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Non-tertiary Coffee Machines

Task 7: Improvement potential – Final version

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ARTS
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Bio Intelligence Service - Scaling sustainable development
Industrial Ecology - Nutritional Health
Bio Intelligence Service S.A.S - bio@biois.com
20-22 Villa Deshayes - 75014 Paris - France
Tél. +33 (0)1 53 90 11 80 - Fax. +33 (0)1 56 53 99 90

Contact BIO Intelligence Service
Shailendra Mudgal – Benoît Tinetti
☏ + 33 (0) 1 53 90 11 80
shailendra.mudgal@biois.com
benoit.tinetti@biois.com

Project Team

BIO Intelligence Service

Mr. Shailendra Mudgal

Mr. Benoît Tinetti

Mr. Lorcan Lyons

Ms. Perrine Lavelle

Arts et Métiers Paristech / ARTS

Mr. Alain Cornier

Ms. Charlotte Sannier

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7. TASK 7 – IMPROVEMENT POTENTIAL

The purpose of this task is to identify design options, their monetary consequences in terms of life-cycle cost to the consumer, their environmental costs and benefits and the solutions with the Least Life-Cycle Cost (LLCC) and the Best Available Technology (BAT).

The assessment of monetary life cycle cost is relevant to indicate whether design solutions might negatively or positively impact the total expenditure of an EU consumer over the total product life (purchase price, running costs, etc.). The distance between the LLCC and the BAT indicates – where an LLCC solution is set as a minimum target – the remaining space for product differentiation (competition). The BAT is a medium-term target that would probably more subject to promotional measures than restrictions.

7.1. IDENTIFICATION OF DESIGN OPTIONS

This section presents the different improvement options applicable to each Base-Case. In the context of the Ecodesign Directive, design option(s) should:

- not cause significant variation in functionality or performance parameters compared to the Base-Cases, or in the product-specific inputs;
- have a significant potential for ameliorating one or more environmental impacts without significantly deteriorating other impact parameters; and
- not entail excessive costs, or burden on the manufacturer.

Energy savings that result from different technologies cannot always be directly added when combining various improvement options. Some options overlap each other, and therefore the effect of implementing two or more of them would not be a simple addition of their respective savings. In this study, the improvement potential of a particular improvement option or a combination of improvement options is evaluated using the MEEuP EcoReport tool.

The cost-effectiveness of an improvement option can be expressed in terms of payback time in years, defined as a ratio:

(Cost increase with reference to the Base-Case) / (annual electricity consumption difference in kWh*electricity tariff)

The impact of each individual design option on the life cycle cost (LCC) of the Base-Case can also be calculated. In this way, the combination of design options with the least LCC can be identified.

In Task 8, scenarios will be investigated as a basis for defining future Ecodesign requirements, taking into account, among other parameters, LCCs and technical constraints.

In this Task, inputs come from various stakeholders that have been contacted.

7.1.1. Base-case 1: Drip filter coffee machine

The potential improvement options for drip filter coffee machines are presented in Table 7-21. Drip filter coffee machines are significantly different to the other product categories and are a mature technology with product features and sales progressing only very slowly in recent years. Therefore, some improvement options identified for the other Base-Cases do not apply to this product category, while others have been analysed slightly differently as described below.

Table 7-1: Identified energy saving potential for drip filter coffee machines

	Description	Energy consumption / coffee period (kWh)	Annual electricity consumption (kWh)	Comparison to Base-Case		
				Energy savings (%)	Increase in product price (€)	Payback time (years)
Base-Case 1	Drip filter	0.232	174.11	-	-	-
Option 0[1]	Standby Regulation	0.232	172.10	1.2	1	0
Option 1a	Auto-power down 60 minutes	0.198	146.91	15.6	1	0.22
Option 1b	Auto-power down 30 minutes	0.164	122.09	29.9	1	0.12
Option 2	Zero standby	0.232	169.36	2.7	1	1.27
Option 4	Thermos jug	0.130	97.27	44.1	40	3.14
Scenario A	1b+2	0.164	119.72	31.2	2	0.17

7.1.1.1. Option 0: Standby Regulation

- Environmental impacts: Power consumption in standby mode is set at 0.5 W as a result of the Standby Regulation and an auto-power down of two hours is assumed, reducing electricity consumption.
- Costs: The implementation of this option is estimated to increase the price by €1 per product due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: No constraints are envisaged.

[1] All subsequent options and scenarios include Option 0.

7.1.1.2. Option 1a: Auto-power down 60 minutes

- Environmental impacts: The machine is set to power down (going into a standby mode) automatically after 60 minutes, thereby reducing energy consumption.
- Costs: The implementation of this option is estimated to increase the price by €1 per product due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.1.3. Option 1b: Auto-power down 30 minutes

- Environmental impacts: The machine is set to power down automatically after 30 minutes, thereby reducing energy consumption.
- Costs: The implementation of this option is estimated to increase the price by €1 per product due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.1.4. Option 1c: Auto-power down 5 minutes

Option 1c was excluded because a 5 minute auto-power down delay was considered too short given the user behaviour associated with BC 1.

7.1.1.5. Option 2: "Zero standby"

- Environmental impacts: This option assumes that standby mode consumes close to 0 W, i.e. standby mode effectively becomes off mode. Standby mode energy consumption is therefore set to zero.
- Costs: The product price is assumed to increase by an amount equal to that for auto-power down options, i.e. €1.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.1.6. Option 3: Flow-through heater

The flow-through heater option was excluded because it was not considered relevant to non-tertiary drip filter machines, which are already flow-through heaters albeit using steam.

7.1.1.7. Option 4: Additional insulation (Thermos jug)

- Environmental impacts: The addition of a thermos jug avoids the electricity normally consumed for the keeping hot function.

- Costs: The implementation of this option is estimated to increase the price by €40 per product compared to the Base-Case product that does not have a thermos jug.
- Modification to the BOM: Assumed equal to +50% by weight of the coffee pot.
- Constraints: Adding a thermos jug would reduce heat losses but might result in some loss of function for consumers who prefer a transparent jug.

7.1.1.8. Scenario A: 1b+2

- Environmental impacts: For drip filter coffee machines, this scenario is a combination of 30 minutes auto-power down and “zero” standby. Energy consumption is significantly reduced as a result.
- Costs: The increase in product price as a result of this combination is assumed to be €1.50, since both options together should cost less than the sum.
- Modification to the BOM: Electronics, 98-controller board: +150 g.
- Constraints: None are envisaged.

7.1.2. Base-case 2: Pad filter coffee machine

The potential improvement options for pad filter coffee machines are presented in Table 7-2.

Table 7-2: Identified energy saving potential for pad filter coffee machines

	Description	Energy consumption per coffee period (kWh)	Annual electricity consumption (kWh)	Comparison to Base-Case		
				Energy savings (%)	Increase in product price (€)	Payback time (years)
Base-Case 2	Pad filter coffee machine	0.093	162.06	-	-	-
Option 0[2]	Standby Regulation	0.093	114.43	29.4	1	0.12
Option 1a	Auto-power down 60 minutes	0.091	101.20	37.6	1	0.10
Option 1b	Auto-power down 30 minutes	0.083	93.26	42.5	1	0.09
Option 1c	Auto-power down 5 minutes	0.077	86.64	46.5	1	0.08
Option 2	Zero standby	0.093	101.84	37.2	3	0.30
Option 3	Flow-through heater	0.051	55.51	65.7	50	2.83
Option 4	Additional	0.088	98.75	39.1	5	0.48

[2] All subsequent options and scenarios include Option 0.

	Description	Energy consumption per coffee period (kWh)	Annual electricity consumption (kWh)	Comparison to Base-Case		
				Energy savings (%)	Increase in product price (€)	Payback time (years)
	insulation					
Scenario A	1c+2	0.077	84.63	47.8	3	0.19
Scenario B	1c+2+4	0.073	80.40	50.4	8	0.55

7.1.2.1. Option 0: Standby Regulation

- Environmental impacts: It is assumed that the Standby Regulation is fully implemented and so standby consumption is set at 0.5 W and auto-power down is set at two hours, thereby reducing energy consumption.
- Costs: The implementation of this option is estimated to increase the price by €1 per product due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150 g.
- Constraints: No constraints are envisaged.

7.1.2.2. Option 1a: Auto-power down 60 minutes

- Environmental impacts: The machine is set to switch off automatically after 60 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.
- Costs: The implementation of this option is estimated to increase the price by €1 per product due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150 g.
- Constraints: None identified.

7.1.2.3. Option 1b: Auto-power down 30 minutes

- Environmental impacts: The machine is set to switch off automatically after 30 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.
- Costs: The implementation of this option is estimated to increase the price by €1 per product due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150 g.
- Constraints: None identified.

7.1.2.4. Option 1c: Auto-power down 5 minutes

- Environmental impacts: The machine is set to switch off automatically after 5 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.
- Costs: The implementation of this option is estimated to increase the price by €1 per product due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150 g.
- Constraints: None identified.

7.1.2.5. Option 2: "Zero standby"

- Environmental impacts: This option assumes that standby mode consumes close to 0 W, i.e. standby mode effectively becomes off mode. Standby mode energy consumption is therefore set to zero. This option affects the 11 hours per day in standby but not the coffee period.
- Costs: The product price is assumed to increase by an amount slightly greater than that for auto-power down options, i.e. €3.
- Modification to the BOM: Electronics, 98-controller board: +150 g.
- Constraints: None identified.

7.1.2.6. Option 3: Flow-through heater

- Environmental impacts: This option implements a flow-through water heater. The effect is that there is no time spent in ready-to-use mode during the coffee period, significantly reducing energy consumption.
- Costs: The product price is assumed to increase by €50 due to the addition of this technology.
- Modification to the BOM: No overall change is assumed due to a lack of data from stakeholders.
- Constraints: None identified.

7.1.2.7. Option 4: Additional insulation

- Environmental impacts: It is assumed that it is possible to save 5% of energy in on-mode by using a thicker/denser layer of insulation.
- Costs: The implementation of this option is estimated to increase the price by €5 per product.
- Modification to the BOM: Assumed equal to +50% by weight of the material required for the water tank.

- Constraints: Adding thicker insulation would reduce heat losses but would result in an increase of the coffee machine size and/or a decrease of the internal volume.

7.1.2.8. Scenario A: 1c+2

- Environmental impacts: This scenario is a combination of 5 minutes auto-power down and zero standby. Energy consumption is significantly reduced as a result.
- Costs: The increase in product price as a result of this combination is assumed to be €3, i.e. more than either option alone but less than both options combined since the electronics components are assumed to be the same for both.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None are envisaged.

7.1.2.9. Scenario B: 1c+2+4

- Environmental impacts: This scenario goes beyond Scenario A to add insulation. Energy consumption is further reduced as a result.
- Costs: The increase in product price as a result of this combination is assumed to be €8, i.e. €5 in addition to Scenario A for the extra insulation.
- Modification to the BOM:
    - Electronics, 98-controller board: +150 g
    - Insulation material: Assumed equal to +50% by weight of the material required for the water tank.
- Constraints: Insulation constraints as for Option 4.

7.1.3. Base-case 3: Hard cap espresso machine

The potential improvement options for hard cap espresso machines are presented in Table 7-3.

Table 7-3: Identified energy saving potential for hard cap espresso machines

	Description	Energy consumption per coffee period (kWh)	Annual electricity consumption (kWh)	Comparison to Base-Case		
				Energy savings (%)	Increase in product price (€)	Payback time (years)
Base-Case 3	Hard cap espresso machine	0.073	120.45	-	-	-
Option 0[3]	Standby Regulation	0.073	89.24	25.9	1	0.18

[3] All subsequent Options and Scenarios include Option 0.

	Description	Energy consumption per coffee period (kWh)	Annual electricity consumption (kWh)	Comparison to Base-Case		
				Energy savings (%)	Increase in product price (€)	Payback time (years)
Option 1a	Auto-power down 60 minutes	0.072	80.57	33.1	1	0.15
Option 1b	Auto-power down 30 minutes	0.067	75.37	37.4	1	0.13
Option 1c	Auto-power down 5 minutes	0.063	71.03	41.0	1	0.12
Option 2	Zero standby	0.073	80.30	33.3	1	0.15
Option 3	Flow-through heater	0.051	55.46	54.0	50	4.64
Option 4	Additional insulation	0.070	78.29	35.0	5	0.71
Scenario A	1c+2	0.063	69.03	42.7	1.50	0.18
Scenario B	1c+2+4	0.060	65.58	45.6	6.50	0.71

7.1.3.1. Option 0: Standby Regulation

- Environmental impacts: It is assumed that the Standby Regulation is fully implemented and so standby consumption is set at 0.5 W with a two-hour auto-power down, thereby reducing energy consumption.
- Costs: The product price of the coffee machine is assumed to increase by €1, based on stakeholder input.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: No constraints are envisaged.

7.1.3.2. Option 1a: Auto-power down 60 minutes

- Environmental impacts: The machine is set to switch off automatically after 60 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.
- Costs: The product price of the coffee machine is assumed to increase by €1, based on stakeholder input.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.3.3. Option 1b: Auto-power down 30 minutes

- Environmental impacts: The machine is set to switch off automatically after 30 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.

- Costs: The product price is assumed to increase by €1, based on stakeholder input.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.3.4. Option 1c: Auto-power down 5 minutes

- Environmental impacts: The machine is set to switch off automatically after 5 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.
- Costs: The product price is assumed to increase by €1, based on stakeholder input.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.3.5. Option 2: "Zero standby"

- Environmental impacts: This option assumes that standby mode consumes virtually 0 W, i.e. standby mode effectively becomes off mode. Standby mode energy consumption is therefore set to zero.
- Costs: The product price is assumed to increase by €1, based on stakeholder input.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.3.6. Option 3: Flow-through heater

- Environmental impacts: This option implements a flow-through water heater. The effect is that there is no time spent in ready-to-use mode during the coffee period, significantly reducing energy consumption.
- Costs: The product price is assumed to increase by €50 due to the addition of this technology.
- Modification to the BOM: No overall change is assumed due to a lack of data from stakeholders.
- Constraints: None identified.

7.1.3.7. Option 4: Additional insulation

- Environmental impacts: It is assumed that it is possible to save 5% of energy in on-mode by using a thicker/denser layer of insulation.
- Costs: The implementation of this option is estimated to increase the price by €5 per product.

- Modification to the BOM: Assumed equal to +50% by weight of the material required for the water tank.
- Constraints: Adding thicker insulation would reduce heat losses but would result in an increase of the coffee machine size and/or a decrease of the internal volume.

7.1.3.8. Scenario A: 1c+2

- Environmental impacts: This scenario is a combination of 5 minutes auto-power down and zero watt standby. Energy consumption is significantly reduced as a result.
- Costs: The increase in product price as a result of this combination is estimated at €1.50, i.e. more than either option alone but less than both options combined since the electronics components are assumed to be the same for both.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None are envisaged.

7.1.3.9. Scenario B: 1c+2+4

- Environmental impacts: This scenario goes beyond Scenario A to add insulation and a high efficiency power supply. Energy consumption is further reduced as a result.
- Costs: The increase in product price as a result of this combination is estimated at €6.50, i.e. the same as Scenario A plus €5 for additional insulation.
- Modification to the BOM:
  - Electronics, 98-controller board: +150 g
  - Insulation material: Assumed equal to +50% by weight of the material required for the water tank.
- Constraints: Insulation constraints as for Option 4.

7.1.4. Base-Case 4: Semi-automatic espresso machine

The potential improvement options for semi-automatic espresso machines are presented in Table 7-4. As semi-automatic espresso machines are covered by the Standby Regulation (1275/2008/EC), Option 0 includes this parameter. The energy savings in percentage terms, the increases in product price and the payback times are given compared to the Base-Case.

Table 7-4: Identified energy saving potential for semi-automatic espresso machines

	Description	Energy consumption per coffee period (kWh)	Annual electricity consumption (kWh)	Comparison to Base-Case		
				Energy savings (%)	Increase in product price (€)	Payback time (years)
Base-Case 4	Semi-automatic espresso machine	0.083	195.28	-	-	-
Option 0[4]	Standby Regulation	0.083	111.51	42.9	1	0.08
Option 1a	Auto-power down 60 minutes	0.079	88.24	54.8	1	0.06
Option 1b	Auto-power down 30 minutes	0.066	74.28	62.0	1	0.05
Option 1c	Auto-power down 5 minutes	0.055	62.64	67.9	1	0.05
Option 2	Zero standby	0.083	90.89	53.5	1	0.06
Option 3	Flow-through heater	0.059	64.79	66.8	50	2.31
Option 4	Additional insulation	0.079	88.35	54.8	10	0.56
Scenario A	1c+2	0.055	60.64	68.9	1.50	0.07
Scenario B	1c+2+4	0.053	57.6	70.5	11.50	0.50

7.1.4.1. Option 0: Standby Regulation

- Environmental impacts: It is assumed that the Standby Regulation is fully implemented and so standby consumption is set at 0.5 W with an auto-power down of two hours, thereby reducing energy consumption.
- Costs: The product price of the coffee machine is assumed to increase by €1, based on stakeholder input.
- Modification to the BOM: Electronics, 98-controller board: +150g
- Constraints: None identified.

7.1.4.2. Option 1a: Auto-power down 60 minutes

- Environmental impacts: The machine is set to switch off automatically after 60 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.
- Costs: The product price of the coffee machine is assumed to increase by €1, based on stakeholder input.

[4] All subsequent Options and Scenarios include Option 0.

- Modification to the BOM: Electronics, 98-controller board: +150g
- Constraints: None identified.

7.1.4.3. Option 1b: Auto-power down 30 minutes

- Environmental impacts: The machine is set to switch off automatically after 30 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.
- Costs: The product price is assumed to increase by €1, based on stakeholder input.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.4.4. Option 1c: Auto-power down 5 minutes

- Environmental impacts: The machine is set to switch off automatically after 5 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.
- Costs: The product price is assumed to increase by €1, based on stakeholder input.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.4.5. Option 2: "Zero standby"

- Environmental impacts: This option assumes that standby mode consumes 0 W, i.e. standby mode effectively becomes off mode. Standby mode energy consumption is therefore set to zero.
- Costs: The product price is assumed to increase by €1, based on stakeholder input.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.4.6. Option 3: Flow-through heater

- Environmental impacts: This option implements a flow-through water heater. The effect is that there is no time spent in ready-to-use mode during the coffee period, significantly reducing energy consumption.
- Costs: The final product price is assumed to increase by €50 due to the addition of this technology.
- Modification to the BOM: No overall change is assumed due to a lack of data from stakeholders.

- Constraints: None identified.

7.1.4.7. Option 4: Additional insulation

- Environmental impacts: It is assumed that it is possible to save 5% of energy in on-mode by using a thicker/denser layer of insulation.
- Costs: The implementation of this option is estimated to increase the price by €10 per product.
- Modification to the BOM: Assumed equal to +50% by weight of the material required for the water tank (1-BlkPlastics, 10-ABS).
- Constraints: Adding thicker insulation would reduce heat losses but would result in an increase of the coffee machine size and/or a decrease of the internal volume.

7.1.4.8. Scenario A: 1c+2

- Environmental impacts: This scenario is a combination of 5 minutes auto-power down and zero watt standby. Energy consumption is significantly reduced as a result.
- Costs: The increase in product price as a result of this combination is assumed to be €1.50, i.e. more than either option alone but less than both options combined since the electronics components are assumed to be the same for both.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None are envisaged.

7.1.4.9. Scenario B: 1c+2+4

- Environmental impacts: This scenario goes beyond Scenario A to add insulation. Energy consumption is further reduced as a result.
- Costs: increase in product price as a result of this combination is assumed to be €1.50 as for Scenario A, plus €10 for additional insulation.
- Modification to the BOM:
    - Electronics, 98-controller board: +150 g
    - Insulation material: Assumed equal to +50% by weight of the material required for the water tank (1-BlkPlastics, 10-ABS).
- Constraints: Insulation constraints as for Option 4.

7.1.5. Base-case 5: Fully automatic espresso machine

The potential improvement options for fully automatic espresso machines are presented in Table 7-5. As fully automatic espresso coffee machines are covered by the Standby Regulation (1275/2008/EC), options aim to reduce the energy consumption of the equipment in on-mode exclusively.

The energy savings in percentage terms, the increase of product price and the payback time are given compared to the Base-Case.

Table 7-5: Identified energy saving potential for fully automatic espresso machine

	Description	Energy consumption per coffee period (kWh)	Annual electricity consumption (kWh)	Comparison to Base-Case		
				Energy savings (%)	Increase in product price (€)	Payback time (years)
Base-Case 5	Fully automatic espresso machine	0.062	113.26	-	-	-
Option 0[5]	Standby Regulation	0.062	77.78	31.3	1	0.15
Option 1a	Auto-power down 60 minutes	0.060	67.93	40.0	1	0.13
Option 1b	Auto-power down 30 minutes	0.055	62.01	45.2	1	0.12
Option 1c	Auto-power down 5 minutes	0.050	57.09	49.6	1	0.11
Option 2	Zero standby	0.062	67.89	40.1	1	0.13
Option 3	Flow-through heater	0.040	43.52	61.6	50	4.32
Option 4	Additional insulation	0.059	66.50	41.3	10	1.29
Scenario A	1c+2	0.050	55.08	51.4	1.50	0.16
Scenario B	1c+2+4	0.048	52.32	53.8	11.50	1.14

7.1.5.1. Option 0: Standby Regulation

- Environmental impacts: It is assumed that the Standby Regulation is fully implemented and so standby consumption is set at 0.5 W and auto-power down is set at two hours, thereby reducing energy consumption.
- Costs: The implementation of this option is estimated to increase the price by €1 per product, due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150g
- Constraints: None identified.

[5] All subsequent options and scenarios include Option 0.

7.1.5.2. Option 1a: Auto-power down 60 minutes

- Environmental impacts: The machine is set to switch off automatically after 60 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.
- Costs: The implementation of this option is estimated to increase the price by €1 per product, due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150g
- Constraints: None identified.

7.1.5.3. Option 1b: Auto-power down 30 minutes

- Environmental impacts: The machine is set to switch off automatically after 30 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.
- Costs: The implementation of this option is estimated to increase the price by €1 per product, due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.5.4. Option 1c: Auto-power down 5 minutes

- Environmental impacts: The machine is set to switch off automatically after 5 minutes of inactivity, reducing the amount of time spent in ready-to-use mode and thereby reducing energy consumption.
- Costs: The implementation of this option is estimated to increase the price by €1 per product, due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.5.5. Option 2: "Zero standby"

- Environmental impacts: This option assumes that standby mode consumes 0 W, i.e. standby mode effectively becomes off mode. Standby mode energy consumption is therefore set to zero.
- Costs: The implementation of this option is estimated to increase the price by €1 per product, due to the additional electronics required.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None identified.

7.1.5.6. Option 3: Flow-through heater

- Environmental impacts: This option implements a flow-through water heater. The effect is that there is no time spent in ready-to-use mode during the coffee period, significantly reducing energy consumption.
- Costs: The product price is assumed to increase by €50 due to the addition of this technology.
- Modification to the BOM: No overall change is assumed due to a lack of data from stakeholders.
- Constraints: None identified.

7.1.5.7. Option 4: Additional insulation

- Environmental impacts: It is assumed that it is possible to save 5% of energy in on-mode by using a thicker/denser layer of insulation.
- Costs: The implementation of this option is estimated to increase the price by €10 per product.
- Modification to the BOM: Assumed equal to +50% by weight of the material required for the water tank (1-BlkPlastics, 10-ABS).
- Constraints: Adding thicker insulation would reduce heat losses but would result in an increase of the coffee machine size and/or a decrease of the internal volume.

7.1.5.8. Scenario A: 1c+2

- Environmental impacts: This scenario is a combination of 5 minutes auto-power down and zero standby. Energy consumption is significantly reduced as a result.
- Costs: The increase in product price as a result of this combination is assumed to be €1.50, i.e. more than either option alone but less than both options combined since the electronics components are assumed to be the same for both.
- Modification to the BOM: Electronics, 98-controller board: +150 g
- Constraints: None are envisaged.

7.1.5.9. Scenario B: 1c+2+4

- Environmental impacts: This scenario goes beyond Scenario A to add insulation. Energy consumption is further reduced as a result.
- Costs: The increase in product price as a result of this combination is assumed to be €11.50, i.e. €10 in addition to Scenario A for the extra insulation.
- Modification to the BOM:

- Electronics, 98-controller board: +150 g
- Insulation material: Assumed equal to +50% by weight of the material required for the water tank (1-BlkPlastics, 10-ABS).

- Constraints: Insulation constraints as for Option 4.

7.2. IMPACT ANALYSIS

7.2.1. BASE-CASE 1: DRIP FILTER COFFEE MACHINE

The environmental impacts of the improvement options for Base-Case 1 are presented in Table 7-6. Option 0 does not show much improvement compared to the Base-Case because low standby power consumption is already assumed. For all other improvement options except Option 2, there is a significant reduction in most environmental impacts compared to the Base-Case.

Figure 7-1 shows that the option having the lowest total energy consumption is Option 4, with 6.6 GJ (42% savings compared to the Base-Case). Scenario A also does very well, for machines without a thermos jug.

The weight of non-hazardous waste produced by each improvement option for Base-Case 1 is presented in Figure 7-2. Option 4 is again the option with the lowest impact. This is also the case for the indicator GWP, as shown in Figure 7-3 and for emissions of Volatile Organic Compounds (VOCs) (Figure 7-4).

Table 7-6: Environmental impacts by improvement option for BC 1
(green: minimum impact / red: maximum impact)

life-cycle indicators per unit	unit	Base-case	Option0	Option1a	Option1b	Option2	Option4	ScenarioA
OTHER RESOURCES AND WASTE								
Total Energy (GER)	GJ	11,4	11,3	9,8	8,1	11,2	6,6	8,1
	% change with BC	0%	-1%	-14%	-29%	-2%	-42%	-29%
of which, electricity	primary GJ	11,1	11,0	9,5	7,8	10,9	6,3	7,7
	MWh	1,1	1,0	0,9	0,7	1,0	0,6	0,7
	% change with BC	0%	-1%	-15%	-30%	-2%	-44%	-30%
Water (process)	kL	4,5	4,5	4,5	4,3	4,6	4,2	4,4
	% change with BC	0%	0%	-1%	-5%	1%	-7%	-3%
Water (cooling)	kL	29,4	29,1	24,9	20,7	28,6	16,6	20,3
	% change with BC	0%	-1%	-15%	-30%	-3%	-44%	-31%
Waste, non-haz./ landfill	kg	15,1	15,0	13,4	11,3	15,0	9,6	11,4
	% change with BC	0%	-1%	-11%	-25%	-1%	-37%	-25%
Waste, hazardous/ incinerated	kg	1,8	1,8	1,9	1,7	1,9	1,8	1,8
	% change with BC	0%	0%	3%	-4%	5%	1%	1%
EMISSIONS (AIR)								
Greenhouse Gases in GWP100	t CO2 eq.	0,5	0,5	0,4	0,4	0,5	0,3	0,4
	% change with BC	0%	-1%	-13%	-28%	-1%	-42%	-28%
Acidification, emissions	kg SO2 eq.	3,0	2,9	2,6	2,1	3,0	1,7	2,2
	% change with BC	0%	-1%	-13%	-28%	0%	-42%	-27%
Volatile Organic Compounds (VOC)	kg	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	-1%	6%	-24%	17%	-34%	-6%
Persistent Organic Pollutants (POP)	µg i-Teq	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	% change with BC	0%	-1%	-12%	-25%	-1%	-37%	-25%
Heavy Metals to air	g Ni eq.	0,3	0,3	0,3	0,2	0,3	0,2	0,3
	% change with BC	0%	-1%	-6%	-19%	2%	-27%	-16%
PAHs	g Ni eq.	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	-1%	14%	-16%	21%	-23%	6%
Particulate Matter (PM, dust)	kg	0,3	0,3	0,3	0,3	0,3	0,3	0,3
	% change with BC	0%	0%	-2%	-5%	1%	-4%	-4%
EMISSIONS (WATER)								
Heavy Metals to water	g Hg/20	0,1	0,1	0,2	0,1	0,2	0,1	0,2
	% change with BC	0%	-1%	28%	-15%	35%	-17%	20%
Eutrophication	kg PO4	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	0%	20%	-3%	21%	11%	18%

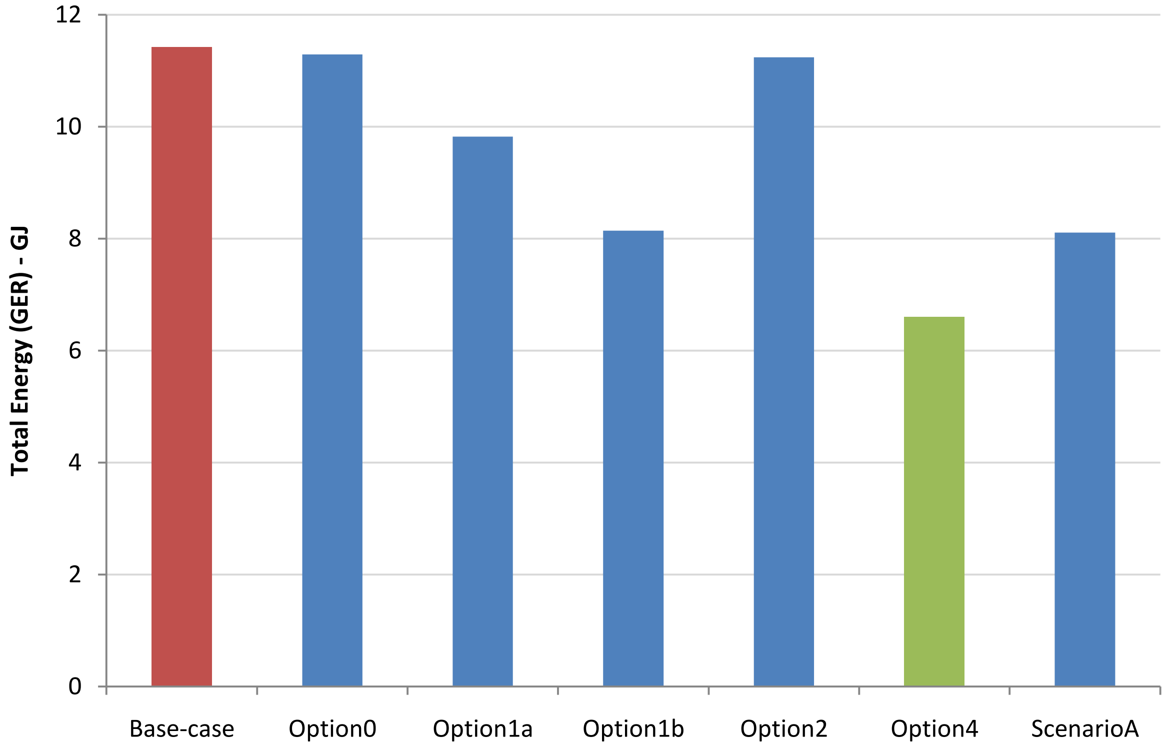

Figure 7-1: Comparison of improvement options for BC1 according to the indicator Total Energy (GER)

(green: minimum impact / red: maximum impact)

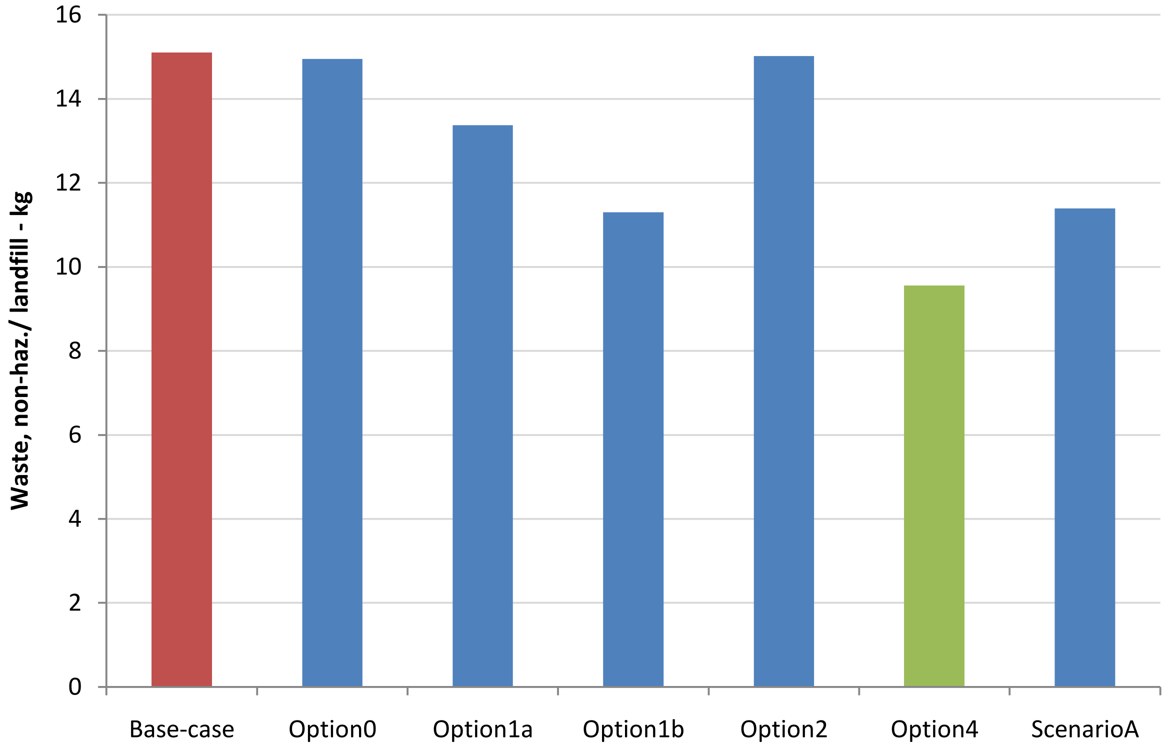

Figure 7-2: Comparison of improvement options for BC1 according to the indicator Non-hazardous waste (green: minimum impact / red: maximum impact)

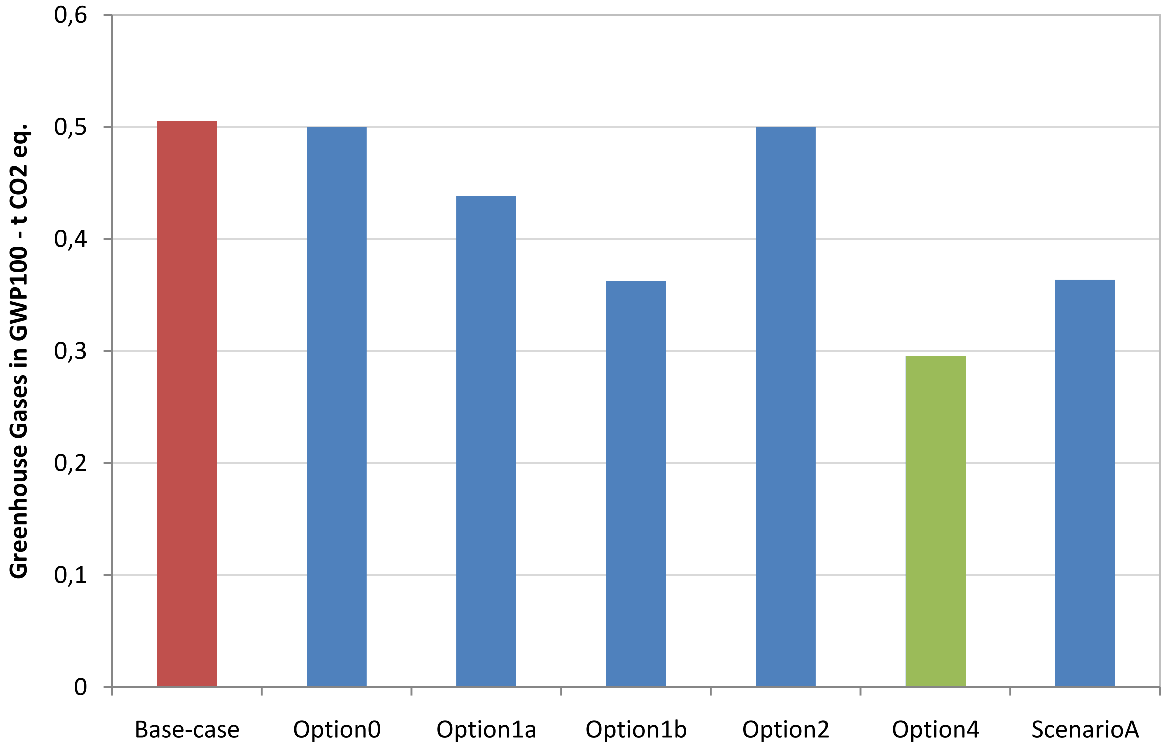

Figure 7-3: Comparison of improvement options for BC 1 according to the indicator GWP (global warming potential) (green: minimum impact / red: maximum impact)

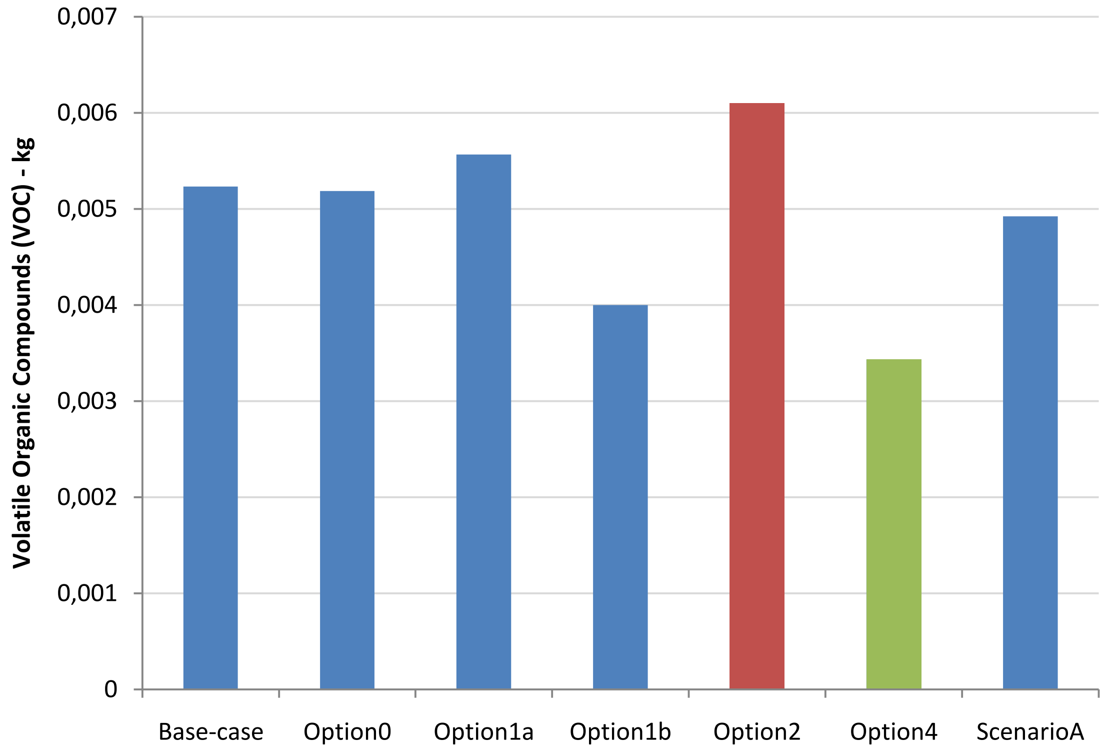

Figure 7-4: Comparison of improvement options for BC1 according to the indicator Volatile Organic Compounds (green: minimum impact / red: maximum impact)

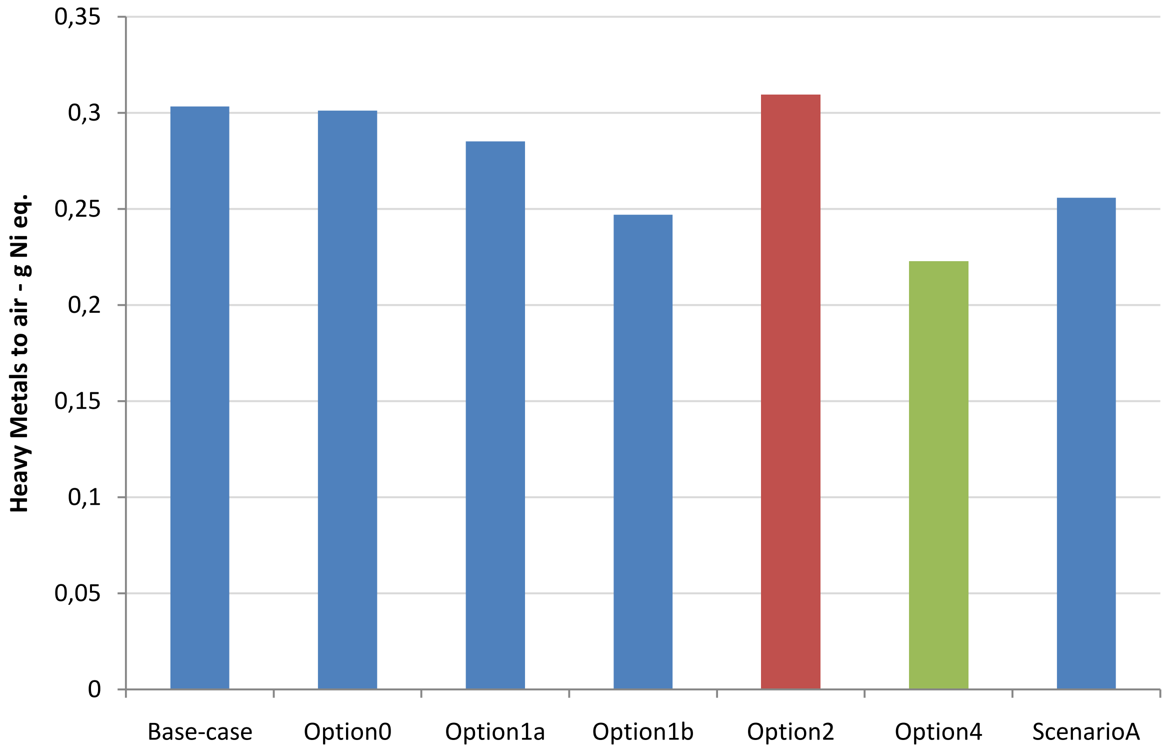

Figure 7-5: Comparison of improvement options for BC1 according to the indicator Heavy metals to air (green: minimum impact / red: maximum impact)

7.2.2. Base-Case 2: Pad filter coffee machine

This section presents the results of the life-cycle assessment of the improvement options for Base-Case 2. Table 7-7 presents the environmental impacts by improvement option for Base-Case 2. For all environmental impacts Option 3, the flow-through heater, is the most beneficial.

Table 7-7: Environmental impacts by improvement option for BC 2
(green: minimum impact / red: maximum impact)

life-cycle indicators per unit	unit	Base-case	Option0	Option1a	Option1b	Option1c	Option2	Option3	Option4	ScenarioA	ScenarioB
OTHER RESOURCES AND WASTE											
Total Energy (GER)	GJ	12,2	8,7	7,9	7,3	6,8	7,9	4,4	7,6	6,7	6,4
	% change with BC	0%	-29%	-36%	-40%	-44%	-35%	-64%	-38%	-45%	-48%
of which, electricity	primary GJ	12,0	8,5	7,6	7,0	6,5	7,6	4,1	7,3	6,4	6,1
	MWh	1,1	0,8	0,7	0,7	0,6	0,7	0,4	0,7	0,6	0,6
	% change with BC	0%	-29%	-37%	-42%	-46%	-36%	-65%	-39%	-47%	-49%
Water (process)	kL	2,7	2,4	2,4	2,4	2,4	2,4	2,1	2,4	2,4	2,3
	% change with BC	0%	-9%	-8%	-10%	-11%	-8%	-20%	-12%	-11%	-12%
Water (cooling)	kL	31,9	22,6	20,0	18,5	17,2	20,1	11,0	19,5	16,8	15,9
	% change with BC	0%	-29%	-37%	-42%	-46%	-37%	-65%	-39%	-47%	-50%
Waste, non-haz./ landfill	kg	17,4	13,4	12,5	11,8	11,3	12,5	8,3	12,0	11,1	10,7
	% change with BC	0%	-23%	-28%	-32%	-35%	-28%	-52%	-31%	-36%	-38%
Waste, hazardous/ incinerated	kg	1,5	1,4	1,5	1,5	1,5	1,5	1,3	1,5	1,5	1,5
	% change with BC	0%	-5%	0%	-1%	-2%	0%	-12%	-1%	-2%	3%
EMISSIONS (AIR)											
Greenhouse Gases in GWP100	t CO2 eq.	0,5	0,4	0,4	0,3	0,3	0,4	0,2	0,3	0,3	0,3
	% change with BC	0%	-28%	-35%	-39%	-43%	-34%	-63%	-37%	-45%	-47%
Acidification, emissions	kg SO2 eq.	3,2	2,3	2,1	2,0	1,8	2,1	1,2	2,0	1,8	1,7
	% change with BC	0%	-28%	-34%	-39%	-43%	-34%	-63%	-38%	-44%	-46%
Volatile Organic Compounds (VOC)	kg	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	-24%	-13%	-17%	-20%	-12%	-53%	-31%	-21%	-23%
Persistent Organic Pollutants (POP)	µg i-Teq	0,1	0,1	0,1	0,1	0,1	0,1	0,0	0,1	0,0	0,0
	% change with BC	0%	-27%	-33%	-38%	-41%	-33%	-60%	-36%	-42%	-45%
Heavy Metals to air	g Ni eq.	0,3	0,2	0,2	0,2	0,2	0,2	0,1	0,2	0,2	0,2
	% change with BC	0%	-23%	-25%	-29%	-32%	-24%	-51%	-30%	-33%	-34%
PAHs	g Ni eq.	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	% change with BC	0%	-7%	0%	-1%	-2%	0%	-16%	-10%	-2%	-3%
Particulate Matter (PM, dust)	kg	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3
	% change with BC	0%	-7%	-7%	-8%	-9%	-7%	-15%	-6%	-9%	-7%
EMISSIONS (WATER)											
Heavy Metals to water	g Hg/20	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	% change with BC	0%	-18%	17%	14%	12%	17%	-40%	-23%	11%	10%
Eutrophication	kg PO4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	-5%	24%	24%	23%	25%	-10%	-4%	23%	24%

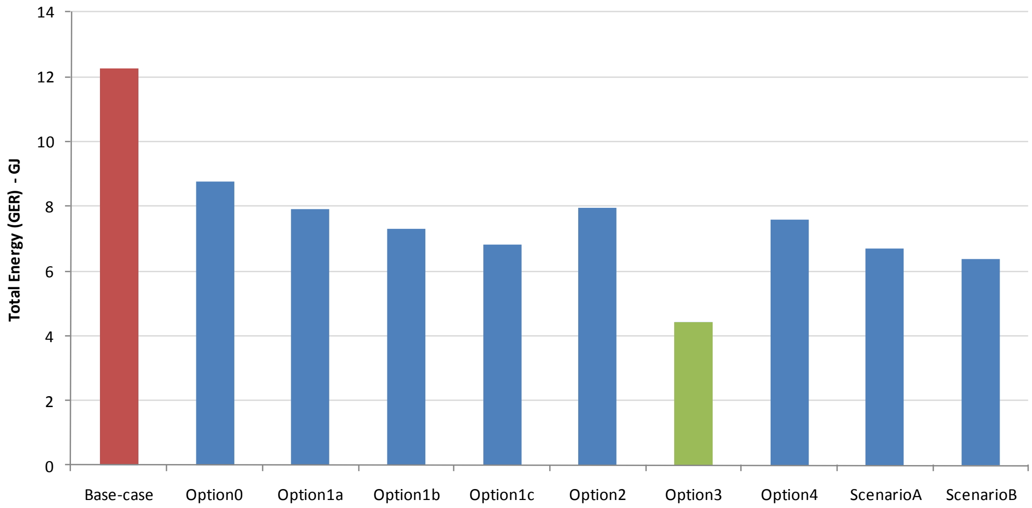

Figure 7-6: Comparison of improvement options for BC 2 according to the indicator Total Energy (GER)
(green: minimum impact / red: maximum impact)

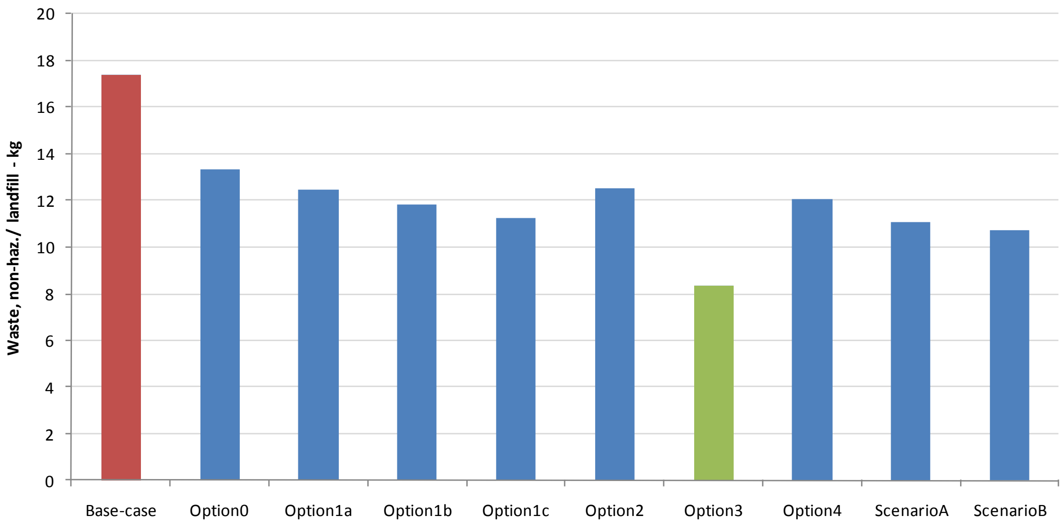

Figure 7-7: Comparison of improvement options for BC 2 according to the indicator Waste, non-hazardous
(green: minimum impact / red: maximum impact)

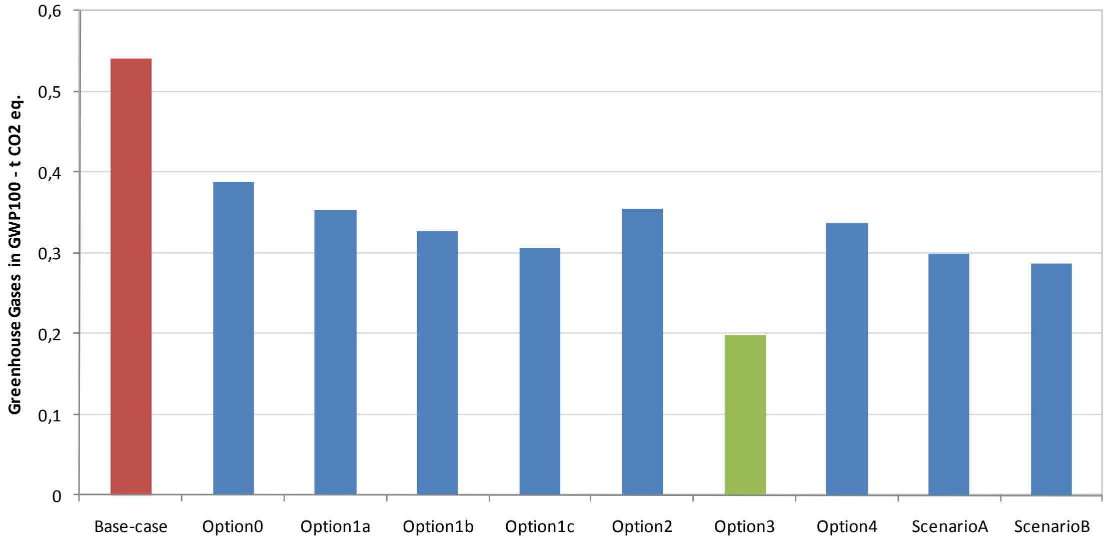

Figure 7-8: Comparison of improvement options for BC 2 according to the indicator GWP
(green: minimum impact / red: maximum impact)

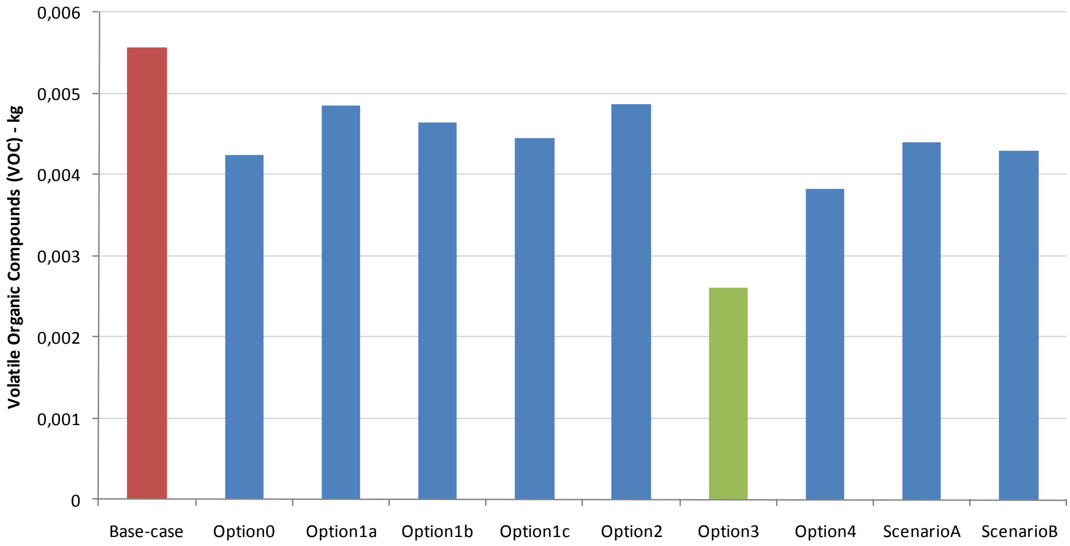

Figure 7-9: Comparison of improvement options for BC 2 according to the indicator Volatile Organic Compounds
(green: minimum impact / red: maximum impact)

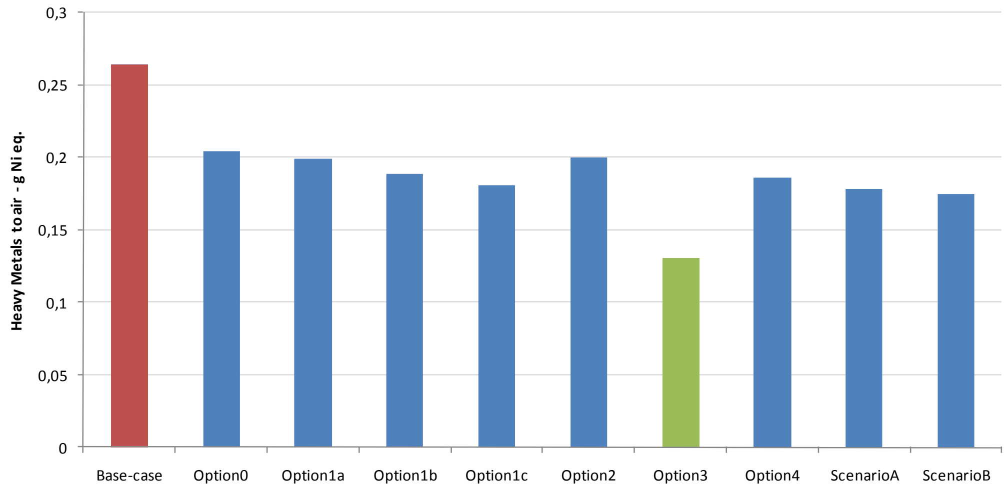

Figure 7-10: Comparison of improvement options for BC 2 according to the indicator Heavy metals emissions (green: minimum impact / red: maximum impact)

7.2.3. Base-case 3: Hard cap espresso machine

The results of the life cycle assessment of the improvement options for Base-Case 3 are presented in Table 7-8. As might be expected, Scenario C brings about the greatest energy savings. In some other indicators it is out-performed by Option 3 however, as shown in Figure 7-11, Figure 7-12, Figure 7-13, Figure 7-14 and Figure 7-15.

Table 7-8: Environmental impacts by improvement option for BC 3 (green: minimum impact / red: maximum impact)

life-cycle indicators per unit	unit	Base-case	Option0	Option1a	Option1b	Option1c	Option2	Option3	Option4	ScenarioA	ScenarioB
OTHER RESOURCES AND WASTE											
Total Energy (GER)	GJ	9,3	7,0	6,5	6,1	5,8	6,4	4,5	6,2	5,6	5,4
	% change with BC	0%	-25%	-30%	-34%	-38%	-31%	-51%	-33%	-39%	-42%
of which, electricity	primary GJ	8,9	6,6	6,1	5,7	5,4	6,1	4,2	5,8	5,2	5,0
	MWh	0,9	0,6	0,6	0,5	0,5	0,6	0,4	0,6	0,5	0,5
	% change with BC	0%	-26%	-32%	-36%	-40%	-32%	-53%	-35%	-41%	-44%
Water (process)	kL	2,5	2,3	2,4	2,4	2,3	2,4	2,2	2,3	2,3	2,3
	% change with BC	0%	-6%	-5%	-6%	-7%	-5%	-13%	-8%	-7%	-8%
Water (cooling)	kL	23,9	17,8	16,1	15,1	14,2	16,0	11,1	15,6	13,8	13,2
	% change with BC	0%	-26%	-33%	-37%	-40%	-33%	-53%	-35%	-42%	-45%
Waste, non-haz./ landfill	kg	14,2	11,6	11,1	10,7	10,3	11,1	8,7	10,7	10,1	9,9
	% change with BC	0%	-19%	-22%	-25%	-28%	-22%	-39%	-25%	-29%	-31%
Waste, hazardous/ incinerated	kg	1,6	1,6	1,7	1,6	1,6	1,7	1,5	1,6	1,6	1,7
	% change with BC	0%	-3%	2%	1%	1%	2%	-7%	1%	1%	6%
EMISSIONS (AIR)											
Greenhouse Gases in GWP100	t CO2 eq.	0,4	0,3	0,3	0,3	0,3	0,3	0,2	0,3	0,3	0,2
	% change with BC	0%	-24%	-29%	-33%	-37%	-29%	-51%	-33%	-38%	-41%
Acidification, emissions	kg SO2 eq.	2,4	1,8	1,7	1,7	1,6	1,7	1,2	1,6	1,5	1,5
	% change with BC	0%	-24%	-28%	-32%	-36%	-28%	-50%	-33%	-37%	-40%
Volatile Organic Compounds (VOC)	kg	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	-21%	-3%	-6%	-9%	-3%	-43%	-28%	-11%	-13%
Persistent Organic Pollutants (POP)	µg i-Teq	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	% change with BC	0%	-14%	-17%	-20%	-22%	-17%	-30%	-19%	-23%	-24%
Heavy Metals to air	g Ni eq.	0,3	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
	% change with BC	0%	-16%	-16%	-18%	-20%	-16%	-33%	-21%	-21%	-22%
PAHs	g Ni eq.	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	% change with BC	0%	-5%	4%	3%	2%	4%	-11%	-7%	2%	1%
Particulate Matter (PM, dust)	kg	0,3	0,3	0,3	0,3	0,3	0,3	0,2	0,3	0,3	0,3
	% change with BC	0%	-5%	-4%	-5%	-6%	-4%	-10%	-3%	-6%	-3%
EMISSIONS (WATER)											
Heavy Metals to water	g Hg/20	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	% change with BC	0%	-13%	27%	25%	23%	27%	-26%	-17%	22%	21%
Eutrophication	kg PO4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	-2%	20%	20%	19%	20%	-5%	-1%	19%	21%

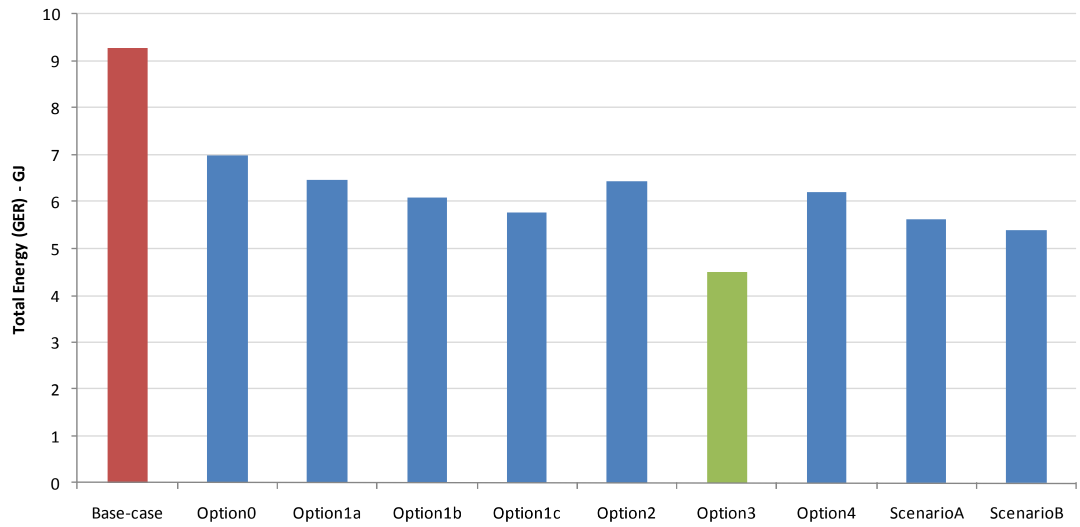

Figure 7-11: Comparison of improvement options for BC 3 according to the indicator Total Energy (GER)
(green: minimum impact / red: maximum impact)

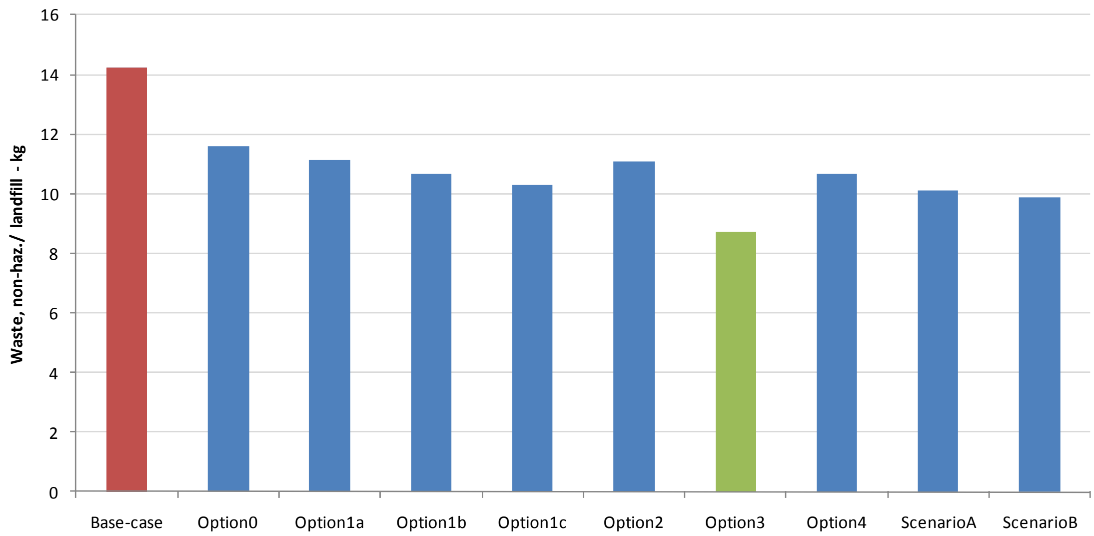

Figure 7-12: Comparison of improvement options for BC 3 according to the indicator Waste, non-hazardous
(green: minimum impact / red: maximum impact)

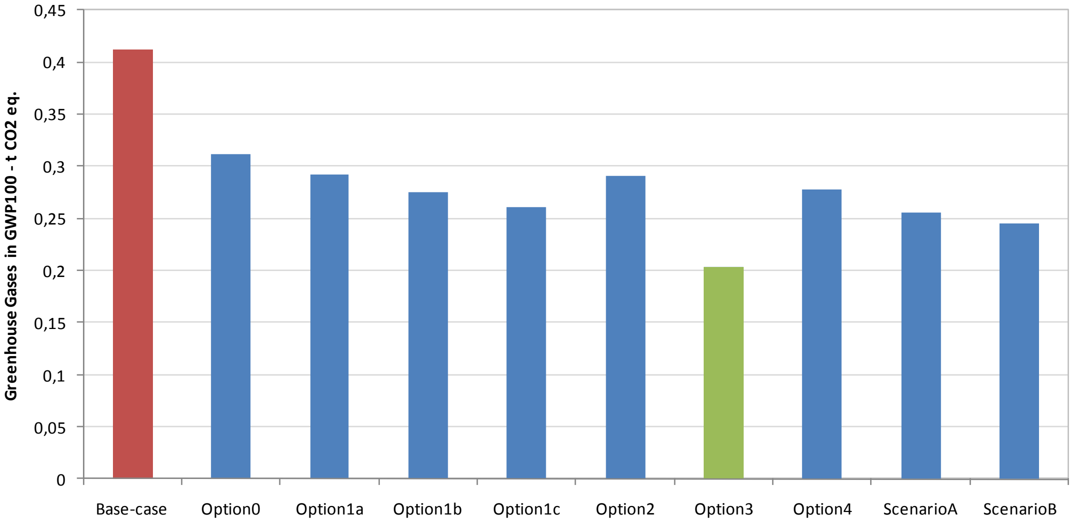

Figure 7-13: Comparison of improvement options for BC3 according to the indicator GWP
(green: minimum impact / red: maximum impact)

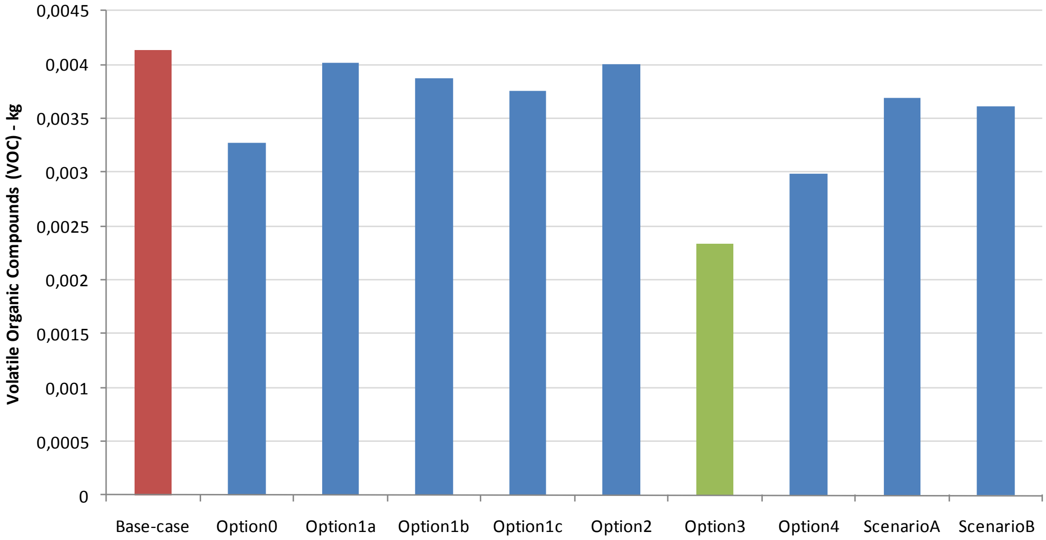

Figure 7-14: Comparison of improvement options for BC3 according to the indicator VOCs
(green: minimum impact / red: maximum impact)

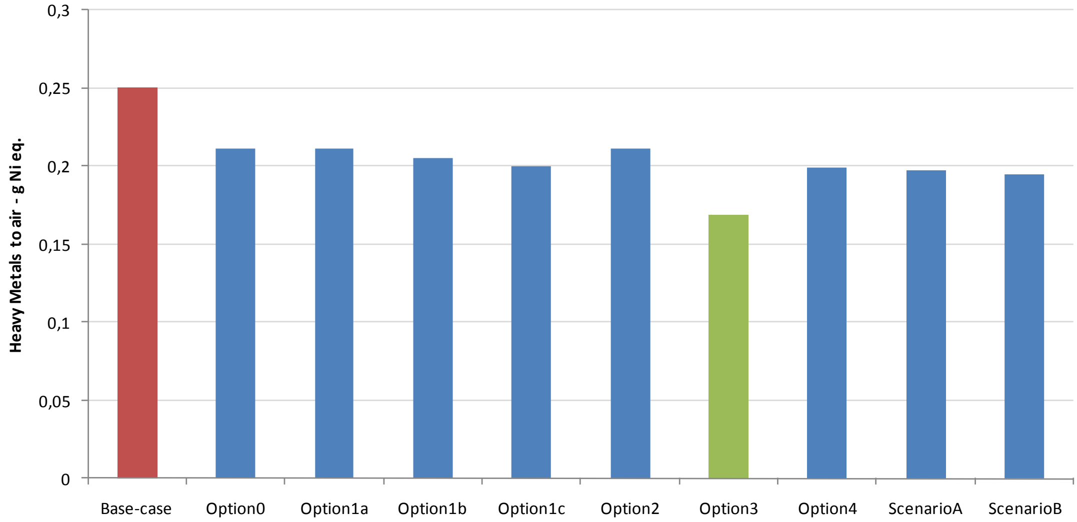

Figure 7-15: Improvement options for BC3 according to the indicator Heavy metals to air
(green: minimum impact / red: maximum impact)

7.2.1. BASE-CASE 4: SEMI-AUTOMATIC ESPRESSO MACHINE

This section presents the results of the life-cycle assessment of the improvement options for Base-Case 4. Table 7-9 presents the environmental impacts by improvement option for Base-Case 4. Figure 7-16 shows that Scenario B has the lowest primary energy consumption over its life cycle. As shown in the subsequent figures, Scenarios A and B also have the lowest impacts according to the other indicators, except for eutrophication, where Scenario B is in fact the worst of the options considered.

Table 7-9: Environmental impacts by improvement option for BC 4
(green: minimum impact / red: maximum impact)

life-cycle indicators per unit	unit	Base-case	Option0	Option1a	Option1b	Option1c	Option2	Option3	Option4	ScenarioA	ScenarioB
OTHER RESOURCES AND WASTE											
Total Energy (GER)	**GJ**	15,1	8,9	7,3	6,3	5,4	7,5	5,5	7,2	5,2	5,1
	% change with BC	0%	-41%	-51%	-58%	-64%	-50%	-64%	-52%	-66%	-66%
of which, electricity	**primary GJ**	14,5	8,4	6,7	5,7	4,8	6,9	4,9	6,7	4,6	4,5
	MWh	1,4	0,8	0,6	0,5	0,5	0,7	0,5	0,6	0,4	0,4
	% change with BC	0%	-42%	-54%	-61%	-67%	-52%	-66%	-54%	-68%	-69%
Water (process)	**kL**	2,9	2,5	2,5	2,4	2,3	2,5	2,3	2,4	2,3	2,3
	% change with BC	0%	-14%	-15%	-18%	-20%	-15%	-22%	-18%	-23%	-20%
Water (cooling)	**kL**	38,7	22,3	17,8	15,0	12,7	18,3	13,1	17,8	12,3	11,8
	% change with BC	0%	-42%	-54%	-61%	-67%	-53%	-66%	-54%	-68%	-70%
Waste, non-haz./ landfill	**kg**	23,5	16,3	14,6	13,4	12,4	14,8	12,3	14,4	12,0	12,0
	% change with BC	0%	-30%	-38%	-43%	-47%	-37%	-47%	-39%	-49%	-49%
Waste, hazardous/ incinerated	**kg**	2,9	2,8	2,9	2,8	2,8	2,9	2,7	2,8	2,7	2,9
	% change with BC	0%	-5%	-3%	-4%	-4%	-3%	-8%	-3%	-8%	-1%
EMISSIONS (AIR)											
Greenhouse Gases in GWP100	**t CO2 eq.**	0,7	0,4	0,3	0,3	0,2	0,3	0,2	0,3	0,2	0,2
	% change with BC	0%	-40%	-50%	-57%	-63%	-49%	-63%	-51%	-65%	-65%
Acidification, emissions	**kg SO2 eq.**	3,9	2,4	2,0	1,7	1,5	2,0	1,5	1,9	1,4	1,4
	% change with BC	0%	-40%	-50%	-56%	-62%	-48%	-63%	-51%	-65%	-64%
Volatile Organic Compounds (VOC)	**kg**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	-34%	-29%	-35%	-39%	-28%	-53%	-43%	-55%	-41%
Persistent Organic Pollutants (POP)	**µg i-Teq**	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	% change with BC	0%	-24%	-30%	-34%	-37%	-29%	-37%	-31%	-39%	-39%
Heavy Metals to air	**g Ni eq.**	0,4	0,3	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
	% change with BC	0%	-29%	-34%	-38%	-42%	-33%	-45%	-36%	-46%	-44%
PAHs	**g Ni eq.**	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	-22%	-11%	-15%	-18%	-11%	-34%	-28%	-35%	-19%
Particulate Matter (PM, dust)	**kg**	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
	% change with BC	0%	-8%	-9%	-10%	-11%	-9%	-12%	-8%	-13%	-10%
EMISSIONS (WATER)											
Heavy Metals to water	**g Hg/20**	0,2	0,1	0,2	0,2	0,2	0,2	0,1	0,1	0,1	0,2
	% change with BC	0%	-23%	0%	-4%	-7%	1%	-36%	-29%	-37%	-8%
Eutrophication	**kg PO4**	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	-4%	10%	9%	9%	10%	-6%	-3%	-6%	11%

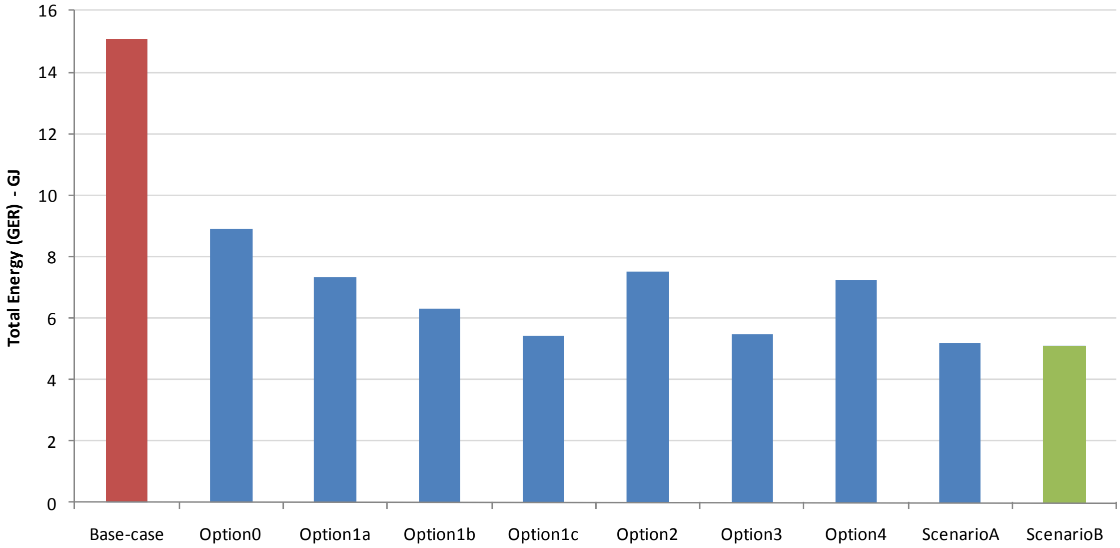

Figure 7-16: Comparison of improvement options for BC 4 according to the indicator Total Energy (GER)
(green: minimum impact / red: maximum impact)

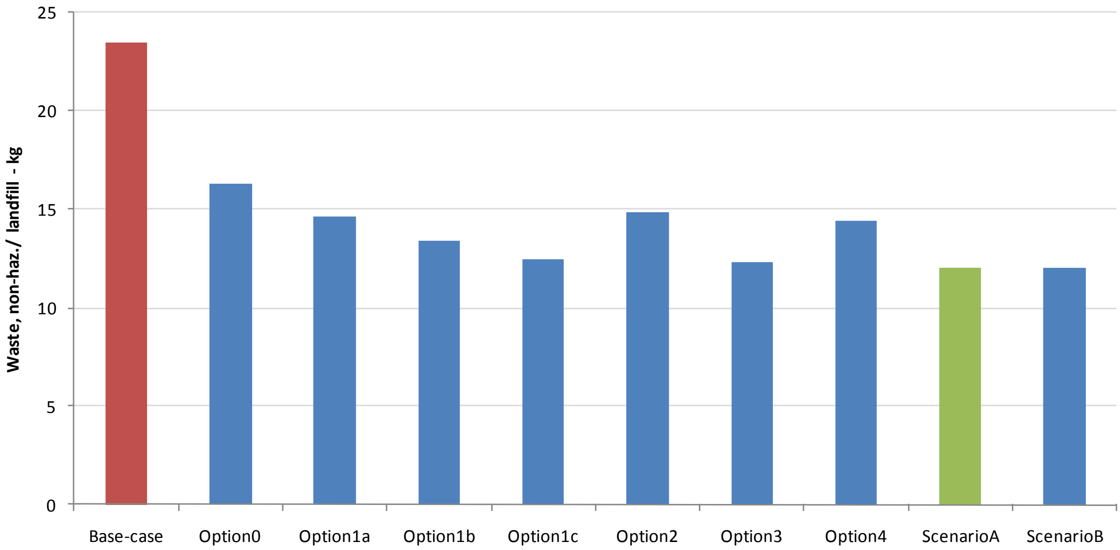

Figure 7-17: Comparison of improvement options for BC4 according to the indicator Waste, non-hazardous
(green: minimum impact / red: maximum impact)

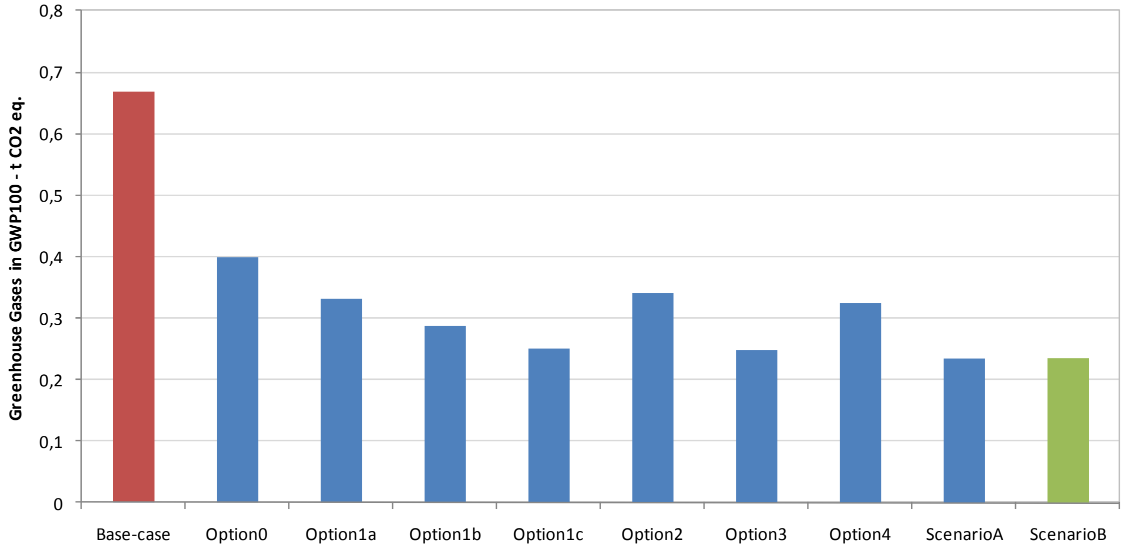

Figure 7-18: Comparison of improvement options for BC 4 according to the indicator GWP
(green: minimum impact / red: maximum impact)

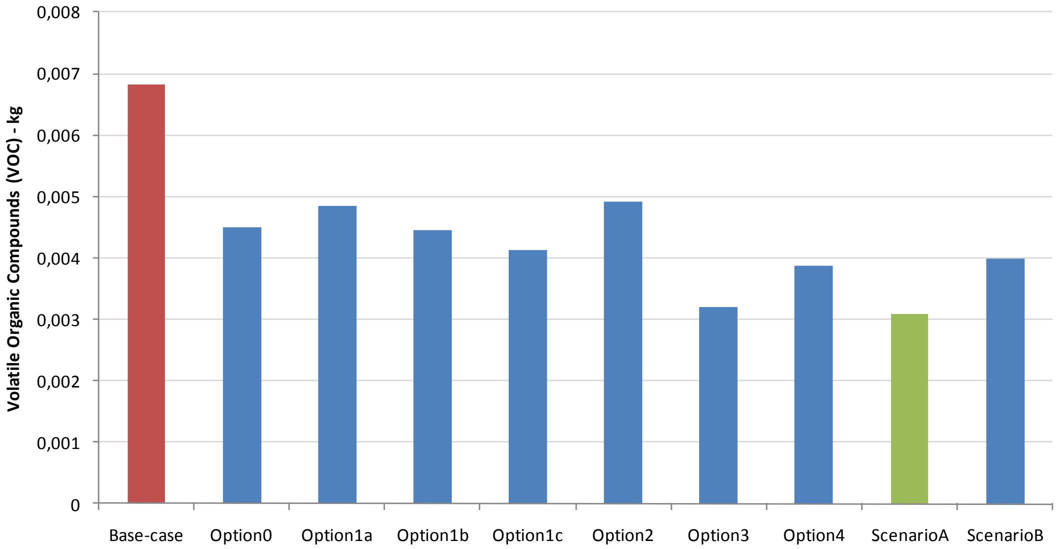

Figure 7-19: Comparison of improvement options for BC 4 according to the indicator VOCs
(green: minimum impact / red: maximum impact)

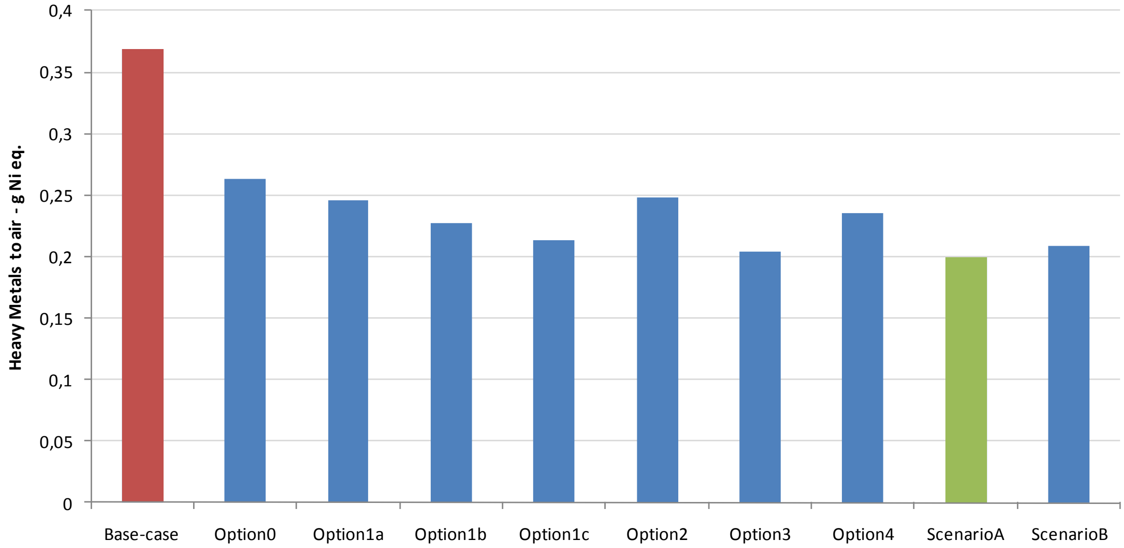

Figure 7-20: Improvement options for BC 4 according to the indicator Heavy metals to air
(green: minimum impact / red: maximum impact)

7.2.2. Base-case 5: Fully automatic espresso machine

This section presents the results of the life cycle assessment of the improvement options for Base-Case 5. Table 7-10 presents the environmental impacts by improvement option.

The results present similar patterns for the different environmental impacts, with Option 3 presenting the lowest values during the fully automatic espresso machine life cycle. Figure 7-21 shows a reduction of 56% compared to the total energy consumption of the Base-Case.

Table 7-10: Environmental impacts by improvement option for BC 5
(green: minimum impact / red: maximum impact)

life-cycle indicators per unit	unit	Base-case	Option0	Option1a	Option1b	Option1c	Option2	Option3	Option4	ScenarioA	ScenarioB
OTHER RESOURCES AND WASTE											
Total Energy (GER)	GJ	13,0	9,3	8,4	7,8	7,2	8,4	5,7	8,1	7,0	6,8
	% change with BC	0%	-29%	-36%	-40%	-44%	-36%	-56%	-38%	-46%	-48%
of which, electricity	primary GJ	12,1	8,4	7,4	6,8	6,3	7,4	4,8	7,2	6,1	5,8
	MWh	1,2	0,8	0,7	0,6	0,6	0,7	0,5	0,7	0,6	0,6
	% change with BC	0%	-31%	-39%	-44%	-48%	-39%	-61%	-41%	-50%	-52%
Water (process)	kL	3,6	3,3	3,3	3,3	3,3	3,3	3,1	3,3	3,3	3,2
	% change with BC	0%	-7%	-7%	-8%	-9%	-7%	-14%	-9%	-9%	-10%
Water (cooling)	kL	32,4	22,5	19,8	18,1	16,7	19,8	12,9	19,4	16,2	15,4
	% change with BC	0%	-31%	-39%	-44%	-48%	-39%	-60%	-40%	-50%	-52%
Waste, non-haz./ landfill	kg	23,2	18,9	18,0	17,2	16,6	17,9	14,7	17,5	16,4	16,1
	% change with BC	0%	-19%	-23%	-26%	-28%	-23%	-37%	-24%	-29%	-31%
Waste, hazardous/ incinerated	kg	5,8	5,8	5,8	5,8	5,8	5,8	5,7	5,8	5,8	5,9
	% change with BC	0%	-1%	0%	0%	-1%	0%	-3%	0%	-1%	1%
EMISSIONS (AIR)											
Greenhouse Gases in GWP100	t CO2 eq.	0,6	0,4	0,4	0,3	0,3	0,4	0,3	0,4	0,3	0,3
	% change with BC	0%	-28%	-35%	-39%	-43%	-35%	-55%	-37%	-45%	-47%
Acidification, emissions	kg SO2 eq.	3,4	2,5	2,3	2,1	2,0	2,3	1,6	2,2	1,9	1,9
	% change with BC	0%	-28%	-34%	-38%	-42%	-34%	-55%	-37%	-44%	-46%
Volatile Organic Compounds (VOC)	kg	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	-18%	-11%	-14%	-16%	-11%	-36%	-24%	-17%	-19%
Persistent Organic Pollutants (POP)	µg i-Teq	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	% change with BC	0%	-23%	-28%	-32%	-35%	-28%	-45%	-30%	-37%	-38%
Heavy Metals to air	g Ni eq.	0,4	0,3	0,3	0,3	0,3	0,3	0,2	0,3	0,3	0,3
	% change with BC	0%	-18%	-19%	-22%	-25%	-19%	-35%	-23%	-26%	-27%
PAHs	g Ni eq.	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	% change with BC	0%	-9%	0%	-2%	-3%	0%	-17%	-11%	-3%	-4%
Particulate Matter (PM, dust)	kg	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8
	% change with BC	0%	-3%	-3%	-3%	-4%	-3%	-5%	-2%	-4%	-3%
EMISSIONS (WATER)											
Heavy Metals to water	g Hg/20	0,2	0,2	0,2	0,2	0,2	0,2	0,1	0,1	0,2	0,2
	% change with BC	0%	-14%	11%	9%	7%	11%	-27%	-18%	6%	6%
Eutrophication	kg PO4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	% change with BC	0%	-2%	9%	9%	8%	9%	-4%	-1%	8%	9%

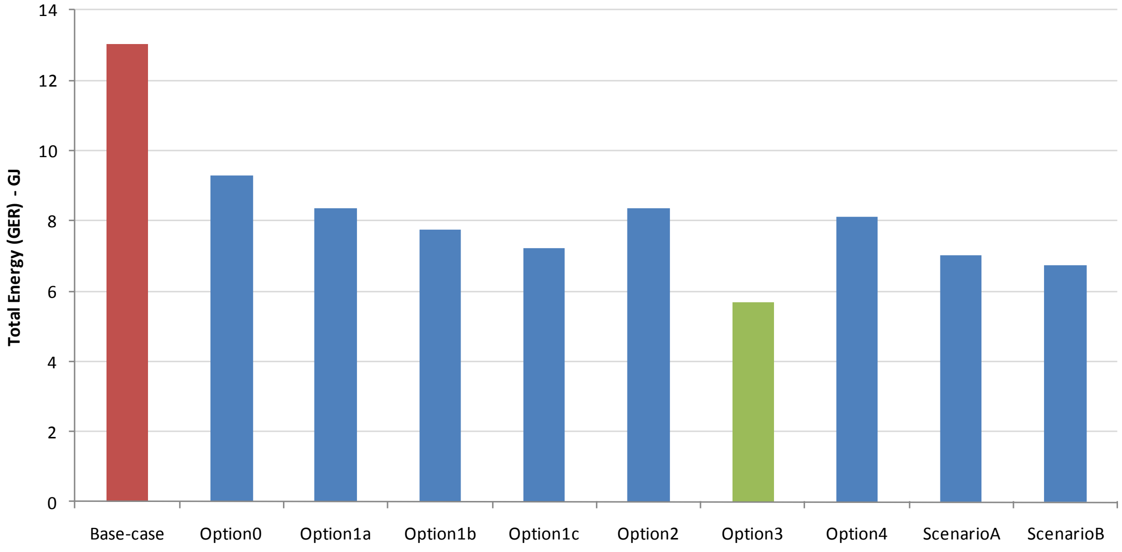

Figure 7-21: Comparison of improvement options for BC 5 according to the indicator Total Energy (GER)
(green: minimum impact / red: maximum impact)

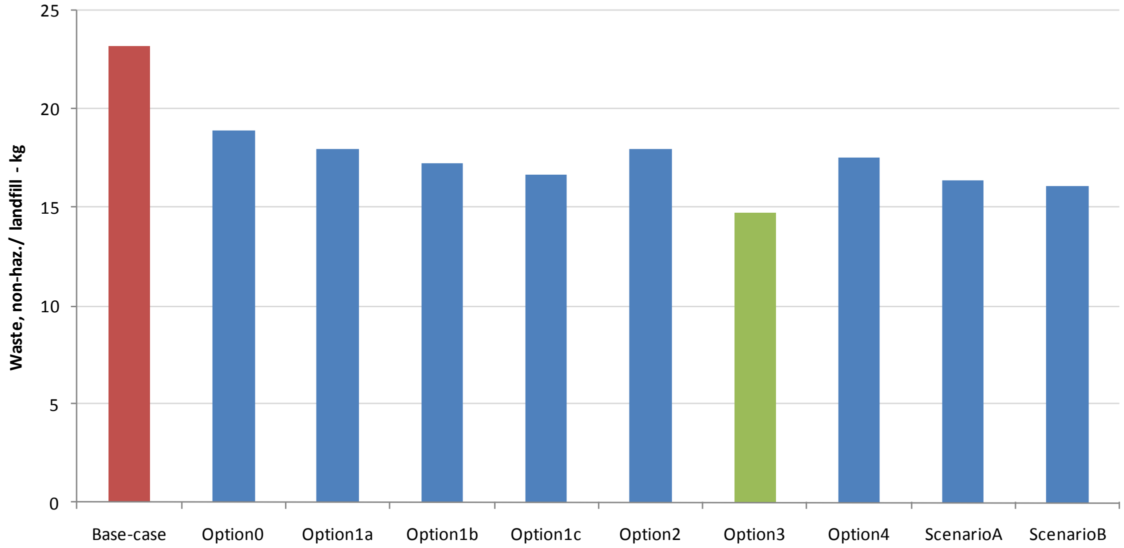

Figure 7-22: Comparison of improvement options for BC 5 according to the indicator Waste, non-hazardous
(green: minimum impact / red: maximum impact)

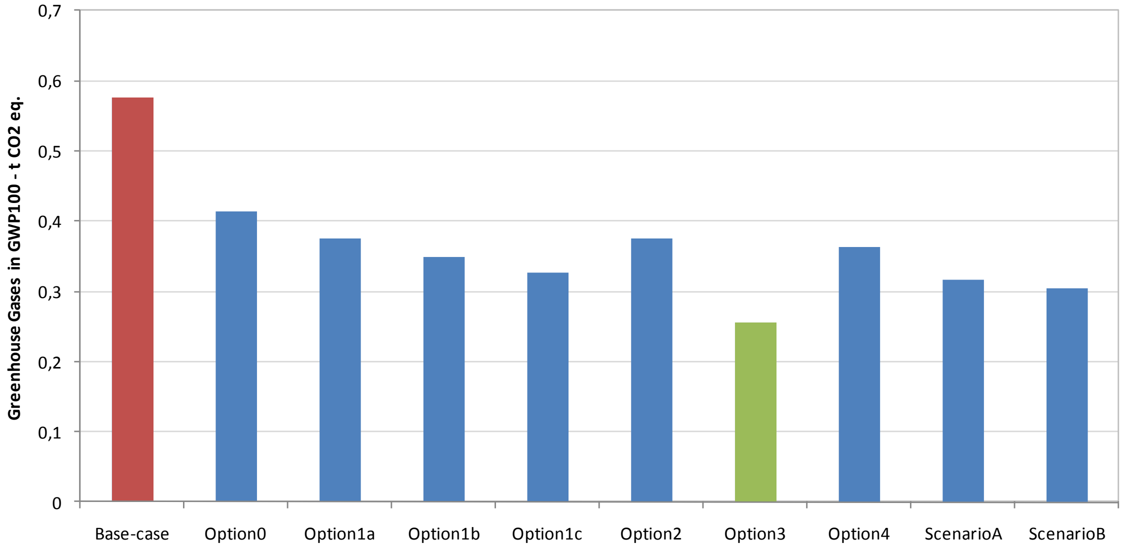

Figure 7-23: Comparison of improvement options for BC5 according to the indicator GWP
(green: minimum impact / red: maximum impact)

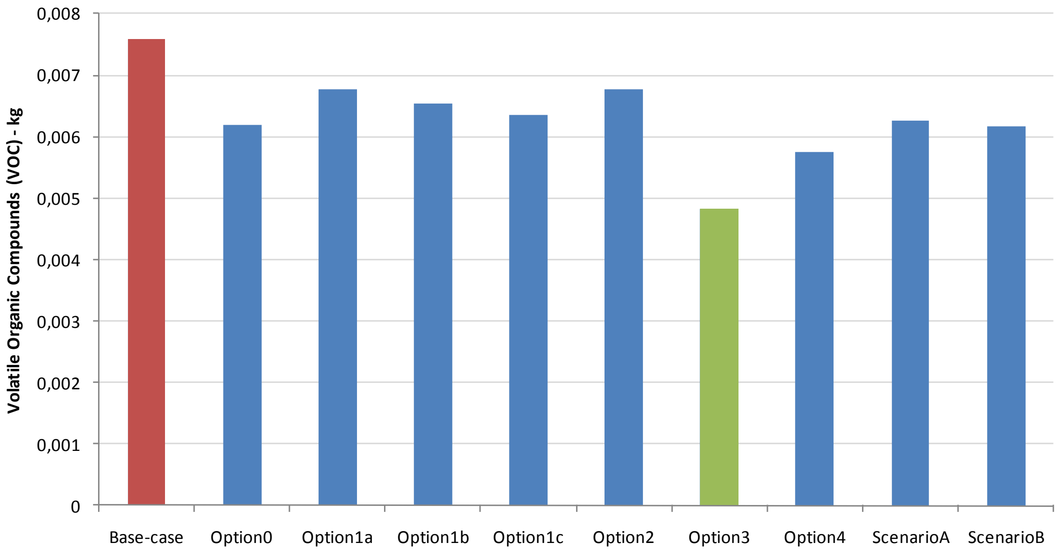

Figure 7-24: Comparison of improvement options for BC 5 according to the indicator VOCs
(green: minimum impact / red: maximum impact)

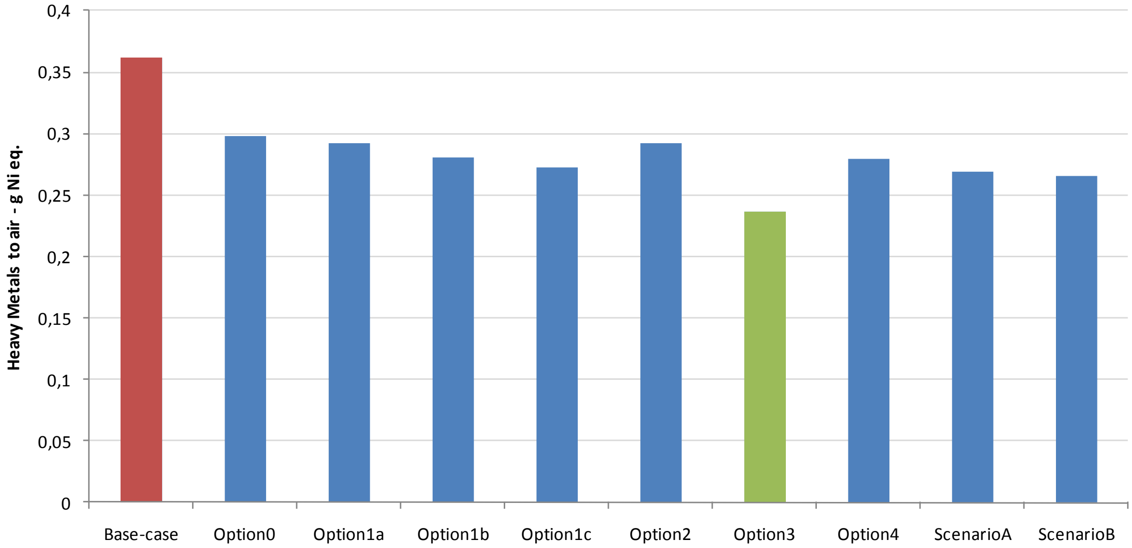

Figure 7-25: Comparison of improvement options for BC 5 according to the indicator Heavy metals emissions
(green: minimum impact / red: maximum impact)

7.3. COST ANALYSIS

7.3.1. BASE-CASE 1: DRIP FILTER COFFEE MACHINE

Figure 7-26 presents the shares of purchase price and electricity cost in the whole life cycle cost of the improvement options for BC 1 (costs due to other consumables, i.e. water, filters and coffee, are not presented as they are similar for the Base-Case and its improvement options). Detailed figures are also presented in Table 7-11.

Table 7-11: Life cycle cost by improvement option for Base-Case 1

	Description	Purchase price (€)	Electricity costs (€)	LCC (€)
Base-Case 1	Drip filter coffee machine	35	152	2 262
Option 0	Standby Regulation	35	150	2 260
Option 1a	Auto-power down 60 minutes	36	128	2 239
Option 1b	Auto-power down 30 minutes	36	106	2 217
Option 2	Zero standby	36	147	2 258
Option 4	Additional insulation	75	85	2 235
Scenario A	1b+2	37	104	2 216

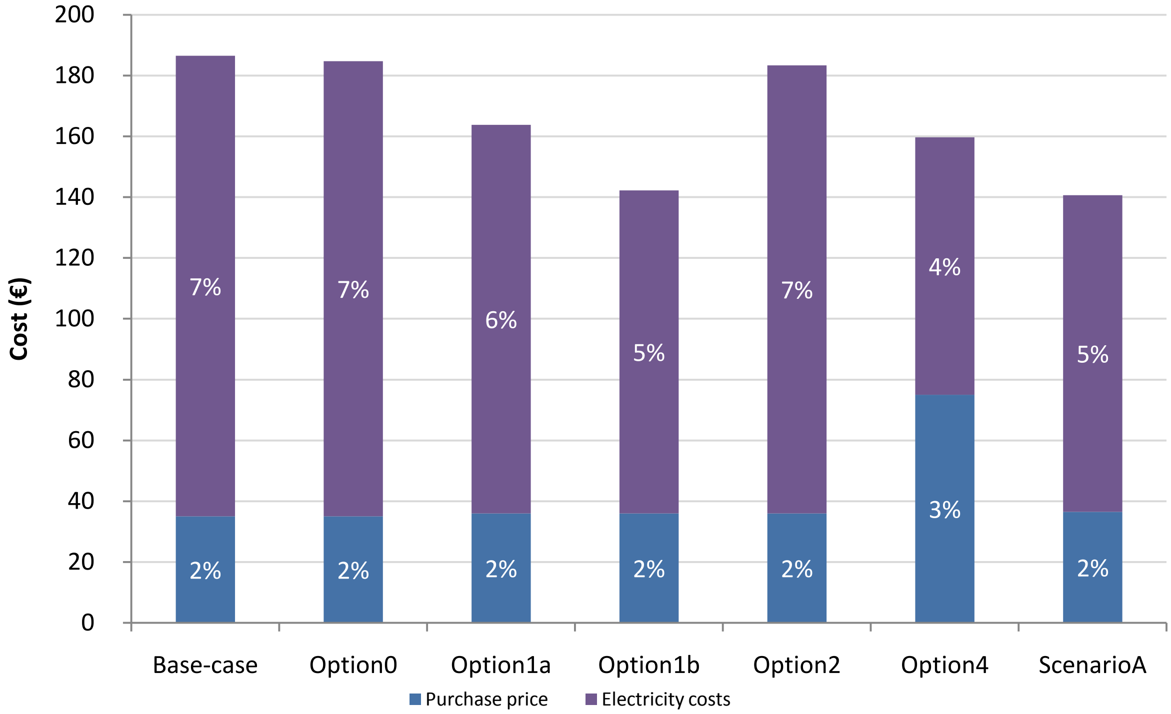

Figure 7-26: Life cycle cost of the improvement options for BC 1

7.3.2. BASE-CASE 2: PAD FILTER COFFEE MACHINE

The LCCs of the improvement options for Base-Case 2 are presented in Table 7-12. Figure 7-27 presents the share of each type of costs.

Table 7-12: Life-cycle cost by improvement option for BC 2

	Description	Purchase price (€)	Electricity costs (€)	LCC (€)
Base-Case 2	Pad filter	81	161	4 262
Option 0	Standby Regulation	81	114	4 215
Option 1a	Auto-power down 60 minutes	82	101	4 202
Option 1b	Auto-power down 30 minutes	82	93	4 194
Option 1c	Auto-power down 5 minutes	82	86	4 188
Option 2	Zero standby	84	101	4 205
Option 3	Flow-through heater	131	55	4 206
Option 4	Additional insulation	86	98	4 204

	Description	Purchase price (€)	Electricity costs (€)	LCC (€)
Scenario A	1c+2	84	84	4 187
Scenario B	1c+2+4	89	80	4 188

Scenario A is the product with the least life-cycle cost, saving €75 compared to the Base-Case, about the same as Scenario B and Option 1c on its own.

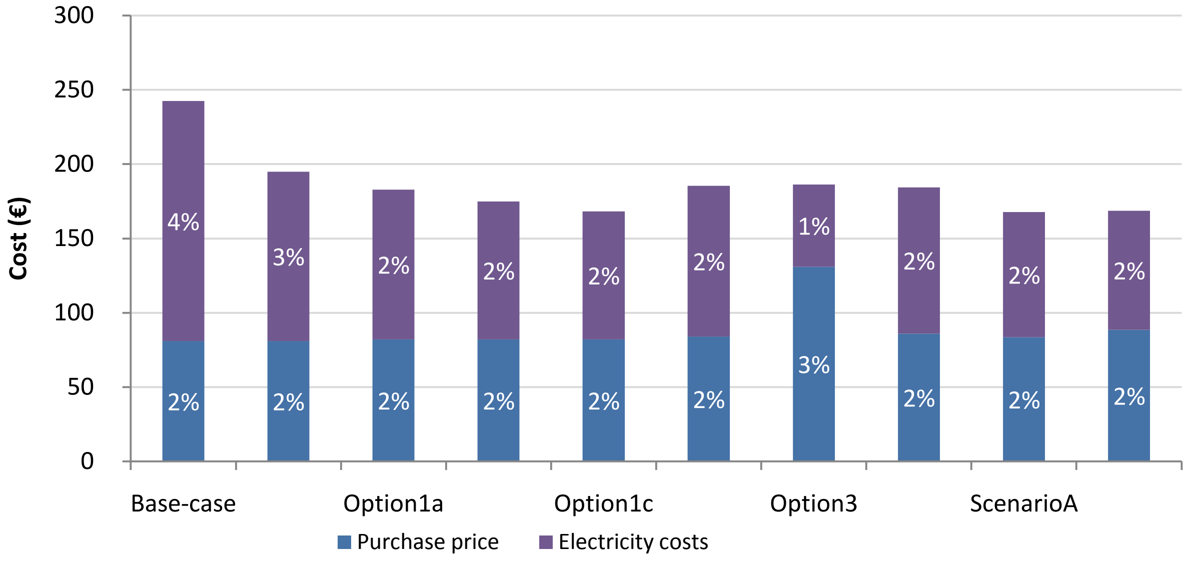

Figure 7-27: Life-cycle cost of the improvement options for BC 2

7.3.3. Base-case 3: Hard cap espresso machine

The results of the life cycle cost analysis of the improvement options for BC 3 are shown in Table 7-13 and Figure 7-28.

Table 7-13: Life cycle cost by improvement option for Base-case 3

	Description	Purchase price (€)	Electricity costs (€)	LCC (€)
Base-Case 3	Hard cap espresso	156	120	8 239
Option 0	Standby Regulation	156	89	8 208
Option 1a	Auto-power down 60 minutes	157	80	8 200
Option 1b	Auto-power down 30 minutes	157	75	8 195
Option 1c	Auto-power down 5 minutes	157	71	8 191
Option 2	Zero standby	157	80	8 200

	Description	Purchase price (€)	Electricity costs (€)	LCC (€)
Option 3	Flow-through heater	206	55	8 224
Option 4	Additional insulation	161	78	8 202
Scenario A	1c+2	158	69	8 189
Scenario B	1c+2+4	163	65	8 191

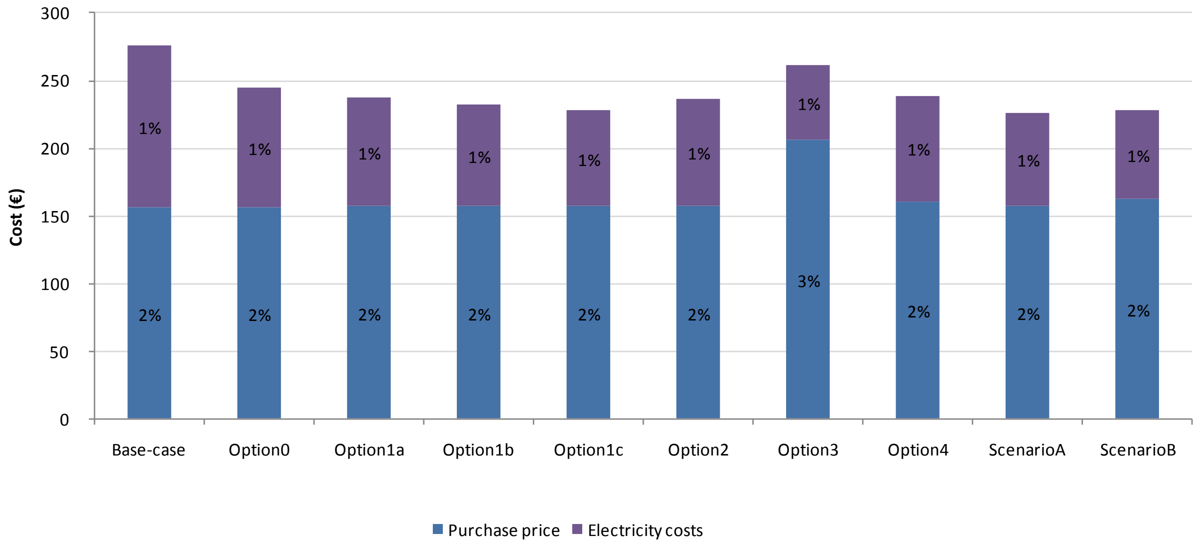

Figure 7-28: Life cycle cost of the improvement options for BC 3

7.3.4. BASE-CASE 4: SEMI-AUTOMATIC ESPRESSO MACHINE

The results of the LCC analysis of the improvement options for BC 4 are shown in Table 7-14 and Figure 7-29.

Table 7-14: Life cycle cost by improvement option for Base-case 4

	Description	Purchase price (€)	Electricity costs (€)	LCC (€)
Base-Case 4	Semi-automatic espresso machine	103	195	2 582
Option 0	Standby Regulation	103	111	2 499
Option 1a	Auto-power down 60 minutes	104	88	2 476
Option 1b	Auto-power down 30 minutes	104	74	2 462

	Description	Purchase price (€)	Electricity costs (€)	LCC (€)
Option 1c	Auto-power down 5 minutes	104	62	2 451
Option 2	Zero standby	104	91	2 479
Option 3	Flow-through heater	153	65	2 502
Option 4	Additional insulation	113	88	2 485
Scenario A	1c+2	105	60	2 449
Scenario B	1c+2+4	115	57	2 456

Implementing improvement options will increase the share of the purchase price in the life cycle cost. Option 3 has the highest share of electricity (6%).

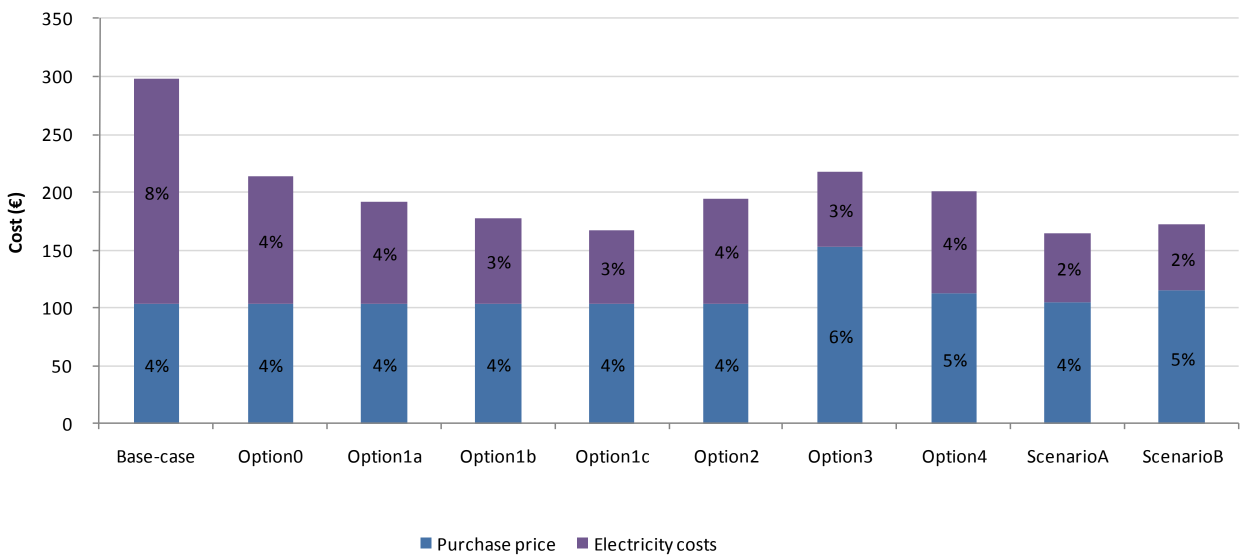

Figure 7-29: Life cycle cost of the improvement options for BC 4

7.3.5. Base-case 5: Fully automatic espresso machine

The results of the life cycle cost analysis of the improvement options for BC 5 are shown in Table 7-15 and Figure 7-30.

Table 7-15: Life cycle cost by improvement option for Base-Case 5

	Description	Purchase price (€)	Electricity costs (€)	LCC (€)
Base-Case 5	Fully automatic espresso machine	595	152	3 931
Option 0	Standby Regulation	595	105	3 883

	Description	Purchase price (€)	Electricity costs (€)	LCC (€)
Option 1a	Auto-power down 60 minutes	596	91	3 871
Option 1b	Auto-power down 30 minutes	596	83	3 863
Option 1c	Auto-power down 5 minutes	596	77	3 856
Option 2	Zero standby	596	91	3 871
Option 3	Flow-through heater	645	59	3 887
Option 4	Additional insulation	605	90	3 878
Scenario A	1c+2	597	74	3 854
Scenario B	1c+2+4	607	70	3 861

Implementing improvement options will increase the share of the purchase price in the life cycle cost. Option 3 has the highest share of electricity (17%).

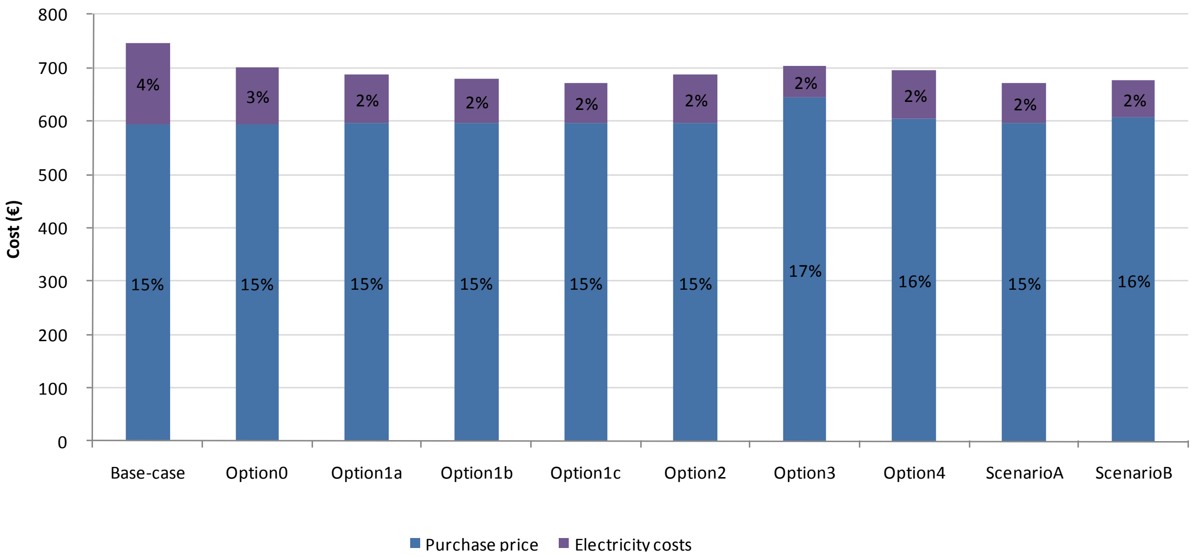

Figure 7-30: Life cycle cost of the improvement options for BC 5

7.4. ANALYSIS OF BAT AND LLCC

In this section, the design options identified in the technical, environmental and economic analysis in section 7.1 are ranked to identify the Best Available Technology (BAT) and the LLCC. Drawing an LCC-curve (Y1-axis= Primary energy consumption, Y2-axis=LCC, X-axis=options) allows identification of these LLCC and BAT points.[6]

Performance will be compared by applying the improvement options to the weighted Base-Case. The comparison is made in terms of primary energy consumption, non-hazardous wastes, GWP, VOC, heavy metals to water and LCC.

LLC is the sum of the Base-Case price, plus the cost of improvements, energy costs and the costs consumables and of installation and maintenance (if any), as described in the Task 5 report.

7.4.1. BASE-CASE 1: DRIP FILTER COFFEE MACHINE

Figure 7-31 allows the identification of the LLCC and BAT products. The LLCC product is Scenario A, with a life-cycle cost of €2 216, which represents a €46 saving compared to the Base-Case. The BAT product is Option 4, the thermos jug, which would result in around 4.8 GJ savings relative to the Base-Case.

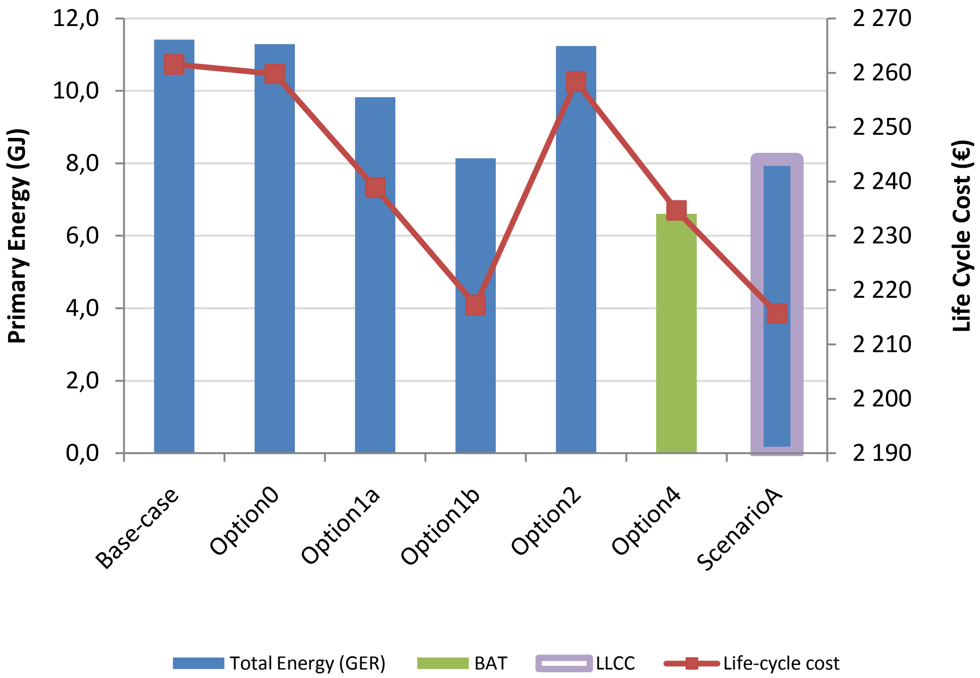

Figure 7-31: Identification of BAT and LLCC products for BC 1

[6] This is usually the last point of the curve showing the product design with the lowest environmental impact, irrespective of the price.

7.4.2. Base-Case 2: Pad filter coffee machine

Figure 7-32 shows the primary energy consumed by the various improvement options and the LCC, allowing the identification of the LLCC and BAT products. The LLCC products are Scenario A, Scenario B and Option 1c, because of their electricity savings. The BAT product, however, is Option 3, which would reduce primary energy consumption by 7.8 GJ.

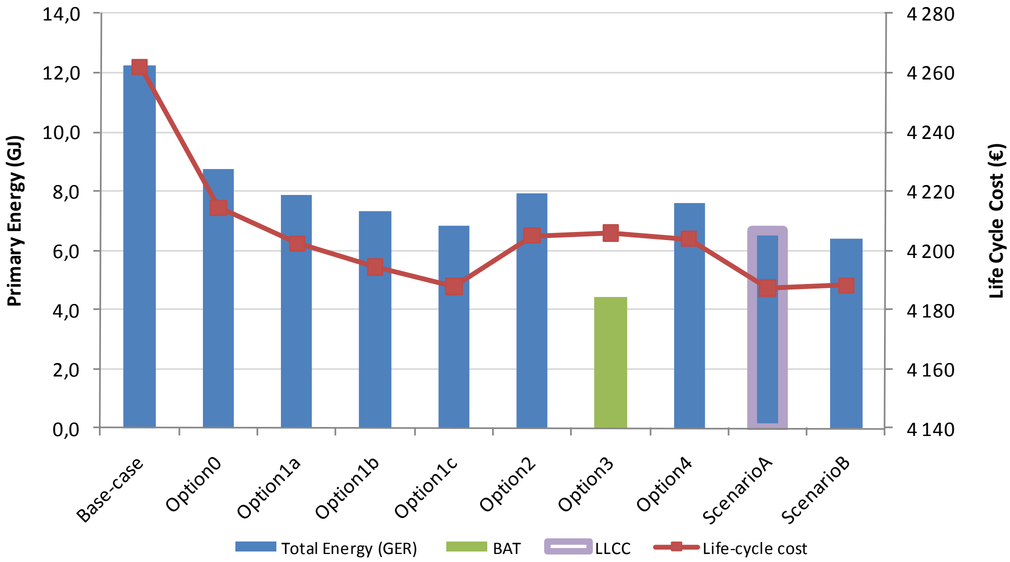

Figure 7-32: Identification of BAT and LLCC products for BC 2

7.4.3. Base-case 3: Hard cap espresso machine

The identification of the BAT and LLCC products is shown in Figure 7-33. Considering life-cycle cost, Scenario A is the cheapest product to use. Option 3 would reduce primary energy consumption further, but at a higher cost.

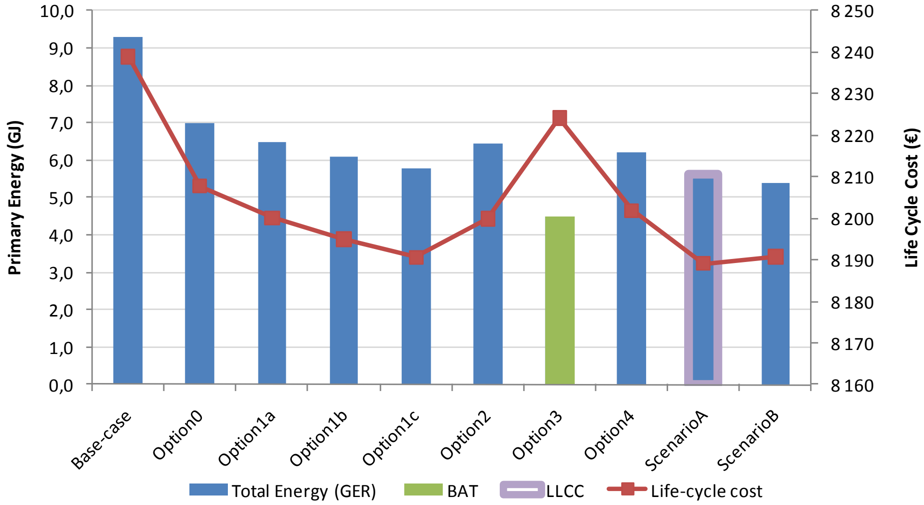

Figure 7-33: Identification of BAT and LLCC products for BC 3

7.4.4. Base-case 4: Semi-automatic espresso machine

The identification of the BAT and LLCC products is possible in Figure 7-34.

Considering life-cycle cost, Scenario A is the cheapest product to use. However, Scenario B allows slightly higher energy savings over the life cycle of the product.

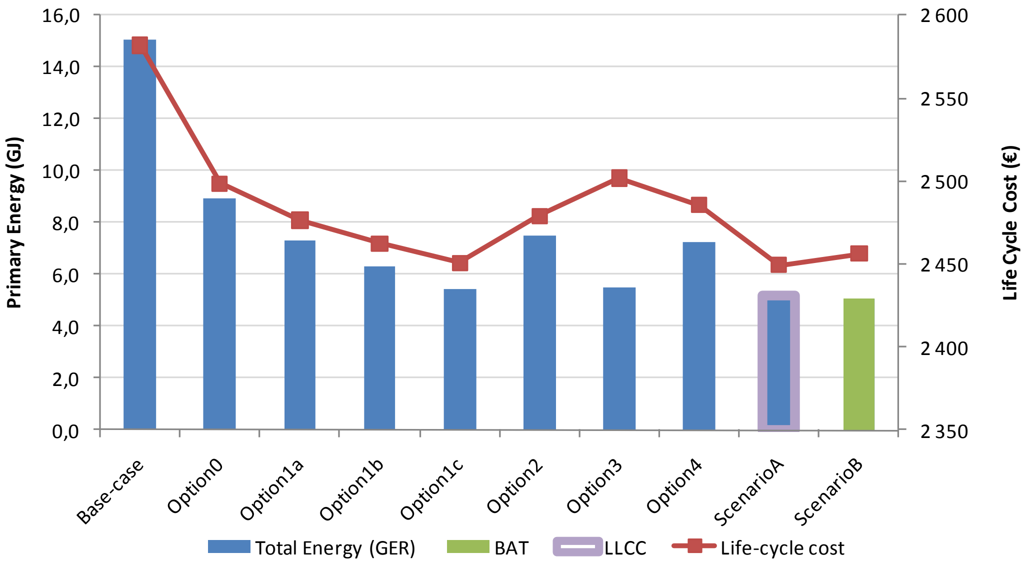

Figure 7-34: Identification of BAT and LLCC products for BC 4

7.4.5. Base-case 5: Fully automatic espresso machine

The identification of the BAT and LLCC products is possible in Figure 7-35. Considering life cycle cost, Scenario A is the cheapest product to use.

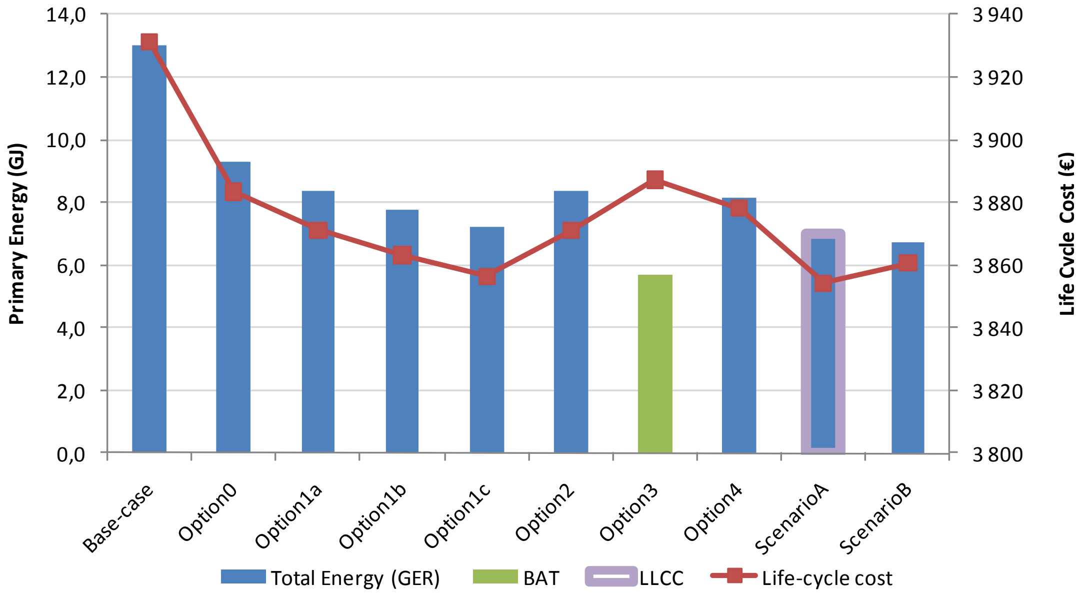

Figure 7-35: Identification of BAT and LLCC products for BC 5

7.5. CONCLUSIONS

There are several improvement options available that can reduce the environmental impacts of non-tertiary coffee machines, and especially those related to electricity consumption, without a significant negative effect on functionality or taste. The improvement potential is 42-66% depending on the Base-Case. These results will be considered in Task 8 when recommending policy options and when defining scenarios to 2025.

It should be noticed that several options (or combinations) reduce the life cycle cost of the coffee machine, even if it is in a low share (as consumables costs represent a big share of the LCC). The rankings of the options have to be considered with cautious, as for some Base-Cases the difference in LCC between several options is of a few Euros. This is especially due to the various assumptions used in the study.