the user perspective, societal life cycle costs need to be calculated, as well. These include the costs for external damages of air emissions ($\widetilde{LCC}$) based on a given list of fixed prices as given in Table 6-4. These values are to be multiplied by the total mass of emissions from the EcoReport 2011 and have to be added to the life cycle costs from the user perspective in the respective phases.

Table 6-4:Summary of monetary values attributed to emissions to the air based on the MEErP methodology (source: MEErP methodology)

Emissions	Euro/kg
Global warming potential in CO_2-eq.	0.014
Acidification potential in SO_2-eq.	16.00
Volatile organic compounds VOC	2.80
Particulate matter PM10	37.50

For the kettles with their design options, estimates for increased product prices are indicated in Table 6-5. These values have been derived from available documented evidence and information gained from the stakeholder consultation. These in prices are made under the assumption that a broader utilization of the design options takes places, i.e. that economies of scale apply. Some options such as the water level indicator are rather simple changes in design and are expected to be (nearly) no cost measures.

Table 6-5: Estimates of the marginal prices of the design options by base case based on desk research and stakeholder feedback

		Base case 1	Base case 2	Base case 3
1	Water level indicator	Unchanged	Unchanged	Unchanged
2	Heating element	+3,50 Euro	+2,00 Euro	+2,00 Euro
3	Sensor and controller	+4,00 Euro	+ 4,00 Euro	Unchanged
4	Insulation of the container	+2,00 Euro	+3,00 Euro	+3,00 Euro
5	Pre-set temperature		+2,00 Euro	
6	Keep-warm function			Unchanged

Based on these inputs and the results of the energy and other environmental impacts analysis (section 6.2), the life cycle costs per design option is determined. Table 6-6 to Table 6-8 show the resulting life cycle costs for the different base cases. The category 'purchase' indicates the initial price of the kettles, 'operation (electricity)' covers the expenditures for energy demand and 'operation (non-electricity) incl. EOL' reflects the expenditures related to regular descaling of the kettles. From the results, it can be observed that all design options are cost-effective from a life cycle perspective, i.e. additional costs from the implementation of the design options are lower than the life cycle savings due to electricity costs if applied individually.

Table 6-6: Life cycle costs (in Euro) of the design options without considering interaction effects for base case 1 as net present value

		User perspective				Societal perspective
		Purchase	Operation (electricity)	Operating (non-electricity) incl. EOL	Life Cycle Cost	Life Cycle Cost
0	Base case	16	107	20	143	155
1	Water level indicator	16	102	20	138	149
2	Heating element	20	101	20	140	151
3	Sensor and controller	20	102	20	142	153
4	Insulation of the container	18	106	20	144	155

Table 6-7: Life cycle costs (in Euro) of the design options without considering interaction effects for base case 2 as net present value

		User perspective				Societal perspective
		Purchase	Operation (electricity)	Operating (non-electricity) incl. EOL	Life Cycle Cost	Life Cycle Cost
0	Base case	26	114	24	164	176
1	Water level indicator	26	103	24	152	164
2	Heating element	28	105	24	156	168
3	Sensor and controller	30	108	24	162	174
4	Insulation of the container	29	112	24	165	178
5	Pre-set temperature	28	110	24	162	174

Table 6-8: Life cycle costs (in Euro) of the design options without considering interaction effects for base case 3 as net present value

		User perspective				Societal perspective
		Purchase	Operation (electricity)	Operating (non-electricity) incl. EOL	Life Cycle Cost	Life Cycle Cost
0	Base case	62	170	25	257	276
1	Water level indicator	62	154	25	240	258
2	Heating element	64	157	25	246	263
3	Sensor and controller	62	162	25	249	267
4	Insulation of the container	65	140	25	230	246
6	Keep-warm function	62	142	25	229	245

6.4. Subtask 6.4 - Analysis of least life cycle costs and BAT

The aim of this subtask is to determine the least life cycle costs (LLCC) for each base case. The MEErP requires an analysis of the least life cycle costs across several steps both from a consumer as well as from a societal perspective.

6.4.1. Ranking of individual design options

For determining the least life cycle costs, the design options need to be sorted by their economic performance. For the sorting, the difference of the life cycle costs in the case where the design options are applied compared to a situation without any design option, i.e. the pure base case, is considered. This means that economically favourable measures are ranked higher than those that are economically less attractive. The (unaltered) base case always holds the first rank "zero".

The results of this ranking under the consideration of interaction effects (one options affects the impact of another) is shown in Table 6-9. The results from the ranking analysis show identical results in ranking for the design options and the base cases.

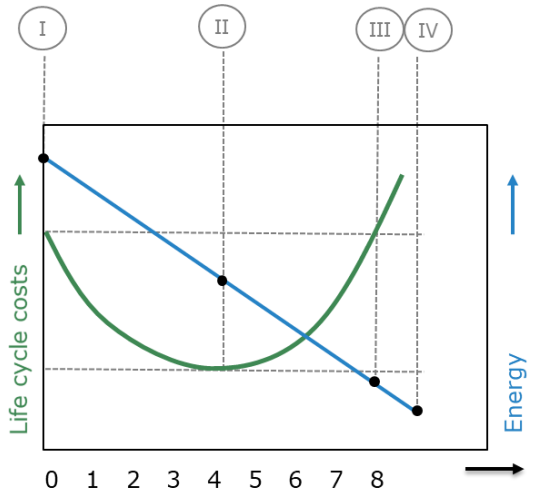
Table 6-9: Ranking of the design options for the different base cases when ordered by the change in the LCC as compared to the base case (both the ranking according to the user perspective and the societal perspective coincide)

		Base case 1	Base case 2	Base case 3
0	Base case	0	0	0
1	Water level indicator	1	1	3
2	Heating element	2	2	4
3	Sensor and controller	3	4	5
4	Insulation of the container	4	5	2
5	Pre-set temperature		3	
6	Keep-warm function			1

6.4.2. Estimation of the cumulative improvement and cost effect

Based on the previous ranking, the cumulative improvement potential and the effect on costs can to be calculated. For this purpose, a least life cycle cost (LCC) curve as shown in Figure 6-2 is needed. To the left of the figure (I), the life cycle costs of the base case are indicated. Then the interacting design options are added by their ranks. According to theory, some design options will reduce the overall life cycle costs while other will then start to increase the costs due to decreasing benefits after applying several design options. As a result, a least life cycle cost (II) will be obtained after applying various design options. Adding further design option will then decrease energy consumption further, but will add to the life cycle costs until a break-even point (III) with the base case situation is reached. At this point, energy consumption is thus lower "at the same life cycle price" as for the base case. Adding further measure to reduce the consumption could increase costs further (IV).

Figure 6-2:Illustration of the least life cycle curve



Design options ranked according to LCC impact

I: Base Case
II: Least Life Cycle Cost
III No financial loss (break-even point)
IV: Best available technology

Following this concept, the life cycle curves for the three kettle base cases with their design options are shown in in Figure 6-3 to Figure 6-5. For improved visibility, vertical axes do not start at zero in all cases.

Figure 6-3: Least life cycle for base case 1 (user perspective)

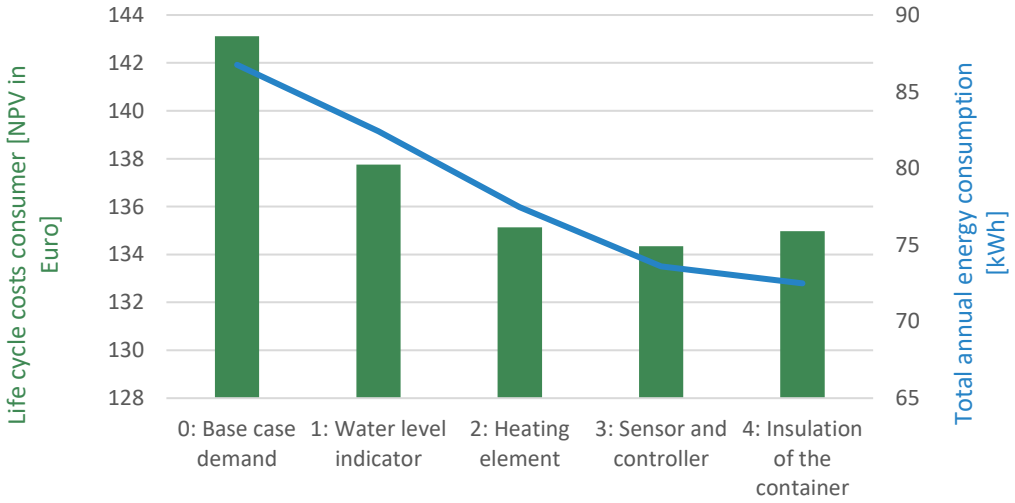


Figure 6-4: Least life cycle for base case 2 (user perspective)

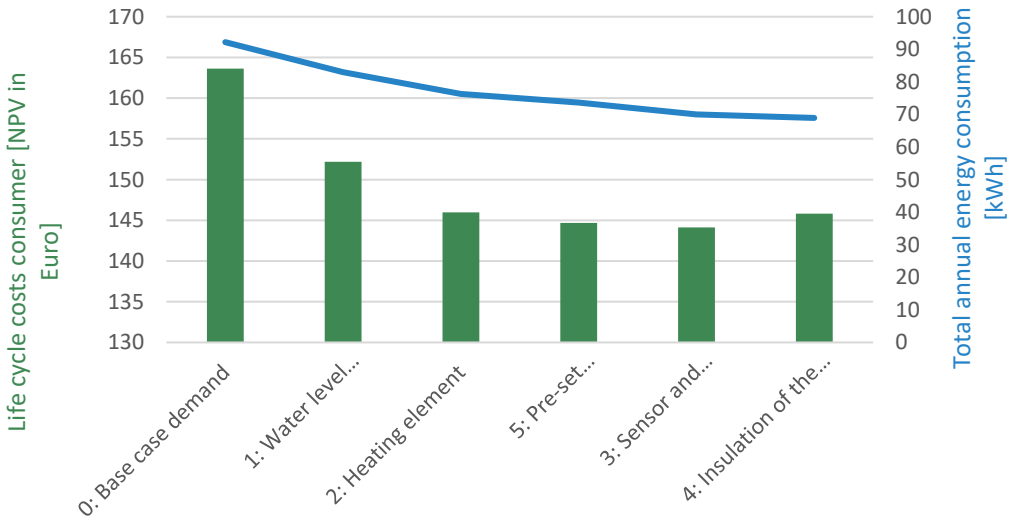
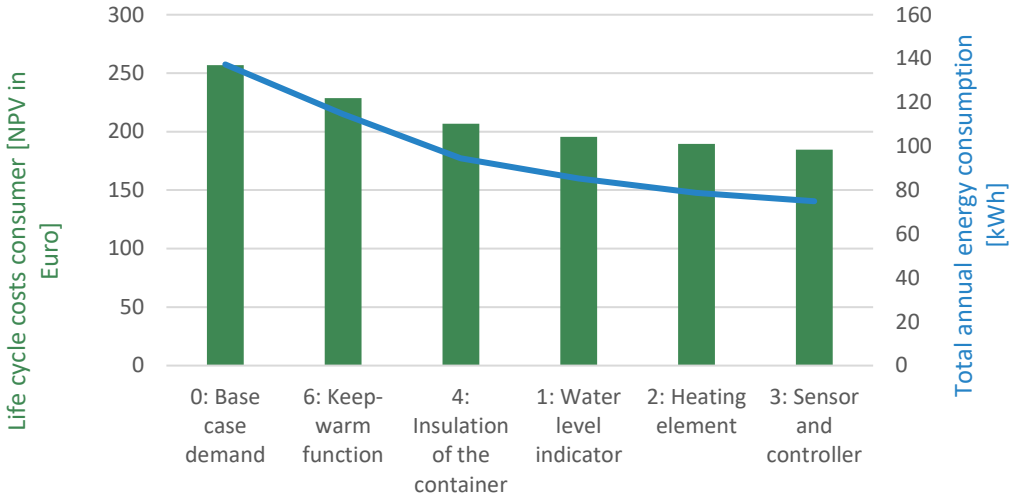


Figure 6-5: Least life cycle for base case 3 (user perspective)



Based on the visualization, these main conclusions follow:

- For base case 1, the least life cycle cost is achieved after applying the first three design options.
- For base case 2, the least life cycle costs is reached after the first four measures in ranking.
- For base case 3, all design options lead to a reduction in overall life cycle costs.
- All design options reduce the overall costs from the user perspective as compared to the base case and lead to additional savings in electricity demand.

The results in numeric terms with further details are given in Table 6-10 to Table 6-12.

Table 6-10: Energy demand and net present value for the ranked and successively combined design options considering interaction for base case 1 (user perspective)

		Annual energy consumption	Purchase price	Operation expense (energy)	Operating expense (non-energy) incl. EOL	Life Cycle Cost (Consumer)
		[kWh]	[Euro]	[Euro]	[Euro]	[Euro]
0	Base case demand	87	16	107	20	143
1	Water level indicator	82	16	102	20	138
2	Heating element	77	20	96	20	135
3	Sensor and controller	74	24	91	20	134
4	Insulation of the container	72	26	90	20	135

Table 6-11: Energy demand and net present value for the ranked and successively combined design options considering interaction for base case 2 (user perspective)

		Annual energy consumption	Purchase price	Operation expense (energy)	Operating expense (non-energy) incl. EOL	Life Cycle Cost (Consumer)
		[kWh]	[Euro]	[Euro]	[Euro]	[Euro]
0	Base case demand	92	26	114	24	164
1	Water level indicator	83	26	103	24	152
2	Heating element	76	28	94	24	146

5	Pre-set temperature	74	30	91	24	145
3	Sensor and controller	70	34	87	24	144
4	Insulation of the container	69	37	85	24	146

Table 6-12: Energy demand and net present value for the ranked and successively combined design options considering interaction for base case 3 (user perspective)

		Annual energy consumption	Purchase price	Operation expense (energy)	Operating expense (non-energy) incl. EOL	Life Cycle Cost (Consumer)
		[kWh]	[Euro]	[Euro]	[Euro]	[Euro]
0	Base case demand	137	62	170	25	257
6	Keep-warm function	115	62	142	25	229
4	Insulation of the container	95	65	117	25	207
1	Water level indicator	85	65	106	25	196
2	Heating element	79	67	97	25	189
3	Sensor and controller	75	67	93	25	185

6.4.3. Possible positive or negative side effects of the individual options

Design options could have additional positive or negative side effects beyond the direct effects captured in the life cycle analysis. The MEErP methodology requires an assessment and discussion of these effects.

The impact of the design options of life cycle costs on electricity demand, environmental performance and costs is already covered by the previous steps. Major areas of potential impacts could related to the durability of the products or user behaviour. No particular side effects have been identified for the design options, yet the following items should be mentioned:

- Concerning design option 3 'sensor and controller', one stakeholder pointed out that users might perceive a kettle as defective if there is no 'bubbling sound' when boiling. Experience from kettle testing indicates, however, that kettles emit noise well below the 95°C threshold. As a positive side effect of the earlier switch-off from the user perspective, the time for 'completing boiling' decreases. In addition, the calcification process is not linear, so that heating water to 95°C instead of the physical boiling point will reduce the formation of limescale deposit.

- In case of design option 4 'insulation of the container', the temperature of the outer shell of the boiler will be decreased due to a lower heat transfer. As a positive side effect, this might improve the safety of operation since the container will be less hot to touch.

- In case of design option 6 'keep-warm function', users could expect the kettle to hold the temperature beyond a 30 minutes threshold. Yet this function is currently not (yet) very common in kettles on the one hand and existing models with this functionality have different keep-warm settings. In consequence, there does not seem to be an established expectation among users concerning the 'keep-warm function'. Furthermore, a limitation of this function could be an additional safety feature, helping to avoid the kettle to run dry if the function is used for a long time.

6.5. Subtask 6.5 - Long term targets and system analysis

The aim of this final subtask within Task 6 is two-fold. It shall look beyond the specific design options that are available as BAT in the long term. First, the long-term technical potentials as best not yet available technologies (BNAT) are to be discussed based on the assessment of applied and fundamental research, which still address the context of the present product archetype. Second, the long-term potential based on changes to the total system to which the present archetypal product belongs shall be discussed.

6.5.1. Long-term technical potentials based on BNAT

With regard to long-term technical potentials, it should be noted that electric kettles already come close to the theoretical minimum for the boiling process (excluding warm-keeping). Thus, from a physical perspective, no major break-through BNAT to reduce energy demand, for example similar to the change from the incandescent lamps to LED technology, can be expected.

Major levers concerning boiling (beyond the suggested design options) lies mainly in developing solutions to help users make better use of kettles to more adequately cover their actual boiled water demand, especially by avoiding over-heating (too high temperatures) and over-boiling (too much water). Digital innovations (e.g. alert functions) may assist here, but they might also cause additional consumption. One the one hand due to their own energy consumption and on they other hand if they act as independent agents and start boiling water based on predicted user behaviour in future scenarios. First kettles moving in this direction are already being advertised (Figure 6-6).

Figure 6-6: Excerpt of a smart kettle advertisement

„A brand new iOS and Android App, re-designed from the ground up packs in many new features in a simple and intuitive way to control your [kettle]. Using the latest Blink-Up technology, your connection is now even more secure, giving you that extra peace of mind. The customisable water temperature feature allows you to select any temperature between 20-100c. […] The water level sensor tells you exactly how much water is in your kettle directly on your App, so you know how many cups you can make. The new formula mode makes night feeds even easier, with the ability to connect to your Nest cam with IFTTT, it will boil the water and then notify you when it is at your desired temperature. Schedule the [kettle] to start heating at any time with Wake Up Mode, to make sure you get your day off to the best start possible. [It] also welcomes you home as soon as you walk in the door, select your normal time of arrival and the [kettle] will ask if you would like to boil the kettle."
(Excerpt of smart kettle description on www.amazon.co.uk)

6.5.2. Long-term changes to the total system

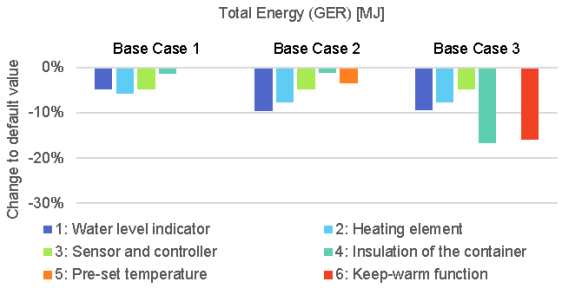
There are no evident long-term changes to the demand of hot water. However, based on available evidence, modern induction heating cooktops using traditional kettles to boil water seem to be able to compete with electric kettles in terms of both performance and time. If such cooktops become broadly used, this might affect the need for stand-alone electric kettles unless they offer additional services to the users.

6.6. Annex A: Detailed impact of the design options on the environmental performance

Energy, water and waste

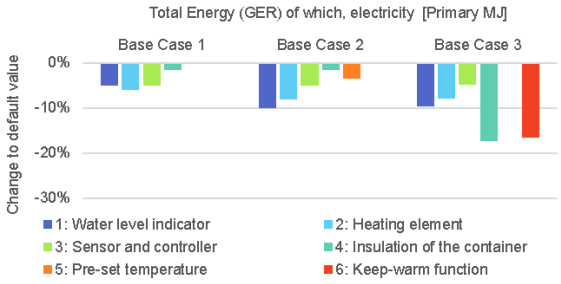
Total Energy (GER) — **MJ**

	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	4.898	5.239	7.687
1: Water level indicator	4.663	4.742	6.971
2: Heating element	4.614	4.835	7.104
3: Sensor and controller	4.663	4.991	7.329
4: Insulation of the container	4.836	5.180	6.402
5: Pre-set temperature		5.063	
6: Keep-warm function			6.460



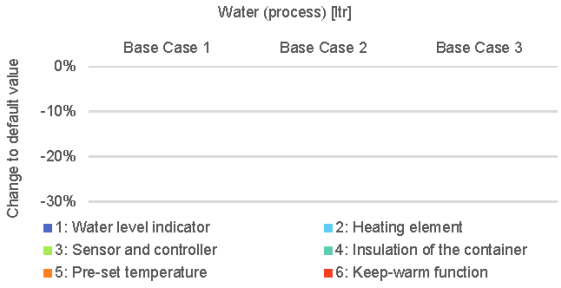
Total Energy (GER) of which, electricity — **Primary MJ**

	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	4.726	5.030	7.469
1: Water level indicator	4.492	4.533	6.753
2: Heating element	4.445	4.631	6.890
3: Sensor and controller	4.492	4.782	7.111
4: Insulation of the container	4.659	4.960	6.173
5: Pre-set temperature		4.856	
6: Keep-warm function			6.242



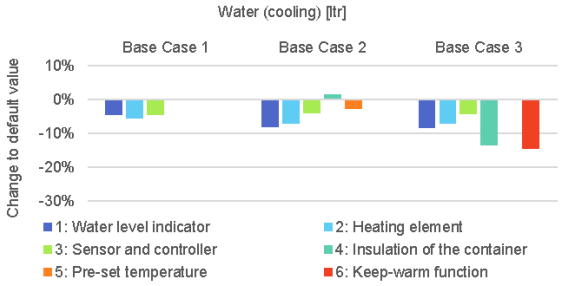
Water (process) — **ltr**

	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	5.438	5.453	5.453
1: Water level indicator	5.438	5.453	5.453
2: Heating element	5.435	5.448	5.448
3: Sensor and controller	5.438	5.453	5.453
4: Insulation of the container	5.438	5.453	5.454
5: Pre-set temperature		5.448	
6: Keep-warm function			5.453



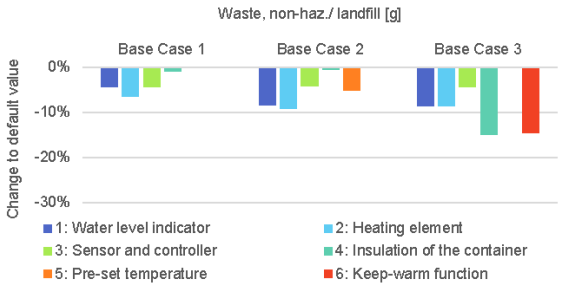
Water (cooling) — **ltr**

	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	238	269	379
1: Water level indicator	228	247	347
2: Heating element	225	250	352
3: Sensor and controller	228	258	363
4: Insulation of the container	239	273	327
5: Pre-set temperature		262	
6: Keep-warm function			324

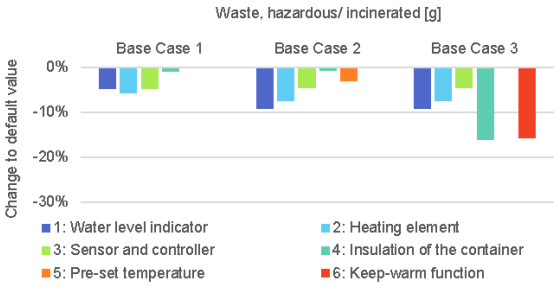


Waste, non-haz./ landfill — **g**

	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	2.764	3.056	4.327
1: Water level indicator	2.643	2.801	3.958
2: Heating element	2.585	2.775	3.953
3: Sensor and controller	2.643	2.930	4.142
4: Insulation of the container	2.740	3.041	3.678
5: Pre-set temperature		2.901	
6: Keep-warm function			3.694

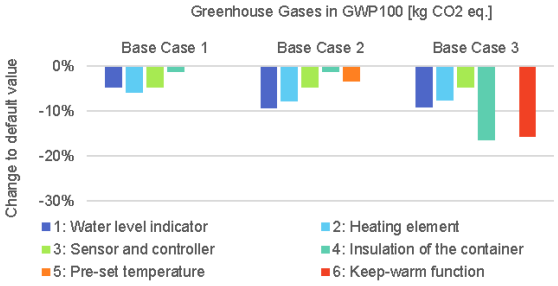


Waste, hazardous/ incinerated	g		
	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	79	85	123
1: Water level indicator	75	77	112
2: Heating element	74	78	114
3: Sensor and controller	75	81	118
4: Insulation of the container	78	84	103
5: Pre-set temperature		82	
6: Keep-warm function			104

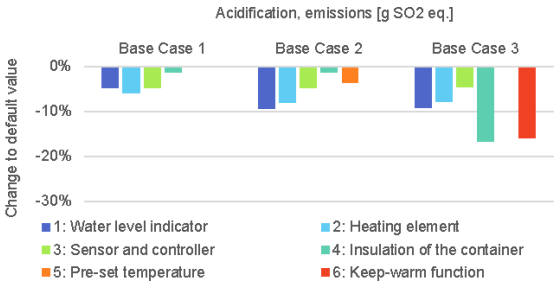


Emissions (Air)

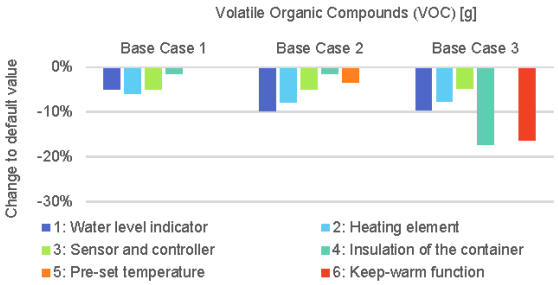
Greenhouse Gases in GWP100	kg CO2 eq.		
	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	213	228	333
1: Water level indicator	203	207	302
2: Heating element	201	211	308
3: Sensor and controller	203	218	317
4: Insulation of the container	211	226	278
5: Pre-set temperature		220	
6: Keep-warm function			280



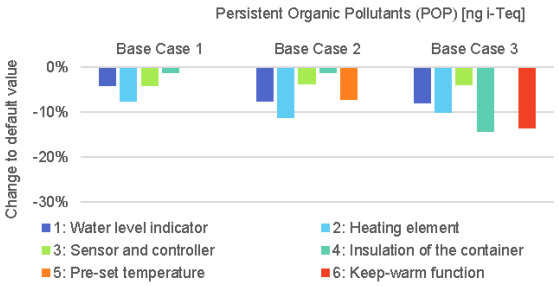
Acidification, emissions	g SO2 eq.		
	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	933	1.000	1.462
1: Water level indicator	889	906	1.327
2: Heating element	878	920	1.349
3: Sensor and controller	889	953	1.395
4: Insulation of the container	921	988	1.219
5: Pre-set temperature		964	
6: Keep-warm function			1.231



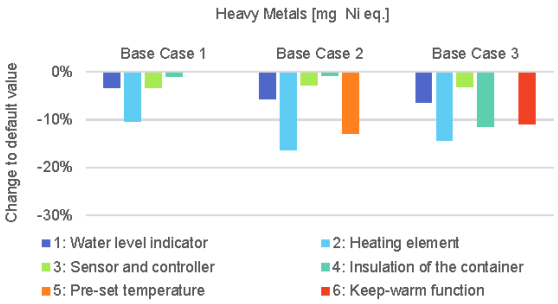
Volatile Organic Compounds (VOC)	g		
	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	106	112	167
1: Water level indicator	100	101	151
2: Heating element	99	103	154
3: Sensor and controller	100	107	159
4: Insulation of the container	104	111	138
5: Pre-set temperature		108	
6: Keep-warm function			140



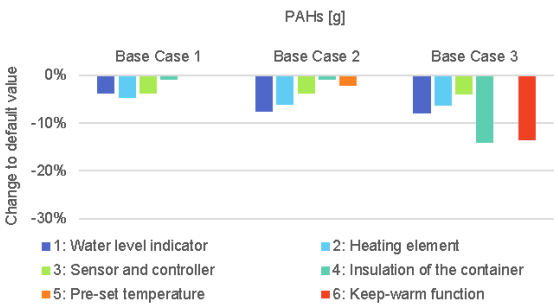
Persistent Organic Pollutants (POP)	ng i-Teq		
	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	13	15	21
1: Water level indicator	13	14	19
2: Heating element	12	14	19
3: Sensor and controller	13	15	20
4: Insulation of the container	13	15	18
5: Pre-set temperature		14	
6: Keep-warm function			18



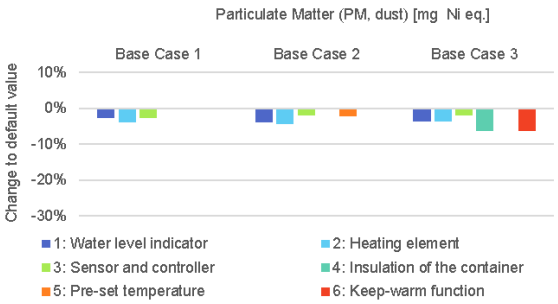
Heavy Metals	mg Ni eq.		
	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	73	88	114
1: Water level indicator	71	83	107
2: Heating element	66	74	98
3: Sensor and controller	71	86	110
4: Insulation of the container	72	88	101
5: Pre-set temperature		77	
6: Keep-warm function			101



PAHs	g		
	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	14	15	21
1: Water level indicator	14	14	20
2: Heating element	14	14	20
3: Sensor and controller	14	15	20
4: Insulation of the container	14	15	18
5: Pre-set temperature		15	
6: Keep-warm function			18

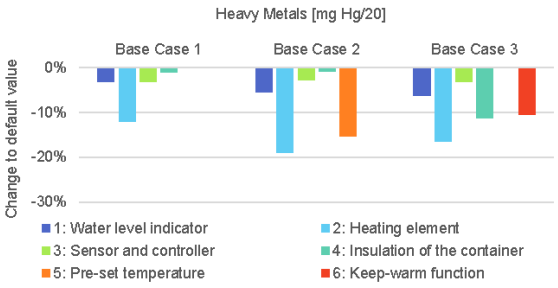


Particulate Matter (PM, dust)	mg Ni eq.		
	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	37	51	79
1: Water level indicator	36	49	76
2: Heating element	36	49	76
3: Sensor and controller	36	50	78
4: Insulation of the container	37	51	74
5: Pre-set temperature		50	
6: Keep-warm function			74

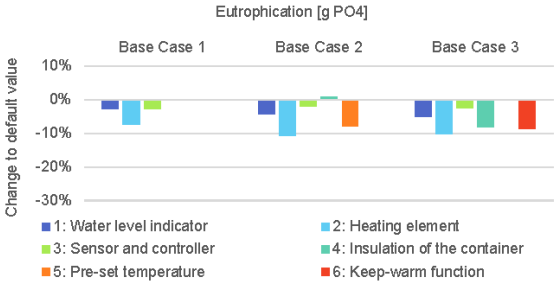


Emissions (Water)

Heavy Metals	mg Hg/20		
	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	31	39	50
1: Water level indicator	30	37	47
2: Heating element	27	32	42
3: Sensor and controller	30	38	49
4: Insulation of the container	31	39	44
5: Pre-set temperature		33	
6: Keep-warm function			45



Eutrophication	g PO4		
	Base Case 1	Base Case 2	Base Case 3
0: Base case demand	2	2	3
1: Water level indicator	2	2	3
2: Heating element	2	2	2
3: Sensor and controller	2	2	3
4: Insulation of the container	2	2	2
5: Pre-set temperature		2	
6: Keep-warm function			2



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Task 7: Policies and scenarios

Final report

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B-1049 Brussels

Preparatory study for Kettles implementing the Ecodesign Working Plan 2016-2019

Task 7: Policies and scenarios

Final report

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LIST OF ABBREVIATIONS AND ACRONYMS

BAT	Best Available Technology
BAU	Business-as-Usual
BoM	Bill of Materials
DO	Design Option
EC	European Commission
EEI	Energy Efficiency Index
EU	European Union
GHG	Greenhouse Gases
IEC	International Electrotechnical Commission
LLCC	Least Life Cycle Cost
MEErP	Methodology for Ecodesign of Energy-related Products
MEPS	Minimum Energy Performance Standards
PCR	Post-Consumer Recycled Materials
R_{cyc}	Recyclability rate
R_{post}	Post-consumer materials content
UK	United Kingdom

7. TASK 7 – POLICIES AND SCENARIOS

The purpose of this task is to provide an understanding of the impacts of future scenarios in line with policy measures that could be introduced at EU-level. This is a key task as it requires the combination of the results of all previous tasks. Its purpose is to derive estimates of the impacts of different Ecodesign policy measures and design options. Thereby, it is aimed at providing an analytical basis in support of the Ecodesign decision-making process. It contains a set of quantitative scenarios for the market penetration levels of various kettle technologies and the consequences for the environment, users and industry. To this end, a stock model has been developed to estimate future sales and stocks of kettles under different policy scenarios. The outcomes are then compared with the Business-as-Usual situation.

Please note that the conclusions drawn here are preliminary and solely represent the view of the consortium. They do not necessarily reflect the opinion of the European Commission. Tasks 1 to 6 provide the baseline data for future work conducted by the European Commission (impact assessment, further discussions in the Consultation Forum and the development of implementing measures, if any). Unlike the previous tasks, Task 7 serves to provide a summary of policy implications as seen by the consortium. Furthermore, elements of this task may be analyzed further in greater depth during the impact assessment.

7.1. Analysis of policies

Based on the review of the existing policies and standards (see Task 1), the feedback of the stakeholders and the cost-optimized technical improvement potential of the technologies (see Task 6), this task identifies and discusses policy options aimed at fostering the energy efficiency of kettles and reducing their impacts on the environment.

The following policy options are discussed later:

- minimum energy performance standards (MEPS)
- policy actions related to requirements regarding keep-warm
- energy labelling
- information requirements on the performance of the kettles
- policy actions related to behaviour
- policy actions related to circular economy
- policy actions related to materials

Furthermore, this task will include aspects related to measurements.

7.1.1. Scoping of possible policy requirements and key definitions

Objective:

This section describes the prospective boundaries and "electric water kettle" definitions to address the Ecodesign performance improvement from this study. The proposed policy measures themselves and potential legislative instruments to be used are discussed in subsequent sections.

Based on the work carried out in the study and on the definition provided in IEC 60530:1975, the following product definition is suggested for the scope of this analysis of policies and scenarios:

> *"Electric kettle" is a portable appliance for boiling water with means for pouring, either a lip or spout. Potentially it also includes the possibility to heat water below boiling temperature and/or a warm-keeping function after heating. It is an electric mains-operated appliance with a rated volume up to 10 litres.*
>
> *The scope exclude kettles which are not stand-alone or which are pressurized appliances.*

7.1.2. Proposed requirements to consider in policy measures

7.1.2.1. Specific ecodesign requirements

Based on the work carried out in Task 4 (Technologies) and Task 6 (Design Options), there is room for improving the energy efficiency of kettles for the boiling phase and for the keeping-warm phase (for kettles with this feature).

7.1.2.1.1. Specific energy efficiency requirement for boiling

Minimum energy performance standards (MEPS) is the main policy option to transform the appliance market towards higher energy efficiency. A precondition for establishing and implementing MEPS is the availability of measurement method.

Measurement method

A main challenge for electric water kettles is the lack of test standards. Task 1 reviewed existing regulations and voluntary labels around the world. Based on this review, Table 7-1 provides an overview of the related test conditions and energy efficiency metrics applied for kettles.

Table 7-1: Overview of the measurement methods and energy efficiency metrics related to electric kettles (source: Fraunhofer ISI)

Name / Reference	Country	Volume [l]	Start temperature of the water [°C]	End temperature of the water [°C]	Energy efficiency metric	Detail
IEC 60530:1975		1	15	95	None (focus on boiling time)	
Blue Angel / RAL-UZ 133[1]	Germany	1	20	100 (switch off)	Specific energy consumption [kWh/l] W20 = WM * 80 / TM	• WM: power consumption until automatic switch-off of the kettle • Temperature difference compared to the boiling temperature of 100°C
TopTen[2]	Switzerland	1	15	100 (switch off)	Yearly energy consumption [kWh/a] $E_{kettle} = E_{boil} + E_{keep\ warm} + E_{stand\text{-}by}$	• Eboil = 365 * $E_{consumption}$ to heat 1 litre if T-setting feature is available: -10% • $E_{keep\ warm} = P_{keep\ warm}$ x 0.5 x (max time keep-warm) x 365 if no measurement possible: 15 W x 1h x 365 • $E_{stand\text{-}by}$: $P_{stand\text{-}by}$ x 8760 h
ESR003	UK				not specified	
Eco-Label Standard[3] (EL408:2013)	South Korea	1	15	99	Specific energy consumption [kWh/l]	
GB/T 22089-2008	China	Rated volume	20[4]	80	$\eta = \frac{C * M * (80 - T1)}{E} * 100\%$	T1: start temperature
Greenmark N126[5]	Taiwan	1	15	99	Specific energy consumption [kWh/l]	
Energy Efficiency Label[6]	Thailand		30	90	η=ϱ*(90-30)/(0,24 P*t)*100	
ISIRI 7875[7]	Iran	1	20	90	Specific energy consumption [kWh/l]	
Manufacturer			20	98	Efficiency: η = Q / Energy Consumption	With: Q=(98-20)x4186xVolume

1 https://www.blauer-engel.de/en/products/electric-devices/water-boilers-electric-kettles

2 https://storage.topten.ch/source/files/Technische-Kriterien-Wasserkocher-2017.pdf

3 http://el.keiti.re.kr/enservice/enpage.do?mMenu=2&sMenu=1

4 not clearly specified, but the thermal efficiency test requires to "make the initial water temperature as consistent with the ambient temperature as possible", ambient temperature is 20 +/- 5 °C.

5 http://greenliving.epa.gov.tw/GreenLife/uploadfiles/Criteria/126/7ab784a7-239c-4e83-86c5-ca7331a47b72.pdf

6 http://labelno5.egat.co.th/new58/wp-content/uploads/2016/form/mn/ele_kettle.pdf

7 http://www.behsa.ir/index.php/booklibrary/standards/20-isiri-7875/file

Key findings:

- most of the regulations focus on boiling water and are based on the specific energy consumption to heat 1 litre of water, but the scope of the regulations was rather small kettles (volume < 2.5 litres)
- most of the standards assume that the kettles are tested with a volume of 1 litre. Therefore, they cannot deal with kettles with less than 1 litre of capacity, although such kettles are theoretically within the scope of the standards
- the definition of "boiling water" is not harmonized
- only in few cases (China, Thailand or manufacturers) energy efficiency is considered and it is defined as ratio between the measured energy and the theoretical energy to warm up water
- only the TopTen approach takes the "keep warm performance" into account

To regulate the energy efficiency of kettles, an appropriate methodology to assess the energy consumption and/or the energy efficiency has to be elaborated.

Measurement method for electric kettles

A measurement method could be elaborated based on the experience from IEC 60530:1975 to assess the energy efficiency of kettles, for which the Technical Committee TC 59[8] "Performance of household and similar electrical appliances" and especially SC 59L "Performance measurement of small household appliances and similar electrical appliances except for surface cleaning appliances" are responsible.

According to IEC 60530-1975, "the time to boil 1 l of water is the time taken to raise the temperature of the water 80°C above its initial value" (which is 15°C). While this temperature level is used for determining boiling time, the standard does not take into account the real duration until the kettle will stop heating water. Therefore, it does not reflect the real use situation: neither the real energy consumption nor the real boiling time. Compared to IEC 60530:1975, the following changes are suggested:

1. The measurement method should describe how to measure energy consumption (in addition to the boiling time).

2. The values should be based on heating water from 15°C until shut off with the requirement to increase temperature by at least 80°C, i.e. attaining at least 95°C.

While the elaboration and the adoption of a measurement method from scratch usually takes a long time, drafting a measurement method for kettles is relatively straightforward. At the end of this report, "Annex B – Input to legislation" provides the main elements of the suggested measurement method.

A rationale behind suggesting the proposed measurement method is to minimize over-heating. **Over-heating** is defined here as heating water too long or at an excessive temperature[9], which leads to a waste of energy and thus lower environmental performance[10]. As long as there is no requirements regarding the energy consumption of kettles and no information to be provided on the boiling time, manufacturers might have a tendency to design and produce over-heating kettles.

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8 https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1275,25

9 meaning higher than required for the usage

10 not to be confused with "over-boiling", which is defined as boiling too much water

However:

- IEC 60530:1975 implicitly defines boiling temperature as 95°C, since the "boiling time" is defined as the time required to heat up 1 litre of cold water (15 °C) by 80°C (see Task 1).
- water kettles are used to prepare beverages, whose required temperature usually does not exceed 95°C. Solely the preparation of distilled water (e.g for ironing or filling an aquarium) requires boiling water.[11]
- the calcification process accelerates with the temperature increase. Avoiding over-heating contributes to addressing the limescale issue (see also 7.1.2.5)

Thus, the proposed measurement method used for an Ecodesign regulation is expected to give an incentive to avoid or at least reduce overheating.

Table 7-2 provides an overview of the regulations and voluntary standards identified in Task 1. The specific energy consumptions to heat 1 litre of water was estimated for a temperature increase of 80°C.

Furthermore, it is suggested to assess the energy efficiency (Energy Efficiency Index) as a ratio of the heat - theoretically needed to bring a certain amount of water to the target temperature - and the electricity consumed to heat the same amount of water under the same real conditions (when the kettle shuts off). EEI is defined as follows:

$$EEI = Q / E_{95°C}$$

With:

$$Q = Cp \cdot M_{rated} \cdot (95 - 15)/3{,}600 \text{ [Wh]}$$

Cp = 4,186 J/kg/K as specific heat capacity of water at 15°C and 101 kPa

M_{rated}: rated water capacity of the kettle [kg]

$E_{95°C}$: electricity consumed to heat the rated water capacity from 15°C by 80°C, it is measured until the kettle shuts off.

Overview of regulations/voluntary schemes

Few regulations and voluntary schemes for kettles have been identified in Task 1. Table 7-2 shows the requirements and formulates them according to the test method and the EEI suggested by the project team.

[11] please note, that the boiling point depends on the surrounding environmental pressure: water boils at 100°C at sea level but at a lower temperature at a higher altitude (e.g. 93.4°C at 1,905 m). Accordingly, the boiling temperature is usually lower than 100°C.

Table 7-2: Requirements for identified regulations, indicated for 80K temperature increase (Fraunhofer ISI)

Name	Country	Temperature increase [°C]	Specific energy consumption [Wh/l] to heat 1 litre of water	Specific energy consumption[12] [Wh/l] to heat 1 litre of water	EEI[13] [%]
		a	b	c	d
		Conditions of the specific measurement method		*Calculated for 80°C increase*	
Blue Angel / RAL-UZ 133	Germany	80	115	115	81%
TopTen	Switzerland	85	123[14]	116	80%
GB/T 22089-2008	China	60	-	116	80%
Eco-Label Standard	South Korea	84	120	114	81%
Greenmark N126	Taiwan	84	117	111	83%
ISIRI 7875	Iran	70	125	143	65%

While the ISIRI 7875 standard (Iran) sets a rather low performance requirement, the five other standards listed in Table 7-2 have more stringent boiling requirements ranging between 111 and 116 Wh/l, and 115 Wh/l on average (for 80°C increase). This corresponds to an EEI range of 83% to 80%, with an average EEI of 81%.

Specific energy consumption and filling level of the container

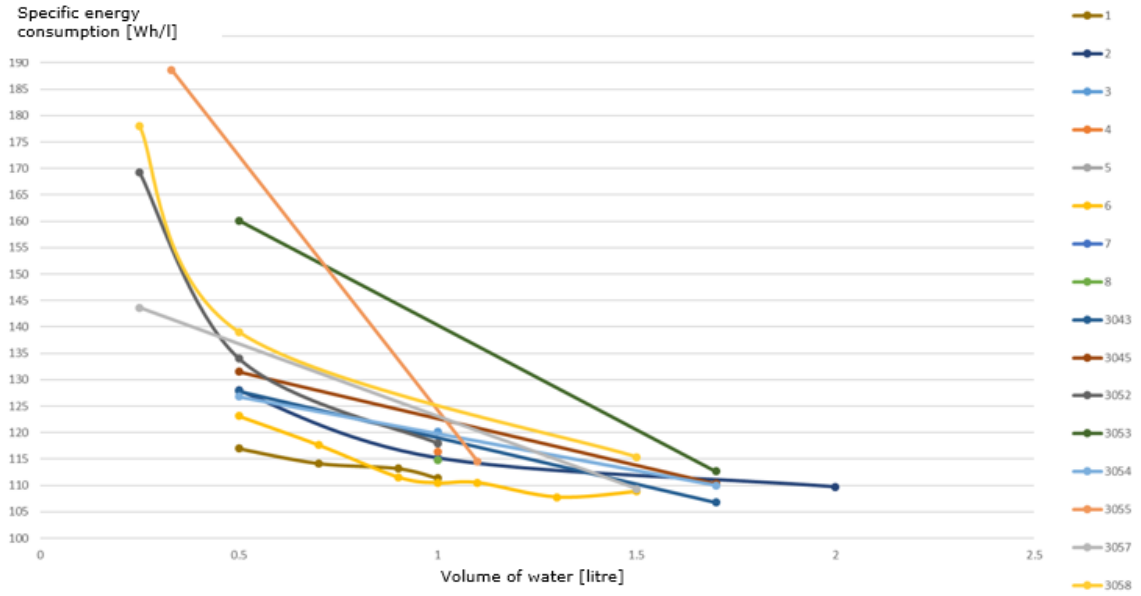
The specific energy consumption (Wh/l) decreases with the increase of the volume of water to be heated. This could be observed by analysing data collected through measurements carried out by Fraunhofer ISI and the Swedish Energy Agency (see Figure 7-1), where the measurements for each kettle were repeated for different levels of water to be heated until the kettle shuts off. One of the reasons for the higher specific consumption at lower water levels might be, that the thermal mass of the kettle – which impacts the energy efficiency of the kettle - is always constant, no matter how full the kettle is. Moreover, for kettles with a controller which is based on the steam detection, a larger volume of steam has to be generated if the kettle is only partly filled compared to a fully filled kettle. This leads to an extended shut-off time and higher electricity consumption.

[12] where: c = b x 80 / a

[13] where: d = 4,186 x (80)/3,600) / c

[14] estimated for a basic kettle (without keep warm), with: 45 x 1,000 /365 = 123 Wh for 1 litre

Figure 7-1: Specific energy consumption at maximum temperature (shut-off) according to the volume heated (Source: Fraunhofer ISI and Swedish Energy Agency)[15]



Many regulations focus on the energy consumption measured with 1 litre of water. However, for kettles with a rated capacity below 1 litre such a test is not applicable. Furthermore, large kettles will be filled with far more than 1 litre (up to 10 litres) and therefore 1 litre will not correspond to a realistic usage. Hence, it seems reasonable to focus on the energy consumption of kettles measured at rated capacity when defining the EEI requirement.[16]

Specific energy consumption at rated volume

Looking at the specific energy consumption of kettles: Fraunhofer ISI and Stiftung Warentest carried out tests on a sample of 26 kettles[17] in total, of which 16 were measured at rated volume.[18] The results are presented in Table 7-3. Hereby, the energy consumption of the kettle was measured until shut-off. In addition, the energy consumption for an 80K temperature increase was measured during the same test. This allowed the calculation of the specific energy consumption for raising the water temperature by 80K[19] and specific energy consumption until shut-off [Wh/l][20]. The energy efficiency was calculated as the ratio of the heat required to heat the water by a certain level divided by the electricity consumed. The column (F) of Table 7-3 shows the EEI of the kettles according to the proposed measurement method. The column (E) shows the EEI of the kettles, if they would have really shut off at 95°C, which is the minimum water temperature of the proposed measurement method.

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15 Even if the specific energy consumption is higher for a small filling volume than for the rated volume, heating the right amount of water is always the best way to save energy.

16 as done in the Chinese standard GB/T 22089-2008

17 8 for Fraunhofer ISI (tests performed in 2020) and 18 for Stiftung Warentest (tests performed before this study)

18 n=1 for 1.0 litre, n=5 for 1.5 litres, n=9 for 1.7 litres and n=1 for 2 litres

19 see (A) in Table 7-3

20 see (B) in Table 7-3

Table 7-3: Specific energy consumption and energy efficiency of kettles, measured at the rated capacity

	Size of the sample	Specific energy consumption to raise T by 80°C [Wh/l]	Specific energy consumption until shut-off [Wh/l]	Saving potential [%] 80°C increase vs. shut-off	Thermal efficiency measured at shut-off [%][21]	EEI [%] (theoretical) [22]	EEI [%] (practical)[23]
		(A)	(B)	(C)	(D)	(E)	(F)
1.0 l	1	107.2	111.4	-3.7%	86.8%	86.1%	83.5%
1.5 l	5	102.2	111.6	-8.3%	91.1%	88.2%	83.4%
1.7 l	9	102.3	109.5	-6.6%	91.0%	90.3%	85.0%
2.0 l	1	107.9	109.7	-1.6%	86.2%	86.8%	84.8%
Min	16	96.7	107.1	-17.1%	86.2%	84.7%	79.7%
Max		107.9	116.7	-1.6%	96.2%	92.3%	86.9%
Quartile 1		**101.6**	**108.7**	**-7.4%**	**89.3%**	**87.7%**	**83.6%**
Quartile 2		102.6	110.0	-6.5%	90.6%	89.4%	84.6%
Quartile 3		104.2	111.2	-5.2%	91.5%	90.9%	85.6%
Quartile 4		107.9	116.7	-1.6%	96.2%	92.3%	86.9%
Average		102.9	110.3	-6.6%	90.4%	89.2%	84.4%

Based on the figures in Table 7-3, the first quartile of the sample has an EEI of 87.7% (see E). This is still theoretical, since the controller of the kettles does not shut off at 95°C, leading, in practice, to higher electricity consumption. Considering this, the first quartile of the sample has a tested EEI of 83.6% (see F) and may be used as MEPS.

Due to the current situation and based on the available data (Table 7-2 and Table 7-3), it is assumed that a moderate MEPS with EEI >= 81% could be set already in 2023, giving enough time to the European Commission to go through the Ecodesign legislative process and to give manufacturers room to test their products and if necessary, adapt them to fulfil requirements on energy consumption. Based on a larger set of data,[24] the MEPS could be re-assessed 2 years later:

- they could be tightened (e.g. EEI >= 84%, based Table 7-3)
- and/or be based on a characteristic line depending on the rated volume

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[21] defined as: $Q_{shut\text{-}off}/E_{shut\text{-}off}$

[22] defined as: $Q_{95°C}/E_{95°C}$

[23] defined as: $Q_{95°C}/E_{shut\text{-}off}$

[24] currently, there is still a lack of data for kettles below 1.2 litre as well as over 2.0 litres

7.1.2.1.2. Specific requirement for keep-warm

As detailed in the previous tasks, a few measures can contribute to reducing the keep-warm energy consumption.

- **Maximum keep-warm time**

Until now, there is no limitation of the keep-warm time. Some kettles available on the market offer a time limit of 2 hours for keep-warm. Many stakeholders supported the idea of limiting the maximum keep-warm time. It is therefore suggested to **limit the keep-warm time to a maximum of 30 minutes**. Since such a requirement is easy to implement, the project team assumes that it can be implemented in the first stage of an Ecodesign regulation.

The results of Task 6 show that reducing the keep-warm time from 60 to 30 minutes would reduce the yearly energy consumption of Base Case 3 by 16.5%.[25]

- **Default setting** regarding keep warm function

Due to the considerable influence of the keep-warm function on energy demand, it should only be consciously activated by the user. In other words, the function should be off by default when a user switches on the kettle.

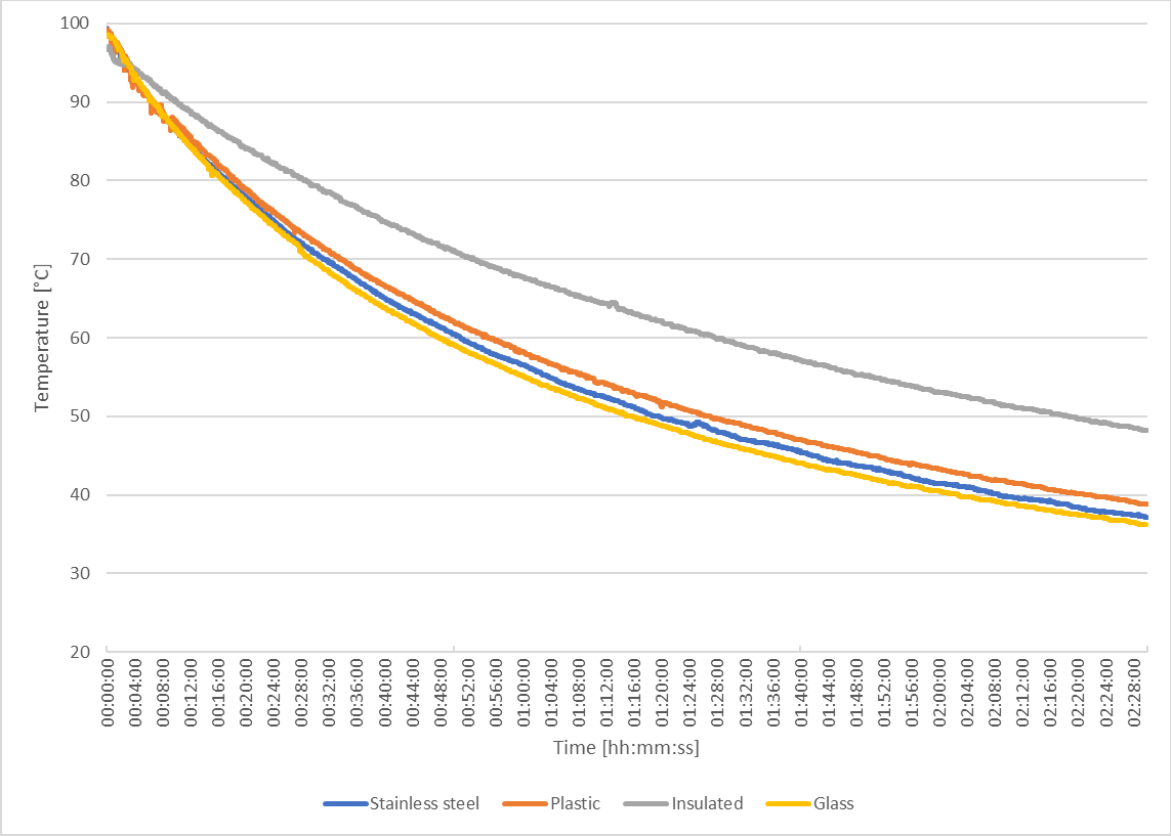
- **Specific energy efficiency requirements for keep-warm**

There is very little data regarding the real-world use of the keep-warm functions, partly since it is currently only available for a smaller market share. The project team carried out keep-warm and cool-down measurements on a very limited sample of four kettles with different types of container (see Figure 7-2):

- plastic (single wall)
- glass (single wall)
- stainless steel (single wall)
- plastic (insulated)

[25] See Task 5 for more detailed regarding the way to calculate the yearly energy consumption.

Figure 7-2: Cool down measurement of kettles with different containers (Source: Fraunhofer ISI, with 1 l of water heated at maximum temperature)



The tests presented in Figure 7-2 indicate that all single wall kettles had similar heat losses during the cool-down phase[26], while the insulated container had a much better performance.[27] Based on these measurements, Table 7-4 shows the temperature drop after 15, 30 and 60 min for single wall kettles and for the insulated kettle.

Table 7-4: Temperature drop during the cool-down test (Source: Fraunhofer ISI, with 1 l of water heated at maximum temperature)

Time after shut-off	Single wall[28]	Insulated	Insulated vs. single wall
15 min	-16.5 °C	-9.6 °C	-42%
30 min	-27.8 °C	-17.3 °C	-38%
60 min	-42.0 °C	-28.8 °C	-31%

Furthermore, the type of container had an important impact on the average power required to keep 1 litre of water warm. Figures in Table 7-5 show that the average keep-warm power for an

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[26] 42°C water temperature decrease within 1 hour

[27] only 29°C water temperature decrease during the first hour. However, more detailed analysis and larger sample of kettles tested would be required to quantify the impact of other factors (e.g. geometry, opening for spout...) on the cool down.

[28] average of the 3 single wall kettles: 1 x glass, 1 x stainless steel and 1 x plastic

insulated kettle was roughly half of the power required for a single-wall kettle. According to Task 5, the energy required to boil 1 litre of water is typically 115 Wh.

Table 7-5: Impact of the container on the keep-warm power (Fraunhofer ISI, with 1 l of water at maximum temperature)

Kettle	Unit	Single wall[29]	Insulated
Average power [1l @ Tmax]	[W/l]	120	56

According to the figures in Task 6, insulating the container (see Design Option 4) is a cost effective measure only for Base Case 3, i.e. the base case that includes a keep-warm function. An insulated container does not have a great impact on the boiling consumption. However, for kettles without keep-warm function (Base Case 1 and 2), the Design Option 4 was not cost effective since the heat losses through the container are low during the relatively short time required to boil the water.

Consequently, it would be reasonable to require a minimum level of insulation for kettles with a keep-warm function. As the repeatability and accuracy in measuring heat transfer coefficient [W/m2/K] is challenging,[30] it is suggested to define a requirement based on the temperature drop after 30 min, e.g.: max 20K temperature drop allowed for kettles with keep-warm function.[31]

Keep-warm or re-boil?

The higher the temperature difference between the water in the kettle and the ambient temperature, the greater the heat loss through the container and the kettle lid. Consequently, **keeping-warm the water at the target temperature will consume more energy than re-heating the water up to the same target temperature**, when the water will be needed. However, the keep-warm function delivers a different service than the solely boil function and might be useful, for users who need to have a certain volume of hot water ready anytime over a limited time period.

7.1.2.2. Specific requirement for "lift-off / switch-off"

The "lift-off / switch-off" function switches off a kettle when the container is lifted from the base. This function improves the safety but also can save energy, since the kettle will remain "switched off" when the container is placed back on the base. As mentioned by some stakeholders, the function is common on the EU market but still not standard. The project team suggests including this feature in the mandatory requirements.

7.1.2.3. Generic Ecodesign requirement

Currently, customers only have access to some technical data when purchasing a water kettle:

- rated capacity of the container (V_{rated})
- rated input power (P_{rated}), which shall be an indirect indicator on how fast the kettle can boil water
- availability of some features (keep warm, temperature pre-setting,...)

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29 average of the 3 single wall kettles: 1 x glass, 1 x stainless steel and 1 x plastic

30 stakeholders' comments

31 see "cool-down test" in Annex B – Input to legislation

However, there is no information regarding the performance of a kettle thus consumers do not have the possibility to choose a product according to performance or energy efficiency criteria. In order to improve this situation, a generic ecodesign requirement would cover the mandatory provision of the following additional technical data[32]:

- energy consumption $E_{95°C,Vmin}$ [Wh] and time required $t_{95°C,Vmin}$ [s] for heating the minimum volume of the container (V_{min}) by 80K water temperature increase[33] – measured until the kettle shuts off;
- energy consumption $E_{95°C,1}$ [Wh] and time required $t_{95°C,1}$ [s] for heating 1 litre of water by 80K water temperature increase – measured until the kettle shuts off;
- energy consumption $E_{95°C,Vrated}$ [Wh] and time required $t_{95°C,Vrated}$ [s] for heating the maximum volume of the container (V_{rated}) by 80K water temperature increase – measured until the kettle shuts off;
- $E_{70°C,Vrated}$ [Wh] and $t_{70°C,Vrated}$ [s] for the performance at 70°C pre-set temperature (or the nearest pre-set temperature above 70°C) and V_{rated} – measured until the kettle shuts off;
- $E_{70°C,Vmin}$ [Wh] and $t_{70°C,Vmin}$ [s] for the performance at 70°C pre-set temperature (or the nearest pre-set temperature above 70°C) and V_{min} – measured until the kettle shuts off;
- information regarding a standardised energy consumption (SEC) [kWh] for heating 100 litres of water as follows:[34]

$$SEC = \frac{100}{1000} \cdot \frac{\left(30\% \cdot E_{95°C,Vmin} + 50\% \cdot E_{95°C,Vrated} + 20\% \cdot E_{70°C,Vrated}\right)}{30\% \cdot V_{min} + 70\% \cdot V_{reated}} + P_{standby} \cdot \frac{8760}{1000} \cdot \frac{1}{8}$$

- specific input power $p_{kw,Vrated}$ [W/l] to keep warm the rated water capacity when the highest keep-warm temperature is selected; ;
- maximum keep-warm time t_{KWmax} [min];
- power consumption in standby mode $P_{standby}$ [W];
- power consumption in off mode $P_{off\text{-}mode}$ [W];
- water temperature drop measured during the cool-down test T_{drop} [°C].

7.1.2.4. Proposed policy actions related to behaviour

The energy consumption of an electric kettle is directly related to the amount of water heated. Therefore, **over-boiling** – defined as boiling a larger water volume than required – is one of the major issues to be addressed. The following requirements may have an impact for the users:

7.1.2.4.1. Minimum water capacity (V_{min})

Some kettles either have no clear indication regarding a minimum water level or indicate an unnecessary high volume (e.g. 0.7 litre). Still, it is difficult to set a direct requirement on the minimum capacity, especially for kettles with immersed heating elements, since the heating element has to be surrounded by enough water.

To incentivise manufacturers to minimise V_{min}, it is suggested to:

- set a requirement regarding a **mandatory indication of the minimum capacity of water** (V_{min});
- take into account the **performance of kettle at V_{min} in the calculation of the SEC**.

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[32] see *Annex B – Input to legislation* for more details regarding the measurement method and the definitions

[33] initial water temperature of 15°C for all the tests

[34] weighting factors: own assumptions

7.1.2.4.2. Indication of the water volume

According to Task 2 figures, 90% of the kettles have an outside water level indication.[35] It is unclear whether the indication is in litre or cup (e.g. with 1 cup = 0.125 litre)[36], yet, both indicators are helpful for the user in order to fill the right amount of water required for the usage. A survey from Philips confirmed also that dual water level indication contributes to reducing over-boiling (see Task 3). Consequently, the project team suggests including a **requirement regarding a mandatory dual water level indication**. The capacity of a cup shall be harmonized.

7.1.2.4.3. Information requirements regarding over-boiling

Information regarding over boiling should be provided (e.g. in the instruction manual), with following recommendation (as example):

> **"Ensuring that only the required amount of water is heated to the required temperature can significantly reduce the energy use of your kettle, save time and money".**

In addition, a table showing the energy consumption for heating different volumes of water (V_{min}, 1 litre[37] and V_{rated}) at different temperatures shall be included in the instruction manual. As the pre-set temperatures are not harmonised and in order to limit the administrative burden for manufacturers, information should be provided for two water temperature increases: 55K and 80K.[38]

Furthermore, the project team highly supports the idea of indicating the required time to heat different volumes of water (V_{min}, 1 litre and V_{rated}) on a separate piece of paper inserted in the container. Such information might be an additional incentive for the users to avoid over-boiling as they might pay more attention to the heating time than to the relative low energy consumption per use. However, it should be clearly mentioned that the figures have been measured with the same model, but under test conditions, and might be subject to deviations.[39]

7.1.2.5. Proposed policy actions related to limescale

Many regions in the EU have access to "hard" - i.e. calciferous - tap water. When hard water is used in a kettle, limescale deposits are formed. When the temperature rises, the concentration of carbonic acid decreases, the so-called lime-carbonic acid balance shifts and the water becomes increasingly supersaturated with calcium carbonate. In practice, the precipitated lime tends to settle at the hottest points (e.g. the immersed heating element, see Figure 7-3).

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35 4% have an inside indication and 6% do not have any

36 see EN 60661:2015 "Methods for measuring the performance of electric household coffee makers"

37 if applicable

38 corresponding to 70°C and 95°C water temperature

39 e.g. depending on water temperature or power supply. Tolerances of the figures could be indicated

Figure 7-3: Limescale deposit in kettles: immersed (left) and concealed (right)



The poor thermal conductivity of lime has the consequence that a supposedly layer of lime of 2 mm already reduces the heat transfer by about 15% and affects the energy efficiency of kettles accordingly.[40] The calcification process accelerates with the temperature, meaning that heating water to 95°C instead of the physical boiling point will significantly reduce the formation of limescale deposit. In addition, limescale deposit has a negative impact on the kettle technical lifetime. For all these reasons, **mandatory information in the instruction manual regarding the need to descale and how to proceed** shall be provided. Many manufacturers already provide clear instructions, but not all.

7.1.2.6. Proposed policy actions related to circular economy

The Circular Economy Action Plan[41] of the European Commission lists some sustainable principles. Among them, some would be particularly relevant for kettles:

- improving product durability, reusability, upgradability and reparability, addressing the presence of hazardous chemicals in products, and increasing their energy and resource efficiency;
- increasing recycled content in products, while ensuring their performance and safety;
- enabling remanufacturing and high-quality recycling;
- reducing carbon and environmental footprints;
- restricting single-use and countering premature obsolescence.

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[40] see: https://www.sbz-online.de/sbz-schwerpunkt/chemiefreie-wasserbehandlung-energiesparer

[41] https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf

7.1.2.6.1. Recycling

Based on the figures of the Bill-of-Materials (BoM) and EcoReport in Task 5 over 90% (in weight[42]) of a kettle consists of materials which can be recycled. This would be higher than the WEEE requirement for this product group.[43]

EN 45555:2019 "General methods for assessing the recyclability and recoverability of energy-related products" provides a general method for assessing the recyclability and recoverability of energy-related products. As base of discussion, the project team suggests following threshold on the recyclability rate (R_{cyc}):

$$R_{cyc} \geq 75\%$$

A product specific standard based on EN 45555:2019 would have to be elaborated.

In addition, an information requirement should include the recyclability rate (R_{cyc}) of the kettle to be provided on the packaging, in the instruction manual and online.

7.1.2.6.2. Post-consumer recycled materials

Post-consumer recycled (PCR) materials could be easily used for parts[44] that are not in contact with water, i.e. for all parts except for the container[45], the lid and the filter. Based on the figures of BoM and EcoReport in Task 5, the weight of recyclable parts, which are not in contact with water, was in a range between 30% and 42% of the total weight of a kettle. At this stage, no requirement on a minimum PCR content can be set. Nevertheless, an information requirement should include the post-consumer materials content (R_{post}) of the kettle to be provided on the packaging, in the instruction manual and online.

EN 45557:2020 "General method for assessing the proportion of recycled material content in energy-related products" provides a general method for assessing the proportion of recycled material content in energy-related products.

A product specific standard based on EN 45557:2020 will have to be elaborated.

7.1.2.6.3. Further requirements related to circular economy

- Possible information requirement regarding:
    - the **provision of the BoM**;
    - the **material of the parts of the container** which are in contact with water shall be indicated in the instruction manual as well as on the packaging, in the instruction manual and online.
- Requirement for **marking plastic components** heavier than 25 g
- Requirements for **dismantling, material recovery and recycling**:

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[42] without packaging and instruction manual

[43] 75 % shall be recovered, and 55 % shall be prepared for re-use and recycled, see DIRECTIVE 2012/19/EU on Waste Electrical and Electronic Equipment in Task 1

[44] similar appliances are already producing a noticeable portion of recycled plastics, see: https://www.philips.com/a-w/about/sustainability/sustainable-planet/circular-economy/senseo.html

[45] the inner part of the container, which is directly in contact with water.

- appliances shall be designed in such a way that the materials and components referred to in Annex VII to Directive 2012/19/EU can be removed with the use of commonly available tools;

- obligations laid down in Point 1 of Article 15 of Directive 2012/19/EU shall be fulfilled.

- Proposed policy actions related to reparability and durability:

  Kettles are relatively simple appliances and have a typical lifetime of 6 years (see Task 3). Improving the durability and the reparability would contribute to extending the lifetime and decreasing the environmental impact for the energy service delivered.

  For this purpose, the following sub-actions are suggested:

  - **minimum number of cycles**: 10,000 (heating 1 litre of water) could be required. The Ecodesign Working Plan study stated that the industry runs over 10,000 test cycles on the kettles.[46] Assuming that a cycle test would take 5 min,[47] such a test routine will need in average 35 days. If no durability requirement is set, at least the indication of number of cycles should be required;
  - **possibility to repair some components**: According to Which?,[48] faulty lids and broken limescale filters are the two major faults. As these components are rather simple and cheap, manufacturers shall be required to make at least these two components repairable.[49] Furthermore, availability requirements could be set on additional components, such as: motherboards, switches, heating elements, temperature sensors, fuses and bases. However, due to safety reasons, some spare parts may not be made available to laymen;
  - **availability of spare parts for a minimum period** of six years after placing the last unit of the model on the market. In addition, requirement on maximum delivery time of spare parts should be set. This requirement is applied for recent Ecodesign regulations;
  - **affordability of spare parts**: figures regarding spare parts prices and shipping costs should be provided, in order to improve the information transparency;
  - **access to repair and maintenance information** in the instruction manual and on the website of the manufacturer.

  The last four sub-actions go hand in hand.

7.1.2.7. Proposed policy actions related to materials

Several requirements regarding materials are suggested by the study team in order to reduce the toxicity of the materials used. They are mainly based on the Blue Angel scheme.[50]

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[46] For comparison: GB/ 22089-2008 in China requires more than 8,000 cycles for Grad A level. Also, some suppliers manufacture controllers that consistently exceed 12,000 cycles of normal operation (see e.g. https://strix.com/de/safety/)

[47] the heating time for 1 litre of water ranged between 189 seconds and 390 seconds according to the Base Cases (see Task 5)

[48] see Task 2 and https://www.which.co.uk/reviews/kettles/article/top-kettle-brands-aKCUC9s1znQZ

[49] removable limescale filter

[50] Voluntary environmental label in Germany (see also Task 1). For more information, see: https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20133-201309-en%20Criteria-2020-01-07.pdf

- Plastic parts intended to be touched in normal use (e.g. handles and controls) shall contain less than 10 mg/kg of polycyclic aromatic hydrocarbons (PAHs) and less than 1 mg/kg benzo[a]pyrene

- Plastics in the container and base plate:

  No substances may be added to the plastics as constituent parts, which are classified as:

  a) carcinogenic of category 1 or 2 according to Table 3.2 or category 1A or 1B according to Table 3.1 of Annex VI to Regulation (EC) No 1272/2008[51]

  b) mutagenic of category 1 or 2 according to Table 3.2 or category 1A or 1B according to Table 3.1 of Annex VI to Regulation (EC) No 1272/2008

  c) toxic to reproduction of category 1 or 2 according to Table 3.2 or category 1A or 1B according to Table 3.1 of Annex VI to Regulation (EC) No 1272/2008

  d) being of very high concern for other reasons according to the criteria of Annex XIII to the REACH Regulation, provided that they have been included in the List (so-called "Candidate List"[52]) set up in accordance with REACH, Article 59, paragraph 1.

  Halogenated polymers shall not be permitted.[53] Nor may halogenated organic compounds be added as flame retardants as they represent a major issue in the recycling of plastics[54]. Moreover, no flame retardants may be added that are classified pursuant to Table 3.1 or 3.2 in Annex VI to Regulation (EC) 1272/2008 as very toxic to aquatic organisms with long-term adverse effects and assigned the Hazard Statement H410 or Risk Statement R50/53.

  The following shall be exempt from this rule:

  - process-related, technically unavoidable impurities;

  - fluoroorganic additives (as, for example, anti-dripping agents) used to improve the physical properties of plastics, provided that they do not exceed 0.5 weight percent;

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[51] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006, Annex VI Harmonized classification and labelling for certain hazardous substances, Part 3: Harmonized classification and labelling – Tables, Table 3.2, – List of harmonized classification and labelling of dangerous substances from Annex I to Directive 67/548/EEC.

[52] link to the Candidate List in Regulation (EC) No. 1907/2006 concerning the Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH): https://echa.europa.eu/web/guest/candidate-list-table

[53] see A.P. Mouritz (2007): Durability of composites exposed to elevated temperature and fire. Woodhead Publishing Series in Civil and Structural Engineering.

[54] as mentioned in the preamble of the Ecodesign regulation on TV (EU) 2019/2021: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R2021&from=EN. See also Jandric, Aleksander & Part, Florian & Fink, N & Cocco, V & Mouillard, F & Huber-Humer, M & Salhofer, Stefan & Zafiu, Christian. (2019). Investigation of the heterogeneity of bromine in plastic components as an indicator for brominated flame retardants in waste electrical and electronic equipment with regard to recyclability. Journal of hazardous materials. 390. 121899. 10.1016/j.jhazmat.2019.121899.

- plastic parts, less than 25 grams in mass.

Later in the process it should be decided whether the aforementioned material requirements would be set within a possible kettle Ecodesign regulation or rather in a generic regulation.[55]

Furthermore, some stakeholders stressed that during the first cycles of use, chemical substances (especially at the seals) of a new kettle may dissolve in the water. It is therefore recommended not to consume the water boiled during the first use cycles of a new kettle.

Accordingly, the project team would support following mandatory information requirement:

> **"Important recommendation before preparing the first beverage with a brand new kettle: boil the maximum volume of water and remove the water. Repeat this procedure 5 times".**

Ideally, this requirement shall be complemented by a removable sticker on the kettle or an instruction printed on paper in the container.[56]

7.1.3. Policy measures excluded for further analysis

7.1.3.1. Energy label

MEPS and energy labels are the basic pillars of the market regulation for products. However, an energy label makes sense only for products, where a wide range of performances could be observed and the differences need to be shown to the customers in a clear way, so that they can make the right purchasing decision.

The study team had access to several test datasets of around 35 kettles. The energy efficiency of the kettles did not cover a wide range of performance.

In addition, the work carried out in Task 6 showed a fair potential for improvement: between 16% and 45% depending on the base case. However, some of the Design Options – like DO 1 "water level indicator"[57] – will impact the behaviour and indirectly the yearly energy consumption of the kettle, but not the energy efficiency of the product itself.

Accordingly, the relevance of elaborating an energy label for electric kettles is not guaranteed at this stage of the study. Even among many of the stakeholders (including NGOs), there was uncertainty about the usefulness of an energy label. Consequently, it is suggested to investigate the pertinence of an energy label only after enough market data has been collected (see 7.1.2.1.1).

In any case, the mandatory provision of information regarding the energy efficiency of kettles will be an incentive for manufacturers to invest in technical innovations and place better performing products on the market. In the medium term, this might broaden the range of energy efficiency performance of products on the market and make an energy label more justifiable.

7.1.3.2. Airborne noise

Some Consumer Organisations[58] assess – quantitatively or qualitatively – the noise level when testing and comparing products. However, according to a consumer survey in the UK, the noise level is not a relevant criterion when buying a kettle. Therefore, we do not support any requirement (maximum level or information requirement) regarding noise level in this study.

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[55] e.g. REACH

[56] In general, to minimise the environmental impact, all the information provided could be printed on recycled paper

[57] assuming to lead to energy savings between 5% and 10% of energy depending on the base case

[58] Which? (UK) or Stiftung Warentest (DE)

There is no kettle specific standard to measure the airborne noise level, nevertheless IEC 60704-3:2019 "Household and similar electrical appliances - Test code for the determination of airborne acoustical noise - Part 3: Procedure for determining and verifying declared noise emission values" would be suitable for kettles.

7.1.3.3. Mandatory limescale protection

Based on the information provided in 7.1.2.5, technical requirements regarding limescale protection might be meaningful, such as:

- mandatory built-in water filter OR
- mandatory limescale filter (removable or not)

However, the impact of such requirements on the yearly energy consumption of a kettle is difficult to estimate. Moreover, using hard tap water does not concern all EU-users and/or the ones who are concerned might already fill their kettles with filtered tap water. Therefore, this policy option is not further considered. Furthermore, the measure targeting over-heating will have a positive impact on the limescale issue.[59]

7.1.4. Summary of the stakeholders' positions

Apart from the bilateral exchanges with several stakeholders along the process, registered stakeholders were invited to two meetings (see Annex A – Meetings with stakeholders):

- a formal stakeholder meeting on 15.07.2020. This meeting was dedicated to commenting on draft reports for the Task 1, 2, 3 and 4. Also, first assumptions regarding Base Cases and Design Options as well as possible policy options were shortly presented and discussed.
- an exchange with stakeholders took place on 21.10.2020 to discuss the main comments on Tasks 1,2,3 and 4 and to review a document summarizing the assumptions for Task 5 and 6 reports as well as the first policy options.

Due to the COVID-19 crisis, both meetings took place online instead of physically.[60] The main comments regarding policy options are summarized here and classified by topic. The positions of the Consultation Forum, which took place on 29.01.2021, are not summarized here.[61]

7.1.4.1. Scope

APPLiA supported the proposed scope and suggested to make clear, what is excluded (e.g. coffee machines). However, some stakeholders (Danish Energy Agency, BAM and ECOS) discussed the opportunity to have a larger scope, including for example boiling water heaters, coffee machines or urns up to 26 litres.

7.1.4.2. Usage

Due to the lack of data / surveys, the average usage of a kettles (including the yearly amount of water boiled[62]) was a controversial topic. A formula to calculate the average energy consumption of

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[59] See 7.1.2.5: The calcification process is not linear, so that heating water to 95°C instead of the physical boiling point will significantly reduce the formation of limescale deposit.

[60] Thanks to the stakeholders, the quality of the exchanges was at least as good as in a physical meeting. In addition, it offered probably the chance to have more participants and to get more feedback.

[61] see positions of the stakeholders after the Consultation Forum on https://circabc.europa.eu/

[62] 1,000 litres per year in the first draft report for Task 3

a kettle will remain a critical issue. However, ANEC-BEUC supported the pragmatic approach of Top10 Switzerland[63] regarding the calculation of the yearly energy consumption.

7.1.4.3. Standardisations

It was recognised by all actors, that there is a lack of standards to address energy efficiency or energy consumption for kettles, which is an issue for a regulation. In addition, the only standard dealing with the boiling times of kettles (IEC 60530:1975) is not often applied when testing kettles. Therefore, not only is there a lack of data but also the available test data[64] have not been always measured in a harmonized way.

The project team elaborated a measurement method. The stakeholders commented on the first draft and suggested using kg instead of litre to make the test easier to carry out.

Industry suggested measuring the efficiency of kettles at the rated volume, UBA/BAM and ECOS supported testing a standard volume of 1 litre in order to make the comparison between products easier.

UBA/BAM suggested testing for 15°C-95°C, 15°C-shutoff and keep-warm function. When applicable, test should cover different (target) water temperatures. Furthermore, the agency suggested checking if the measurement of the accuracy of the temperature settings is possible - in case different temperatures are indicated.

APPLiA explained that the measurement method shall require reaching the boiling point and measuring the energy consumption until the controls automatically switch-off the kettle. 95 °C shall not be used as reference temperature.

ECOS stressed on (if temperature settings are possible) measuring at different temperatures as it is done at maximum temperature (heat up 1 litre from cold to each set temperature individually) and including this in the calculation of the yearly energy consumption.

UBA/BAM mentioned, that for hygienic reasons it has to be assured that water in a kettle can reach 100 degrees.

According to APPLiA, measurement of the heat transfer coefficient [W/m2/K] of the container would be difficult and therefore repeatability and accuracy would not be ensured.

7.1.4.4. Energy efficiency metric

For stakeholders like APPLiA, UBA/BAM or Danish Energy Agency, energy efficiency should be defined as the ratio between the theoretical value needed to boil a discrete amount of water and the measured energy consumption.

According to ANEC-BEUC, the calculation of the yearly energy consumption with the following components seems reasonable and feasible: $AEc = AEc\ boiling + AEc\ keep-warm + AEc\ standby$. In order to keep it simple and feasible AEc boiling and AEc keep-warm should not be considered separately.

7.1.4.5. Energy labelling

APPLiA recommended avoiding energy labelling for this category due to the very small range of the EEI values.

UBA/BAM stressed that an energy label only makes sense if the products on the market show sufficiently large differences in energy consumption to allow a spread of energy efficiency classes. NEA had a similar position and the Danish Energy Agency does not consider energy labelling being an appropriate measure for electric kettles.

ECOS expressed its support of assessing the possibility of an energy label for electric kettles. The NGO mentioned also that this is important to be able to award bonuses to kettles with specific

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[63] see Task 1 report

[64] gathered by the industry, consumer organisations or the Swedish Energy Agency

environmental-friendly features. Finally, it stressed, that the benefits of different temperature settings can be best accounted for with an energy label.

ANEC/BEUC would also welcome the introduction of the energy label for electric kettles.

UBA/BAM supported information requirement on rated input power, boiling time (1l and V_{rated}) and some specific performance data (e.g. $EC_{boiling}$ and $P_{keep\text{-}warm}$).

7.1.4.6. Over-boiling

Many stakeholders supported the idea of improving information regarding the water level as well as providing better guidance on how to use a kettle in order to reduce the energy consumption.

UBA/BAM supported 0.3 l as minimum volume, and providing boiling time for V_{min}, 1 l and V_{rated}. The Danish Energy Agency was in favour of measuring the energy efficiency of kettles when boiling only a small amount of water (for instance 0.2-0.3 litre corresponding to a cup of water).

APPLiA stressed, that a minimum level of 0.2 l is not realistic for all kettles and provided explanations. The association disagrees with a mandatory water level indicator and would prefer a requirement formulated in a way that the solution is not predefined.

7.1.4.7. Keep warm

Many stakeholders (e.g. ECOS, ANEC-BEUC, APPLiA) support the idea that keep-warm function should always be off by default and the maximum keep-warm time should be limited. For kettles with a keep-warm function, ANEC-BEUC and UBA/BAM suggested also setting heat transfer coefficient requirements for the container or requiring a double wall container.

7.1.4.8. Material

UBA/BAM suggested checking the possibility of the requirement on PCR content.

ECOS strongly suggested assessing the setting of a minimum mandatory requirement in new kettles for the recycled content from PCR. The NGO supported also a requirement for the recyclability of at least 75% of the kettle weight (figure to be demonstrated based on recycling data).

APPLiA stressed, that a common definition for "recyclable" is missing and thus a recyclability criterion without a further assessment seems premature at this stage of the study. The association did not support requirements on PAHs and benzopyrene.

ANEC and BEUC support the introduction of further chemical restrictions under the Ecodesign implementing instrument, which would ensure safer products to consumers.

7.1.4.9. Limescale protection

No stakeholder (including NGOs) supported the approach of a mandatory limescale protection (built-in filter or limescale filter) but most of them were in favour of requiring information on how to deal with limescale in the instruction manual.

7.1.4.10. Durability and spare parts

UBA/BAM agreed with the reparability and durability requirements suggested in October. As a minimum duration of the guarantee seems not to be adequate within ecodesign, UBA/BAM suggested sticking to the numbers of cycles and carefully checking the number given.

UBA supported the reparability and durability requirements presented in October 2020, however suggested checking the number of cycles.

APPLiA stressed that not all limescale filters are removable.

7.2. Scenario analysis

Subtask 7.2 establishes scenarios according to the policy measures described in subtask 7.1. To this end, the analyses on the previous tasks have been extended to the defined scenarios in comparison with the Business-as-Usual (BAU) scenario and the Best Available Technology (BAT) scenario.

7.2.1. Scenarios overview

Different scenarios have been drawn up to illustrate quantitatively the improvements that can be achieved at the EU level by 2040 with suitable Ecodesign policy actions against the BAU scenario. Taking into account the time needed to elaborate and implement any regulation, the regulatory provisions are assumed to enter into force in 2023 for each policy scenario.

The reference case and main technical improvement option scenarios based on the findings of Task 6 are defined as follows:

- **BAU scenario**: the products placed on the EU market have the same level of performance as the Base Case defined in Task 5,
- **Ecodesign scenario:** from 2023, the products placed on the EU market have to fulfil the policy requirements mentioned in 7.1. The following main requirements could be directly taken into account in the scenario:
    - water level indicator improved and requirements on minimum volume[65]
    - for kettles with keep-warm function: keep-warm time is limited by 30 minutes and container has to be insulated[66]
    - EEI >= 81%[67], no energy label
- **LLCC (Least Life Cycle Cost) scenario**: from year 2023, all kettles placed on the market comply with the LLCC performance level as assessed in Task 6
- **Best Available Technology (BAT) scenario**: from year 2023, all kettles placed on the market comply with the BAT performance level as assessed in Task 6.

No Break-Even Point scenario will be considered.[68]

Table 7-6 provides an overview of the main assumptions of new products placed on the market from 2023 for each product Base Case and scenario. The figures are derived from the results of Tasks 4, 5 and 6.

[65] see Design Option 1 in Task 6 report

[66] see Design Options 4 and 6 in Task 6 report

[67] This requirement is expected to have a limited effect on the energy efficiency of the Base Cases.

[68] The break-even point is defined in the MEErP methodology as the highest energy efficiency level for which the Life Cycle Costs (LCC) do not exceed those of the Base Case configuration. In this scenario, the energy savings are maximized without increasing the total costs.

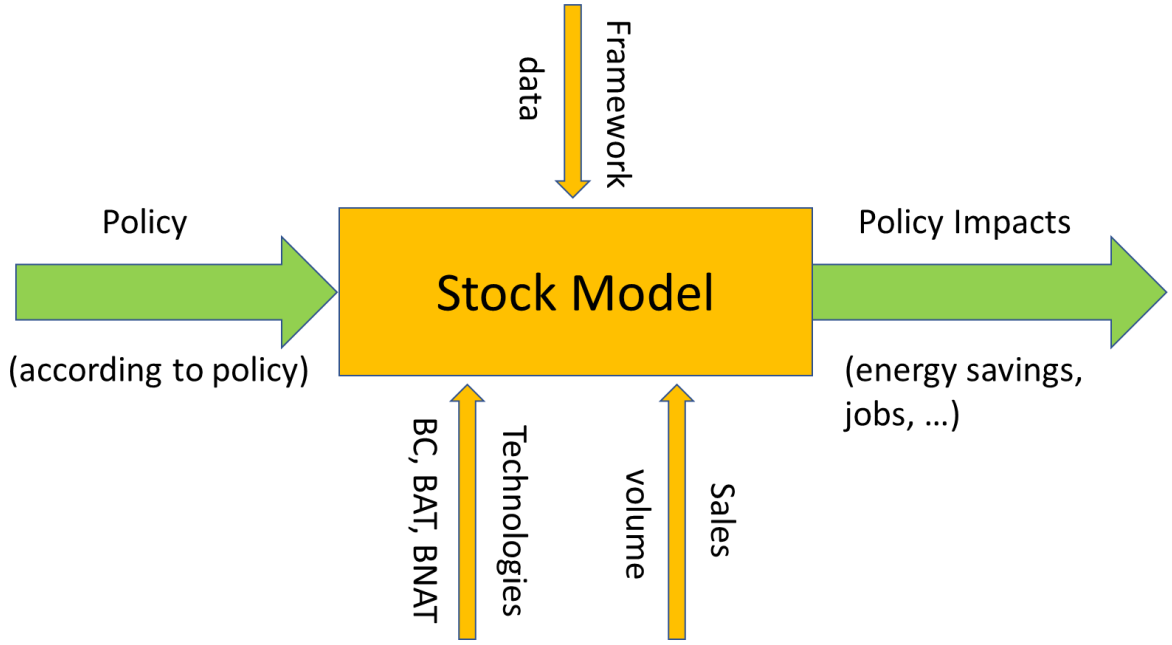
Table 7-6: Overview of the parameters, for the kettles considered, according to the scenario and product Base Case

Base Case	Level of Performance / Scenario	Design options implemented	total year energy consumption	Purchase Cost	Maintenance	Maintenance yearly
			[kWh/a]	[Euro]	[Euro]	[Euro]
1	BAU	no	86.8	16.0	20.0	3.3
	Ecodesign	1	82.4	16.0	20.0	3.3
	LLCC	1, 2, 3	73.6	23.5	20.0	3.3
	BAT	all (1, 2, 3, 4)	72.5	25.5	20.0	3.3
2	BAU	no	92.2	26.0	24.0	4.0
	Ecodesign	1	82.1	26.0	24.0	4.0
	LLCC	1, 2, 3, 5	70.0	34.0	24.0	4.0
	BAT	all (1, 2, 3, 4, 5)	68.9	37.0	24.0	4.0
3	BAU	no	137.3	62.0	25.0	4.2
	Ecodesign	1, 4, 6	91.7	65.0	25.0	4.2
	LLCC	all (1, 2, 3, 4, 6)	75.0	67.0	25.0	4.2
	BAT	all (1, 2, 3, 4, 6)	75.0	67.0	25.0	4.2

7.2.2. Approach

For the purpose of producing the quantified scenario impact analyses under subtask 7.2, an Excel based stock-model was developed for this product group. The structure of the model is shown in Figure 7-4.

Figure 7-4: Simplified overview of the model (Source: Fraunhofer ISI)



With:

- Technologies and policies: an overview of the main data for each Base Case according to the level of technology considered was provided in Table 7-6
- Framework data: electricity (see Table 7-7) and socio-economic figures for typical market actors of the sector (see Table 7-8)

Table 7-7: Electricity prices and related GHG emissions (source: PRIMES 2015 and EEA[69])

Parameter	Unit	2020	2025	2030	2035	2040
Electricity tariff (Households)	[€/kWh]	0.20	0.21	0.21	0.22	0.22
Electricity GHG emission	[kg CO2eq/kWh]	0.275	0.240	0.200	0.170	0.150

[69] https://www.eea.europa.eu/data-and-maps/indicators/overview-of-the-electricity-production-3/assessment

Table 7-8: Framework data[70]

Variable name and unit	Value	Source
ProductLife[71] [a]	6	based on sales & stock
WholeMargin [-]	5%	few manufacturers[72]
Jobs Industry ([1/mln euros revenue*]	4	APPLiA[73]
Jobs Install [1/mln euros revenue*]	n.a.	
Jobs Maint [1/mln euros revenue*]	n.a.	
Jobs Energy Companies [1/mln euros energy]	1	Impact Assessment Lot 15 (EC 2015)

*including EBIT

- Sales and stock:

The model used is a stock model, wherein:

$$stock_{BC_i,Y} = \sum_{j=Y-lifetime+1}^{Y} sales_{BC_i,j}$$

$$stock_{kettles,Y} = \sum_{i=1}^{3} stock_{BC_i,Y}$$

Where:

- *Y* = year
- *lifetime* = 6 years
- *BC* = Base Case
- *i* = index of the BC

Also, sales figures can be calculated based on stock figures:

$$sales_{BC_i,Y} = stock_{BC_i,Y} - stock_{BCi,Y-1} + sales_{BC_i,Y-lifetime+1}$$

The market volume is calculated based on the stock increase and the replacement of old appliances, which have reached the technical lifetime.

Task 2 provides sales and stock figures for the EU kettle market and the same data are used in the stock model.[74]

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[70] Based on the published data of the listed companies. No specific figures related to the kettle business activities of the companies could be found.

[71] see Task 3

[72] based on the annual reports of Whirlpool, BSH, Arcelik, Electrolux, Philips, Groupe SEB, De'Longhi

[73] Statistical Report – 2018-2019, see https://www.applia-europe.eu/statistical-report-2018-2019/introduction/index.html (accessed: 05.11.2020)

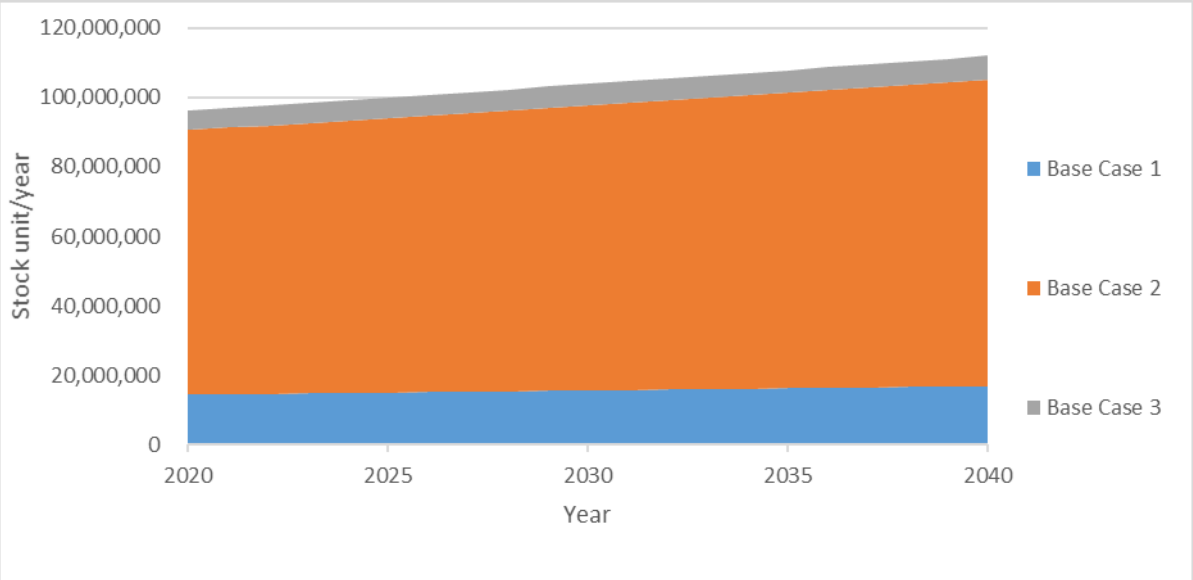
[74] Based on Task 2; however, due to the modelling approach in the Task 7 stock model, there might be a few deviations between the figures presented here and those reported in Task 2.

The stock figures are provided in Table 7-9 (based on the findings from the Task 2 report). For the period 2019-2040, the same equipment rate trend is assumed as the one calculated over 2013-2018.[75] Figure 7-5 provides an overview of the evolution of sales over time.

Table 7-9: Evolution of the kettles stock per Base Case (EU-27)

	2020	2025	2030	2035	2040
BC1	14,452,687	15,006,447	15,581,425	16,178,433	16,798,316
BC2	76,117,487	79,033,956	82,062,172	85,206,414	88,471,129
BC3	5,781,075	6,002,579	6,232,570	6,471,373	6,719,326
Total water kettles	96,351,249	100,042,983	103,876,167	107,856,220	111,988,771

Figure 7-5: Evolution of the kettles stock per Base Case (EU-27)



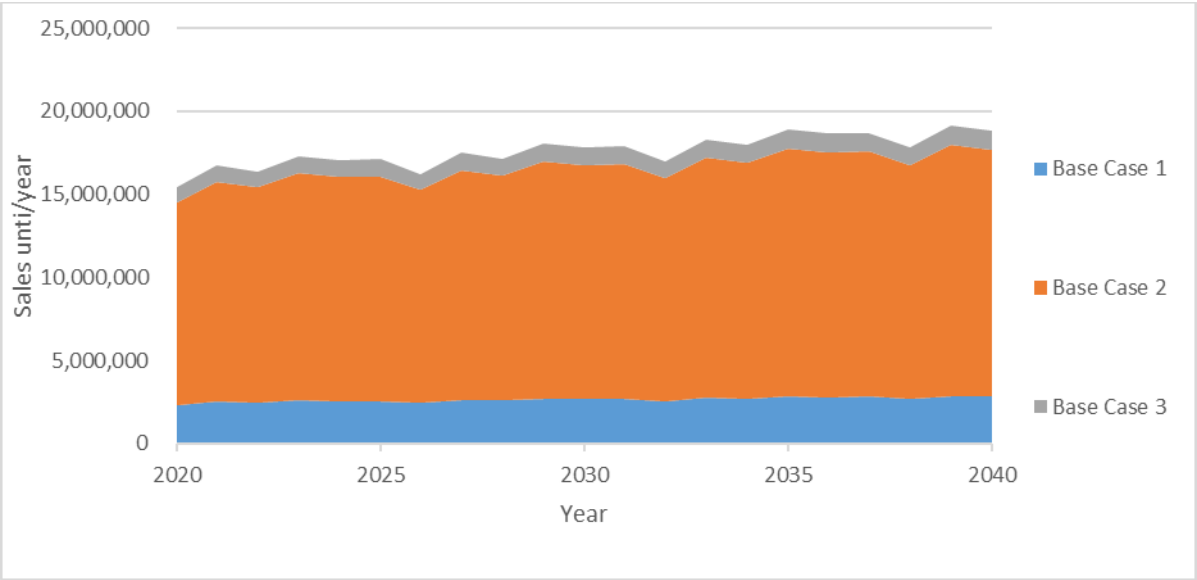
The sales figures are provided in Table 7-9 and Figure 7-6.

Table 7-10: Sales evolution of kettles per Base Case (EU-27)

	2020	2025	2030	2035	2040
BC1	2,319,837	2,565,311	2,677,327	2,831,771	2,818,878
BC2	12,217,808	13,510,639	14,100,588	14,913,991	14,846,090
BC3	927,935	1,026,124	1,070,931	1,132,708	1,127,551
Total water kettles	15,465,579	17,102,074	17,848,846	18,878,470	18,792,520

[75] +1.4% per year

Figure 7-6: Sales evolution of kettles per Base Case (EU-27)



7.2.3. Environmental impacts

As Figure 7-7 and Table 7-11 show, there is an increase in the electricity consumption of the total electric kettle stock under the design option scenarios. Between 2020 and 2040, the energy demand slightly increases from 9.06 to approximately 10.54 TWh per year in the BAU scenario. Under the BAT and LLCC scenarios there is an absolute decrease in electric kettle energy demand, and the total energy consumption is projected to be 7.82 and 7.93 TWh respectively by 2040. The Ecodesign scenario is a moderate scenario (9.27 TWh per year in 2040), which achieves half the savings of the BAT scenario.

Figure 7-7: Electricity consumption in TWh/year (EU-27 stock)

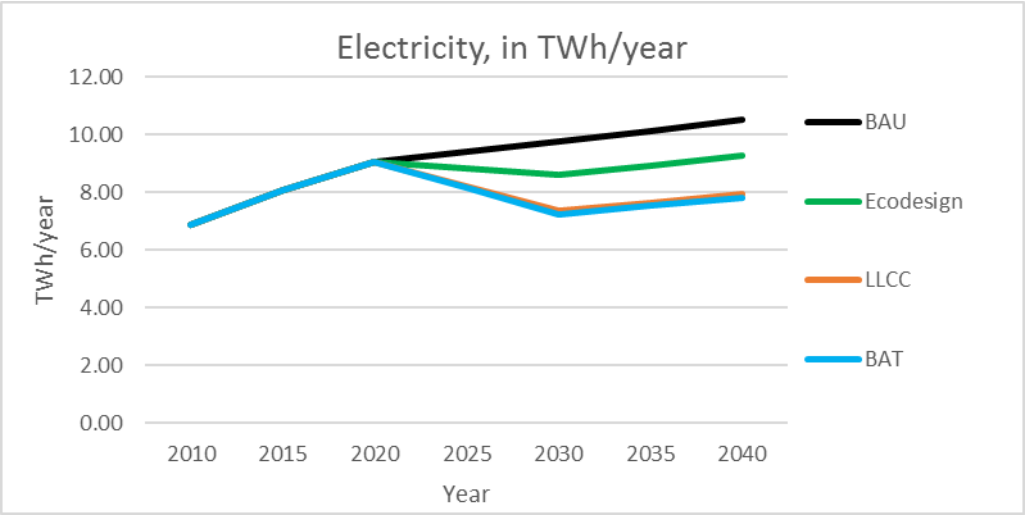


Table 7-11: Electricity consumption in TWh/year (EU-27 stock)

	2010	2015	2020	2025	2030	2035	2040
BAU	6.88	8.10	9.06	9.41	9.77	10.15	10.54
BAT	6.88	8.10	9.06	8.16	7.25	7.53	7.82
Ecodesign	6.88	8.10	9.06	8.83	8.60	8.93	9.27
LLCC	6.88	8.10	9.06	8.21	7.36	7.64	7.93
Absolute difference to BAU							
BAU	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BAT	0.00	0.00	0.00	-1.25	-2.52	-2.62	-2.72
Ecodesign	0.00	0.00	0.00	-0.58	-1.18	-1.22	-1.27
LLCC	0.00	0.00	0.00	-1.20	-2.42	-2.51	-2.61
Relative difference to BAU							
BAU	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BAT	0.0%	0.0%	0.0%	-13.3%	-25.8%	-25.8%	-25.8%
Ecodesign	0.0%	0.0%	0.0%	-6.2%	-12.0%	-12.0%	-12.0%
LLCC	0.0%	0.0%	0.0%	-12.7%	-24.7%	-24.7%	-24.7%

Figure 7-8 and Table 7-12 present the GHG emissions according to the scenarios. Due to the decarbonisation of the electricity mix in the EU, the GHG emissions are expected to decrease in the BAU scenario from 2.27 $MtCO_2$ in 2020 to 1.58 $MtCO_2$ in 2040. Compared to the BAU scenario, the largest GHG reductions are achieved in the scenario BAT (-25.8%), followed by LLCC (-24.7%). Here again, the Ecodesign scenario achieves half the possible improvement observed in the BAT scenario.

Figure 7-8: GHG emissions in Mt CO2eq/year (EU-27 stock)

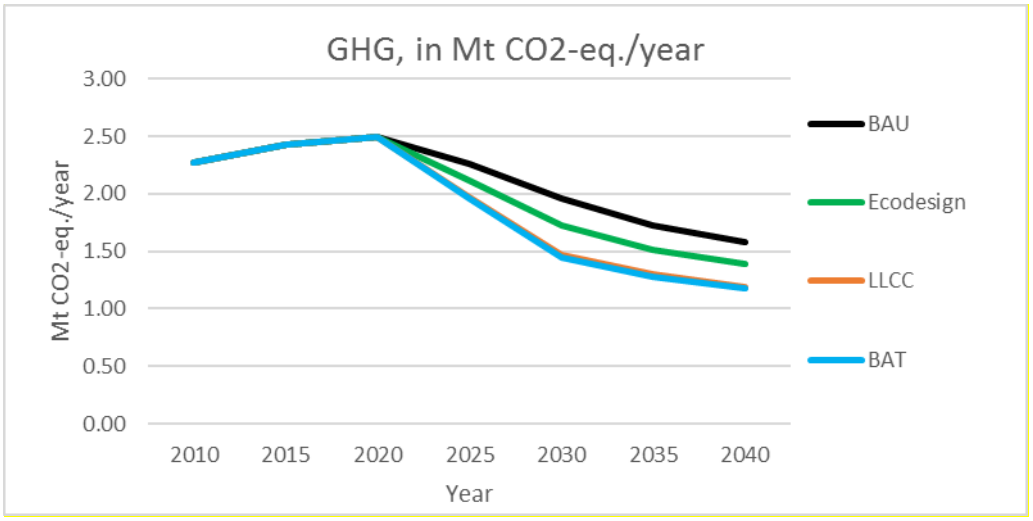


Table 7-12: GHG emissions in Mt CO2eq/year (EU-27 stock)

	2010	2015	2020	2025	2030	2035	2040
BAU	2.27	2.43	2.49	2.26	1.95	1.73	1.58
BAT	2.27	2.43	2.49	1.96	1.45	1.28	1.17
Ecodesign	2.27	2.43	2.49	2.12	1.72	1.52	1.39
LLCC	2.27	2.43	2.49	1.97	1.47	1.30	1.19
Absolute difference to BAU							
BAU	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BAT	0.00	0.00	0.00	-0.30	-0.50	-0.44	-0.41
Ecodesign	0.00	0.00	0.00	-0.14	-0.24	-0.21	-0.19
LLCC	0.00	0.00	0.00	-0.29	-0.48	-0.43	-0.39
Relative difference to BAU							
BAU	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BAT	0.0%	0.0%	0.0%	-13.3%	-25.8%	-25.8%	-25.8%
Ecodesign	0.0%	0.0%	0.0%	-6.2%	-12.0%	-12.0%	-12.0%
LLCC	0.0%	0.0%	0.0%	-12.7%	-24.7%	-24.7%	-24.7%

7.3. Impact analysis industry and consumers

Impacts on consumers

Table 7-13 and Figure 7-9 show the purchase costs incurred by customers under the different scenarios. In the BAU scenario, total purchase costs increase from 0.41 bln.€ in 2020 to 0.50 bln.€ in 2040. The Ecodesign scenario is almost the same as the BAU scenario, +0.7% by 2040. One can observe a similar pattern in the BAT and LLCC scenarios: the total purchase costs increase by 39.1% and 29.1% respectively by 2040 due to the additional costs of the Design Options required.[76]

[76] see Task 6 report

Figure 7-9: Purchase costs in Bln. € (EU-27 market)

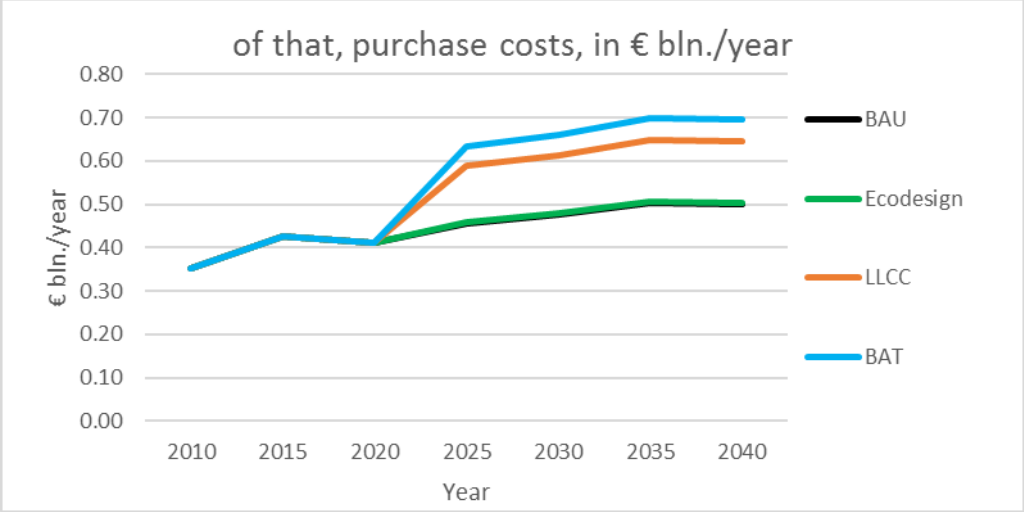


Table 7-13: Purchase costs in Bln. € (EU-27 market)

	2010	2015	2020	2025	2030	2035	2040
BAU	0.35	0.43	0.41	0.46	0.48	0.50	0.50
BAT	0.35	0.43	0.41	0.63	0.66	0.70	0.70
Ecodesign	0.35	0.43	0.41	0.46	0.48	0.51	0.50
LLCC	0.35	0.43	0.41	0.59	0.61	0.65	0.65
Absolute difference to BAU							
BAU	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BAT	0.00	0.00	0.00	0.18	0.19	0.20	0.20
Ecodesign	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LLCC	0.00	0.00	0.00	0.13	0.14	0.15	0.15
Relative difference to BAU							
BAU	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BAT	0.0%	0.0%	0.0%	39.1%	39.1%	39.1%	39.1%
Ecodesign	0.0%	0.0%	0.0%	0.7%	0.7%	0.7%	0.7%
LLCC	0.0%	0.0%	0.0%	29.1%	29.1%	29.1%	29.1%

The energy costs (bills) are presented in Figure 7-10 and Table 7-14 for the whole EU electric kettle stock. While the BAU scenario shows an increase from 1.84 bln.€ in 2020 to 2.27 bln.€ in 2040, the BAT scenario shows a decrease from 1.84 bln.€ in 2020 to 1.68 bln.€ in 2040, which is around 26% below the BAU level. The LLCC scenario indicates the smaller decrease in energy costs: from 1.84 bln.€ in 2020 to 1.71 bln.€ in 2040. In the Ecodesign scenario, the energy costs can be reduced by 12% in 2040 compared to the BAU level.

Figure 7-10: Energy costs in Bln. €/year (EU-27 stock)

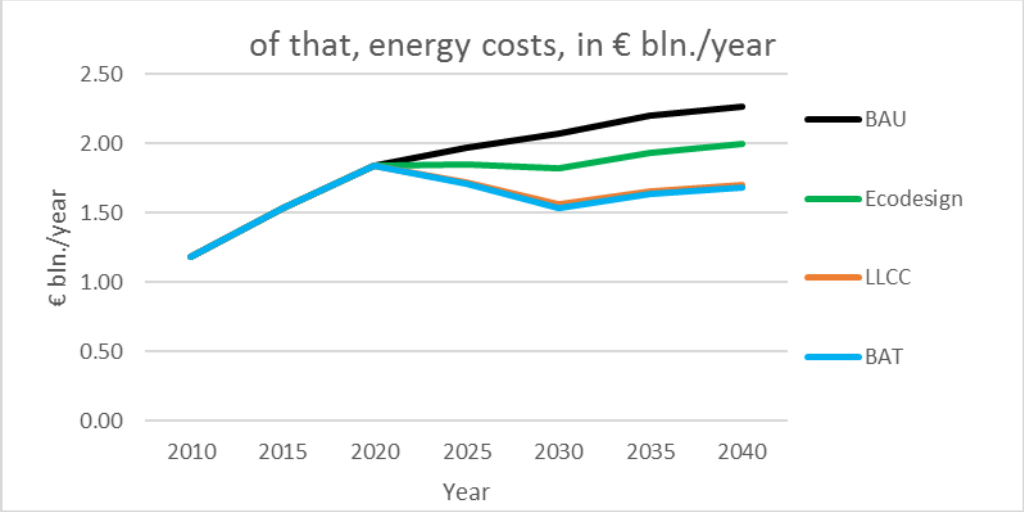


Table 7-14: Energy costs in Bln. €/year (EU-27 stock)

	2010	2015	2020	2025	2030	2035	2040
BAU	1.18	1.54	1.84	1.97	2.07	2.20	2.27
BAT	1.18	1.54	1.84	1.71	1.54	1.63	1.68
Ecodesign	1.18	1.54	1.84	1.85	1.82	1.94	1.99
LLCC	1.18	1.54	1.84	1.72	1.56	1.66	1.71
Absolute difference to BAU							
BAU	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BAT	0.00	0.00	0.00	-0.26	-0.53	-0.57	-0.58
Ecodesign	0.00	0.00	0.00	-0.12	-0.25	-0.27	-0.27
LLCC	0.00	0.00	0.00	-0.25	-0.51	-0.54	-0.56
Relative difference to BAU							
BAU	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BAT	0.0%	0.0%	0.0%	-13.3%	-25.8%	-25.8%	-25.8%
Ecodesign	0.0%	0.0%	0.0%	-6.2%	-12.0%	-12.0%	-12.0%
LLCC	0.0%	0.0%	0.0%	-12.7%	-24.7%	-24.7%	-24.7%

Finally, the total expenditure is presented in Figure 7-11 and Table 7-15. The figures include: purchase costs (sales), O&M costs (stock) and energy costs (stock). In the BAU scenario, the expenditure is expected to increase from 2.63 bln. € in 2020 to 3.21 bln. € in 2040. In general, the impact of the choice of scenario on the total expenditure is limited with the greatest difference compared to the BAU being a 12.9% decrease by 2040 for the LLCC scenario. The BAT scenario leads to a decrease of 12.1% in expenditure by 2040. The Ecodesign scenario is an intermediate scenario, in which the total expenditure decreases 8.4% by 2040 compared to the BAU level.

Figure 7-11: Expenditure in Bln. €/year (EU-27 stock)

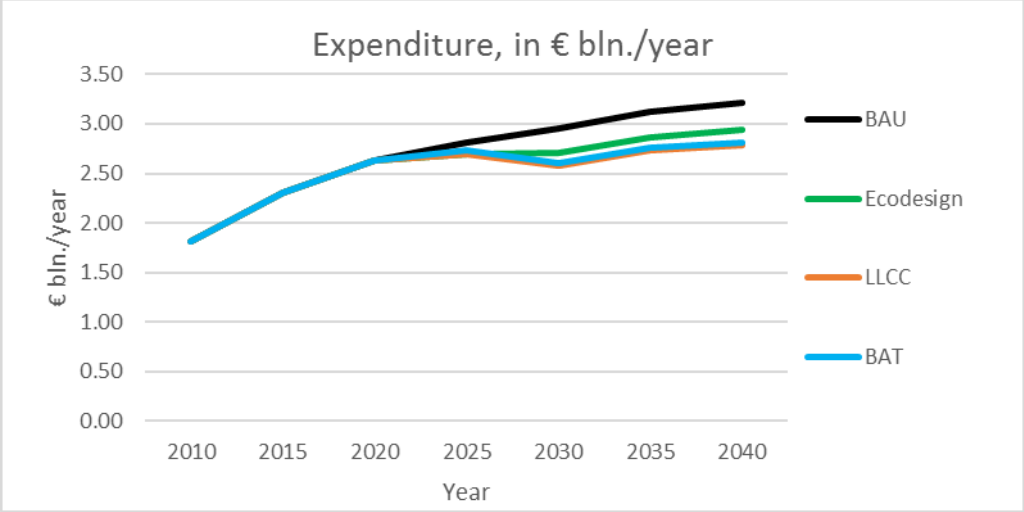
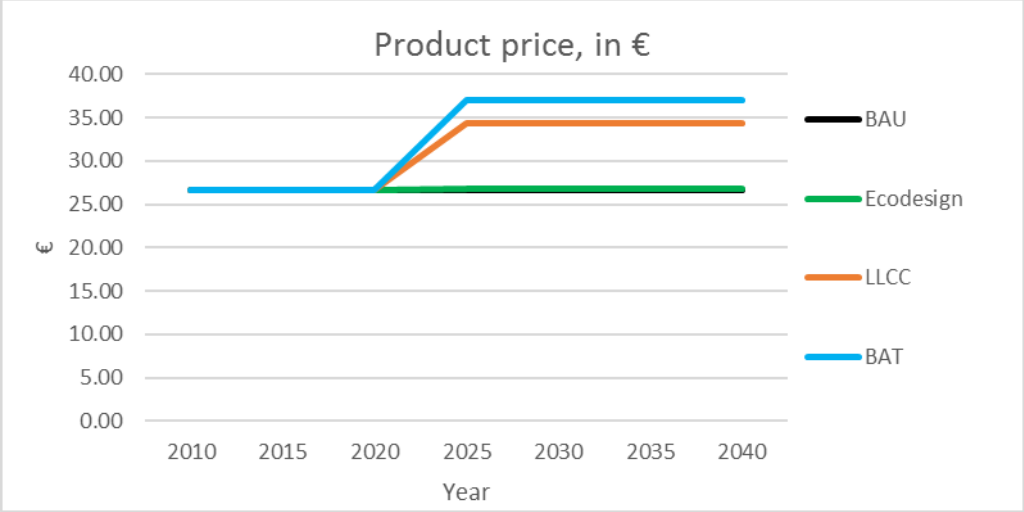


Table 7-15: Expenditure in Bln. €/year (EU-27 stock)

	2010	2015	2020	2025	2030	2035	2040
BAU	1.82	2.30	2.63	2.82	2.96	3.13	3.21
BAT	1.82	2.30	2.63	2.73	2.61	2.76	2.82
Ecodesign	1.82	2.30	2.63	2.70	2.71	2.87	2.94
LLCC	1.82	2.30	2.63	2.70	2.58	2.73	2.79
Absolute difference to BAU							
BAU	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BAT	0.00	0.00	0.00	-0.08	-0.35	-0.37	-0.39
Ecodesign	0.00	0.00	0.00	-0.12	-0.25	-0.26	-0.27
LLCC	0.00	0.00	0.00	-0.12	-0.37	-0.40	-0.42
Relative difference to BAU							
BAU	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BAT	0.0%	0.0%	0.0%	-2.9%	-11.8%	-11.9%	-12.1%
Ecodesign	0.0%	0.0%	0.0%	-4.2%	-8.3%	-8.4%	-8.4%
LLCC	0.0%	0.0%	0.0%	-4.2%	-12.7%	-12.7%	-12.9%

Figure 7-12 shows the price of an average new kettle, placed on the EU market. It takes into account the purchase price of each Base Case and the market volume in each scenario. In the LLCC scenario, an average kettle costs 29% more than in the BAU scenario; in the BAT scenario, the marginal costs are even 39% higher. Details on the costs of the individual Design Options required for LLCC and BAT can be found in Task 6 report. The Ecodesign scenario does not require expensive Design Options, and only the purchase price for Base Case 3 is expected to increase by 3 € due to the insulation of the container. As the market share of this Base Case is low, the impact on the average kettle price in the Ecodesign scenario is negligible: +0.7% compared to the BAU level.

Figure 7-12: Average price of a new kettle placed on the EU-27 market



7.3.1. Impacts on business

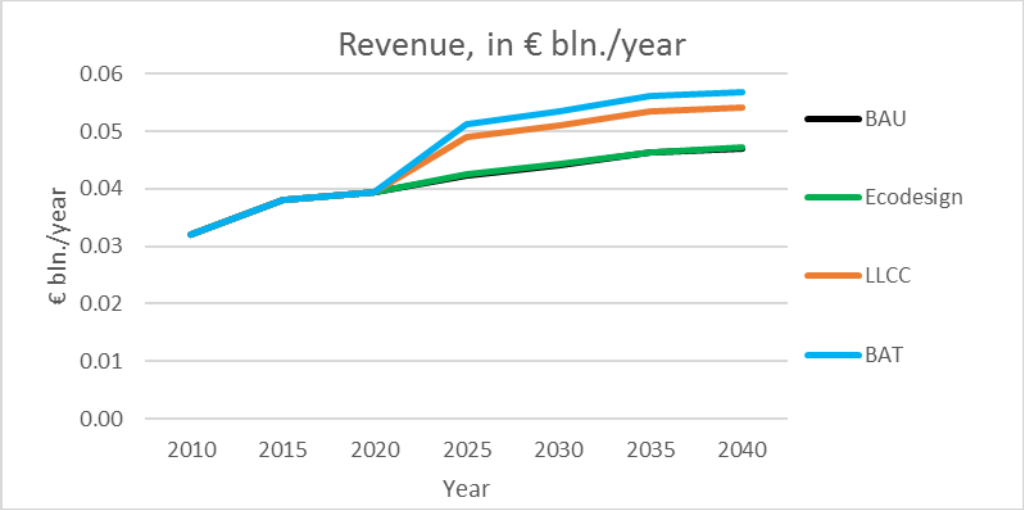
In this sub-section, the impact of the different policy scenarios on the business actors is presented.

In terms of turnover, it is assumed that:

- manufacturer turnover corresponds to the annual product purchase costs, i.e. it corresponds solely to the turnover due to the production and sale of kettles;
- the turnover of the maintenance companies corresponds to the maintenance costs (e.g.. spare parts);
- the turnover of the electricity companies corresponds to the electricity costs.

The revenue of the "kettles" sector is based on the turnover of the kettles manufacturers multiplied by their margins. Figure 7-13 shows the estimate of the revenue of the "kettles" sector according to the choice of scenario.

Figure 7-13: Revenue in Bln. € of kettles manufacturers (EU-27)



7.3.2. Impacts on employment

In this sub-section, the impact of the different policy scenarios on jobs is presented.

The number of jobs in the sector is estimated from the turnover figures and the ratio of jobs / turnover (see Table 7-16). Figure 7-14 and Figure 7-15 show the projected number of jobs according to the scenario and the job classification (manufacturers and energy companies).

Figure 7-14: Manufacturing jobs (1,000s)

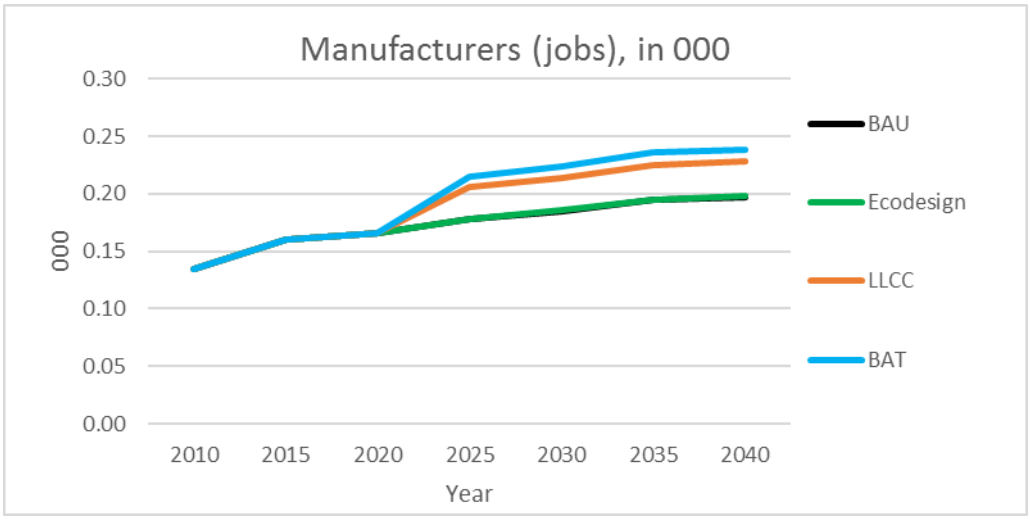
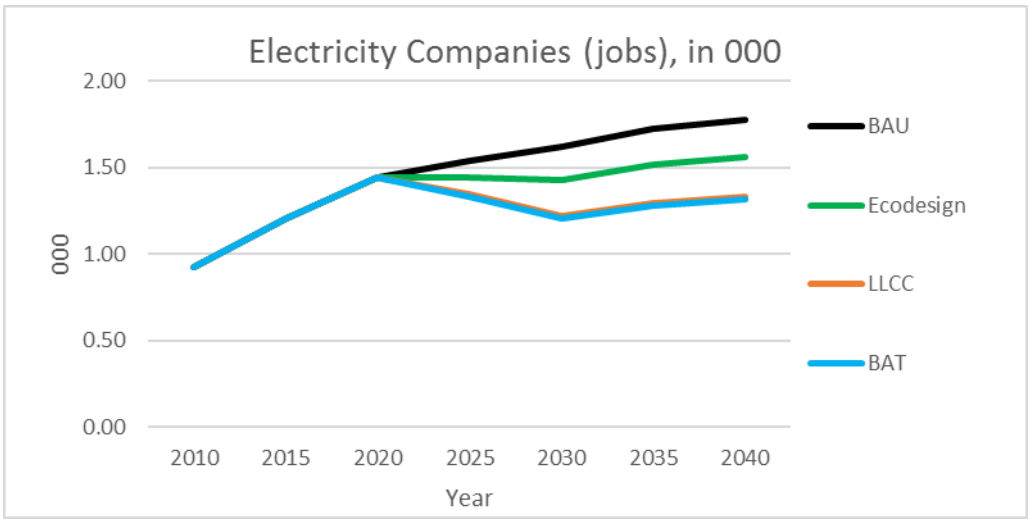


Figure 7-15: Number of jobs in electricity companies (1,000s)



7.4. Sensitivity analysis on the main parameters

7.4.1. High Sales projection

The Task 2 report reported between 96 and 165 million units in 2020. The baseline scenario corresponds to the lower figures. For the sensitivity analysis, we consider a "high sales scenario", whereby the sales volume is assumed to be 71%[77] higher than in the baseline scenario.

The main impacts in the case of the high sales projection for 2040 are provided in Table 7-16.

[77] 71% = (165/96 – 1)

Table 7-16: Main impacts of the scenarios by 2040 (high sales projection)

Criteria			MAIN IMPACTS IN YEAR 2040			
			1	2	3	4
			BAU	Ecodesign	LLCC	BAT
ENVIRONMENT						
	efficiency (weighted average)	%				
	Electricity	TWh/year	18.04	15.87	13.58	13.39
	GHG	Mt CO2-eq./	2.71	2.38	2.04	2.01
CONSUMER						
EU totals	Expenditure	€ bln./year	5.49	5.03	4.78	4.82
	of that, purchase costs	€ bln./year	0.86	0.86	1.11	1.19
	of that, installation costs	€ bln./year	0.00	0.00	0.00	0.00
	of that, maintenance costs	€ bln./year	0.75	0.75	0.75	0.75
	of that, energy costs	€ bln./year	3.88	3.42	2.92	2.88
Per product sold	Sales (regulated)	000	32,181.89	32,181.89	32,181.89	32,181.89
	Product price	€	26.66	26.84	34.41	37.08
	Installation costs	€	0.00	0.00	0.00	0.00
	Energy costs	€/year	20.25	17.81	15.24	15.03
	Payback (SPP)	years	0.00	0.00	0.00	0.00
BUSINESS						
EU turnover	Manufacturers	€ bln./year	0.86	0.86	1.11	1.19
	Installers	€ bln./year	0.00	0.00	0.00	0.00
	Maintenance	€ bln./year	0.75	0.75	0.75	0.75
	Electricity Companies	€ bln./year	3.88	3.42	2.92	2.88
	Revenue	€ bln./year	0.08	0.08	0.09	0.10
EMPLOYMENT						
Employment (jobs)	Manufacturers	000	0.34	0.34	0.39	0.41
	Maintenance	000	0.00	0.00	0.00	0.00
	Installers	000	0.00	0.00	0.00	0.00
	Electricity Companies	000	3.04	2.67	2.29	2.25
	Indirect Employment	000	0.00	0.00	0.00	0.00
	TOTAL	000	3.37	3.01	2.68	2.66

7.4.2. Electricity prices

In line with the MEErP methodology, the scenarios have been recalculated with higher and lower (+/-50%) energy prices.

The overview of the scenarios in 2040 with energy prices 50% below the former assumptions (see Table 7-7) is presented in Table 7-17:[78]

[78] Same sales and stock assumption as in 7.2.2

Table 7-17: Main impact of the scenarios by 2040 (low energy price scenario)

Criteria			MAIN IMPACTS IN YEAR 2040			
			1	2	3	4
			BAU	Ecodesign	LLCC	BAT
ENVIRONMENT						
	efficiency (weighted average)	%				
	Electricity	TWh/year	10.54	9.27	7.93	7.82
	GHG	Mt CO2-eq./	1.58	1.39	1.19	1.17
CONSUMER						
EU totals	Expenditure	€ bln./year	2.07	1.94	1.94	1.98
	of that, purchase costs	€ bln./year	0.50	0.50	0.65	0.70
	of that, installation costs	€ bln./year	0.00	0.00	0.00	0.00
	of that, maintenance costs	€ bln./year	0.44	0.44	0.44	0.44
	of that, energy costs	€ bln./year	1.13	1.00	0.85	0.84
Per product sold	Sales (regulated)	000	18,792.52	18,792.52	18,792.52	18,792.52
	Product price	€	26.66	26.84	34.41	37.08
	Installation costs	€	0.00	0.00	0.00	0.00
	Energy costs	€/year	10.12	8.90	7.62	7.51
	Payback (SPP)	years	0.00	0.00	0.00	0.00
BUSINESS						
EU turnover	Manufacturers	€ bln./year	0.50	0.50	0.65	0.70
	Installers	€ bln./year	0.00	0.00	0.00	0.00
	Maintenance	€ bln./year	0.44	0.44	0.44	0.44
	Electricity Companies	€ bln./year	1.13	1.00	0.85	0.84
	Revenue	€ bln./year	0.05	0.05	0.05	0.06
EMPLOYMENT						
Employment (jobs)	Manufacturers	000	0.20	0.20	0.23	0.24
	Maintenance	000	0.00	0.00	0.00	0.00
	Installers	000	0.00	0.00	0.00	0.00
	Electricity Companies	000	0.89	0.78	0.67	0.66
	Indirect Employment	000	0.00	0.00	0.00	0.00
	TOTAL	000	1.08	0.98	0.90	0.90

The overview of the scenarios in 2040 with energy prices 50% above the former assumptions (see Table 7-17) is presented in Table 7-18:[79]

[79] Same sales and stock assumption as in 7.2.2

Table 7-18: Main impact of the scenarios by 2040 (high energy price scenario)

Criteria			MAIN IMPACTS IN YEAR 2040			
			1	2	3	4
			BAU	Ecodesign	LLCC	BAT
ENVIRONMENT						
	efficiency (weighted average)	%				
	Electricity	TWh/year	10.54	9.27	7.93	7.82
	GHG	Mt CO2-eq./	1.58	1.39	1.19	1.17
CONSUMER						
EU totals	Expenditure	€ bln./year	4.34	3.93	3.64	3.66
	of that, purchase costs	€ bln./year	0.50	0.50	0.65	0.70
	of that, installation costs	€ bln./year	0.00	0.00	0.00	0.00
	of that, maintenance costs	€ bln./year	0.44	0.44	0.44	0.44
	of that, energy costs	€ bln./year	3.40	2.99	2.56	2.52
Per product sold	Sales (regulated)	000	18,792.52	18,792.52	18,792.52	18,792.52
	Product price	€	26.66	26.84	34.41	37.08
	Installation costs	€	0.00	0.00	0.00	0.00
	Energy costs	€/year	30.37	26.71	22.86	22.54
	Payback (SPP)	years	0.00	0.00	0.00	0.00
BUSINESS						
EU turnover	Manufacturers	€ bln./year	0.50	0.50	0.65	0.70
	Installers	€ bln./year	0.00	0.00	0.00	0.00
	Maintenance	€ bln./year	0.44	0.44	0.44	0.44
	Electricity Companies	€ bln./year	3.40	2.99	2.56	2.52
	Revenue	€ bln./year	0.05	0.05	0.05	0.06
EMPLOYMENT						
Employment (jobs)	Manufacturers	000	0.20	0.20	0.23	0.24
	Maintenance	000	0.00	0.00	0.00	0.00
	Installers	000	0.00	0.00	0.00	0.00
	Electricity Companies	000	2.66	2.34	2.00	1.97
	Indirect Employment	000	0.00	0.00	0.00	0.00
	TOTAL	000	2.86	2.54	2.23	2.21

7.5. Summary

This section provides a summary of the main outcomes of the previous analyses, looking at suitable policy options to achieve improvements in the environmental performance of kettles and in the light of the life cycle costs as determined in Task 6.

7.5.1. Main policy recommendation

The analyses provided in Task 6 as well as in sections 7.2 and 7.3 of this report show that there are substantial cost-effective energy saving potentials: up to 25%. Some of the Design Options do not improve the specific energy consumption of the kettles as such, but would rather reduce the yearly energy consumption, as they impact the way the kettles will be used: less water to be heated, slightly lower water temperature, shorter keep-warm time. For these measures, there are still some uncertainties on:

- how the impact of the requirement will be on the user. Even if the impact will be positive, the magnitude is difficult to quantify without any additional survey, and;
- how the impact on the average energy consumption over the period of one year will be.

Still, the measures could be easily addressed within the Ecodesign framework by setting information requirements (e.g. better water level indication) or technical requirements (e.g. max boiling keep-warm of 30 min).

By 2040, the BAT scenario saves 2.72 TWh/a electricity compared to the BAU scenario (10.54 TWh/a), the LLCC scenario is very close to the BAT with 2.61 TWh/a electricity savings. Even if

both BAT and LLCC scenarios are cost efficient, they have a major impact on the purchase price of an average kettle, which would increase by 10.42€ (+39%) in the BAT scenario and by 7.75€ (+29%) in the LLC.

Fortunately, the Ecodesign scenario has almost no impact on the purchase costs of the products but is expected to tap half of the saving potentials shown in the BAT scenario, so that this policy option would be a very interesting compromise. In this scenario, the MEPS requirement would be set at EEI >= 81%.

A pre-condition for setting a MEPS would be the definition of a common measurement method, which would be mandatory. However, as far as possible, measurement methods should be developed within a valid CEN/CENELEC mandate in standardisation. In order to limit over-heating, it is proposed to measure the energy consumption until shut off of the kettle, while it would be required to heat up the water up from 15°C by 80K. More information on the measurement method is provided in Annex B – Input to legislation.

Introducing a measurement method and information requirements on the performance of kettles will make the competition among manufacturers stronger. Without any mandatory measurement method, manufacturers cannot really promote the advantage of the energy efficiency thick film kettles and will not convince many customers to buy energy efficient products. At the moment, the broad range of kettles, in terms of performance, is still too limited to justify an energy label.

In addition to energy efficiency requirements, several requirements on material would be meaningful in order to ensure that end-users will consume a proper hot water and that the environmental impacts will be reduced, by promoting circular economy. For the requirements related to the EN 4555x standard family, product-specific standards should be developed.

7.5.2. Main outcomes of the scenarios

Based on the criteria mentioned in Art. 15 of 2009 /125/EC (Ecodesign Directive), the impacts of the scenarios have been assessed in this report.

The main figures are presented in 2030 (see Table 7-19) and 2040 (see Table 7-20).

Table 7-19: Main impacts of the scenarios in 2030 (normal sales and electricity prices)

Criteria			MAIN IMPACTS IN YEAR 2030			
			1	2	3	4
			BAU	Ecodesign	LLCC	BAT
ENVIRONMENT						
	efficiency (weighted average)	%				
	Electricity	TWh/year	9.77	8.60	7.36	7.25
	GHG	Mt CO2-eq./	1.95	1.72	1.47	1.45
CONSUMER						
EU totals	Expenditure	€ bln./year	2.96	2.71	2.58	2.61
	of that, purchase costs	€ bln./year	0.48	0.48	0.61	0.66
	of that, installation costs	€ bln./year	0.00	0.00	0.00	0.00
	of that, maintenance costs	€ bln./year	0.41	0.41	0.41	0.41
	of that, energy costs	€ bln./year	2.07	1.82	1.56	1.54
Per product sold	Sales (regulated)	000	17,848.85	17,848.85	17,848.85	17,848.85
	Product price	€	26.66	26.84	34.41	37.08
	Installation costs	€	0.00	0.00	0.00	0.00
	Energy costs	€/year	19.97	17.57	15.03	14.82
	Payback (SPP)	years	0.00	0.00	0.00	0.00
BUSINESS						
EU turnover	Manufacturers	€ bln./year	0.48	0.48	0.61	0.66
	Installers	€ bln./year	0.00	0.00	0.00	0.00
	Maintenance	€ bln./year	0.41	0.41	0.41	0.41
	Electricity Companies	€ bln./year	2.07	1.82	1.56	1.54
	Revenue	€ bln./year	0.04	0.04	0.05	0.05
EMPLOYMENT						
Employment (jobs)	Manufacturers	000	0.19	0.19	0.21	0.22
	Maintenance	000	0.00	0.00	0.00	0.00
	Installers	000	0.00	0.00	0.00	0.00
	Electricity Companies	000	1.62	1.43	1.22	1.20
	Indirect Employment	000	0.00	0.00	0.00	0.00
	TOTAL	000	1.81	1.61	1.44	1.43

Table 7-20: Main impacts of the scenarios in 2040 (normal sales and electricity prices)

Criteria			MAIN IMPACTS IN YEAR 2040			
			1	2	3	4
			BAU	Ecodesign	LLCC	BAT
ENVIRONMENT						
	efficiency (weighted average)	%				
	Electricity	TWh/year	10.54	9.27	7.93	7.82
	GHG	Mt CO2-eq./	1.58	1.39	1.19	1.17
CONSUMER						
EU totals	Expenditure	€ bln./year	3.21	2.94	2.79	2.82
	of that, purchase costs	€ bln./year	0.50	0.50	0.65	0.70
	of that, installation costs	€ bln./year	0.00	0.00	0.00	0.00
	of that, maintenance costs	€ bln./year	0.44	0.44	0.44	0.44
	of that, energy costs	€ bln./year	2.27	1.99	1.71	1.68
Per product sold	Sales (regulated)	000	18,792.52	18,792.52	18,792.52	18,792.52
	Product price	€	26.66	26.84	34.41	37.08
	Installation costs	€	0.00	0.00	0.00	0.00
	Energy costs	€/year	20.25	17.81	15.24	15.03
	Payback (SPP)	years	0.00	0.00	0.00	0.00
BUSINESS						
EU turnover	Manufacturers	€ bln./year	0.50	0.50	0.65	0.70
	Installers	€ bln./year	0.00	0.00	0.00	0.00
	Maintenance	€ bln./year	0.44	0.44	0.44	0.44
	Electricity Companies	€ bln./year	2.27	1.99	1.71	1.68
	Revenue	€ bln./year	0.05	0.05	0.05	0.06
EMPLOYMENT						
Employment (jobs)	Manufacturers	000	0.20	0.20	0.23	0.24
	Maintenance	000	0.00	0.00	0.00	0.00
	Installers	000	0.00	0.00	0.00	0.00
	Electricity Companies	000	1.77	1.56	1.33	1.32
	Indirect Employment	000	0.00	0.00	0.00	0.00
	TOTAL	000	1.97	1.76	1.56	1.55

References for Task 7

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EC (2015): COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT Accompanying the document Commission Regulation implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Ecodesign requirements for solid fuel boilers. Online: http://ec.europa.eu/smart-regulation/impact/ia_carried_out/docs/ia_2015/swd_2015_0092_en.pdf. Accessed: 10/10/2018.

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EU (2017): Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU. Online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R1369&from=EN. Accessed: 07/02/2019.

KU LEUVEN (2018) Repairability criteria for energy related products. Online: http://www.benelux.int/files/7915/2896/0920/FINAL_Report_Benelux.pdf. Accessed: 07/07/2019.

Norms and standards

EN 45555:2019: General methods for assessing the recyclability and recoverability of energy-related products

EN 45557:2020: General method for assessing the proportion of recycled material content in energy-related products

IEC 60530:1975: Methods for measuring the performance of electric kettles and jugs for household and similar use

IEC 60530:1975/AMD1:1992: Amendment 1 - Methods for measuring the performance of electric kettles and jugs for household and similar use

IEC 60530:1975/AMD2:2004: Amendment 2 - Methods for measuring the performance of electric kettles and jugs for household and similar use

7.6. Annex A – Meetings with stakeholders

General remark: All members of APPLiA represented the position of APPLiA at the meetings.

7.6.1. Stakeholder meeting on 15th July 2020: minutes

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Date :	15/07/2020	Ref.	ENER/C4/FV 2019-467/06/FWC 2015-619 LOT1/05
From :	Fraunhofer ISI	Annex(es):	**PowerPoint presentations of the meeting (here)**

Minutes of stakeholder Meeting for Ecodesign Preparatory Study on electric kettles - First Stakeholder meeting on 15/07/2020

Online event

Participants

Organization	Role
DG ENER	European Commission
Fraunhofer ISI	Project team
APPLiA Home Appliance Europe	Stakeholders
BSH Hausgeräte GmbH / APPLiA	
Danish Energy Agency	
De'Longhi Appliances / APPLiA	
ECOS	
EEB	
IEP	
Karlsuher Institute für Technologie	
Netherlands Enterprise Agency	
Öko-Institut	
Otter Controls Limited	
SEB / APPLiA	
Swedish Energy Agency	
Topten	
Umweltbundesamt	
Which?	

Distribution: General

Objective of the meeting

The meeting was the stakeholder meeting for the Ecodesign preparatory study for electric kettles. The purpose of this meeting was to discuss with stakeholders the implementation of the stakeholder feedback on Tasks 1-4 and the outlook of Tasks 5-7. Stakeholders can provide comments on the draft reports of Tasks 1-4, which are available here. Documents related to the stakeholder meeting are available under the same link. Preliminary figures related to Task 5-6 have been sent per email to the stakeholders after the stakeholder meeting.

Agenda

12:45 – 13:10	Arrival of participants
13:10 – 13:20	**Welcome and presentation of the consortium**
	Fraunhofer ISI
13:20 – 13:25	**Methodology and context of the study**
	Fraunhofer ISI
13:25 – 13:50	**Presentation of Task 1: Scope**
	Fraunhofer ISI
13:50 – 14:35	**Presentation of Task 2: Markets**
	Fraunhofer ISI
14:35 – 14:40	Break
14:40 – 15:30	**Presentation of Task 3: Users**
	Fraunhofer ISI
15:30 – 16:20	**Presentation of Task 4: Technologies**
	Fraunhofer ISI
16:20 – 16:50	**Presentation of an insight in Tasks 5-6-7**
	Fraunhofer ISI
16:50	**Closing**
	Fraunhofer ISI

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Minutes

Welcome and Short presentation of the consortium

Fraunhofer ISI opened the meeting. He welcomed the participants and explained the housekeeping rules for the online meeting. He presented the agenda for the meeting and shortly introduced the consortium. The study is carried out by the project team at Fraunhofer ISI and the project is managed by VITO. Although not a part of the call, an additional stakeholder meeting is likely to be held in Oct/Nov 2020. Stakeholders will have three weeks to comment on the draft reports and are requested to follow the provided template. The whole work (incl. working document for the Consultation Forum) has to be completed by end of January 2021.

ISI presented the background on methodology and context on the study followed by Task 1: Scope (see PowerPoint).

The presentation was followed by a discussion:

abbr.	Comment/answer
ECOS	Where does the 10 l limitation come from, it is not specified in the working plan 2015-17? ISI: The 10 l threshold is based on the safety standard *(20.7.2020: EN 60335–2–15:2002+A2:2008 "Household and similar electrical appliances — Safety — Part 2-15: Particular requirements for appliances for heating liquids", which covers "kettles and other appliances for boiling water, having a rated capacity not exceeding 10 l")*
ECOS	Are we certain that appliances with a larger capacity than 10 l don't have a significant environmental impact? ISI: For the market data in task 2 we didn't consider that limitation and these appliances are included but have a really low market share
Umweltbundesamt	Regarding the boiling water heaters: if you have your base case of 1000 l, how is the energy used compared to the kettles. ISI: More information is available in the VHK report[1].
APPLiA	Will you complete the list of excluded appliances, like coffee machines, urns and appliances producing directly hot drinks, tea makers? ISI: The list could indeed be more precise, we will to do it after the meeting.
APPLiA	The UK pattern of use is different from the UK 27. ISI: We excluded UK for all statistics and we try to look for data on the Member States but if there is no data from EU27, we will use the UK data.

ISI presented Task 2: markets (see PowerPoint).

Afterwards there was a discussion:

abbr.	Comment/answer
ECOS	Market figures: is it only household or restaurants and hotels are also included? ISI: B2B channels are not included in the GfK data, therefore we do not know to what extent the data from hotels and restaurants is included.

[1] see Energy analysis for Quooker (VHK 2010): https://www.vhk.nl/downloads/Reports/2010/Energy%20analysis%20Quooker.zip

BSH	Lime scale filter: you should differentiate between the lime scale filter and consumable filter (cartridge) and on slide 59: it should be water filter instead of built-in lime filter ISI: built-in water filter use cartridge (e.g. Brita) and filter the water that will be boiled.
BSH	What is the definition of a re boil function ISI: category covered by GfK. We will clarify the definition in the report *(20.7.2020: Re-boil is a dynamic function. It ensures the water kettle to restart automatically each time when the temperature of the water in the kettle has cooled down below a certain temperature)*
Umweltbundesamt	Any data about Smart devices? ISI: the category is also covered by GfK but the share is very low, and we couldn't see any significant increasing trend. Data is already included in the report, market share: 0.5%.
Umweltbundesamt	Any data on energy consumption for heating up 1 litre of water? Data could be available from consumer organizations? ISI: Data will be provided in task 5. Since there is no regulation for energy consumption, GfK data doesn't cover data on that. Some consumer organizations like Which? or Stitftung Warentest have tested products and have data, but we can only access the report and not the raw data. The Swedish energy agency carried out a test on around 10 kettles. We received the valuable data of this test and the info is used for in task 5.
Otter	Boil dry protection as additional feature does not affect the energy consumption that much but is necessary for the safety. ISI: We will check and possibly correct this feature
Otter	We have some data on energy consumption of the kettles with different types of elements. I will send it to you after the meeting.
EEB	The table on slide 55 is misleading. There are many correlations among different features, if you do a multi regression analysis you will be able to get more targeted results for each of the features. But the table shown here will not be useful for calculation of the extra costs for a certain feature ISI: the additional price does not correspond to only one feature. The data provided by GfK are not covering all features at once, so we cannot do the multi parameter analysis. If the table is confusing, we will remove it.
Topten	You have no data from B2B, maybe manufactures could provide some data, are you looking into that? ISI: We had already talks with the some manufacturers but so far they could not provide any data. This was also the reason why we had to buy market data.
Which?	Energy consumption: we collect data on that and we can share it with you. Lime scale filter: we collect information on that but there is a correlation between descaling and consumers who throw away their kettles too early. The lime scale problems could have something to do with the owners not maintaining the kettles rather than the fault of the kettle. Smart appliances: we have similar data, so it is the niche market. But it could become a large portion of the market in a few years.

ISI presented Task 3: Users (see PowerPoint).
Afterwards a discussion took place:

abbr.	Comment/answer
De'Longhi	Regarding the 1000 litre per year as the average boiled amount for a kettle: - We still do not have this certainty that this figure is realistic and we believe that UK cannot be used as the use pattern for EU27, the intensity of usage of kettle in UK is much higher. - You refer to a study from TNO, but that one is not clear. The 1000 l is the overall usage in households; 650 l for hot drinks and 350 l for cooking, but I do not believe people use kettle for cooking.

	- I believe 1000 l is overestimating, so I suggest to check again and look for more sources. We also try to support. - Consider this input in sensitivity analysis. ISI: We also agree that UK might not be the closest-to-reality assumption, but we currently have no better data source. The 1000 l has been repeated in various publications. The project team will check the data again, but additional data from the stakeholders is welcome. In an energy-related methodology, the actual shut-off temperature should be used instead of a fixed temperature increase. ISI: The project team agrees.
Topten	How did you come to the 7 year life time, from the data set it seems that it could be lower, if there are studies about that, they should be included ISI: The project teams takes the remark into consideration and will check for additional sources/verification.
Otter	Any test for the energy consumption should have the lid on and the temperature should not be considered 100, because it varies with the pressure, ... So the tests should be lid on and when the kettle automatically turns off ISI: The project team agrees and will take consider this concerning the conclusions towards a potential methodology for measurement.

ISI presented Task 4: Technologies (see PowerPoint).

Afterwards a discussion took place:

abbr.	Comment/answer
EEB	Choice of materials: did you include the full container material perspective (environmental impact and health issues) ISI: such issues will be addressed and considered in Task 5
De'Longhi	We will provide answer to many questions mentioned in this task. Is there more information or drawings about double chamber feature available? ISI: the project team showed an additional slide showing how a double chamber product can look like and explained the working principle on base of a drawing (see back-up slide of the PowerPoint).
ECOS	Why was the digital display feature considered not useful and excluded ISI: Monitoring the temperature is a valuable feature, but it should not be limited on a digital display solely. It would be beneficial to provide a technology-open level playing field. Meaning, that it is up to the producer to find technical solutions to monitor the water temperature. The 3 base cases are out of plastic, isn't it useful to vary on that? ISI: we chose plastic because they are the most kettles sold. Amongst other measures, material substitution will be analysed from environment and energy perspectives in other upcoming tasks.
Netherlands Enterprise Agency	What is the contribution of these options/improvements in energy/material efficiency? ISI: Task 4 shall provide an overview and technical description of technological parameters. Other objectives of task 4 are the definition of Base Cases and the identification of potential measures for standard improvement of electric water kettles. More detailed questions of the named measures on energy/ material efficiency are addressed in task 6
De'Longhi	Over boiling cannot be completely avoided by double chamber ISI: we totally agree, over boiling is a user behaviour issue but certain constructions and control mechanism may lead to a higher sensitivity for the over boiling by users.
Otter	- BC 2 and 3: no or really low aluminium amount, you should check that

	- Not all kettles with concealed element and dry boil protection do reset automatically and the user needs to reset them manually. - It is possible to do a lift up switch off function, it is already available in some kettles - It is difficult to know how each feature is going to improve energy efficiency. The best practice for the best kettle depends on how it is going to be used. - Thick film elements are more efficient, but the efficiency depends on how much water is boiled. So you need to set different tests for looking at the efficiency.

ISI presented the outlook of Tasks 5, 6 and 7:

ISI explained that the work presented in this part was the preliminary stage of the work and therefore still open to recommendations. He requested the stakeholders to provide their feedback on the indicators to be added or on available data sources that they might have access to.

Some general and specific questions were asked following the presentation:

abbr.	Comment/answer
De'Longhi	Will you also provide the Task 5 report? ISI: for Tasks 5-7, there are no reports (yet). We worked on data for Task 5-7 the last weeks and wanted to present the first assumptions, to get comments of the stakeholders. We'll upload a pdf of the presented slides and you can comment on that. Is it possible to extend the deadline? ISI: comments should be sent by 5th of August.
Topten	Suggests to include the information on boiling time in the list of indicators
Umweltbundesamt	Asks if circular economy means recycle material content and recyclability ISI: yes
ECOS	Can we extend the deadline to 21st of August? ISI: we need the feedback by 5th of August. But tell us by then if you will update the comments later. Basically, the schedule of the project is tight: the contract will expire beginning of February 2021 and can't be extended.

Wrap-up of meeting and closure of the meeting

ISI thanked the project team for the presentations and emphasised that carrying out an eco-design study in such a short time would be a novelty. He thanked also the stakeholders for their participation and the valuable contributions during the meeting and for providing further **comments by 5th of August.**

7.6.2. Exchange with stakeholders on 21st October 2020: minutes

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Date :	21/10/2020	Ref.	ENER/C4/FV 2019-467/06/FWC 2015-619 LOT1/05
From :	Fraunhofer ISI	Annex(es):	**PowerPoint presentations of the meeting**

Exchange with stakeholders on 21/10/2020 for Ecodesign Preparatory Study on electric kettles - Minutes of the meeting

Online event

Participants (30 registrants, 26 attendees)

Organization	Role
DG ENER	European Commission
Fraunhofer ISI	Project team
VITO	
AMDEA	Stakeholders
ANEC/BEUC	
APPLiA Home Appliance Europe	
BSH Hausgeräte GmbH / APPLiA	
BAM (Germany)	
Danish Energy Agency (Denmark)	
De'Longhi Appliances / APPLiA	
ECOS	
EURIC	
FPSE (Belgium)	
NEA (Netherlands Enterprise Agency)	
NVE (Norway)	
Öko-Institut e.V. on behalf of BEUC	
Otter Controls Limited	
Philips	
SMEG SpA	
SEB / APPLiA	
Swedish Energy Agency (Sweden)	
Topten Switzerland	
UBA (Umweltbundesamt, Germany)	
Which? (United Kingdom)	
ZVEI (Germany)	

Distribution: General

Objective of the meeting

A document "Key assumptions of the study and possible policy options" has been send to the stakeholders on 9th of October. Stakeholder were invited to provide comments on the assumptions before the meeting, comments regarding the policy options can be done until 28th of October. One objective of this meeting was to report on the stakeholders comments regarding the Base Case and Design Options assumptions, which are the key input data for Task 5 and Task 6. A second objective of the meeting was to report on comments regarding testing procedure, EE metrics and possible policy options, and to provide more explanation to the stakeholders regarding these points and to exchange with them.

Agenda

8:45 – 9:00	**Session opened (technical check)**
9:00 – 9:10	**Welcome and presentation of the consortium** Fraunhofer ISI
9:10 – 10:10	**Reporting on feedbacks regarding the assumptions (Base Cases & Design Options)** Fraunhofer ISI
10:10 – 10:40	**Testing procedure and Energy Efficiency metrics** Fraunhofer ISI
10:40 – 11:50	**Policy options** Fraunhofer ISI
11:50 – 12:00	**Further proceeding and schedule, other issues, closing** Fraunhofer ISI

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Minutes

Welcome and Short presentation of the consortium

Fraunhofer ISI opened the meeting. The moderator welcomed the participants and explained the housekeeping rules for the online meeting. He presented the agenda for the meeting and shortly introduced the consortium. The whole work (incl. working document for the Consultation Forum) has to be completed by end of January 2021.

ISI presented the feedbacks regarding the Base Case assumptions

The presentation was followed by a discussion:

abbr.	Comment/answer
De Longhi	It is important to have a common testing method. Otherwise, it would be difficult to comment on the data. *ISI: We will have a section later dedicated to this topic (methods, volume of water, target temperature...).*
ANEC BEUC	Why are the water costs (for boiling) lower in BC1 than in BC2 and BC3? *ISI: For all base cases the water costs are indeed the same (2,39€).*
Otter Controls	Concerning minimum water levels: It is easier for concealed heating electric appliances to deal with lower minimum water levels (e.g. 0.2 litre). However, this would be more difficult for unconcealed heating elements.
Amdea	Regarding immersed heating elements: The data is from testing on new electric kettles, but the data does not show behaviour over the lifetime of an electric kettle. *ISI: You are right. The assumptions are made for "new kettles". We do not have data regarding the impact of lifetime on the EE performance of the products and would welcome any data regarding this aspect.*
Topten	"Keep warm function": It would be helpful to have a comparison of how much energy is used by boiling vs. keeping the water warm. Without the information / comparison of whether keep-warm function makes sense, we cannot assess whether it is better to re-boil or to keep warm. *ISI: It is difficult to assess whether the feature makes sense, but we will provide information for a comparison*

ISI presented the feedbacks regarding the Design Option assumptions

The presentation was followed by a discussion:

abbr.	Comment/answer
UBA	Regarding the recyclability of electric kettles: Is there a reason why there was no design option regarding PCR? Should be easy to provide information in this area. *ISI: A predominant share of energy consumption within the overall life cycle of a kettle can be assigned to the use phase. PCR or recyclability in general play a minor role.*
Topten	1) Regarding the water level Indicator (overboiling): It is not clear what the proposed change was. The impact should be higher than proposed with regards to the reduced water. *ISI: Figures are based on different studies and adapted to the individual Base Case that is the reason why the saving potential seems to be rather low.* 2) Regarding the Keep-Warm function: If this option is automatically set on, the energy used is higher than when one has to manually activate the option. This should be included in this section of the report.

	ISI: This function is going to be addressed within Task 7 as a new policy option.
De Longhi	1) There are two different meanings of the word "boiling" at certain points in the report/presentation. One needs to be consistent with the meaning of "boiling". *ISI: we will correct. "over boiling" for boiling too much water and "over heating" for heating too long the water* 2) With regards to the minimum level of water – 0.2 litres, for example, are not feasible in some cases – if we look at large volume electric kettles for example. *ISI: Based on your expertise, please let us know what would be suitable minimum water level.* 3) Regarding the figures on Thick Film Heating Elements: It would be good to have more information and if ISI could share to all stakeholders the data. *ISI: We will ask the relevant stakeholder if the figures can be published.* 4) With reference to the 95°C boiling concept: Water boils at 100°C (boiling point) and customers want to hear the noise the electric kettle makes when temperature reaches 100°C. Hence, we do not agree with a temperature lower than 100 degrees. *ISI: We agree that water boils at 100°C at 1 atm. Considering a potential heating process stop at 95°C: we do believe -depending on measuring approach- that boiling noises are occurring at water temperatures of 95°C.*

ISI presented the Testing Procedure and Energy Efficiency Metrics

The presentation was followed by a discussion:

abbr.	Comment/answer
Topten	In the proposed procedure, it is not reflected if/when there are kettles with different pre-setting temperatures. This aspect should be reflected. *ISI: The pre-setting temperatures are not the same for the kettles, therefore it is problematic to include such a test in the procedure. We are open for suggestions to improve the current proposal regarding the test procedure. However, the regulation could take into account this EE feature.* However, it would be good to have some kind of measure anyways!
smeg	1) Proposal: It is easier to measure water by weight compared to volume. Water gets wasted by measuring its volume. Hence, it would be easier to measure the weight than the volume. 2) Regarding the definition of boiling: The reason as to why 100°C were not measured might be that it is quite difficult to measure when it reaches the boiling point in a lab. Furthermore, it depends on air pressure. 3) The regression between air pressure and boiling can be found in any handbook. The question is how to incorporate it into our method? It is not as easy as including a standard correction factor. I would suggest to keep it as described in the standard.
De Longhi	The indicated range of atmospheric pressure could be problematic: either you need an expensive pressure chamber in the test laboratory or it should be possible to apply a correction factor.
Otter	Instead of testing 1 litre only, it would be good to see test results for ½ litre as well and for large volume (when applicable). *ISI: Default is 1 litre. We would appreciate to receive comments on whether the stakeholders agree that other water volumes would be useful to test as well. Please note that the EE depends on the filled-in volume (the more water, the higher energy efficiency)*
ISI	What is the reason behind the approach of changing from degrees to Kelvin?

	Amdea: You were referring to a standard from 1975. Now, K is the SI unit for temperature. Shouldn't we use a new standard for going forward?
De Longhi	Regarding the preference of 1 SH (slide 33), we support the introduction of an eco-design measure. We also agree on the max. keep warm time (slide 35).

ISI presented the possible policy options

The presentation was followed by a discussion:

abbr.	Comment/answer
RVO	In our opinion, energy labelling is only useful if the variation of the range on the market and the theoretical improvement are given. There is a general issue without sufficient data on improvement potential (energy savings). Hence, more data on this is needed! *ISI: We agree. Regarding the lack of data: We were grateful to have received data from the Swedish Energy Agency as well as from one manufacturer (regarding the comparison of heating elements). We have also tested ourselves 8 kettles, in order to have more data for carrying out Task 5-7.*
Topten	If there is no data yet, it is difficult to say "We do not want a label". There is a need for more data.
De Longhi	We are against the indication of boiling time information on the kettle. The information might not be clear to users and an explanation would be needed.
UBA	Temperature display: What would a bonus look like if there are only ecodesign requirements and no label? *ISI: You are right, the bonus is generally used for labelling regulation. If we have only ecodesign requirements, we would have to consider whether a bonus could be included to take into account features that promote energy savings.*
De Longhi	Limescale: We support the information requirement. However, we do not agree to mandatory limescale protection. (The built-in-water filter and the limescale filter have two different functions.) *ISI: The user/customer wants to drink clean boiled water. Without technical measures for limescale, the user might boil a new batch of water and this wastes energy. The solution is therefore a built-in-water-filter or a limescale filter (which can be removable).*
UBA	It would be good to refer to standard EN 45555:2019 in terms of recyclability
RVO	The latest measures of eco-design would be helpful! However, the eco-design cannot influence recyclability of products. It only provides conditions so that product can be recycled.
RVO	Some of the latest ecodesign regulation require the marking of plastic in order to facilitate the recyclability of the materials
De Longhi	Concerning slide 42 (second row of the table): We should avoid different regulations for the same topics.

Wrap-up of meeting and closure of the meeting

The project team thanked the stakeholders for their participation and the valuable contributions during the meeting. Deadline to submit comments regarding the test procedure, the energy efficiency metrics and the possible policy options: **28th of October 2020**

7.7. Annex B – Input to legislation

Remark: In this annex, potential formulations of Ecodesign requirements for kettles are proposed, based on most - but not all - the policy proposals formulated in 7.1.2. A first draft was presented at the Consultation Forum on 29.01.2021. The version presented below includes minor changes, mainly regarding the wording in the measurement method.

Article 1
Subject matter and scope

This Regulation establishes ecodesign requirements for the placing on the market or the putting into service of electric mains-operated kettles with a rated volume up to 10 litres.

This Regulation shall not apply to:

1. kettles which are not stand-alone;
2. pressurized appliances.

Article 2
Definitions

For the purposes of this Regulation the following definitions shall apply:

(1) 'electric mains' means the electricity supply from the grid of 230 (± 10 %) volts of alternating current at 50 Hz;

(2) 'kettle' means a portable appliance for boiling water with means for pouring, either a lip or spout. Potentially it also includes the possibility to heat water below boiling temperature and/or a warm-keeping function after heating.

(3) 'equivalent model' means a model which has the same technical characteristics relevant for the technical information to be provided, but which is placed on the market or put into service by the same manufacturer, importer or authorised representative as another model with a different model identifier;

(4) 'model identifier' means the code, usually alphanumeric, which distinguishes a specific product model from other models with the same trade mark or the same manufacturer's, importer's or authorised representative's name;

(5) 'product database' means a collection of data concerning products, which is arranged in a systematic manner and consists of a consumer-oriented public part, where information concerning individual product parameters is accessible by electronic means, an online portal for accessibility and a compliance part, with clearly specified accessibility and security requirements, as laid down in Regulation (EU) 2017/1369;

For the purposes of the annexes, additional definitions are set out in Annex A.

Article 3
Ecodesign requirements

The ecodesign requirements set out in Annex B shall apply.

Article 4
Conformity assessment

The conformity assessment procedure referred to in Article 8 of Directive 2009/125/EC shall be the internal design control system set out in Annex IV to that Directive or the management system set out in Annex V to that Directive.

1. For the purposes of the conformity assessment pursuant to Article 8 of Directive 2009/125/EC, the technical documentation shall contain a copy of the product information provided in accordance with point 4 of Annex D, and the results of the calculations undertaken in accordance with Annex C.

2. Where the information included in the technical documentation for a particular model has been obtained:

(a) from a model that has the same technical characteristics relevant for the technical information to be provided but is produced by a different manufacturer; or

(b) by calculation on the basis of design or extrapolation from another model of the same or a different manufacturer, or both;

the technical documentation shall include the details of such calculation, the assessment undertaken by the manufacturer to verify the accuracy of the calculation and, where appropriate, the declaration of identity between the models of different manufacturers.

3. The technical documentation shall include a list of all equivalent models, including the model identifiers.

Article 5
Verification procedure for market surveillance purposes

Member States' authorities shall apply the verification procedure set out in Annex XX when performing the market surveillance checks referred to in Article 3, point 2 of Directive 2009/125/EC.

Article 6
Circumvention and software updates

The manufacturer, importer or authorised representative shall not place on the market products designed to be able to detect they are being tested (for example by recognising the test conditions or test cycle) and to react specifically by automatically altering their performance during the test with the aim of reaching a more favourable level for any of the parameters in the technical documentation or included in any documentation provided.

The energy consumption of the product and any of the other declared parameters shall not deteriorate after a software or firmware update when measured with the same test standard originally used for the declaration of conformity, except with explicit consent of the end-user prior to the update. No performance change shall occur as a result of rejecting the update.

A software update shall never have the effect of changing the product's performance in a way that makes it non-compliant with the ecodesign requirements applicable for the declaration of conformity.

Article 7
Indicative benchmarks

The indicative benchmarks for the best-performing products and technologies available on the market at the time of adopting this Regulation are set out in Annex XX.

Article 8
Review

The Commission shall review this Regulation in the light of technological progress and shall present the results of this review, including, if appropriate, a draft revision proposal, to the Consultation Forum by [date - OP please add 6 years after entry into force].

The review shall in particular focus on the following:

- the improvement potential with regard to energy and environmental performance of kettles.
- the effectiveness of existing requirements on resource efficiency;
- the appropriateness of the testing procedure;
- the level of the verification tolerances;
- the calculation of the standard energy consumption;
- the appropriateness of setting additional resource efficiency requirements for products in accordance with the principles of the circular economy, including whether more spare parts should be included.

Article 9
Entry into force and application

This Regulation shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

Article 3 shall apply from [date – OP please insert date one year after entry into force].

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Annex A

Definitions applicable to potential ecodesign requirements

The following definitions shall apply:

(1) 'Energy Efficiency Index' (EEI) means the ratio of the heat - theoretically needed to bring the rated capacity of water from 15°C to 95°C - and the electricity consumed to heat the same amount of water until shut-off, the water has to be heated up to at least 95°C;

(2) 'container' means the reservoir where the water is heated;

(3) 'temperature setting' means a feature by which the target water temperature can be pre-set;

(4) 'keep-warm' means a function, which keeps the water temperature in the range of a pre-set temperature.

(5) 'keep-warm time' mean the duration during which the keep-warm function is active;

(6) 'immersed heating element' means a heating element that is directly integrated in the container of a kettle and stands in immediate and direct heat exchange with the liquid;

(7) 'concealed heating element' means a concealed heating element separated from the liquid by a heat exchanging element;

(8) 'Rcyc' means the recyclability rate;

(9) 'Rpost' means the post-consumer materials content;

(10) 'Post-consumer material' means material recovered from waste generated by households or by commercial, industrial and institutional facilities in their role as end-users of finished product

(11) 'lift-off / switch-off' means a function, which switches off a kettle when the container is lifted from the base. The kettles remains "off" when it is placed back on the base;

(12) 'base' means the component of a cordless kettle, which is directly linked with the power cord

(13) 'cordless kettle' is a kettle, where the container can be removed from the base;

(14) 'spare part' means a separate part that can replace a part with the same or similar function in a product;

(15) 'professional repairer' means an operator or undertaking which provides services of repair and professional maintenance of kettles;

(16) 'declared values' means the values provided by the manufacturer, importer or authorised representative for the stated, calculated or measured technical parameters in accordance with Article 4, for the verification of compliance by the Member State authorities;

(17) 'guarantee' means any undertaking by the retailer or a manufacturer to the consumer to: reimburse the price paid; or replace, repair or handle kettles in any way if they do not meet the specifications set out in the guarantee statement or in the relevant advertising.

Annex B

Proposed Ecodesign requirements

1. ENERGY EFFICIENCY REQUIREMENTS

The energy efficiency index (EEI) of kettles, calculated pursuant to the methodology set out in Annex C, shall not be below 83 %.

2. FUNCTIONAL REQUIREMENTS

Kettles shall meet the following requirements:

(1) Kettles with keep-warm function:

(a) Keep-warm function should be off by default when a user switches on the kettle;

(b) Keep-warm time shall be limited to a maximum of 30 minutes;

(c) Temperature drop (T_{drop}) during cool-down test shall be lower than 20 K.

(2) "lift-off / switch-off" function is mandatory for cordless kettles;

(3) indication of the minimum volume of water to be filled:

(4) mandatory dual water level indication on the appliance in litre and in cup (cup volume of 0.125 litre)

3. MATERIAL EFFICIENCY REQUIREMENTS

Kettles shall meet the following requirements:

3.1. Design for repair and reuse

(1) availability of spare parts:

(a) manufacturers, importers or authorised representatives of kettles shall make available to professional repairers and end-users at least the following spare parts: motherboard, switches, heating elements, temperature sensors, fuses, base, lids and limescale filters for a minimum period of six years, after placing the last unit of the model on the market;

(b) manufacturers shall ensure that these spare parts can be replaced with the use of commonly available tools and without permanent damage to the appliance;

(c) the list of spare parts concerned by point (a) and the procedure for ordering them and finding the repair instructions shall be included in the user manual and made publicly available on the manufacturer's, the importer's or authorised representative's free access website, at the moment of the placing on the market of the first unit of a model and until the end of the period of availability of these spare parts.

(d) The price and shipping costs of the spare parts concerned by point (a), and their period of applicability shall be provided in the product information sheet defined in Annex D.

(2) access to repair and maintenance information:

after the placing on the market of the first unit of a model or of an equivalent model, and for a minimum period of six years, after placing the last unit of the model on the market, the manufacturer, importer or authorised representative shall provide access to the appliance repair and maintenance information to professional repairers in the following conditions:

(a) the manufacturer's, importer's or authorised representative's website shall indicate the process for professional repairers to register for access to information; to accept such a request, manufacturers, importers or authorised representative may require the professional repairer to demonstrate that:

(1) the professional repairer has the technical competence to repair kettles and complies with the applicable regulations for repairers of electrical equipment in the Member States where it operates. Reference to an official registration system as professional repairer, where such system exists in the Member States concerned, shall be accepted as proof of compliance with this point;

(2) the professional repairer is covered by insurance covering liabilities resulting from its activity, regardless of whether this is required by the Member State;

(b) the manufacturers, importers or authorised representatives shall accept or refuse the registration if the repairer does not fulfil the criteria listed under points (a)(1) and (a)(2) within 5 working days from the date of request by the professional repairer;

(c) manufacturers, importers or authorised representatives shall provide free access to the repair and maintenance information or for receiving regular updates;

(d) once registered, a professional repairer shall have access, within one working day after requesting it, to the requested repair and maintenance information. The available repair and maintenance information shall include:

- the unequivocal appliance identification;
- a disassembly map or exploded view;
- list of necessary repair and test equipment;
- component and diagnosis information (such as minimum and maximum theoretical values for measurements);
- wiring and connection diagrams;
- diagnostic fault and error codes (including manufacturer-specific codes, where applicable); and
- data records of reported failure incidents stored on the kettle (where applicable).

(3) maximum delivery time of spare parts:

Without prejudice to point (1), the manufacturer, importer or authorised representatives shall ensure the delivery of the spare parts within 15 working days after having received the order.

3.2. Recyclability requirements

The recyclability rate (in weight) Rcyc of a kettle shall be higher than 75%.

In addition:

(1) Manufacturers, importers or their authorised representatives shall ensure that joining, fastening or sealing techniques do not prevent the removal, using commonly available tools, of the components indicated in point 1 of Annex VII of Directive 2012/19/EU on WEEE or in Article 11 of Directive 2006/66/EC of the European Parliament and of the Council (1) on batteries and accumulators and waste batteries and accumulators, when present.

(2) Manufacturers, importers or their authorised representatives shall, without prejudice to point 1 of Article 15 of Directive 2012/19/EU, make available, on a free-access website, the dismantling information needed to access any of the products components referred to in point 1 of Annex VII of Directive 2012/19/EU.

(3) This dismantling information shall include the sequence of dismantling steps, tools or technologies needed to access the targeted components.

(4) The end of life information listed under points (1), (2) and (3) shall be available until at least 15 years after the placing on the market of the last unit of a product model.

3.3. Requirements on plastic components

(1) Plastic components heavier than 25 g:

(a) shall be marked by specifying the type of polymer with the appropriate standard symbols or abbreviated terms set between the punctuation marks '>' and '<' as specified in available standards. The marking shall be legible.

Plastic components are exempt from marking requirements in the following circumstances:

- the marking is not possible because of the shape or size; or
- the marking would impact on the performance or functionality of the plastic component.

For the following plastic components no marking is required:

- packaging, tape, labels and stretch wraps;
- wiring, cables and connectors, rubber;
- PCB assemblies, PMMA boards, optical components, electrostatic discharge components, electromagnetic interference components, speakers;
- transparent parts where the marking would obstruct the function of the part in question.

(b) shall additionally be marked if they contain flame retardants with the abbreviated term of the polymer followed by hyphen, then the symbol 'FR' followed by the code number of the flame retardant in parentheses. The marking on the enclosure and stand components shall be clearly visible and readable.

(2) Plastic parts intended to be touched in normal use (e.g. handles and controls) shall contain less than 10 mg/kg of polycyclic aromatic hydrocarbons (PAHs) and less than 1 mg/kg benzo[a]pyrene

(3) For plastics used in the container and the base:

(a) No substances may be added to the plastics as constituent parts, which are classified as:

- carcinogenic of category 1 or 2 according to Table 3.2 or category 1A or 1B according to Table 3.1 of Annex VI to Regulation (EC) No 1272/2008[80]
- mutagenic of category 1 or 2 according to Table 3.2 or category 1A or 1B according to Table 3.1 of Annex VI to Regulation (EC) No 1272/2008
- toxic to reproduction of category 1 or 2 according to Table 3.2 or category 1A or 1B according to Table 3.1 of Annex VI to Regulation (EC) No 1272/2008
- being of very high concern for other reasons according to the criteria of Annex XIII to the REACH Regulation, provided that they have been included in the List (so-called "Candidate List9) set up in accordance with REACH, Article 59, paragraph 1.

(b) Halogenated polymers shall not be permitted. Nor may halogenated organic compounds be added as flame retardants. Moreover, no flame retardants may be added that are classified pursuant to Table 3.1 or 3.2 in Annex VI to Regulation (EC) 1272/2008 as very toxic to aquatic organisms with long-term adverse effects and assigned the Hazard Statement H410 or Risk Statement R50/53.

The following shall be exempt from this rule:

- process-related, technically unavoidable impurities;
- fluoroorganic additives (as, for example, anti-dripping agents) used to improve the physical properties of plastics, provided that they do not exceed 0.5 weight percent;

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[80] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006, Annex VI Harmonized classification and labelling for certain hazardous substances, Part 3: Harmonized classification and labelling – Tables, Table 3.2, – List of harmonized classification and labelling of dangerous substances from Annex A to Directive 67/548/EEC.

– plastic parts, less than 25 grams in mass.

4. INFORMATION REQUIREMENTS

Kettles shall be accompanied by the information listed under Annex D.

Annex C

Proposed measurement methods and calculations

1. DEFINITIONS

- V_{rated} [l]: rated water capacity of the kettle;
- V_{min} [l]: minimum water capacity of the kettle;
- E: electricity consumed until the kettle shuts off under the test condition;
- T_{kw} [°C]: average water temperature in keep-warm mode when the highest keep-warm temperature is selected;
- $E_{95°C,Vrated}$ [Wh]: electricity consumed to heat the rated water capacity from T_1 by 80K. It is measured until the kettle shuts off;
- $E_{95°C,1}$ [Wh]: electricity consumed to heat 1 litre of water from T_1 by 80K. It is measured until the kettle shuts off;
- $E_{95°C,Vmin}$ [Wh]: electricity consumed to heat the minimum water capacity from T_1 by 80K. It is measured until the kettle shuts off;
- $E_{70°C,Vrated}$ [Wh]: electricity consumed to heat the rated water capacity from T_1 until shut-off, when 70°C pre-set temperature (or the nearest pre-set temperature above 70°C) is selected. It is measured until the kettle shuts off;
- $E_{70°C,Vmin}$ [Wh]: electricity consumed to heat the minimum water capacity from T_1 until shut-off, when 70°C pre-set temperature (or the nearest pre-set temperature above 70°C) is selected. It is measured until the kettle shuts off;
- P_{rated} [W]: rated input power
- $P_{kw,Vrated}$ [W]: average input power to keep warm the rated water capacity when the highest keep-warm temperature is selected;
- $p_{kw,Vrated}$ [W/l]: specific input power to keep warm the rated water capacity when the highest keep-warm temperature is selected;
- C: specific heat capacity of water;
- $t_{95°C,Vmin}$ [s]: time to raise the temperature of the minimum water capacity from T_1 by 80K. It is measured until the kettle shuts off;
- $t_{95°C,Vrated}$ [s]: time to raise the temperature of the rated water capacity from T_1 by 80K. It is measured until the kettle shuts off;
- $t_{95°C,1}$ [s]: time to raise the temperature of 1 litre of water from T_1 by 80K. It is measured until the kettle shuts off;
- $t_{70°C,Vrated}$ [s]: time to heat the rated water capacity when 70°C pre-set temperature (or the nearest pre-set temperature above 70°C) is selected. It is the time to raise the temperature from T_1 until the kettle shuts off;
- $t_{70°C,Vmin}$ [s]: time to heat the minimum water capacity when 70°C pre-set temperature (or the nearest pre-set temperature above 70°C) is selected. It is the time to raise the temperature from T_1 until the kettle shuts off;
- t_{KWmax} [min]: maximum keep-warm time;
- keep-warm: function which keeps the water temperature in the range of a pre-set temperature.
- $P_{standby}$ [W]: power consumption in stand-by mode
- $P_{off\text{-}mode}$ [W]: power consumption in off-mode
- cool-down test: test carried out to measure how fast water cools down after having be heated in a kettle
- T_{drop} [°C]: water temperature drop measured during the cool-down test

- N_{cyc} [-]: number of cycles carried out successfully with the same kettle during the durability test

2. GENERAL CONDITIONS FOR MEASUREMENTS

In this document, in order to facilitate the testing, **the quantity of cold-water indicated in litre is assumed to be the same in kg**.[81]

Testing conditions:

- ambient temperature and appliance preconditioned at a temperature: 20 +/- 3°C;
- cold water temperature: 15 +/- 1°C;
- the water temperature is measured by a watertight thermocouple situated 10 mm above the bottom centre of the water container (the 10mm position can be adapted to keep the thermocouple within the water for tests with a small amount of water) or the highest end of the electric heating element[82];
- testing room: substantially draught free.
- input: rated input.

3. MEASURING METHODS

3.1. Definition of the energy efficiency

The energy efficiency is calculated as the ratio of the theoretical energy demand needed to bring a defined amount of cold water T_1 to the target temperature T_2 in relation to the measured electricity consumed until shut-off to heat the same amount of water under the same conditions:

$$\eta = \frac{C \cdot V \cdot (T_2 - T_1)}{E \cdot 3600}$$

Where:

- C: specific heat capacity of water, 4186 J/(kg.K), at 15°C and 101 kPa
- V: volume of water in l
- T_1: initial water temperature, expressed in °C; T_1 = 15°C in all tests performed according to this standard
- T_2: final water temperature, expressed in °C;
- E: electricity consumed until shut-off, expressed in Wh.

3.2. Definition of the standardised energy consumption

The standardised energy consumption (SEC) [kWh] for heating 100 litres of water is calculated as follows:

$$SEC = \frac{100}{1000} \cdot \frac{\left(30\% \cdot E_{95°C,Vmin} + 50\% \cdot E_{95°C,Vrated} + 20\% \cdot E_{70°C,Vrated}\right)}{30\% \cdot V_{min} + 70\% \cdot V_{rated}} + P_{standby} \cdot \frac{8760}{1000} \cdot \frac{1}{8}$$

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[81] accordingly, in the sense of this document, V_x and M_x correspond to the same quantity of water (x kg or x litre)

[82] in case of kettles with immersed heating element

Where,

- SEC: standardised energy consumption, expressed in kWh
- $E_{95°C,Vmin}$: electricity consumed to heat the minimum water capacity from T_1 by 80K , measured until the kettle shuts off, expressed in Wh
- $E_{95°C,Vrated}$: electricity consumed to heat the rated water capacity from T_1 by 80K, measured until the kettle shuts off, expressed in Wh
- $E_{70°C,Vrated}$: electricity consumed to heat the rated water capacity from T_1 until shut-off, when 70°C pre-set temperature (or the nearest pre-set temperature above 70°C) is selected. It is measured until the kettle shuts off, expressed in Wh;
- V_{min}: minimum water capacity of the kettle expressed in volume, expressed in litre;
- V_{rated}: rated water capacity of the kettle, expressed in litre;
- $P_{standby}$: power consumption in stand-by mode, expressed in W.

3.3. Tests procedures

Test 1: Energy consumption ($E_{95°C,Vrated}$) and time measurement ($t_{95°C,Vrated}$) for heating water by 80K and until shut-off at rated water capacity to determine the energy efficiency (EEI)

Fill the kettle with cold water (15°C) to the rated water capacity level of the kettle. Start the heating process and start timing ($t=t_s$). Measure the energy consumption $E_{95°C,Vrated}$ until the kettle shuts-off ($t=t_e$). The water temperature has to be heated by at least 80K. The heating time is measured as: $t_{95°C,Vrated} = t_e - t_s$ at test conditions.

Calculate the energy efficiency index as follows:

$$EEI = \eta_{95°C,Vrated} = \frac{C \cdot V_{rated} \cdot (95 - T_1)}{E_{95°C,Vrated} \cdot 3600}$$

Where:

- $\eta_{95°C,Vrated}$: is the energy efficiency of the kettle at rated water capacity and 80K increase.
- C: specific heat capacity of water, 4,186 J/(kg.K) at 15°C and 101 kPa
- V_{rated}: rated water capacity of a kettle, expressed in litre;
- T_1: initial water temperature, expressed in °C; T_1 = 15°C in all tests performed according to this test procedure
- $E_{95°C,Vrated}$: electricity consumed to heat the rated water capacity from T_1 by 80K, measured until the kettle shuts off, expressed in Wh.

Figure 16 shows a typical measurement for heating test to have as an example, in order to calculate the energy efficiency and the EEI of a kettle.

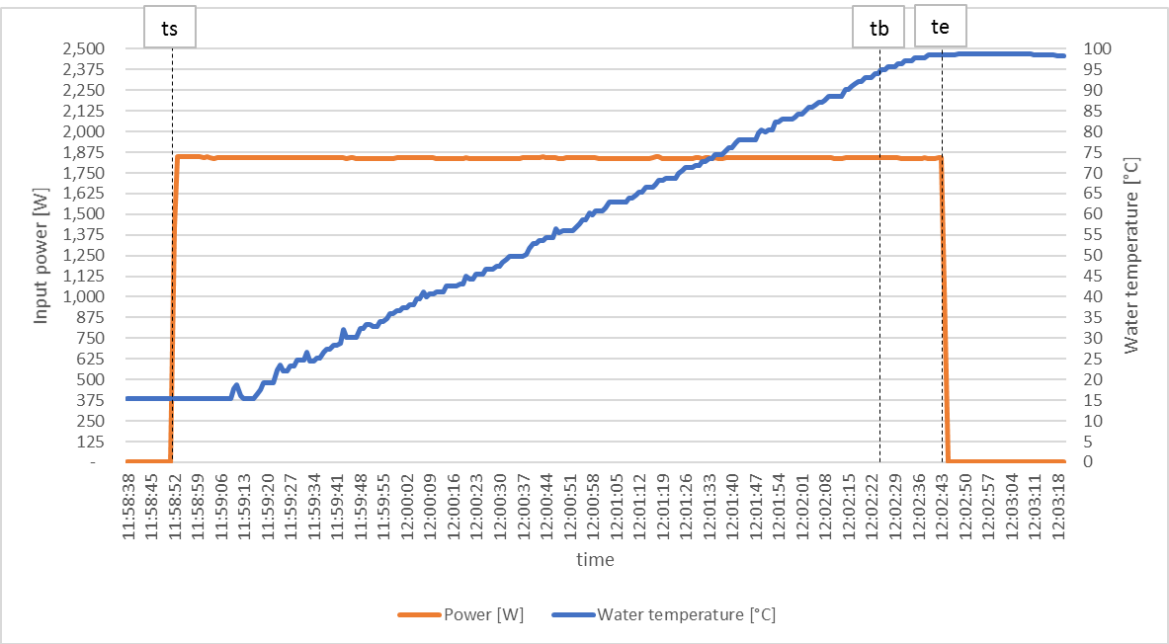


Figure 16. Example of heating test result measurements

Test 2: Energy consumption and time measurement for heating until shut-off at minimum water capacity

Fill the kettle with cold water (15°C) to the minimum water capacity level of the kettle. Start the heating process and start timing ($t=t_s$). Measure the energy consumption $E_{95°Cl,Vmin}$ until the kettle shuts-off ($t=t_e$). The water temperature has to be heated by at least 80K. The heating time is measured as: $t_{95°C,Vmin} = t_e - t_s$ at test conditions.

Test 3: Energy consumption and time measurement for heating tests until shut-off at volume = 1 litre.[83]

Fill the kettle with cold water (15°C) to 1 litre of water. Start the heating process and start timing ($t=t_s$). Measure the energy consumption $E_{95°C,1}$ until the kettle shuts-off ($t=t_e$). The water temperature has to be heated by at least 80K. The heating time is measured as: $t_{95°C,1} = t_e - t_s$ at test conditions.

Test 4: Energy consumption and time measurement for heating until shut-off at pre-set temperature of 70°C (or the nearest pre-set temperature above 70°C) at the rated water capacity

Fill the kettle with cold water (15°C) to the rated water capacity level of the kettle. Start the heating process ($t=t_s$). Measure the energy consumption $E_{70°C,Vrated}$ until the kettle shuts off ($t=t_e$). It shall be verified, that the water temperature is higher than 70°C when the kettle shuts off ($T_{t=te} \geq 70°C$). The heating time is measured as $t_{70°C,Vrated} = t_e - t_s$ at the condition of the test.

83 applicable if $V_{rated}>1$ litre

Figure 17 shows a typical energy efficiency measurement for heating test at pre-set temperature to have as an example.

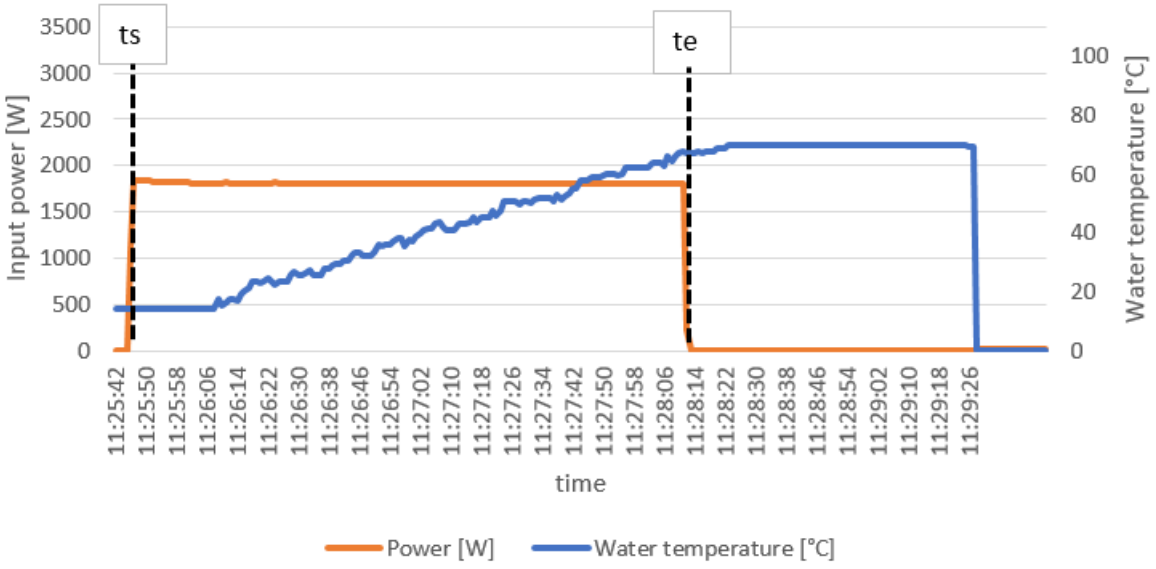


Figure 17. Example of a heating test at pre-set temperature measurements (here with 70°C)

Test 5: Energy consumption and time measurement for heating until shut-off at pre-set temperature of 70°C (or the nearest pre-set temperature above 70°C) at minimum water capacity

Fill the kettle with cold water (15°C) to the minimum water capacity level of the kettle. Start the heating process ($t=t_s$). Measure the energy consumption $E_{70°C,Vmin}$ until the kettle shuts off ($t=t_e$). It shall be verified, that the water temperature is higher than 70°C when the kettle shuts off ($T_{t=te} \geq 70°C$). The heating time is measured as $t_{70°C,Vmin} = t_e - t_s$ at the condition of the test.

Test 6: Average input power, average water temperature and maximum keep warm time measurement for keep warm function at maximum keep warm temperature and maximum time setting at a rated water capacity

Fill the kettle with cold water (15°C) to the rated water capacity level of the kettle; select the highest pre-set temperature for keep-warm function and the longest possible keep-warm time and start. At the end of the heating process, the keep-warm phase starts ($t=t_{kw-s}$). Measure the average input power P_{kw} and the average water temperature T_{kw} during the keep-warm phase. Check that T_{kw} corresponds to the pre-set temperature +/- 3°C. The maximum keep-warm time t_{KWmax} is defined as $t_{kw-e} - t_{kw-s}$.[84]

Calculate the specific average power input as follows:

[84] t_{KWmax} corresponds to an entire number of heating cycles

$$p_{kw,Vrated} = \frac{P_{kw,Vrated}}{V_{rated}}$$

Where:

- $P_{kw,Vrated}$: average input power to keep warm the rated water capacity when the highest keep-warm temperature is selected, expressed in W;
- V_{rated}: rated water capacity of a kettle, expressed in litre;
- $p_{kw,Vrated}$: specific input power to keep warm the rated water capacity when the highest keep-warm temperature is selected, expressed in W/l.

Figure 18 shows a typical measurement of a keep-warm test.

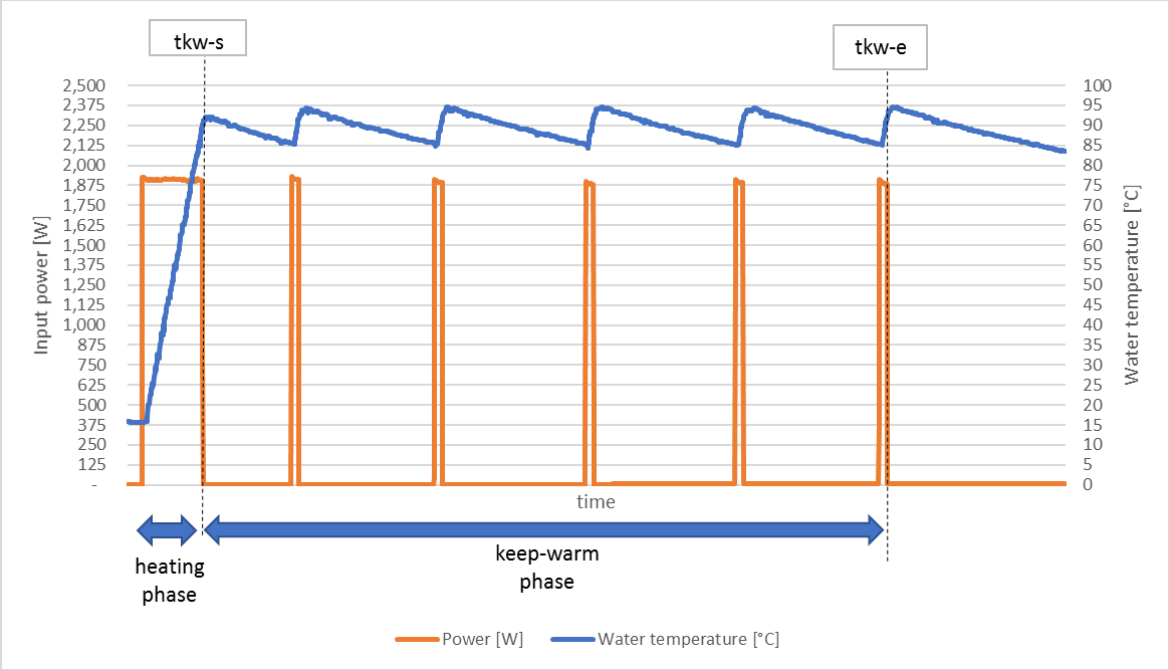


Figure 18. Example of keep-warm test measurements

Test 7: Temperature drop for cool-down 30 minutes after boiling at rated water capacity

Fill the kettle with cold water (15°C) to the rated water capacity level of the kettle. Start the boiling process. Measure the water temperature when the boiling process stops ($t=t_s$) and 30 minutes later. Report the temperature drop $T_{drop} = T_{(t=ts)} - T_{(t=te)}$.

Figure 19 shows typical measurements of a cool-down test to have as an example.

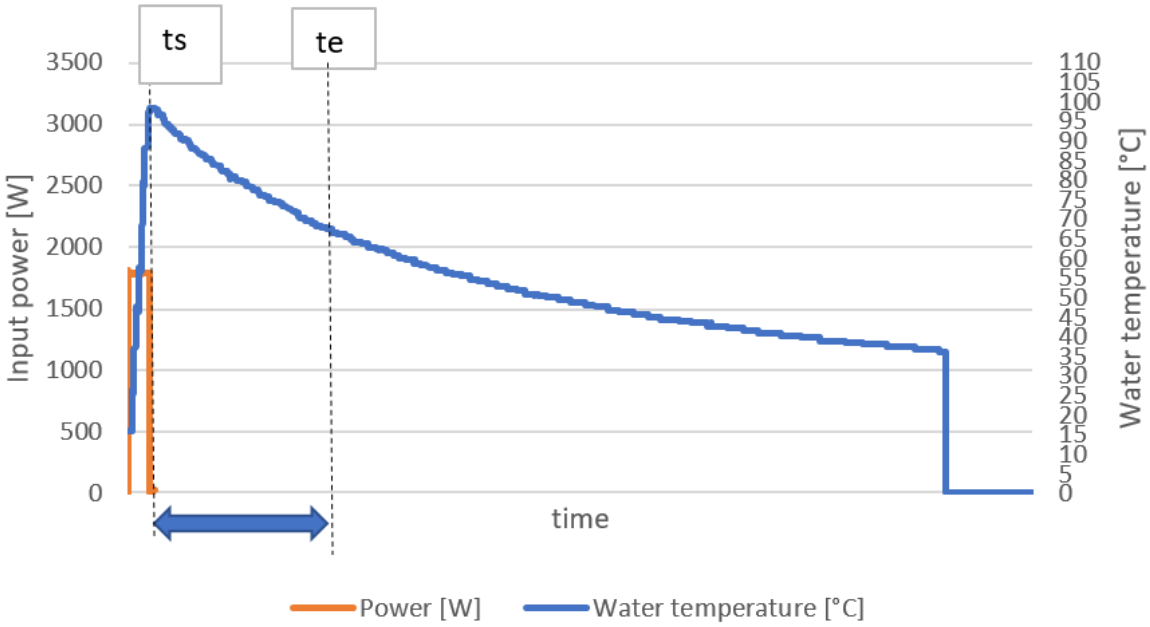


Figure 19. Example of cool-down test measurements

Test 8: Stand-by and off-mode tests

To be measured according to according to current harmonized standard.

Test 9: Durability test

Each cycle is defined as follows: fill in the container with 1 litre of cold water and boil the water, check that the water temperature could at least reach 95°C. After the kettle shuts off, pour the water out. The kettle shall work normally, meaning the power switch shall operate smoothly; the lid shall open and close without smoothly, the container has no leak. Repeat the cycle and when required, descale the kettle.

The maximum number of cycles carried out successfully with the same kettles is N_{cyc}.

Table 21 shows a summary of the required test measurements and calculations.

Table 21. Overview of the test conditions and calculation of the results

Test number	Type of test	Quantity of water	Measurement	Parameters measured or calculated
Test 1	Heating 80K	Rated water capacity	Until shut-off (at least +80K)	$E_{95°C,Vrated}$ $t_{95°C,Vrated}$ EEI
Test 2	Heating 80K	Minimum water capacity	Until shut-off (at least +80K)	$E_{95°C,Vmin}$ $t_{95°C,Vmin}$
Test 3	Heating 80K	1 litre (*)	Until shut-off (at least +80K)	$E_{95°C,1}$ $t_{95°C,1}$
Test 4	Heating	Rated water capacity	Until shut-off, when 70°C pre-set temperature (or the nearest pre-set temperature above 70°C) is selected	$E_{70°C,Vrated}$ $t_{70°C,Vrated}$
Test 5	Heating	Minimum water capacity	Until shut-off, when 70°C pre-set temperature (or the nearest pre-set temperature above 70°C) is selected	$E_{70°C,Vmin}$ $t_{70°C,Vmin}$
Test 6	Keep-warm	Rated water capacity	Max keep-warm temperature selected Longest possible keep-warm time	t_{kwmax} T_{kw} $P_{kw,Vrated}$ $p_{kw,Vrated}$
Test 7	Cool down	Rated water capacity		T_{drop}
Test 8	Standby	0 litre	According to current harmonized standard	$P_{standby}$
Test 9	Durability	1 litre (or V_{rated} if V_{rated} > 1litre)	Until shut-off (at least +80K)	N_{cyc}

n.a. not applicable

* applicable if V_{rated} > 1 litre

Definition of the recyclability rate

The recyclability rate R_{cyc} shall be calculated in conformance with EN 45555:2019 "General methods for assessing the recyclability and recoverability of energy-related products".

Definition of the post-consumer materials content

The post-consumer materials content R_{post} shall be calculated in conformance with EN 45557:2020 "General method for assessing the proportion of recycled material content in energy-related products".

Annex D

Proposed information requirements

The product manufacturer, importer or authorised representative shall make available the following information in a printed format with the product and online, either through the product database set up pursuant to Article 12 of Regulation (EU) 2017/1369 or on a free-access website.

Table 22: Product information sheet

ELECTRIC KETTLE	
Supplier's name or trade mark:	
Supplier's address:	
Model identifier:	
Made in: [Add country where the appliance is assembled]	
1. Recommendations	*Ensuring that only the required amount of water is heated to the required temperature can significantly reduce the energy use of your kettle, save time and money (see below under points 3 and 4)* *Descale the kettle regularly, since limescale deposit will reduce the energy efficiency and the lifetime of your appliance* *If your kettle is damaged or no longer working, it may be repaired. See information regarding spare parts availability under point 5*
2. General information	
Parameter	**Value**
Keep-warm function	YES/NO
Type of heating element	Concealed/Immersed
Rated capacity in l [V_{rated}]	X,X
Rated power in W [P_{rated}]	X
Standby consumptions in W [$P_{standby}$]	X
Temperature settings	[No], [T1, T2,...], [Tmin-Tmax], [Tmin-Tmax with x °C step]
Standardised energy consumption [SEC], in kWh[1]	XXXX,XX
Specific keep-warm power at maximum temperature and rated volume [pkw,V_{rated}] in W/l[2,4]	XX,XX

Maximum keep warm time [t_{KWmax}], in min[2,4]	XXXX	
Temperature decrease after 30 min [T_{drop}], in °C[3,4]	XX	
Rated number of cycles	XXXXX	
Environmental label(s) obtained	Indicate which if any.	
GHG offsetting certificates obtained	Indicate which if any	
Guarantee duration, in years		
Recyclability rate [Rcyc] (>= 75% required)	XX %	
Post-consumer material content [Rpost]	XX %	
3. Energy consumption in Wh		
Water volume in litre	[replace by 70°C pre-set temperature (or the nearest pre-set temperature above 70°C)]**	+80K (until automatic shut-off)
[replace by V_{min}]		
1.0 [remove if V_{rated} =<1]		
[replace by V_{rated}]		
4. Time required (in s)		
Water volume in litre	[replace by 70°C pre-set temperature (or the nearest pre-set temperature above 70°C)]**	+80K (until automatic shut-off)
[replace by V_{min}]		
1 [remove if V_{rated} =<1]		
[replace by V_{rated}]		
5. Spare parts		
Spare parts ordering information	website	

List of available spare parts (also after the time of guarantee)*				
Name	**Part number**	**Available**	**Professional required for reparation/change**	**Maximum Price**
Lid				
Limescale filter				
Container				
Base				

[1] As set in Annex C, section 3.2

[2] As set in Annex C, section 3.3, Test 6.

[3] As set in Annex C, section 3.3, Test 7.

[4] Applicable only for kettles with keep warm function

* Add additional spare parts in the list if applicable

** only applicable for kettle with temperature pre-setting

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