European Commission

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

Task 5: Environment & Economics (final draft)

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

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ABOUT THIS DOCUMENT

14.12.2020 - Final draft: Task 5 draft for stakeholder consultation based on a consultation document with data and assumptions presented and commented by stakeholders (THIS DOCUMENT)

Please be aware that this draft consultation document is only published for receiving stakeholder comments to the Ecodesign Process. It may still undergo substantial revisions prior to being released as a final report of this study.

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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

Description		BC 1	BC 2	BC 3
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.

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.

---

[1] without packaging

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

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 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:

---

[3] one NTC sensor

- 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

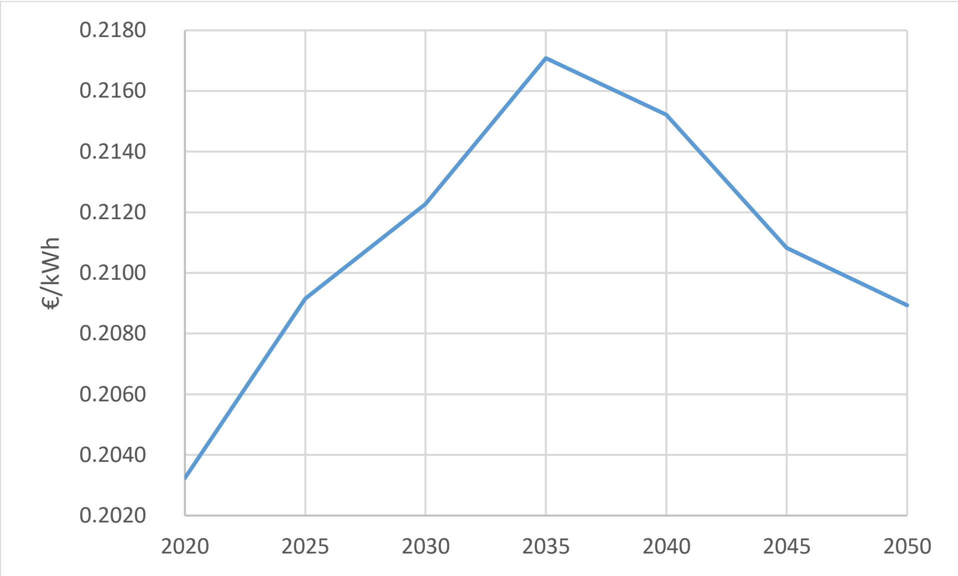
	Description		BC 1	BC 2	BC 3
Market	Sales in 2020	[-]	2,301,402	12,120,719	920,561
	Stock in 2020	[-]	14,536,872	76,560,861	5,814,749
	Lifetime	[a]	6.0	6.0	6.0
Economic data	Price	[€]	16.00	26.00	62.00
	water (for boiling)	[€/a]	2.39	2.39	2.39
	water (for descaling)	[€/a]	0.04	0.07	0.07
	installation	[€/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.

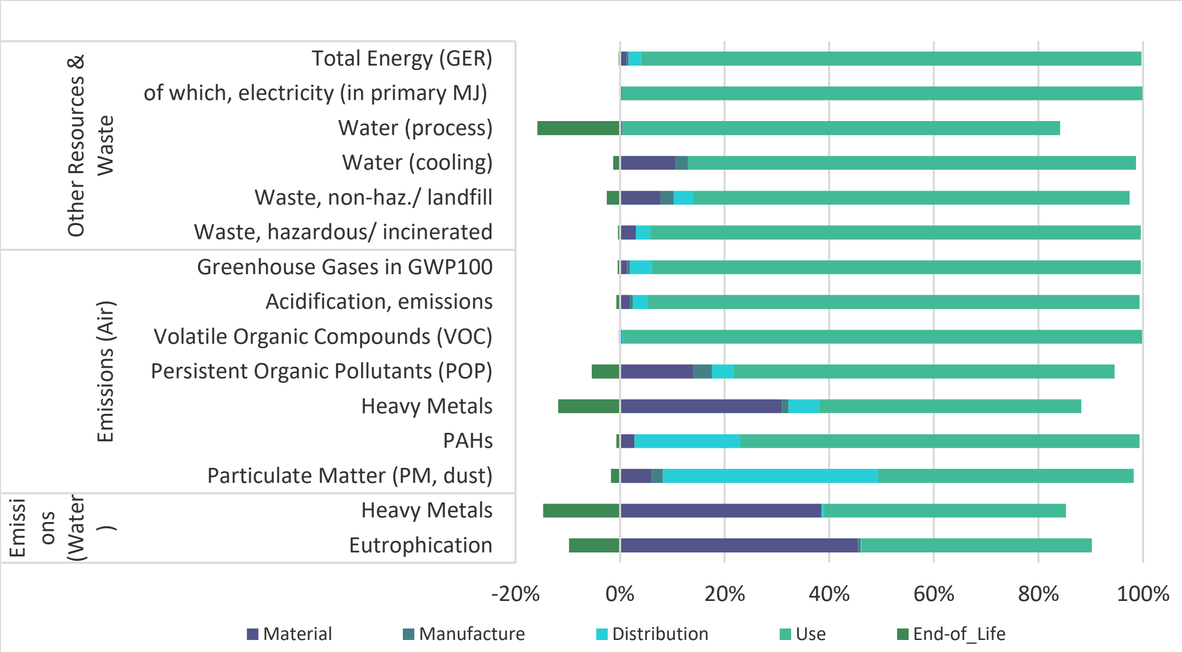
Table 5-7: Base Case 1 – Lifetime impact

	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

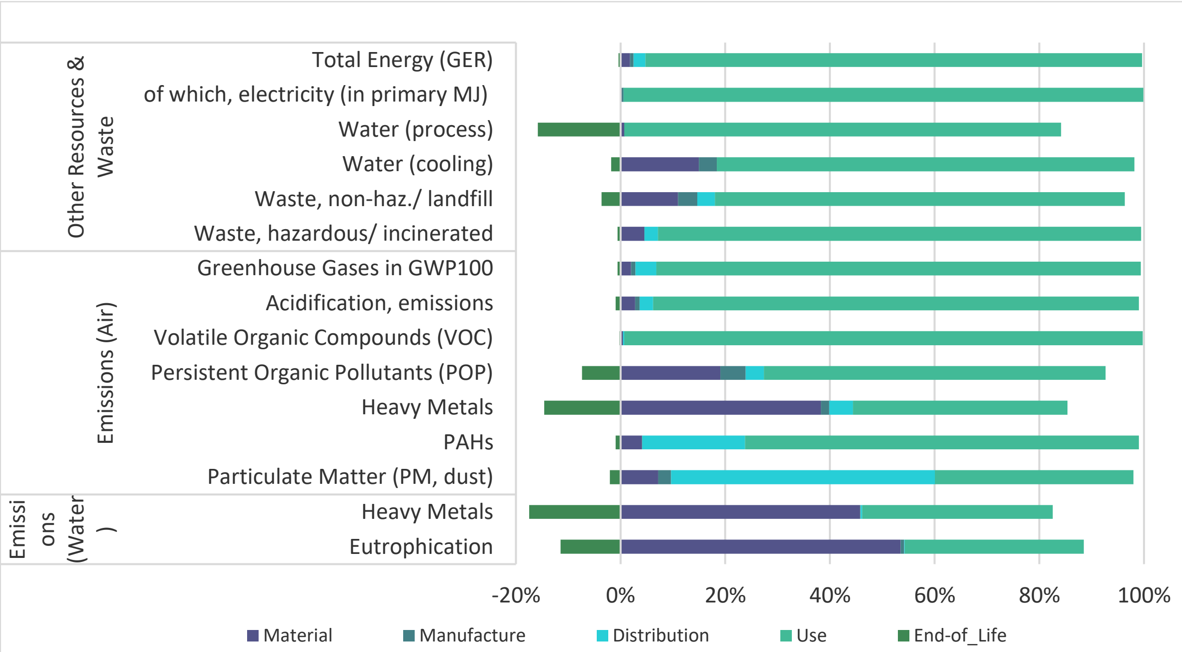
The total environmental impacts over the life cycle for the Base Case 2 according to EcoReport calculations are listed in Table 5-8, and the contribution of each life cycle stage is presented in Figure 5-3. These figures are based on 800 litre water boiled per year for six years.

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

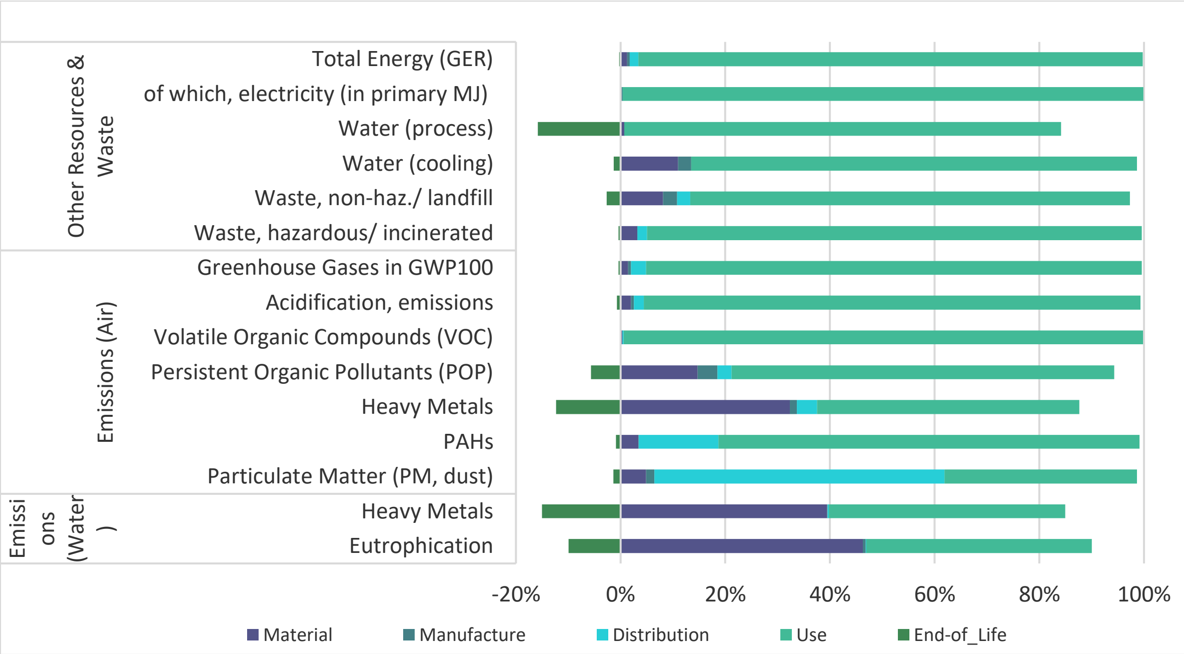
The total environmental impacts over the life cycle for the Base Case 3 according to EcoReport calculations are listed in Table 5-9, and the contribution of each life cycle stage is presented in Figure 5-4. These figures are based on 800 litre water boiled per year for six years.

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.€

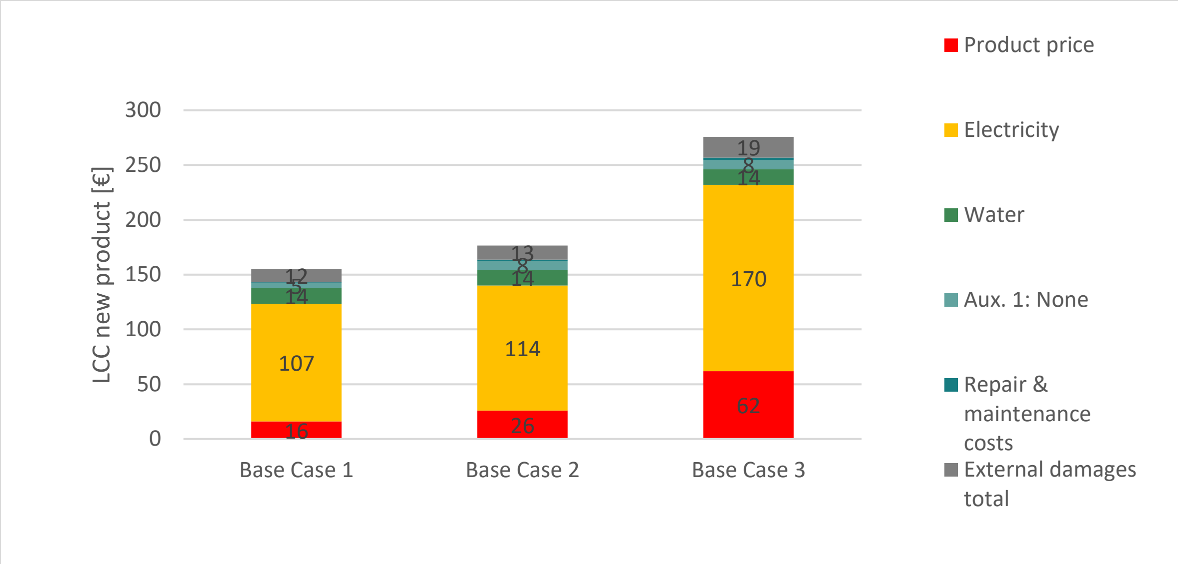
Societal costs, i.e. external damage is 19 Euros per product, or 18 million Euros for all products covered by this Base Case.

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. m³	79.05	96.86	417.45	510.12	31.71	38.74	528.21	645.72
14	Water (cooling)	mio. m³	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

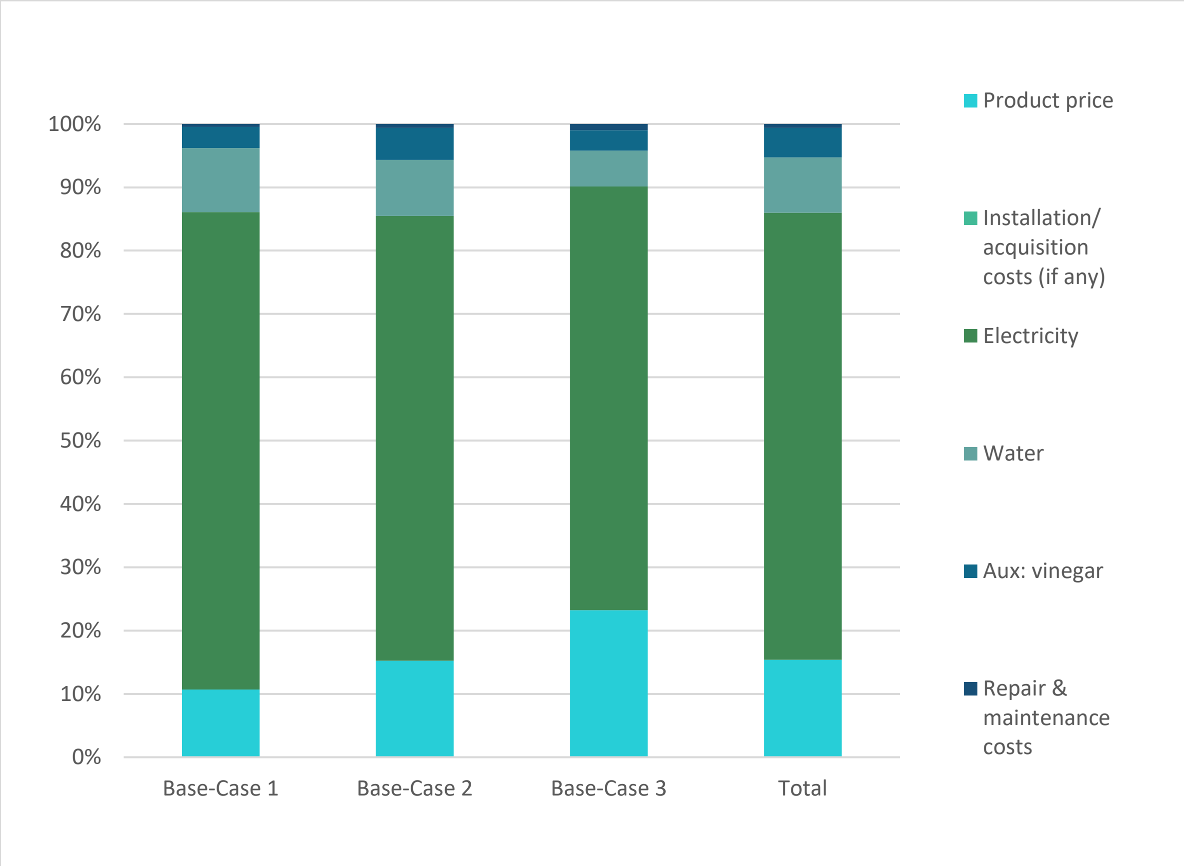
Details on consumer expenditure are provided in Table 5-15. These results come from the EcoReport tool which takes into account the various costs per machine and then extrapolates them for the year 2020 by using the sales and stock data.

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).

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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

Document subject to a legal notice (see below)

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

Version 3.06 VHK for European Commission 2011, modified by IZM for european commission 2014

Document subject to a legal notice (see below)

EcoReport 2014: INPUTS Assessment of Environmental Impact

ECO-DESIGN OF ENERGY RELATED/USING PRODUCTS

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					

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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,
modified by IZM for european commission 2014

Document subject to a legal notice (see below)

EcoReport 2014: INPUTS

Assessment of Environmental Impact

ECO-DESIGN OF ENERGY RELATED/USING PRODUCTS

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 pow er	Simple plastic kettle, medium capacity, no special specifications, higher pow er	Simple plastic kettle, medium capacity, no special specifications, higher pow er
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.

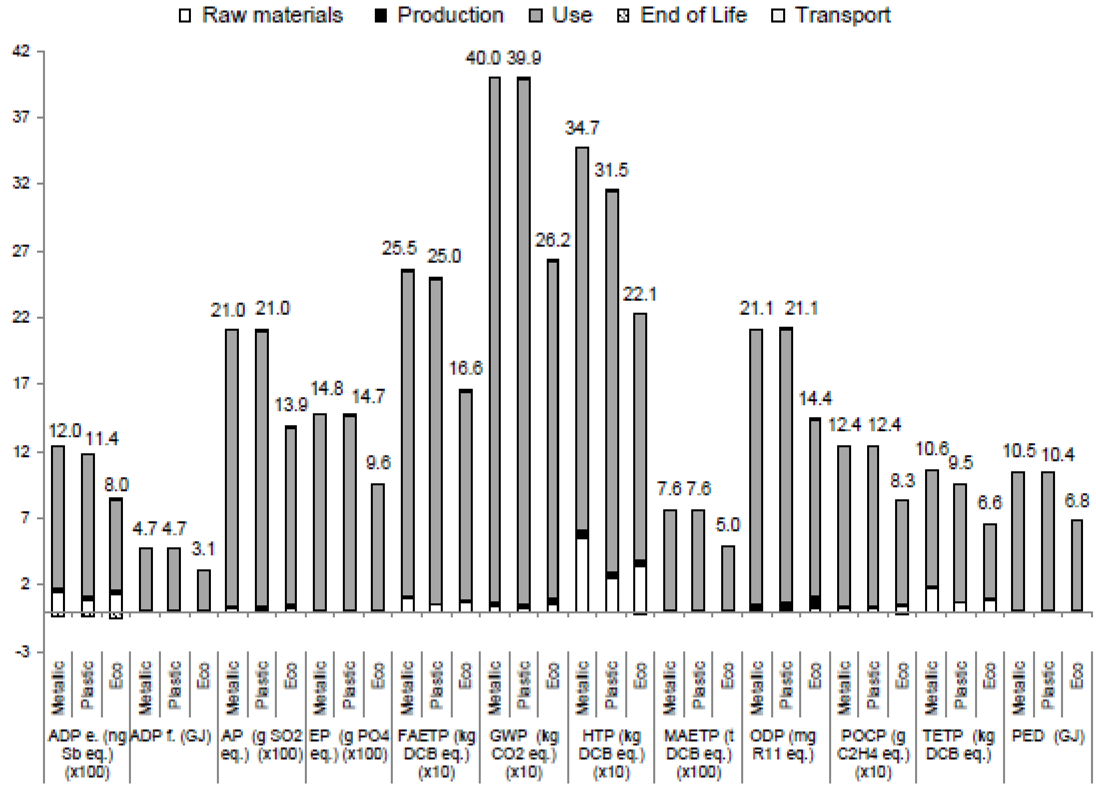
Table 5-16: Environmental impact of extra materials

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)



5.12. Annex G: Comparison of Materials for the container

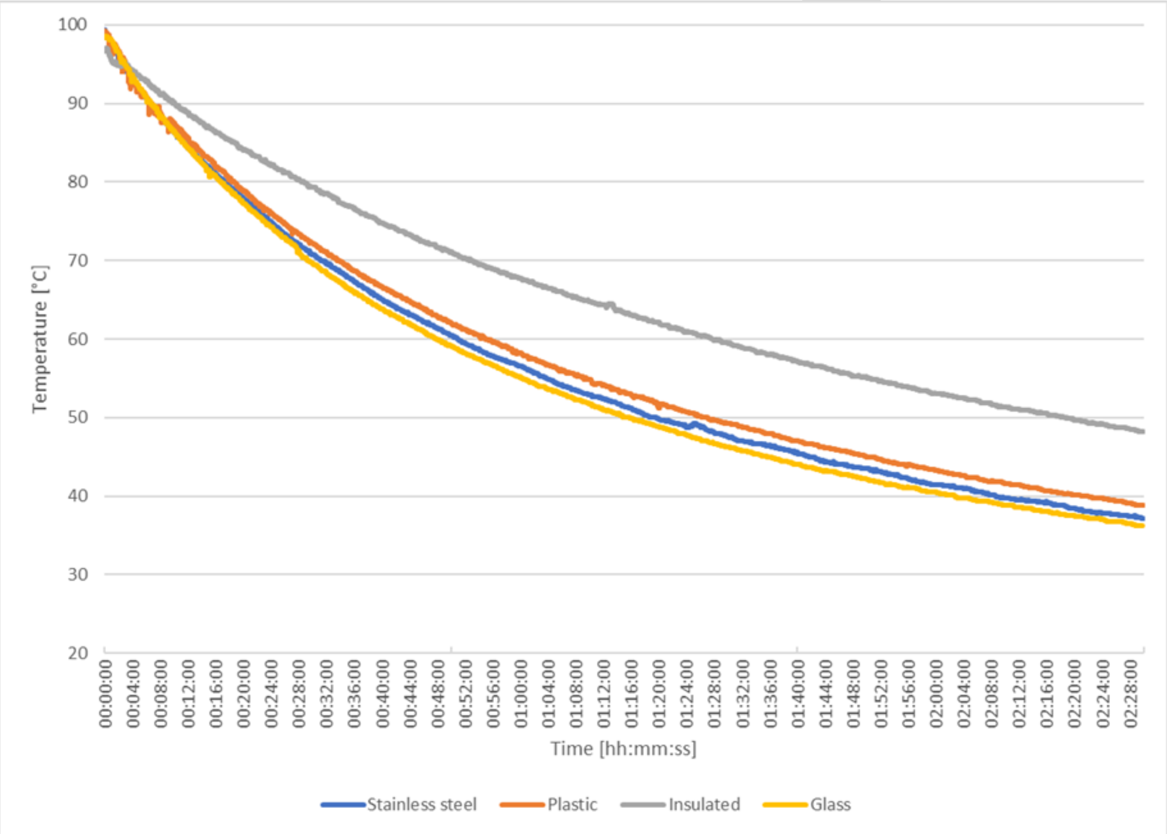
For single-wall kettles, there are three main container materials (see also Task 2 report):

- 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.

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