Preparatory Studies for Ecodesign Requirements of EuPs (III)

ENER Lot 20 – Local Room Heating Products
Task 7: Improvement options

European Commission, DG ENER
25 June 2012

Developed by:

Project description

CLIENT	European Commission, DG ENER
CONTRACT NUMBER	TREN/D3/91-2007-Lot 20-SI2.519986
REPORT TITLE	ENER Lot 20 – Local Room Heating Products Task 7: Improvement options
REPORT SUB-TITLE	Final report
PROJECT NAME	Preparatory Studies for Ecodesign Requirements of EuPs (III)
PROJECT CODE	EuP20
PROJECT TEAM	BIO Intelligence Service
DATE	25 June 2012

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Please cite this publication as:
BIO Intelligence Service (2012) Preparatory Studies for Ecodesign Requirements of EuPs (III), ENER Lot 20 – Local Room Heating Products – Task 7: Improvement options. Prepared for the European Commission, DG ENER.

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Task 7: Improvement potential

Task 7 quantitatively analyses design improvement options, based on the Best Available Technologies (BATs) described in Task 6 for each of the product Base-Cases. The environmental impacts of each of these options are calculated by using the MEEuP EcoReport tool. The economic impacts of each design option are assessed in terms of Life Cycle Cost (LCC). The assessment of LCC is relevant as it indicates whether design solutions may impact the costs to users over the total lifetime of the product (purchase, operating, end-of-life costs, etc.). The assessment of both environmental and economic impacts allows the improvement option with the Least Life Cycle Costs (LLCC) and that results in the most significant reductions in environmental impacts to be identified. The Best Not yet Available Technologies (BNAT) are also discussed, assessing the improvement potential of the product groups in the long-term.

7.1 Identification of design improvement options

This section presents the different improvement options applicable to each Base-Case. The design option(s) should:

- not have a significant variation in the functionality and in the performance parameters compared to the Base-Cases and in the product-specific inputs;
- have a significant potential for ecodesign improvement without significantly deteriorating other impact parameters; and,
- not entail excessive costs and other impacts on manufacturers.

For each of the improvement options, the modifications implied by their implementation in the Base-Case are quantified by the change in energy consumption. It is assumed that the improvement options are equally applicable to all sub-types of equipment in each product category. The improvement potential of a particular improvement option or a combination of improvement options is evaluated by using the MEEuP EcoReport tool.

The cost effectiveness of an improvement option is expressed in terms of payback time in years, defined as the ratio between:

(Cost increase with reference to the Base Case) and (Annual energy consumption difference in kWh*energy cost)

In Task 8, some possible scenarios will be investigated as a basis for defining future Ecodesign requirements, taking into account - among other parameters - life cycle costs and technical constraints.

7.1.1 Base-Case 1: Open combustion/chimney connected flued gas heater

Task 5 identified that reducing total energy consumption during use phase would be an effective way to also reduce the overall environmental impacts of open combustion/chimney connected flued gas heaters. After a detailed analysis of available technologies in Task 6, the improvement options selected to reduce the environmental impacts of BC 1 (an open combustion/chimney connected flued gas heater) aim at reducing the annual energy consumption. Each of the improvement options applicable to the BC 1 are presented in Table 7—1 with their relative impact on the product cost compared to the BC 1.

As it can be seen from the table, although Option 2 through to Option 5 provide fuel savings, an increase of electricity consumption is expected at the same time. However, the amount of electricity required is very low compared to the annual fuel consumption. Option 4 concerning controls include a PI controller, a programmable thermostat with setback functionality, absence detection and a open window detection sensor. This results in 29% energy savings when compared to the Base-Case.

Apart from the energy savings, the design options could result in some other constraints, which would have to be taken into consideration. Switching from a burning pilot light to an electric ignition device, may result in heaters that are more susceptible to corrosion and condensation.

Option 4 has a low payback time of around 2.2 years. The payback times for the remaining options are in the range of 5 years or more. A low payback time makes Option 4 a good candidate for investment.

Table 7—1: Identified energy saving potentials for BC 1: open combustion flued gas heater

	Description	Annual electricity consumption (kWh)	Annual heat energy consumption (kWh)	Product price (€)	Electricity savings compared to Base-Case (%)	Heat energy savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
Base-Case 1		0	1829	600	0	0.0%	0	
Option 1	Balanced flue	0	1 481	850	N/A	19.0%	250	12.98
Option 2	Eliminating pilot flame: electric ignition system	1.13	1 792	615	N/A	2.0%	15	7.40
Option 3	Mechanical draft	1.13	1 774	615	N/A	3.0%	15	4.93
Option 4	Controls	1.13	1 299	666	N/A	29.0%	66	2.24
Option 5 (Op1+Op2+Op3+Op4)	Combination of Option 1, Option 2, Option 3 and Option 4	1.13	878	946	N/A	52.0%	346	6.56

7.1.2 Base-Case 2: Open combustion/chimney connected flue gas fire

Similar to BC 1, the improvement options selected for BC 2 aim at reducing the environmental impacts, in particular the annual energy consumption. Each of the improvement options applicable to the BC 2 are presented in Table 7—2 with their relative impact on the product cost compared to the Base-Case. Option 5 has the lowest payback time of around 1.45 years. The payback times for the remaining options (other than Option 3) are also quite low (less than 3.5 years). A low payback time makes most of the options good candidates for investment.

Table 7—2: Identified energy saving potentials for BC 2: Open combustion flued gas fire

	Description	Annual electricity consumption (kWh)	Annual heat energy consumption (kWh)	Product price (€)	Electricity savings compared to Base-Case (%)	Heat energy savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
Base-Case 2		0	2830	600	0	0.0%	0	
Option 1	Closed combustion: glass fronted	0	1840	725	N/A	35.0%	125	2.28
Option 2	Balanced flue	0	1472	850	N/A	48.0%	250	3.32
Option 3	Eliminating pilot flame: electric ignition system	1.13	2773	615	N/A	2.0%	15	4.78
Option 4	Mechanical draft	1.13	2745	615	N/A	3.0%	15	3.19
Option 5	Controls	1.13	2009	666	N/A	29.0%	66	1.45
Option 6 (Op1+Op3+Op4+Op5)	Combination of Option 1, Option 3, Option 4 and Option 5	1.13	906	821	N/A	68.0%	221	2.07
Option 7 (Op2+Op3+Op4+Op5)	Combination of Option 2, Option 3, Option 4 and Option 5	1.13	594	946	N/A	79.0%	346	2.79

7.1.3 Base-Case 3: Electric portable fan heater

The improvement options selected for BC 3 (electric portable fan heater) aim at reducing the environmental impacts, in particular the annual energy consumption. Two options are selected and both of them concerns controls to regulate the room temperature. The payback time for both the selected options is very low (less than 0.15 years), hence making them good candidates for investment. The two improvement options applicable to BC 3 are presented in Table 7—3 with their relative impact on the product cost compared to the BC 3.

Table 7—3: Identified energy saving potentials for BC 3: portable electric fan heater

	Description	Annual electricity consumption (kWh)	Product price (€)	Electricity savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
Base-Case 3		330.00	30	0.0%	0	
Option 1	Two step on/off controller	59.40	33	82.0%	3	0.07
Option 2	PI controller	52.80	36	84.0%	6	0.13

7.1.4 Base-Case 4: Convector electric fixed

The improvement options selected for BC 4 aim at reducing the environmental impacts, in particular the annual energy consumption. Five options as well as a combination of all four options are selected. All five of these options concern controls to regulate the room temperature. Each of the five improvement options applicable to the BC 4 are presented in Table 7—4 with their relative impact on the product cost compared to the BC 4. The payback time for all the five selected options is low (less than 2 years), hence making them good candidates for investment.

Table 7—4: Identified energy saving potentials for BC 4: convector electric fixed

	Description	Annual electricity consumption (kWh)	Product price (€)	Electricity savings compared to BC (%)	Increase in product price compared to BC (€)	Payback time (years)
Base-Case 4		1131	120	0.0%	0	
Option 1	PI controller	1041	126	8.0%	6	0.41
Option 2	Programmable thermostat with setback functionality	984	150	13.0%	30	1.25
Option 3	Open window detection	1063	135	6.0%	15	1.36
Option 4	Absence detection	1063	135	6.0%	15	1.36
Option 5 (Op1+Op2+Op3+Op4)	Combination of Option 1, Option 2, Option 3 and Option 4	803	186	29.0%	66	1.23
Option 6[1]	Single split reversible heat pump[2]	271	2600	76.0%	2480	10.56

[1] A single split reversible heat pump can be considered a product level BAT for all electric heaters used for primary heating. Many stakeholders (mostly comprising of manufacturers and industry associations including CECED and BEAMA) strongly disagree with the consideration of single split reversible heat pump as a BAT for following reasons:

1) Local room heaters and heat pumps are different products from a design, client, application, and cost range point of view. The heat pump is a split system with an outside heat absorption unit and an inside heat distribution unit.

2) The heating function of heat pumps is already covered under ENER Lot 10 (air to air heat pumps) study and in ENER Lot 1 study (air to water heat pumps).

3) Air to Air heat pumps are suitable for centralised heating systems but not for local room heating which requires several installations for each heating point.

4) Investment, installation and maintenance costs for a heat pump are substantially higher than for a conventional local room heater.

In this report, an example of heat pump as BAT is therefore only considered for one Base-Case (e.g. BC 4) to demonstrate their corresponding costs/benefits compared to local room heaters.

[2] Single split reversible heat pump with a capacity of 2.5 kW and COP (Coefficient of Performance) of 4. The single split reversible heat pump additionally requires installation cost of €1000 and annual maintenance and repair cost (for 12 years) of €60/year.

7.1.5 Base-Case 5a: Static electric storage heater

The improvement options selected for BC 5a aim at reducing the environmental impacts, in particular the annual energy consumption. Two options are selected and both of them concerns automatic charge control of the static storage heater. The payback time for Option 1 (2.7 years) is lower than that of Option 2 (around 6 years), hence making Option 1 a better candidate for investment. Each of the two improvement options applicable to the BC 5a are presented in Table 7—5 with their relative impact on the product cost compared to the Base-Case.

Table 7—5: Identified energy saving potentials for BC 5a: static electric storage heater

	Description	Annual electricity consumption (kWh)	Product price (€)	Electricity savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
Base-Case 5a		1 324	375	0.0%	0	
Option 1	Automatic electro-mechanical charge control	1 258	395	5.0%	20	2.77
Option 2	Automatic (electronic) charge control	1 231	435	7.0%	60	5.94

7.1.6 Base-Case 5b: Dynamic electric storage heater

The improvement options selected for BC 5b aim at reducing the environmental impacts, in particular the total energy consumption. Two options and a combination of both options are selected and all three of them concerns automatic charge control of the dynamic storage heater. Each of the improvement options applicable to the Base-Case are presented in Table 7—6 with their relative impact on the product cost compared to the Base-Case. The payback time for all the three selected options is in the same range (4.5 – 5.5 years).

Table 7—6: Identified energy saving potentials for BC 5b: dynamic electric storage heater

	Description	Annual electricity consumption (kWh)	Product price (€)	Electricity savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
Base-Case 5b		1 351	600	0.0%	0	
Option 1	Automatic electronic charge control and thermostat output control	1215	680	10.0%	80	5.43
Option 2	Sophisticated controls (advanced algorithms for charging and discharging)	1269	640	6.0%	40	4.53
Option 3 (Op1+Op2)	Combination of Option 1 and Option 2	1148	720	15.0%	120	5.43

7.1.7 Base-Case 6a: Electric underfloor heating (primary)

Similar to BC 4, three options and a combination of all four options are selected for analysis. All four of them concern controls to regulate the room temperature, where BC 6a is used. The main aim of the selected improvement options is to reduce the environmental impacts, in particular the annual energy consumption related to BC 6a. Each of the four improvement options applicable to BC 6a are presented in Table 7—7 with their relative impact on the product cost compared to the Base-Case. The payback time for all the four selected options is low (less than 2 years), hence making them all good candidates for investment.

Table 7—7: Identified energy saving potentials for BC 6a: electric underfloor heating (primary)

	Description	Annual electricity consumption (kWh)	Product price (€)	Electricity savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
Base-Case 6a		1 130	560	0.0%	0	
Option 1	PI controller	1108	566	2.0%	6	1.63
Option 2	Programmable thermostat with setback functionality	984	590	13.0%	30	1.25
Option 3	Open window detection	905	611	6.0%	15	1.38
Option 4 (Op1+Op2+Op3)	Combination of Option 1, Option 2, Option 3 and Option 4	1108	566	20.0%	51	1.63

7.1.8 Base-Case 6b: Electric underfloor heating (secondary)

Similar to BC 6a, two options and a combination of these options is selected for analysis. All three of them concern controls to regulate the room temperature where BC 6b is used. Each of the three improvement options applicable to the BC 6b are presented in Table 7—8 with their relative impact on the product cost compared to the Base-Case. It is important to note that contrary to BC 6a, the payback time of the improvement options for BC 6b is approximately 6 times higher (around 11 – 14 years). This difference is due to the lower number of hours of operation of BC 6b (secondary heating) during the use phase compared to BC 6a (primary heating).

Table 7—8: Identified energy saving potentials for BC 6b: electric underfloor heating (secondary)

	Description	Annual electricity consumption (kWh)	Product price (€)	Electricity savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
Base-Case 6b		130	150	0%	0	
Option 1	Thermostat - PI controller	127	156	2%	6	14.16
Option 2	Programmable thermostat with timer for multiple set points	113	180	13%	30	10.89
Option 3 (Op1+Op2)	Combination of Option 1, Option 2, Option 3 and Option 4	117	186	15%	36	11.33

7.1.9 Base-Case 7: Warm air unit heater

The improvement options selected for BC 7 aim at reducing the environmental impacts, in particular the annual energy consumption. Four individual options and three combinations of the four options are selected. Each of the improvement options applicable to the BC 7 are presented in Table 7—9 with their relative impact on the product cost compared to the Base-Case. Two generation efficiencies are considered and reflected in Option 3a and 3b. The product costs for option 3b include extra pipework for condensate discharge, as condensation arises from 94% combustion efficiency and over. The combination of options (Option 5, Option 6 and Option 7) also includes the energy savings (around 19% savings compared to the Base-Case without any controls) resulting from room temperature controls (extended products: on/off thermostat and RT automatic programmable). The payback time for all the selected options varies from 5 to 13 years.

Table 7—9: Identified energy saving potentials for BC 7: non-residential warm air unit heater

	Description	Annual electricity consumption (kWh)	Annual heat energy consumption (kWh)	Product price (€)	Electricity cons. compared to Base-Case (%)	Heat energy savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
Base-Case 7		421	40 000	3 700	0.0%	0.0%	0	
Option 1	Electric ignition system	421	39 200	3 900	0.0%	2.0%	200	6.00
Option 2	Mechanical draft for combustion air supply	497	38 800	3 900	-18.0%	3.0%	200	5.24
Option 3a	Seasonal Net heat generation efficiency: 95%	472	35 600	5 364	-12.0%	10.0%	1 664	9.48
Option 3b	Seasonal Net heat generation efficiency: 98%	472	34 400	6 085	-12.0%	13.0%	2 385	10.57
Option 4	Seasonal Specific air throw[3] <= 5 W/m³/h	644	36 000	5 400	-53.0%	10.0%	1 700	12.88
Option 5 (Op1+Op2+Op3a)	Combination of room temperature controls, Option 1, Option 2 and Option 3a	695	29 200	6 244	-65.0%	-27%	2544	6.24
Option 6 (Op1+Op2+Op3b)	Combination of room temperature controls, Option 1, Option 2 and Option 3b	695	28 400	6 965	-65.0%	-29%	3265	7.41

[3] The specific air throw is assessed as air volume blown by the heater (m³/h at 15 K temperature rise per kW heat in performance). The influence of seasonal variation of heat load on the specific air throw rate is calculated as per following: *Seasonal specific air throw = 0.2 x Specific air throw rate* $_{maximum\ input}$ *+ 0.8 x Specific air throw rate* $_{minimum\ input}$

	Description	Annual electricity consumption (kWh)	Annual heat energy consumption (kWh)	Product price (€)	Electricity cons. compared to Base-Case (%)	Heat energy savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
Option 7 (Op1+Op2+Op3b+ Op4)	Combination of room temperature controls, Option 1, Option 2, Option 3b and Option 4	695	25 200	8 665	-65.0%	-37%	4965	8.65

7.1.10 Base-Case 8a: Luminous radiant heater

The improvement options selected for BC 8a aim at reducing the environmental impacts, in particular the annual energy consumption. Four individual options and two combinations of the four options are selected. Each of the improvement options applicable to the BC 8a are presented in Table 7—10 with their relative impact on the product cost compared to the Base-Case. Two emission efficiencies are considered and reflected for different values of radiant factors in Options 3a and 3b. Luminous radiant heaters evacuate their flue gases together with a ratio of air volume of the heated room[4]. Two types of evacuation (extended product) are considered and reflected in Options 4a (Type 2: mechanical/thermal evacuation 10 m³/hour/kW heat installed) and 4b (Type 3: mechanical/thermal evacuation 10 m³/hour/kW heat installed, openings closed during time burners are not in operation). The combination of options (Option 5 and Option 7) also includes the energy savings (around 17% savings compared to the Base-Case without any controls) resulting from room temperature controls (extended products: on/off thermostat and RT automatic programmable). The payback time for all the selected options lies between 2 to 7 years.

[4] Indirect flue gas evacuation can be realised by natural ventilation of the building or – to reduce losses - by mechanical or thermal evacuation as required by the EN 13410.

Table 7—10: Identified energy saving potentials for BC 8a: luminous radiant heater

	Description	Annual electricity consumption (kWh)	Annual heat energy consumption (kWh)	Product price (€)	Electricity savings compared to Base-Case (%)	Heat energy savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
BC 8a		24.30	20 000	1300	0.0%	0.0%	0	
Option 1	Power control: two stage burner	24.30	19 400	1420	0.0%	3.0%	120	4.80
Option 2	Power control: modulating burner	24.30	19 000	1550	0.0%	5.0%	250	6.00
Option 3a	Radiant factor > 0.65	24.30	17 200	1800	0.0%	14.0%	500	4.28
Option 3b	Radiant factor > 0.75	24.30	15 800	2400	0.0%	21.0%	1 100	6.28
Option 4a	Mechanical flue gas evacuation Type 2	24.30	18 200	1500	0.0%	9.0%	200	2.67
Option 4b	Mechanical flue gas evacuation Type 3	30.38	17 800	1650	-25.0%	11.0%	350	3.86
Option 5 (Op1+Op3a +Op4a)	Combination of room temperature controls, Option 1, Option 3a and Option 4a	24.30	12 800	2550	0.0%	36.0%	1 250	4.16
Option 6 (Op2+Op3b +Op4b)	Combination of room temperature controls, Option 2, Option 3b and Option 4b	30.38	11 800	3430	-25%	41.0%	2 130	6.25

7.1.11 Base-Case 8b: Radiant tube heater

The improvement options selected for BC 8b aim at reducing the environmental impacts, in particular the annual energy consumption. Four individual options and three combinations of the four options are selected. Each of the improvement options applicable to the BC 8b are presented in Table 7—11 with their relative impact on the product cost compared to the Base-Case. Two heat generation efficiencies are considered and reflected in Options 3a and 3b. Two heat emission efficiencies (due to different radiant factors) are considered and reflected in Options 4a and 4b. Improvements of heat emission efficiencies of radiant tube heaters partly comprise improvements of heat generation efficiencies of these products – so the overall energy savings of combinations of improvements of these parameters have to be considered in interaction. In this calculation – as a simple approach – improvements of Options 3a and 3b are taken in to account with 50% of their single impact when combined with Options 4a and 4b. The combination of options (Option 5, Option 6 and Option 7) also includes the energy savings (around 19% savings compared to the Base-Case without any controls) resulting from room temperature controls (extended products: on/off thermostat and RT automatic programmable). The payback time for all the selected options varies between 3 to 8 years.

Table 7—11: Identified energy saving potentials for BC 8b: radiant tube heater

	Description	Annual electricity consumption (kWh)	Annual heat energy consumption (kWh)	Product price (€)	Electricity savings compared to Base-Case (%)	Heat energy savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
BC 8b		92	30 000	1 900	0.0%	0.0%	0	
Option 1	Power control: two stage burner	92	29 100	2 020	0.0%	3.0%	120	3.2
Option 2	Power control: modulating burner	92	28 500	2 300	0.0%	5.0%	400	6.4
Option 3a	Net heat generation efficiency: 90%	110	28 800	2 110	-20.0%	4.0%	210	4.5
Option 3b	Net heat generation efficiency: 92%	110	28 200	2 300	-20.0%	6.0%	400	5.5
Option 4a	Radiant factor > 0.60	92	27 600	2 520	0.0%	8.0%	620	6.2
Option 4b	Radiant factor > 0.70	92	25 500	3 400	0.0%	15.0%	1 500	8.0
Option 5 (Op1+Op3a+Op4a)	Combination of room temperature controls, Option 1, Option 3a and Option 4a	110	20 100	3 280	-20.0%	33.0%	1 380	3.4
Option 6 (Op2+Op3b+Op4a)	Combination of room temperature controls, Option 2, Option 3b and Option 4a	110	18 900	3 750	-20.0%	37.0%	1 850	4.0
Option 7 (Op2+Op3b+Op4b)	Combination of room temperature controls, Option 2, Option 3b and Option 4b	110	17 700	4 630	-20.0%	41.0%	2 730	5.4

7.1.12 Base-Case 9: Air curtain

The improvement options selected for BC 9 aim at reducing the environmental impacts, in particular the annual energy consumption of the air curtain and the building heat losses through the air curtain opening. Two individual options and a combination of both the options are selected. Each of the improvement options applicable to the BC 9 are presented in Table 7—12 with their relative impact on the product cost compared to the Base-Case.

Table 7—12: Identified energy saving potentials for BC 9: air curtain

	Description	Annual electricity consumption (kWh)	Annual heat consumption (kWh)	Product price (€)	Electricity savings compared to Base-Case (%)	Heat savings compared to Base-Case (%)	Increase in product price compared to Base-Case (€)	Payback time (years)
BC 9		340	6624	2 500	0.0%	0.0%	0	
Option 1	Air stream technology	340	6624	2 650	0.0%	0.0%	150	N/A
Option 2	Self-regulating controls	170	1656	2 875	50.0%	75.0%	375	1.6
Option 3 (Op1+Op2)	Combination of Option 1 and Option 2	170	1656	3 025	50.0%	75.0%	525	2.3

7.2 Analysis BAT and LLCC

The design option(s) identified in the technical, environmental and economic analyses are ranked to identify the design improvement option with the least life cycle environmental impacts and the Least Life Cycle Costs (LLCC). Constructing an energy versus LCC-curve (Y-axis = primary energy consumption and LCC, X-axis = design options) allows identification of the most pertinent design options[5].

The performance of each improvement option is compared against the Base-Case. The comparison is made in terms of primary energy consumption and LCC. LCC is the sum of the Base-Case product price, plus cost of improvements, added to the costs of energy, and the costs of installation and maintenance as described in Task 4.

7.2.1 Base-Case 1: Open combustion/chimney connected flue gas fire

An assessment of the environmental and economic impacts was carried out for each improvement option, using the EcoReport tool. Table 7—13 represents the outcomes of this with absolute values (in units) and variations compared with the Base-Case.

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

Table 7—13: Environmental impacts of the BC 1 and its improvement options

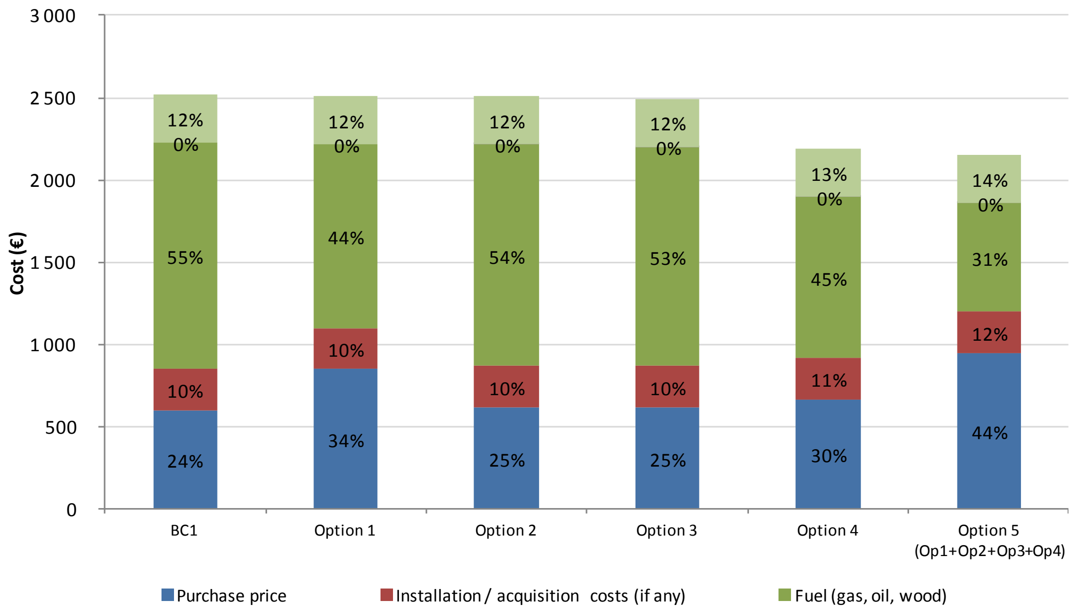
Life-cycle indicators per unit	unit	BC 1	Option 1	Option 2	Option 3	Option 4	Option 5 (Op1+Op2+Op3+Op4)
OTHER RESOURCES AND WASTE							
Total Energy (GER)	GJ	142.7	115.9	140.1	138.7	102.0	69.6
	% change with BC	0%	-19%	-2%	-3%	-29%	-51%
of which, electricity	primary GJ	0.2	0.2	0.4	0.4	0.4	0.4
	final MWh	0.0	0.0	0.0	0.0	0.0	0.0
	% change with BC	0%	0%	112%	112%	112%	112%
Water (process)	m^3	0.0	0.0	0.1	0.1	0.1	0.1
	% change with BC	0%	0%	43%	43%	43%	43%
Water (cooling)	m^3	0.4	0.4	1.0	1.0	1.0	1.0
	% change with BC	0%	0%	177%	177%	177%	177%
Waste, non-haz./ landfill	kg	31.3	31.3	31.6	31.6	31.6	31.6
	% change with BC	0%	0%	1%	1%	1%	1%
Waste, hazardous/ incinerated	kg	0.0	0.0	0.0	0.0	0.0	0.0
	% change with BC	0%	0%	20%	20%	20%	20%
EMISSIONS (AIR)							
Greenhouse Gases in GWP100	t CO_2 eq.	7.9	6.4	7.8	7.7	5.7	3.9
	% change with BC	0%	-19%	-2%	-3%	-28%	-51%
Acidification, emissions	kg SO_2 eq.	2.6	2.1	2.6	2.6	2.0	1.4
	% change with BC	0%	-17%	1%	0%	-23%	-44%
Volatile Organic Compounds (VOC)	kg	0.1	0.1	0.1	0.1	0.1	0.1
	% change with BC	0%	-18%	-2%	-3%	-27%	-48%

Life-cycle indicators per unit	unit	BC 1	Option 1	Option 2	Option 3	Option 4	Option 5 (Op1+Op2+Op3+Op4)
Persistent Organic Pollutants (POP)	µg i-Teq	0.4	0.4	0.4	0.4	0.4	0.4
	% change with BC	0%	0%	0%	0%	0%	0%
Heavy Metals to air	g Ni eq.	0.2	0.2	0.2	0.2	0.2	0.2
	% change with BC	0%	0%	2%	2%	2%	2%
PAHs	g Ni eq.	0.1	0.1	0.1	0.1	0.1	0.1
	% change with BC	0%	-1%	0%	0%	-1%	-2%
Particulate Matter (PM, dust)	kg	1.6	1.6	1.6	1.6	1.6	1.5
	% change with BC	0%	0%	0%	0%	-1%	-1%
EMISSIONS (WATER)							
Heavy Metals to water	g Hg/20	0.1	0.1	0.1	0.1	0.1	0.1
	% change with BC	0%	0%	2%	2%	2%	2%
Eutrophication	kg PO4	0.0	0.0	0.0	0.0	0.0	0.0
	% change with BC	0%	0%	0%	0%	0%	0%
Life-cycle cost	€	2 517.6	2 506.2	2 507.6	2 493.8	2 187.2	2 150.9
	% change with BC	0%	0%	0%	-1%	-13%	-15%

Option 1	Option 2	Option 3	Option 4
Balanced flue	Eliminating pilot flame: electric ignition system	Mechanical draft	Room temperature controls

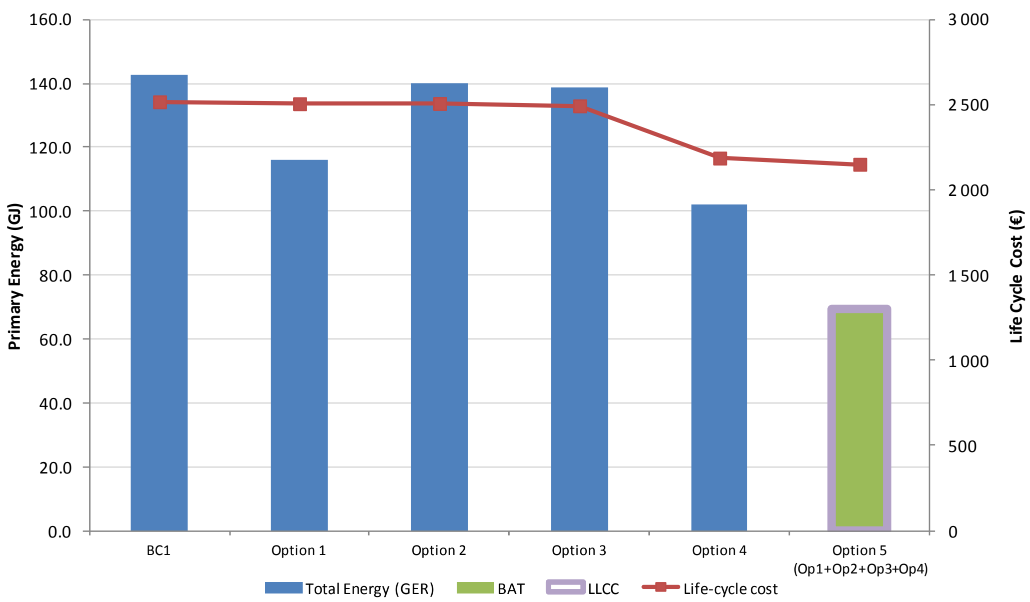
Figure 7-1 shows the share of costs in the LCC for the BC 1 and the improvement options. The fuel costs and the purchase costs over the lifetime have the highest share of LCC. Purchase costs increase from 24% of LCC in the Base-Case up to 44% in one of the improvement options.

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



As shown in Figure 7-2, Option 5 has the least LCC and therefore is the candidate for LLCC. This option is the candidate for greatest energy savings as well. The primary energy consumption is around 51% lower than the Base-Case and the LCC is 15% lower. The second highest energy savings are achieved by Option 4 (29%), which represents also the second lowest LCC (around 13% lower).

Figure 7-2: Identification of BAT option and LLCC option for BC 1



7.2.2 Base-Case 2: Open combustion/chimney connected flue gas fire

Environmental and economical impacts assessments are presented in Table 7–14. Option 6 and Option 7 result in significant reduction of total energy consumption, however it entails a increase in electricity consumption (and water required for cooling related to electricity generation). This is still only a small increase compared to the primary energy savings. Considering environmental impacts and reduction of energy consumption, Option 2 has total energy reduced by 48% compared to Base-Case.

Table 7—14: Environmental impacts of the BC 2 and its improvement options

Life-cycle indicators per unit	unit	BC 2	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6 (Op1+Op3+Op4+Op5)	Option 7 (Op2+Op3+Op4+Op5)
OTHER RESOURCES AND WASTE									
Total Energy (GER)	GJ	220.9	144.5	116.1	216.8	214.6	157.8	72.7	48.7
	% change with BC	0%	-35%	-47%	-2%	-3%	-29%	-67%	-78%
of which, electricity	primary GJ	0.5	0.5	0.5	0.7	0.7	0.7	0.7	0.7
	final MWh	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
	% change with BC	0%	0%	0%	48%	48%	48%	48%	48%
Water (process)	m^3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
	% change with BC	0%	0%	0%	4%	4%	4%	4%	4%
Water (cooling)	m^3	0.2	0.2	0.2	0.8	0.8	0.8	0.8	0.8
	% change with BC	0%	0%	0%	345%	345%	345%	345%	345%
Waste, non-haz./ landfill	kg	37.4	37.4	37.4	37.6	37.6	37.6	37.6	37.6
	% change with BC	0%	0%	0%	1%	1%	1%	1%	1%
Waste, hazardous/ incinerated	kg	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	% change with BC	0%	0%	0%	2%	2%	2%	2%	2%
EMISSIONS (AIR)									
Greenhouse Gases in GWP100	t CO_2 eq.	12.2	8.0	6.4	12.0	11.9	8.7	4.0	2.7
	% change with BC	0%	-35%	-47%	-2%	-3%	-29%	-67%	-78%
Acidification, emissions	kg SO_2 eq.	4.1	2.9	2.4	4.1	4.1	3.2	1.8	1.4
	% change with BC	0%	-30%	-41%	0%	-1%	-23%	-56%	-66%
Volatile Organic Compounds (VOC)	kg	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.1
	% change with BC	0%	-31%	-42%	-2%	-3%	-25%	-60%	-69%

Life-cycle indicators per unit	unit	BC 2	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6 (Op1+Op3+Op4+Op5)	Option 7 (Op2+Op3+Op4+Op5)
Persistent Organic Pollutants (POP)	µg i-Teq	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	% change with BC	0%	0%	0%	0%	0%	0%	0%	0%
Heavy Metals to air	g Ni eq.	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	% change with BC	0%	0%	0%	1%	1%	1%	1%	1%
PAHs	g Ni eq.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	% change with BC	0%	-2%	-2%	0%	0%	-1%	-3%	-3%
Particulate Matter (PM, dust)	kg	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	% change with BC	0%	-1%	-1%	0%	0%	0%	-1%	-1%
EMISSIONS (WATER)									
Heavy Metals to water	g Hg/20	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	% change with BC	0%	0%	0%	1%	1%	1%	1%	1%
Eutrophication	kg PO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% change with BC	0%	0%	0%	0%	0%	0%	0%	0%
Life-cycle cost	€	3 270.3	2 650.5	2 498.8	3 245.2	3 224.0	2 721.6	2 046.7	1 937.6
	% change with BC	0%	-19%	-24%	-1%	-1%	-17%	-37%	-41%

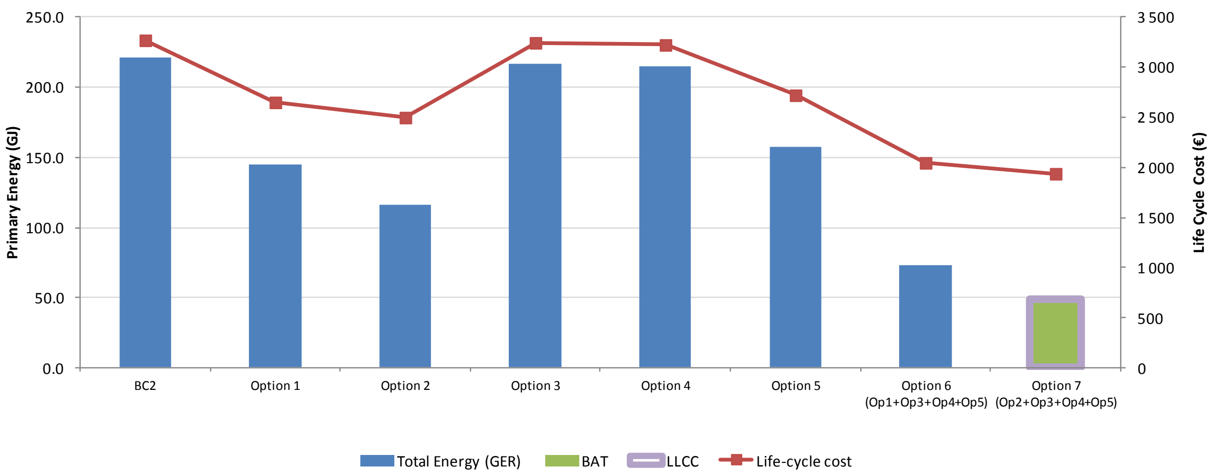
Option 1	Option 2	Option 3	Option 4	Option 5
Closed combustion: Glass fronted	Balanced flue	Eliminating pilot flame: electric ignition system	Mechanical draft	Room temperature controls

Figure 7-3 shows the share of life cycle costs for the BC 2 and its improvement options. In all the options, fuel consumption and product price represent the largest expenditures. Purchase price has also a significant share. Installation costs have the least contribution (from 8% to 13%).

Figure 7-3: Life cycle cost of the improvement options for BC 2

As shown in Figure 7-4, Option 7 is the LLCC as well as the design option with the greatest energy savings. For the Option 7 the primary energy consumption is 78% lower than the Base-Case and the LCC is 41% lower. For the Option 6 the energy savings are around 67% and LCC is 37% lower.

Figure 7-4: Identification of BAT option and LLCC option for BC 2



7.2.3 Base-Case 3: Electric portable fan heater

Table 7–15 presents estimates of environmental and economical impacts for BC 3. Option 1 and Option 2 allows achieving significant reductions in energy consumption: 81% and 83%, respectively, as well as a reduction in environmental impacts compared to the Base-Case.

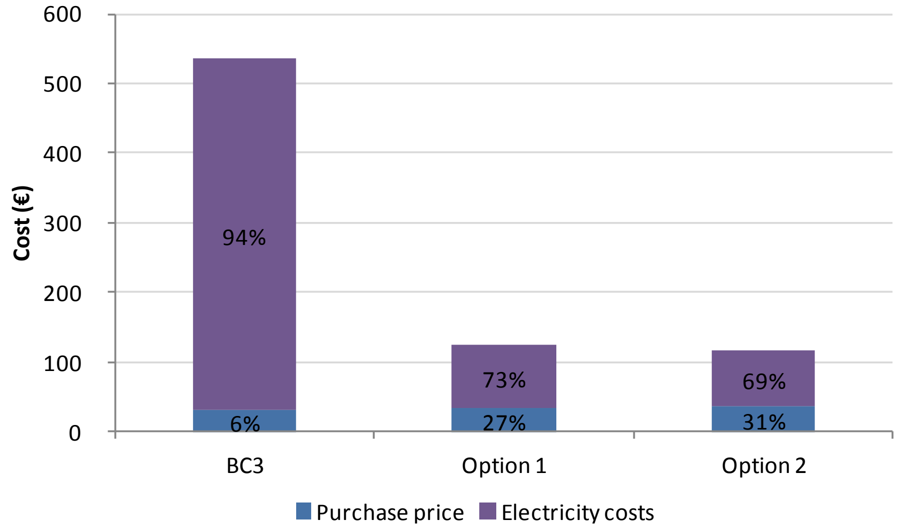
Table 7—15: Environmental impacts of the BC 3 and its improvement option

Life-cycle indicators per unit	unit	BC 3	Option 1	Option 2
OTHER RESOURCES AND WASTE				
Total Energy (GER)	GJ	41.9	7.8	6.9
	% change with BC	0%	-81%	-83%
of which, electricity	primary GJ	41.7	7.6	6.7
	final MWh	4.0	0.7	0.6
	% change with BC	0%	-82%	-84%
Water (process)	m^3	2.8	0.5	0.5
	% change with BC	0%	-81%	-83%
Water (cooling)	m^3	111.0	20.1	17.9
	% change with BC	0%	-82%	-84%
Waste, non-haz./ landfill	kg	50.1	10.6	9.6
	% change with BC	0%	-79%	-81%
Waste, hazardous/ incinerated	kg	1.1	0.3	0.3
	% change with BC	0%	-73%	-75%
EMISSIONS (AIR)				
Greenhouse Gases in GWP100	t CO2 eq.	1.8	0.3	0.3
	% change with BC	0%	-81%	-83%
Acidification, emissions	kg SO2 eq.	10.8	2.0	1.8
	% change with BC	0%	-81%	-83%
Volatile Organic Compounds (VOC)	kg	0.0	0.0	0.0
	% change with BC	0%	-76%	-77%
Persistent Organic Pollutants (POP)	µg i-Teq	0.3	0.1	0.1
	% change with BC	0%	-79%	-81%
Heavy Metals to air	g Ni eq.	0.7	0.1	0.1
	% change with BC	0%	-80%	-82%
PAHs	g Ni eq.	0.1	0.0	0.0
	% change with BC	0%	-73%	-74%
Particulate Matter (PM, dust)	kg	0.4	0.2	0.2
	% change with BC	0%	-48%	-49%
EMISSIONS (WATER)				
Heavy Metals to water	g Hg/20	0.3	0.1	0.1
	% change with BC	0%	-74%	-76%
Eutrophication	kg PO4	0.0	0.0	0.0
	% change with BC	0%	-46%	-47%
Life-cycle cost	€	534.8	123.9	116.8
	% change with BC	0%	-77%	-78%

Option 1	Option 2
Two step on/off controller	PI controller

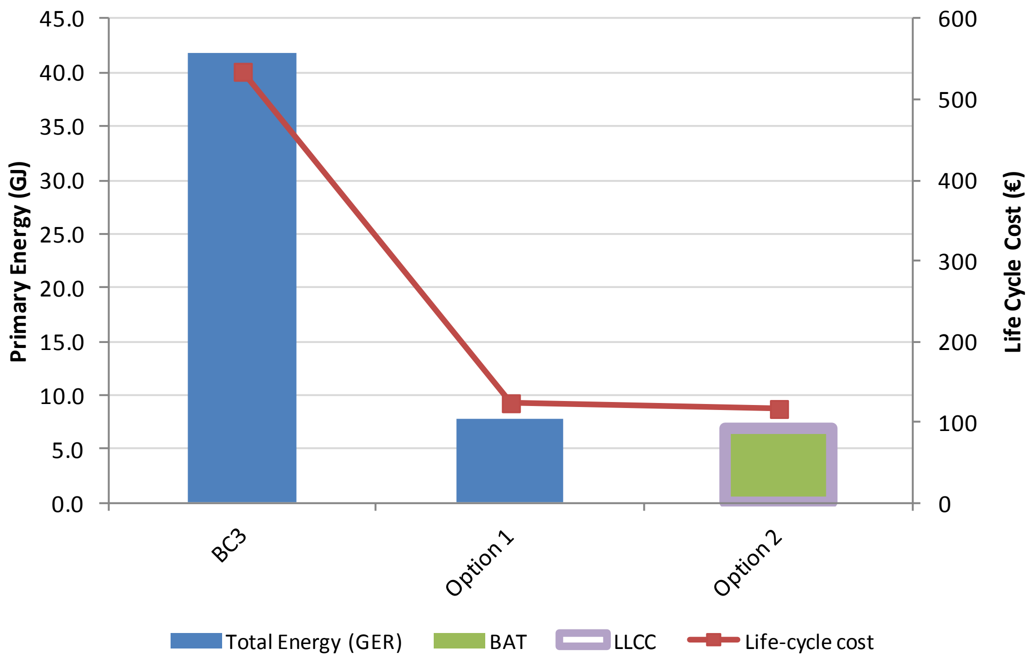
Figure 7-5 presents the share of LCC for the BC 3. As it is shown on the graph below electricity costs contribute the most to the LCC of the Base-Case and the improvement options, however, the share of electricity price compared to purchase price decreases in the Option 1 (73%) and Option 2 (69%) from 94% in the Base-Case.

Figure 7-5: Life cycle cost of the improvement options for BC 3



As shown in Figure 7-6, LLCC is Option 2 and this option is the design option with greatest energy savings as well. The primary energy consumption is around 83% lower than the Base-Case and the LCC is 78% lower. The second highest energy savings are achieved by Option 1 (81%), which presents also the second lowest LCC (77% lower).

Figure 7-6: Identification of BAT option and LLCC option for BC 3



7.2.4 Base-Case 4: Convector electric fixed

According to the assessment of the impacts of the BC 4 presented in the Table 7–16, the Option 6 results in the highest reduction of total energy consumption.

Table 7—16: Environmental impacts of the BC4 and its improvement options

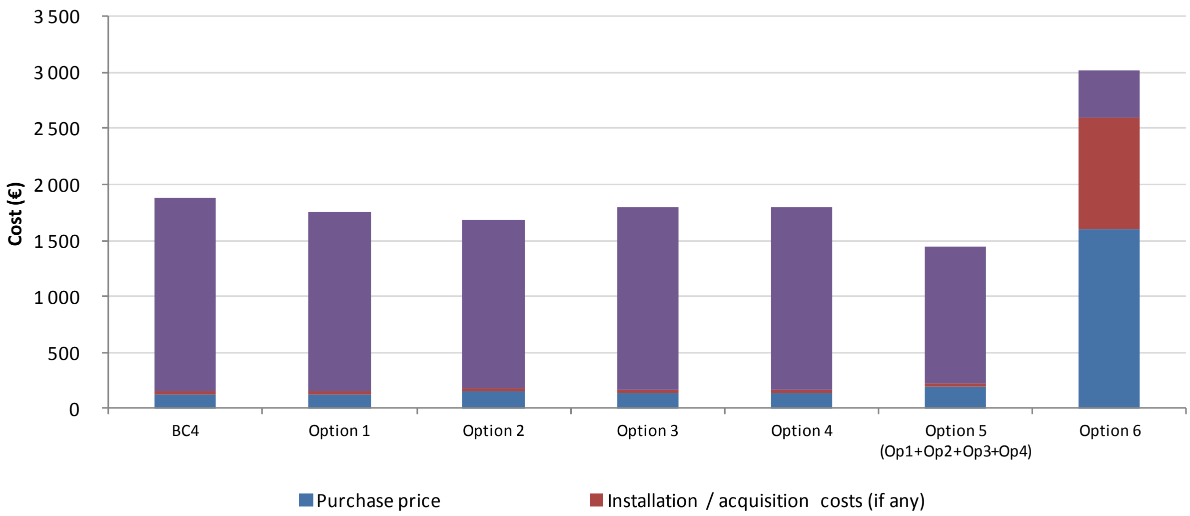
Life-cycle indicators per unit	unit	BC 4	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
OTHER RESOURCES AND WASTE								
Total Energy (GER)	GJ	143.1	131.7	124.5	134.5	134.5	101.7	34.7
	% change with BC	0%	-8%	-13%	-6%	-6%	-29%	-76%
of which, electricity	primary GJ	142.6	131.2	124.1	134.0	134.0	101.3	34.3
	final MWh	13.6	12.5	11.8	12.8	12.8	9.6	3.3
	% change with BC	0%	-8%	-13%	-6%	-6%	-29%	-76%
Water (process)	m^3	9.5	8.8	8.3	8.9	8.9	6.8	2.3
	% change with BC	0%	-8%	-13%	-6%	-6%	-29%	-76%
Water (cooling)	m^3	380.2	349.8	330.8	357.4	357.4	270.0	91.4
	% change with BC	0%	-8%	-13%	-6%	-6%	-29%	-76%
Waste, non-haz./ landfill	kg	172.5	159.3	151.1	162.6	162.6	124.6	47.0
	% change with BC	0%	-8%	-12%	-6%	-6%	-28%	-73%
Waste, hazardous/ incinerated	kg	3.3	3.1	2.9	3.2	3.2	2.4	0.9
	% change with BC	0%	-8%	-13%	-6%	-6%	-28%	-75%
EMISSIONS (AIR)								
Greenhouse Gases in GWP100	t CO_2 eq.	6.3	5.8	5.4	5.9	5.9	4.5	1.5
	% change with BC	0%	-8%	-13%	-6%	-6%	-29%	-76%
Acidification, emissions	kg SO_2 eq.	36.8	33.9	32.0	34.6	34.6	26.2	8.9
	% change with BC	0%	-8%	-13%	-6%	-6%	-29%	-76%
Volatile Organic Compounds (VOC)	kg	0.1	0.1	0.0	0.1	0.1	0.0	0.0
	% change with BC	0%	-8%	-12%	-6%	-6%	-28%	-73%
Persistent Organic Pollutants (POP)	µg i-Teq	1.0	1.0	0.9	1.0	1.0	0.8	0.3
	% change with BC	0%	-7%	-12%	-5%	-5%	-26%	-68%

Life-cycle indicators per unit	unit	BC 4	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Heavy Metals to air	g Ni eq.	2.5	2.3	2.2	2.3	2.3	1.8	0.6
	% change with BC	0%	-8%	-13%	-6%	-6%	-29%	-75%
PAHs	g Ni eq.	0.3	0.3	0.3	0.3	0.3	0.2	0.1
	% change with BC	0%	-8%	-12%	-6%	-6%	-27%	-71%
Particulate Matter (PM, dust)	kg	1.1	1.1	1.0	1.1	1.1	0.9	0.5
	% change with BC	0%	-6%	-9%	-4%	-4%	-20%	-52%
EMISSIONS (WATER)								
Heavy Metals to water	g Hg/20	0.9	0.9	0.8	0.9	0.9	0.7	0.2
	% change with BC	0%	-8%	-13%	-6%	-6%	-28%	-74%
Eutrophication	kg PO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% change with BC	0%	-4%	-7%	-3%	-3%	-15%	-40%
Life-cycle cost	€	1 880	1 748	1 685	1 791	1 791	1 444	3 015
	% change with BC	0%	-7%	-10%	-5%	-5%	-23%	60%

Option 1	**Option 2**	**Option 3**	**Option 4**	**Option 6**
Two step on/off controller	PI controller	Open window detection	Absence detection	Single split reversible heat pump

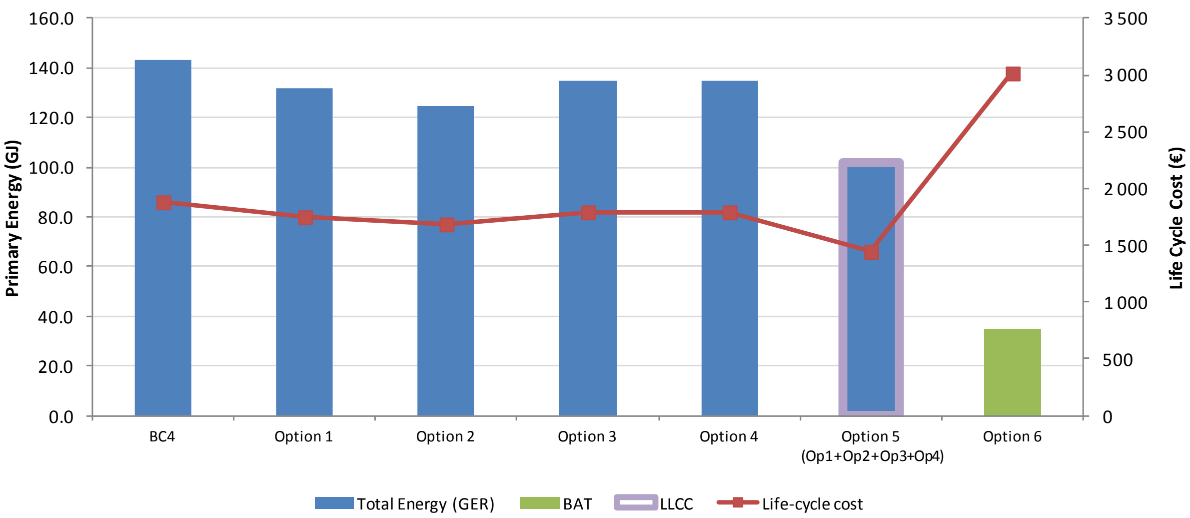
According to Figure 7-7, which presents the life cycle costs of the improvement options for BC 4, the highest share for most of (other than Option 6) options is related to electricity costs (more than 80%). For Option 6, the purchase price and installation costs together contribute more than 85% to the overall LCC.

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



As shown in Figure 7-8, the Option 5 has the lowest LCC and therefore is the candidate for LLCC, whereas Option 6 results in the greatest energy savings. The primary energy savings and LCC compared to the BC 4 are represented by Option 5: 29% and 23%, respectively. With Option 6, the primary energy consumed is around 76% lower than the Base-Case but the LCC is around 60% higher.

Figure 7-8: Identification of BAT option and LLCC option for BC 4



7.2.5 Base-Case 5a: Static electric storage heater

In Table 7–17 results of the environmental and economical assessments are shown for BC 5a. Both design Option 1 and Option 2 lead to a reduction of environmental impacts as well as energy consumption. However, Option 2 has a higher contribution to the improvement of the environmental performance and reduction of total energy consumed.

Table 7—17: Environmental impacts of the BC 5a and its improvement options

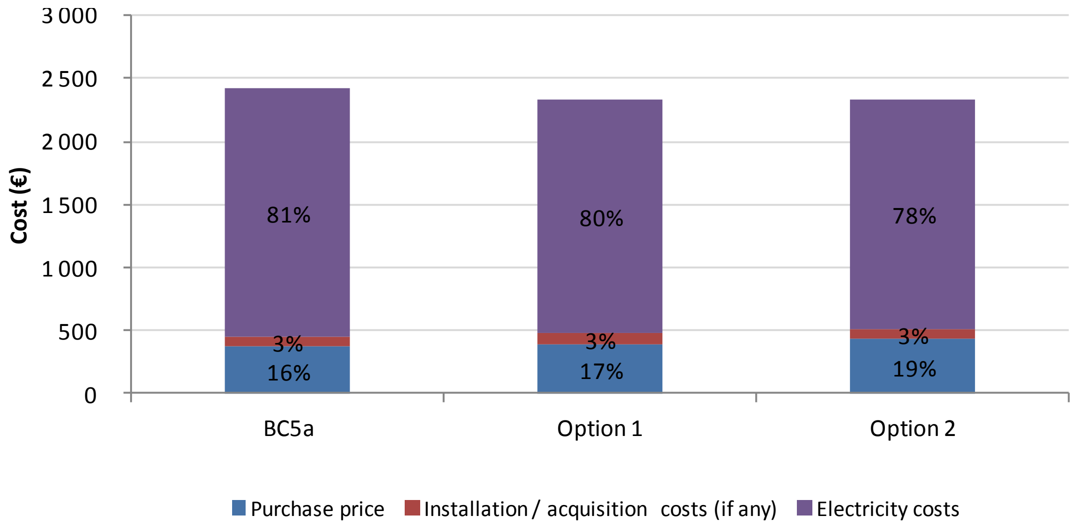
Life-cycle indicators per unit	unit	BC 5a	Option 1	Option 2
OTHER RESOURCES AND WASTE				
Total Energy (GER)	GJ	281.8	267.9	262.4
	% change with BC	0%	-5%	-7%
of which, electricity	primary GJ	278.6	264.6	259.1
	final MWh	26.5	25.2	24.7
	% change with BC	0%	-5%	-7%
Water (process)	m^3	18.9	17.9	17.6
	% change with BC	0%	-5%	-7%
Water (cooling)	m^3	742.8	705.7	690.9
	% change with BC	0%	-5%	-7%
Waste, non-haz./ landfill	kg	406.8	390.7	384.3
	% change with BC	0%	-4%	-6%
Waste, hazardous/ incinerated	kg	6.8	6.4	6.3
	% change with BC	0%	-5%	-7%
EMISSIONS (AIR)				
Greenhouse Gases in GWP100	t CO_2 eq.	12.4	11.8	11.6
	% change with BC	0%	-5%	-7%
Acidification, emissions	kg SO_2 eq.	72.5	68.9	67.5
	% change with BC	0%	-5%	-7%
Volatile Organic Compounds (VOC)	kg	0.1	0.1	0.1
	% change with BC	0%	-4%	-6%
Persistent Organic Pollutants (POP)	µg i-Teq	3.0	2.9	2.9
	% change with BC	0%	-3%	-4%
Heavy Metals to air	g Ni eq.	5.4	5.2	5.1
	% change with BC	0%	-4%	-6%
PAHs	g Ni eq.	0.6	0.5	0.5
	% change with BC	0%	-5%	-7%
Particulate Matter (PM, dust)	kg	5.2	5.1	5.1

Life-cycle indicators per unit	unit	BC 5a	Option 1	Option 2
	% change with BC	0%	-1%	-2%
EMISSIONS (WATER)				
Heavy Metals to water	g Hg/20	2.2	2.1	2.1
	% change with BC	0%	-4%	-6%
Eutrophication	kg PO4	0.0	0.0	0.0
	% change with BC	0%	-1%	-2%
Life-cycle cost	€	2 416.3	2 338.2	2 339.0
	% change with BC	0%	-3%	-3%

Option 1	Option 2
Automatic electromechanical charge control	Automatic (electronic) charge control

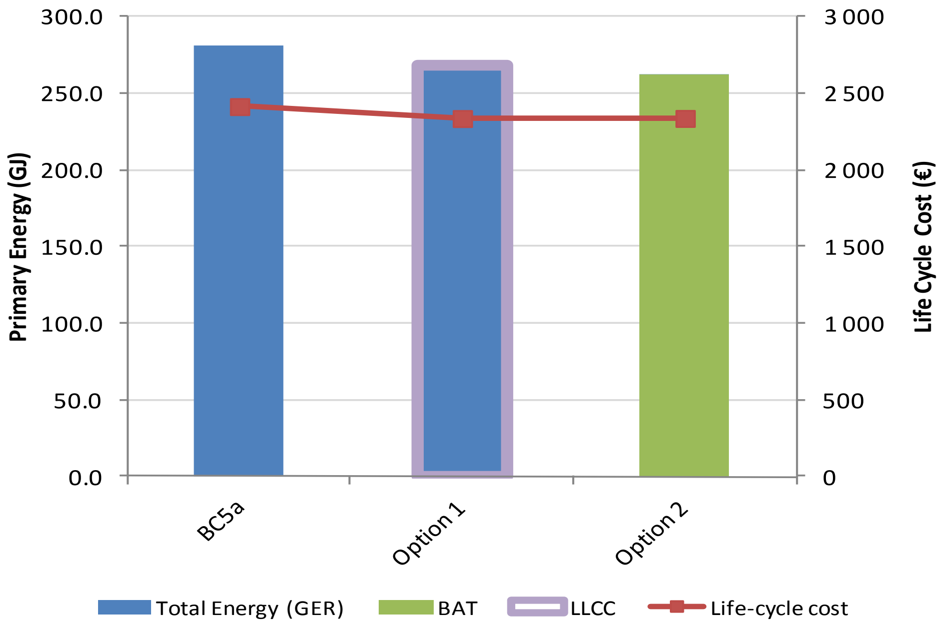
Figure 7-9 represents share of the LCC for BC 5a and its improvement options. According to the assessment, electricity costs have the highest share of the LCC, purchase price varies from 16% to 19% of LCC and installations costs accounts for around 3% of LCC for all design options.

Figure 7-9: Life cycle cost of the improvement options for BC 5a



As shown in Figure 7-10, Option 1 is a candidate for LLCC with a reduction of 3% in LCC compared to Base-Case. Option 2 consumes the least energy with energy savings of 7% compared to the Base-Case. Option 2 also represents LCC savings of around 3%.

Figure 7-10: Identification of BAT option and LLCC option for BC 5a



7.2.6 Base-Case 5b: Dynamic electric storage heater

In Table 7–18 results of the environmental and economical assessments are presented. Combination of design Option 1 and Option 2 leads to reduction of environmental impacts as well as energy consumption. Option 1 has the second highest contribution to the improvement of the environmental performance and energy consumption.

Table 7—18: Environmental impacts of the BC 5b and its improvement options

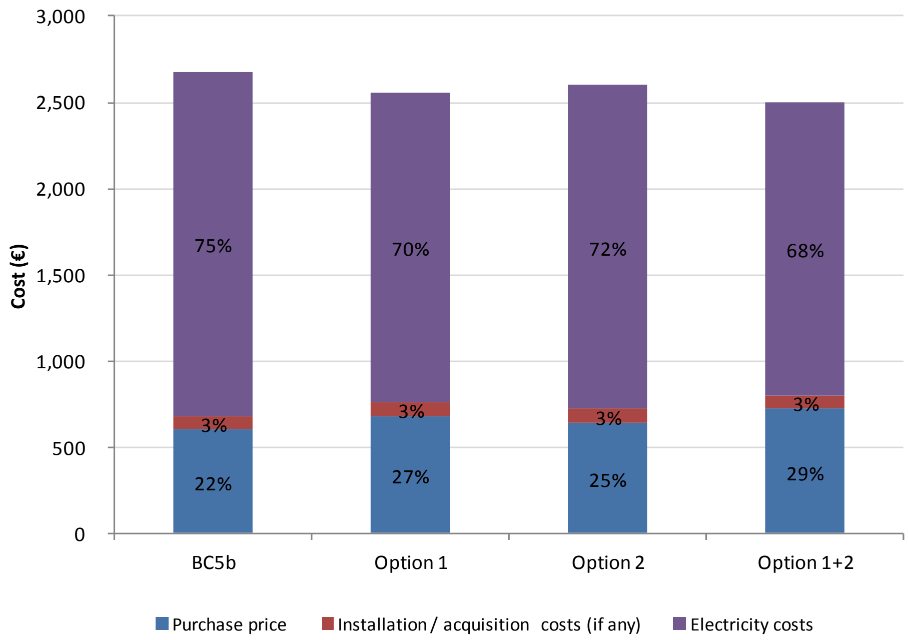
Life-cycle indicators per unit	unit	BC 5b	Option 1	Option 2	Option 3
OTHER RESOURCES AND WASTE					
Total Energy (GER)	GJ	288.3	259.9	271.2	245.7
	% change with BC	0%	-10%	-6%	-15%
of which, electricity	primary GJ	284.2	255.9	267.2	241.7
	final MWh	27.1	24.4	25.4	23.0
	% change with BC	0%	-10%	-6%	-15%
Water (process)	m^3	19.3	17.4	18.2	16.5
	% change with BC	0%	-10%	-6%	-15%
Water (cooling)	m^3	757.9	682.3	712.5	644.5
	% change with BC	0%	-10%	-6%	-15%
Waste, non-haz./ landfill	kg	433.0	400.2	413.3	383.7
	% change with BC	0%	-8%	-5%	-11%
Waste, hazardous/ incinerated	kg	7.0	6.3	6.6	6.0
	% change with BC	0%	-9%	-6%	-14%

Life-cycle indicators per unit	unit	BC 5b	Option 1	Option 2	Option 3
EMISSIONS (AIR)					
Greenhouse Gases in GWP100	t CO_2 eq.	12.8	11.5	12.0	10.9
	% change with BC	0%	-10%	-6%	-15%
Acidification, emissions	kg SO_2 eq.	74.2	66.9	69.8	63.2
	% change with BC	0%	-10%	-6%	-15%
Volatile Organic Compounds (VOC)	kg	0.1	0.1	0.1	0.1
	% change with BC	0%	-8%	-5%	-12%
Persistent Organic Pollutants (POP)	µg i-Teq	3.3	3.1	3.2	3.0
	% change with BC	0%	-6%	-3%	-8%
Heavy Metals to air	g Ni eq.	5.7	5.2	5.4	5.0
	% change with BC	0%	-9%	-5%	-13%
PAHs	g Ni eq.	0.6	0.5	0.5	0.5
	% change with BC	0%	-10%	-6%	-15%
Particulate Matter (PM, dust)	kg	6.1	6.0	6.0	5.9
	% change with BC	0%	-3%	-2%	-4%
EMISSIONS (WATER)					
Heavy Metals to water	g Hg/20	2.3	2.2	2.2	2.1
	% change with BC	0%	-8%	-5%	-12%
Eutrophication	kg PO_4	0.0	0.0	0.0	0.0
	% change with BC	0%	-3%	-2%	-4%
Life-cycle cost	€	2 680.5	2 560.5	2 600.5	2 500.4
	% change with BC	0%	-4%	-3%	-7%

Option 1	**Option 2**
Automatic electronic charge control and thermostat output control	Sophisticated controls (advanced algorithms for charging and discharging)

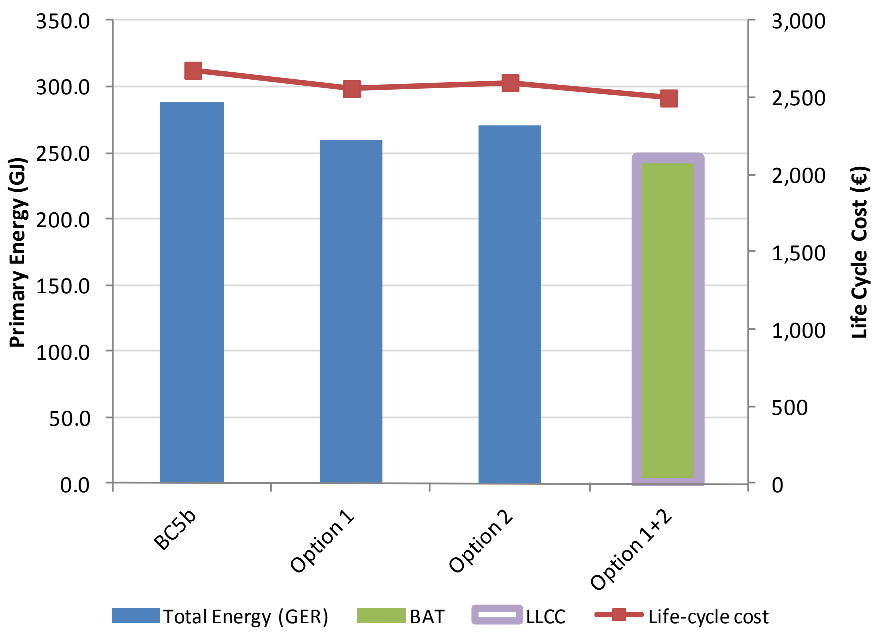
Figure 7-11 shows the share of the LCC for BC 5b and for its improvement options. According to the assessment, electricity costs have the highest share of LCC (from 68% to 75%), purchase price up to 29% of LCC and installations costs are around 3% of LCC.

Figure 7-11: Life cycle cost of the improvement options for BC5b



As shown in Figure 7-12, LLCC and the least energy consumption candidate is Option 1+2. The primary energy consumed for this option is around 15% lower than the Base-Case and the LCC is 7% lower. The second highest energy savings are achieved by Option 1 (10% lower), which represents also the second lowest LCC (4% lower).

Figure 7-12: Identification of BAT option and LLCC option for BC 5b



7.2.7 Base-Case 6a: Electric underfloor heating (primary)

The results of the environmental and economical assessment of BC 6a are presented in the Table 7–19. According to the calculations performed, the highest reduction of energy consumption as well as environmental impacts could be achieved by implementing a combination of design Option 1, Option 2, Option 3 and Option 4. Design Option 2 on its own leads to significant improvement in environmental performance and reduction of energy consumed.

Table 7—19: Environmental impacts of the BC6a and its improvement options

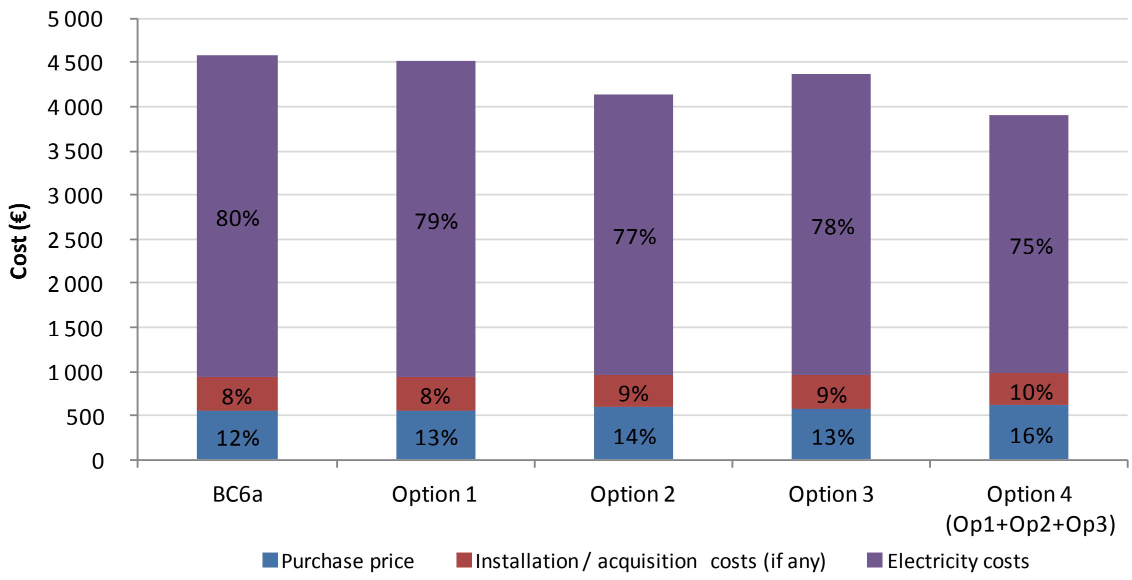
Life-cycle indicators per unit	unit	BC 6a	Option 1	Option 2	Option 3	Option 4 (Op1+Op2+Op3)
Total Energy (GER)	GJ	475.3	465.8	413.5	446.8	380.3
	% change with BC	0%	-2%	-13%	-6%	-20%
of which, electricity	primary GJ	475.1	465.6	413.3	446.6	380.0
	final MWh	45.2	44.3	39.4	42.5	36.2
	% change with BC	0%	-2%	-13%	-6%	-20%
Water (process)	m^3	31.7	31.1	27.6	29.8	25.4
	% change with BC	0%	-2%	-13%	-6%	-20%
Water (cooling)	m^3	1266.8	1241.5	1102.1	1190.8	1013.5
	% change with BC	0%	-2%	-13%	-6%	-20%
Waste, non-haz./ landfill	kg	554.7	543.7	483.1	521.7	444.6
	% change with BC	0%	-2%	-13%	-6%	-20%
Waste, hazardous/ incinerated	kg	11.0	10.7	9.5	10.3	8.8
	% change with BC	0%	-2%	-13%	-6%	-20%
Greenhouse Gases in GWP100	t CO2 eq.	20.7	20.3	18.1	19.5	16.6
	% change with BC	0%	-2%	-13%	-6%	-20%
Acidification, emissions	kg SO2 eq.	122.4	119.9	106.5	115.1	97.9
	% change with BC	0%	-2%	-13%	-6%	-20%
Volatile Organic Compounds (VOC)	kg	0.2	0.2	0.2	0.2	0.1
	% change with BC	0%	-2%	-13%	-6%	-20%
Persistent Organic Pollutants (POP)	µg i-Teq	3.1	3.1	2.7	2.9	2.5
	% change with BC	0%	-2%	-13%	-6%	-20%
Heavy Metals to air	g Ni eq.	8.2	8.0	7.1	7.7	6.6
	% change with BC	0%	-2%	-13%	-6%	-20%
PAHs	g Ni eq.	0.9	0.9	0.8	0.9	0.8
	% change with BC	0%	-2%	-13%	-6%	-20%

Life-cycle indicators per unit	unit	BC 6a	Option 1	Option 2	Option 3	Option 4 (Op1+Op2+Op3)
Particulate Matter (PM, dust)	kg	2.8	2.8	2.5	2.7	2.3
	% change with BC	0%	-2%	-12%	-6%	-18%
Heavy Metals to water	g Hg/20	3.1	3.0	2.7	2.9	2.5
	% change with BC	0%	-2%	-13%	-6%	-20%
Eutrophication	kg PO4	0.0	0.0	0.0	0.0	0.0
	% change with BC	0%	-2%	-12%	-6%	-18%
Life-cycle cost	€	4 584	4 517	4 140	4 380	3 905
	% change with BC	0%	-1%	-10%	-4%	-15%

Option 1	**Option 2**	**Option 3**
Thermostat-PI control	Programmable thermostat with setback functionality	Open window detection

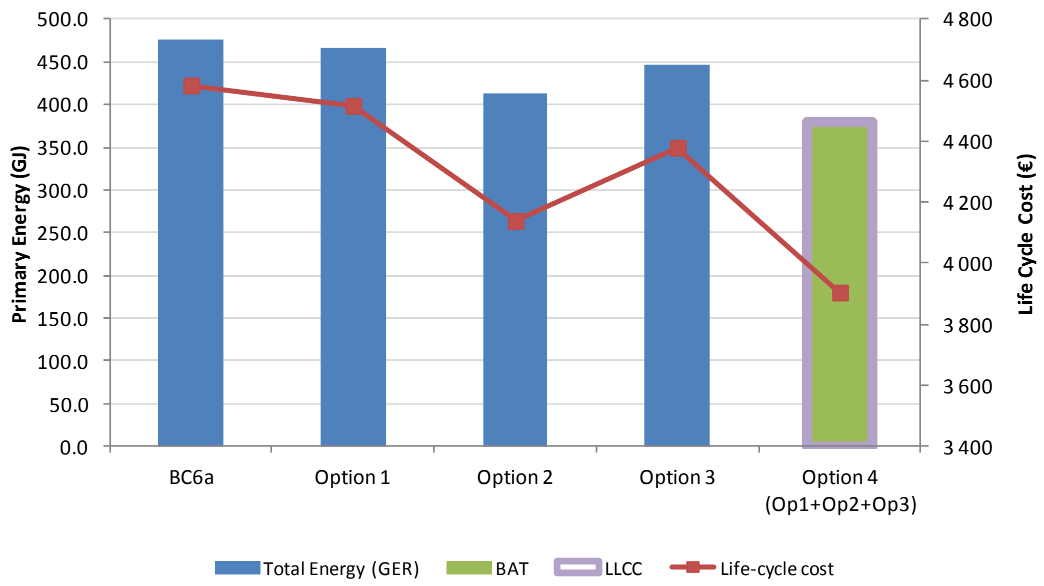
In Figure 7-11 the shares of the LCC for BC 6a and its improvement options are presented. According to the assessment, electricity costs have the highest share of LCC (from 75% to 80%), purchase price from 12% to 16% and installations costs have a share of LCC around 9%.

Figure 7-13: Life cycle cost of the improvement options for BC 6a



As it is shown in Figure 7-14, LLCC is Option 4 and this option is also the one with greatest energy savings. The primary energy consumed is lower than the Base-Case (around 20% lower) and the LCC is 15% lower. The second highest energy savings are achieved by Option 2 with the difference of 13%, Option 2 also represents the second lowest LCC with the difference of 10% compared to Base-Case.

Figure 7-14: Identification of BAT option and LLCC option for BC 6a



7.2.8 Base-Case 6b: Electric underfloor heating (secondary)

Table 7–20 provides an overview of the environmental impact assessment for BC 6b and its improvement options. The Option 3 allows achieving the highest reduction of environmental impacts and energy consumption.

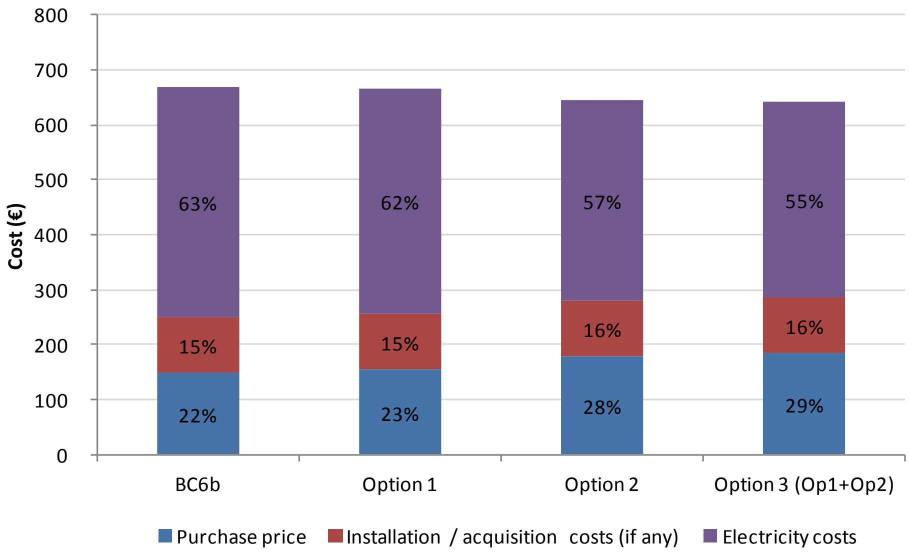
Table 7—20: Environmental impacts of the BC 6b and its improvement options

Life-cycle indicators per unit	unit	BC 6b	Option 1	Option 2	Option 3 (Op1+Op2)
Total Energy (GER)	GJ	54.8	53.8	47.7	46.7
	% change with BC	0%	-2%	-13%	-15%
of which, electricity	primary GJ	54.6	53.5	47.5	46.4
	final MWh	5.2	5.1	4.5	4.4
	% change with BC	0%	-2%	-13%	-15%
Water (process)	m^3	3.7	3.6	3.2	3.1
	% change with BC	0%	-2%	-13%	-15%
Water (cooling)	m^3	145.7	142.8	126.8	123.8
	% change with BC	0%	-2%	-13%	-15%
Waste, non-haz./ landfill	kg	67.3	66.0	59.1	57.8
	% change with BC	0%	-2%	-12%	-14%
Waste, hazardous/ incinerated	kg	1.3	1.2	1.1	1.1
	% change with BC	0%	-2%	-13%	-15%
Greenhouse Gases in GWP100	t CO2 eq.	2.4	2.4	2.1	2.0
	% change with BC	0%	-2%	-13%	-15%
Acidification, emissions	kg SO2 eq.	14.1	13.9	12.3	12.0
	% change with BC	0%	-2%	-13%	-15%
Volatile Organic Compounds (VOC)	kg	0.0	0.0	0.0	0.0
	% change with BC	0%	-2%	-12%	-14%
Persistent Organic Pollutants (POP)	µg i-Teq	0.4	0.4	0.3	0.3
	% change with BC	0%	-2%	-12%	-14%
Heavy Metals to air	g Ni eq.	1.0	1.0	0.8	0.8
	% change with BC	0%	-2%	-13%	-14%
PAHs	g Ni eq.	0.1	0.1	0.1	0.1
	% change with BC	0%	-2%	-12%	-14%
Particulate Matter (PM, dust)	kg	0.5	0.5	0.5	0.5
	% change with BC	0%	-1%	-8%	-9%
Heavy Metals to water	g Hg/20	0.4	0.4	0.3	0.3
	% change with BC	0%	-2%	-12%	-14%
Eutrophication	kg PO4	0.0	0.0	0.0	0.0
	% change with BC	0%	-1%	-8%	-9%
Life-cycle cost	€	669.4	667.0	644.9	642.5
	% change with BC	0%	0%	-4%	-4%

Option 1	Option 2
Thermostat-PI control	Programmable thermostat with setback functionality

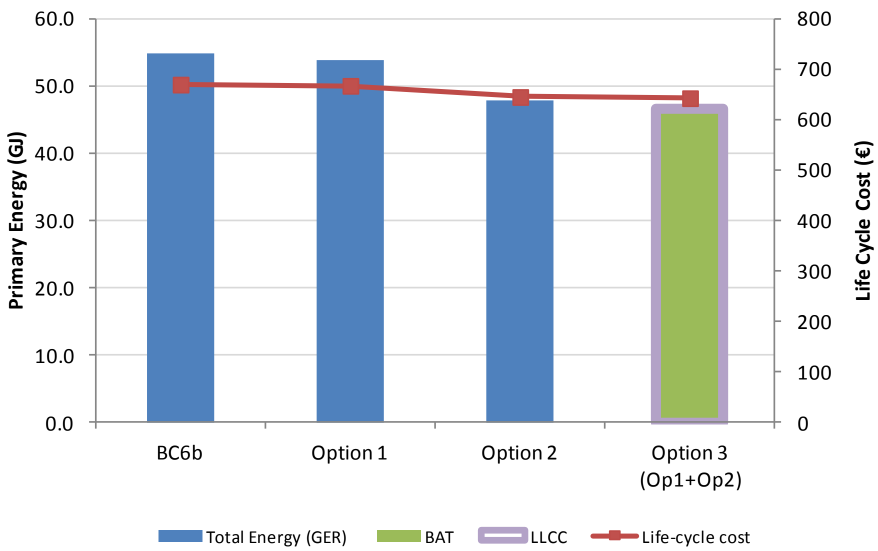
Figure **7-15** shows the share of LCC for the BC 6b and its improvement options. Electricity costs have the highest share of LCC in the Base-Case and throughout all improvement options. The shares of purchase price in relation to LCC vary from 22% to 29%, and installations/acquisition costs have the smallest share of LCC (up to a maximum of 16%).

Figure 7-15: Life cycle cost of the improvement options for BC 6b



As shown in Figure 7-16, Option 3 is the LLCC and this option is the one that consumes least energy as well. The primary energy consumed is around 15% lower than the Base-Case and the LCC is 4% lower.

Figure 7-16: Identification of BAT option and LLCC option for BC 6b



7.2.9 Base-Case 7: Warm air unit heater

Table 7–21 represents the outcomes of the assessment of environmental and economic impacts for the BC 7 and each of its improvement options. The combination of the design options allows achieving the highest reduction of environmental impacts and energy consumption. Implementation of Option 3b on its own, also results in significant reduction of energy consumed and environmental impacts.

Table 7—21: Environmental impacts of the BC 7 and its improvement options

Life-cycle indicators per unit	unit	BC 7	Option 1	Option 2	Option 3a	Option 3b	Option 4	Option 5	Option 6	Option 7
Total Energy (GER)	GJ	2401	2355	2344	2155	2085	2205	1820	1773	1588
	% change with BC	0%	-2%	-2%	-10%	-13%	-8%	-24%	-26%	-34%
of which, electricity	primary GJ	71.5	71.5	83.5	79.5	79.5	106.7	114.6	114.6	114.6
	final MWh	6.8	6.8	7.9	7.6	7.6	10.2	10.9	10.9	10.9
	% change with BC	0%	0%	17%	11%	11%	49%	60%	60%	60%
Water (process)	m^3	7.9	7.9	8.7	8.5	8.5	10.3	10.8	10.8	10.8
	% change with BC	0%	0%	10%	7%	7%	30%	36%	36%	36%
Water (cooling)	m^3	178.2	178.2	210.0	199.4	199.4	271.9	293.2	293.2	293.2
	% change with BC	0%	0%	18%	12%	12%	53%	64%	64%	64%
Waste, non-haz./ landfill	kg	550.1	550.1	563.9	559.3	559.3	590.8	600.1	600.1	600.1
	% change with BC	0%	0%	3%	2%	2%	7%	9%	9%	9%
Waste, hazardous/ incinerated	kg	4.7	4.7	4.9	4.8	4.8	5.5	5.7	5.7	5.7
	% change with BC	0%	0%	6%	4%	4%	17%	21%	21%	21%
Greenhouse Gases in GWP100	t CO_2 eq.	132.3	129.8	129.0	118.6	114.8	121.1	99.7	97.1	86.9
	% change with BC	0%	-2%	-3%	-10%	-13%	-9%	-25%	-27%	-34%
Acidification, emissions	kg SO_2 eq.	60.0	59.2	61.9	57.9	56.8	65.3	61.0	60.3	57.3
	% change with BC	0%	-1%	3%	-3%	-5%	9%	2%	0%	-4%
Volatile Organic Compounds (VOC)	kg	1.8	1.8	1.8	1.7	1.6	1.7	1.4	1.4	1.2
	% change with BC	0%	-2%	-3%	-10%	-13%	-8%	-24%	-26%	-33%
Persistent	µg i-Teq	7.3	7.3	7.4	7.4	7.4	7.5	7.6	7.6	7.6

Life-cycle indicators per unit	unit	BC 7	Option 1	Option 2	Option 3a	Option 3b	Option 4	Option 5	Option 6	Option 7
Organic Pollutants (POP)	% change with BC	0%	0%	1%	1%	1%	3%	4%	4%	4%
Heavy Metals to air	g Ni eq.	4.0	4.0	4.2	4.1	4.1	4.6	4.7	4.7	4.7
	% change with BC	0%	0%	5%	3%	3%	15%	18%	18%	18%
PAHs	g Ni eq.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	% change with BC	0%	0%	2%	1%	1%	6%	7%	7%	6%
Particulate Matter (PM, dust)	kg	13.4	13.4	13.5	13.4	13.4	13.5	13.5	13.5	13.4
	% change with BC	0%	0%	0%	0%	0%	1%	0%	0%	0%
Heavy Metals to water	g Hg/20	3.3	3.3	3.3	3.3	3.3	3.5	3.5	3.5	3.5
	% change with BC	0%	0%	2%	2%	2%	7%	9%	9%	9%
Eutrophication	kg PO4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	% change with BC	0%	0%	0%	0%	0%	1%	1%	1%	1%
Life-cycle cost	€	24 318	24 148	24 095	24 034	24 200	24 555	22 341	22 692	22 911
	% change with BC	0%	-1%	-1%	-1%	0%	1%	-8%	-7%	-6%

Option 1	**Option 2**	**Option 3a**	**Option 3b**	**Option 4**
Electric ignition	Mechanical draft for combustion air supply	Net heat generation efficiency 95%	Net heat generation efficiency 95%	Specific air throw <= 5 W/m³/h

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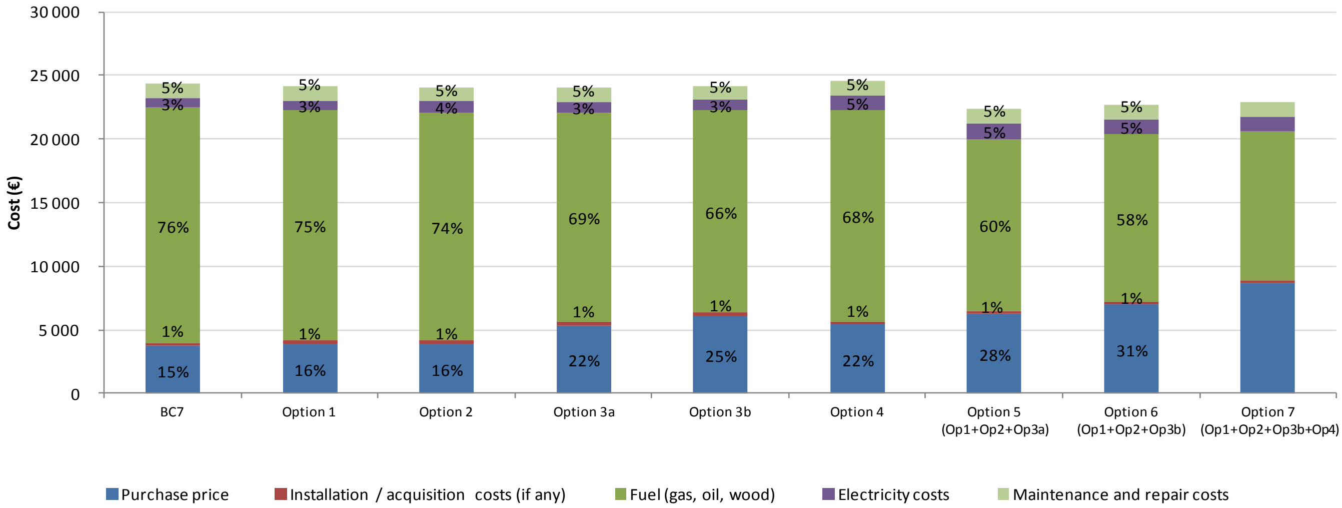
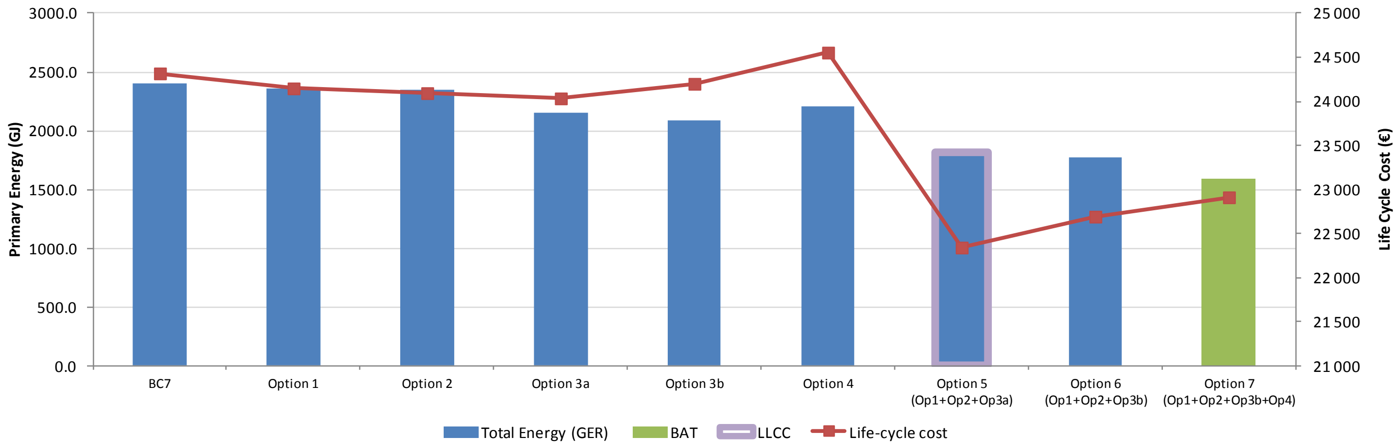
Figure 7-17 presents the share of LCC for the BC 7. Fuel consumption has the largest share of LCC of the Base-Case as well as all the improvement options with a minimum of 51% and maximum of 76%. Purchase price and installation costs have a small share of LCC, maintenance costs have a share of 5% for all the options.

Figure 7-17: Life cycle cost of the improvement options for BC 7



In Figure 7-18 LLCC option is represented by Option 5 (8% lower LCC than BC) whereas the option that consumes the least energy is represented by Option 7 (primary energy consumed is around 34% lower than the Base-Case.

Figure 7-18: Identification of BAT option and LLCC option for BC 7



7.2.10 Base-Case 8a: Luminous radiant heater

Table 7–22 gives an overview of environmental impacts estimations for BC 8a and its improvement options. The Option 6 (combination of the design Option 2, Option 3b and Option 4b) allows achieving the highest reduction of energy consumption, but increases electricity consumption (and the related water required for cooling) and the amount of waste compared to the Base-Case. However, the Option 5 (combination of improvement Option 2, Option 3a and Option 4a) also results in significant reduction of energy consumption while keeping the amount of waste at the same level as the Base-Case.

Table 7—22: Environmental impacts of the BC 8a and its improvement options

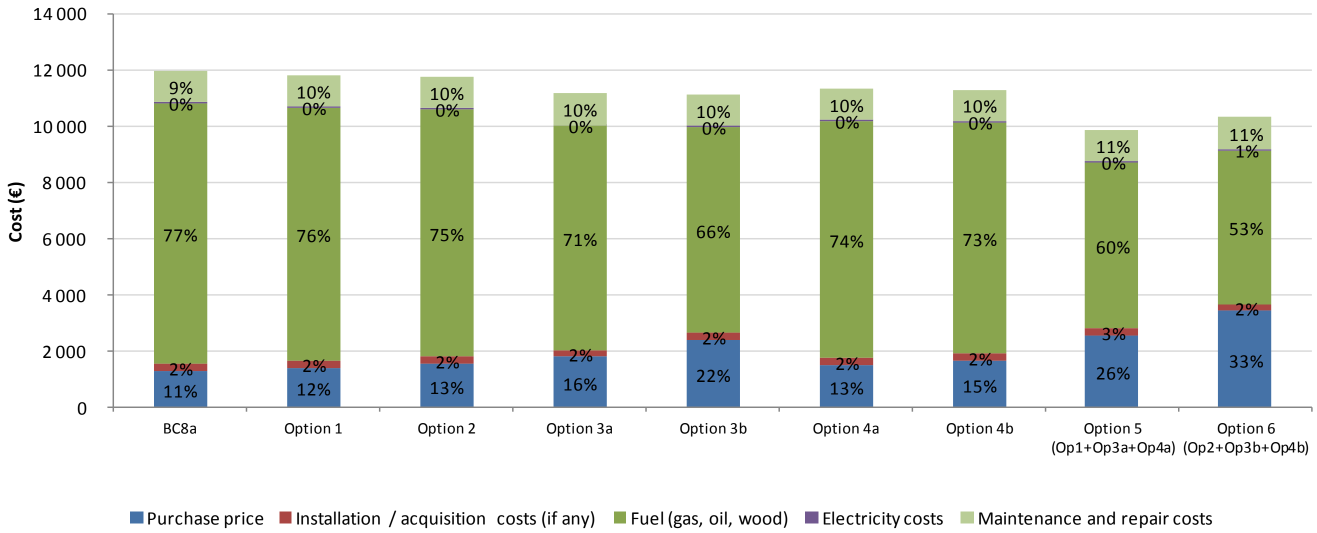
Life-cycle indicators per unit	unit	BC 8a	Option 1	Option 2	Option 3a	Option 3b	Option 4a	Option 4b	Option 5	Option 6
OTHER RESOURCES AND WASTE										
Total Energy (GER)	GJ	1163	1128	1105	1001	920	1059	1036	746	689
	% change with BC	0%	-3%	-5%	-14%	-21%	-9%	-11%	-36%	-41%
of which, electricity	primary GJ	4.2	4.2	4.2	4.2	4.2	4.2	5.2	4.2	5.2
	final MWh	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.5
	% change with BC	0%	0%	0%	0%	0%	0%	23%	0%	23%
Water (process)	m^3	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.6
	% change with BC	0%	0%	0%	0%	0%	0%	13%	0%	13%
Water (cooling)	m^3	10.6	10.6	10.6	10.6	10.6	10.6	13.1	10.6	13.1
	% change with BC	0%	0%	0%	0%	0%	0%	24%	0%	24%
Waste, non-haz./ landfill	kg	30.6	30.6	30.6	30.6	30.6	30.6	31.7	30.6	31.7
	% change with BC	0%	0%	0%	0%	0%	0%	4%	0%	4%
Waste, hazardous/ incinerated	kg	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	% change with BC	0%	0%	0%	0%	0%	0%	6%	0%	6%
EMISSIONS (AIR)										
Greenhouse Gases in GWP100	t CO2 eq.	64.3	62.3	61.1	55.3	50.8	58.5	57.3	41.2	38.1
	% change with BC	0%	-3%	-5%	-14%	-21%	-9%	-11%	-36%	-41%
Acidification, emissions	kg SO2 eq.	20.1	19.5	19.1	17.5	16.2	18.4	18.3	13.4	12.7
	% change with BC	0%	-3%	-5%	-13%	-19%	-8%	-9%	-33%	-37%
Volatile Organic Compounds (VOC)	kg	0.9	0.8	0.8	0.7	0.7	0.8	0.8	0.6	0.5
	% change with BC	0%	-3%	-5%	-14%	-21%	-9%	-11%	-35%	-40%
Persistent Organic Pollutants (POP)	µg i-Teq	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	% change with BC	0%	0%	0%	0%	0%	0%	2%	0%	2%
Heavy Metals to air	g Ni eq.	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	% change with BC	0%	0%	0%	0%	0%	0%	6%	0%	6%

Life-cycle indicators per unit	unit	BC 8a	Option 1	Option 2	Option 3a	Option 3b	Option 4a	Option 4b	Option 5	Option 6
PAHs	g Ni eq.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	% change with BC	0%	-1%	-1%	-3%	-5%	-2%	-1%	-8%	-8%
Particulate Matter (PM, dust)	kg	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3
	% change with BC	0%	0%	-1%	-2%	-3%	-1%	-1%	-5%	-5%
EMISSIONS (WATER)										
Heavy Metals to water	g Hg/20	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	% change with BC	0%	0%	0%	0%	0%	0%	3%	0%	3%
Eutrophication	kg PO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% change with BC	0%	0%	0%	0%	0%	0%	0%	0%	0%
Life-cycle cost	€	11 971	11 813	11 758	11 176	11 128	11 338	11 314	9 890	10 318
	% change with BC	0%	-1%	-2%	-7%	-7%	-5%	-5%	-17%	-14%

Option 1	Option 2	Option 3a	Option 3b	Option 4a	Option 4b
Power control: two stage burner	Power control: modulating burner	Radiant factor >0.65	Radiant factor >0.75	Mechanical flue gas evacuation Type 2	Mechanical flue gas evacuation Type 3

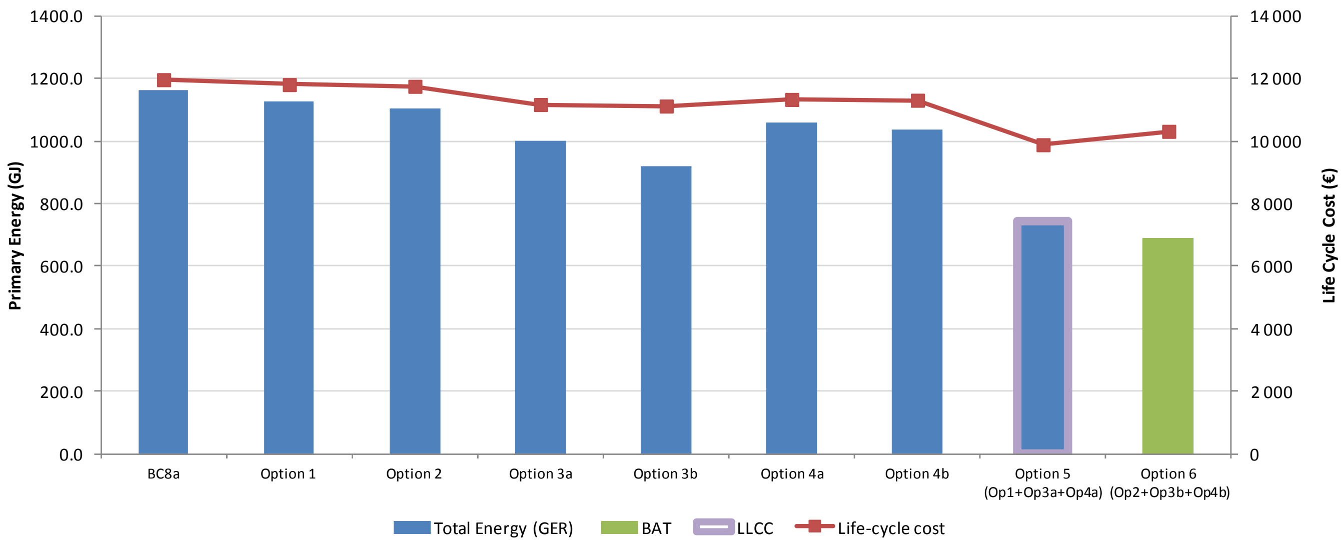
Figure 7-19 represents the shares of the LCC for BC 8a and its improvement options. According to the assessment, fuel consumption has the highest share of the life cycle costs (from 53% to 76%), shares of purchase price (from 11% to 33%) and installation cost (around 10% on average) are significant whereas that of maintenance and repair costs are insignificant (maximum up to 2%).

Figure 7-19: Life cycle cost of the improvement options for BC 8a



As shown in Figure 7-20, LLCC is Option 5 whereas Option 6 leads to greatest savings of energy. The primary energy consumed in Option 5 is around 36% lower than the Base-Case and the LCC is 17% lower. The highest energy savings is achieved by Option 6 (41%) also leading to the second lowest LCC (around 14% lower).

Figure 7-20: Identification of BAT option and LLCC option for BC 8a



7.2.11 Base-Case 8b: Radiant tube heater

The environmental and economical impacts for BC 8b and its improvement options are presented in Table 7–23. The combination of options (Option 5, Option 6 and Option 7 result in significant reduction of total energy consumption and reduction of environmental impacts such as GHG emissions, acidification, PM , VOC and POP. On the other hand, electricity and waste increases compared to the Base-Case.

Table 7—23: Environmental impacts of the BC 8b and its improvement options

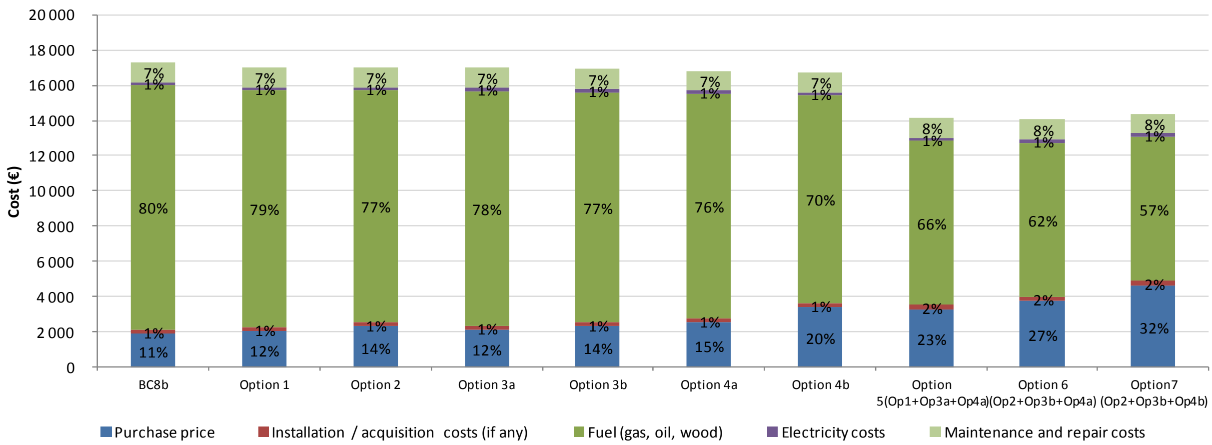
Life-cycle indicators per unit	unit	BC 8b	Option 1	Option 2	Option 3a	Option 3b	Option 4a	Option 4b	Option 5	Option 6	Option 7
OTHER RESOURCES AND WASTE											
Total Energy (GER)	GJ	1758	1705	1671	1691	1656	1619	1497	1188	1118	1049
	% change with BC	0%	-3%	-5%	-4%	-6%	-8%	-15%	-32%	-36%	-40%
of which, electricity	primary GJ	16.3	16.3	16.3	19.2	19.2	16.3	16.3	19.2	19.2	19.2
	final MWh	1.6	1.6	1.6	1.8	1.8	1.6	1.6	1.8	1.8	1.8
	% change with BC	0%	0%	0%	18%	18%	0%	0%	18%	18%	18%
Water (process)	m^3	2.0	2.0	2.0	2.2	2.2	2.0	2.0	2.2	2.2	2.2
	% change with BC	0%	0%	0%	9%	9%	0%	0%	9%	9%	9%
Water (cooling)	m^3	40.3	40.3	40.3	48.0	48.0	40.3	40.3	48.0	48.0	48.0
	% change with BC	0%	0%	0%	19%	19%	0%	0%	19%	19%	19%
Waste, non-haz./ landfill	kg	136.2	136.2	136.2	139.6	139.6	136.2	136.2	139.6	139.6	139.6
	% change with BC	0%	0%	0%	2%	2%	0%	0%	2%	2%	2%
Waste, hazardous/ incinerated	kg	1.6	1.6	1.6	1.7	1.7	1.6	1.6	1.7	1.7	1.7
	% change with BC	0%	0%	0%	4%	4%	0%	0%	4%	4%	4%
EMISSIONS (AIR)											

Life-cycle indicators per unit	unit	BC 8b	Option 1	Option 2	Option 3a	Option 3b	Option 4a	Option 4b	Option 5	Option 6	Option 7
Greenhouse Gases in GWP100	t CO_2 eq.	97.1	94.2	92.3	93.4	91.5	89.4	82.7	65.6	61.7	57.9
	% change with BC	0%	-3%	-5%	-4%	-6%	-8%	-15%	-32%	-36%	-40%
Acidification, emissions	kg SO_2 eq.	33.6	32.8	32.2	33.2	32.7	31.4	29.4	25.1	24.0	22.9
	% change with BC	0%	-2%	-4%	-1%	-3%	-7%	-12%	-25%	-29%	-32%
Volatile Organic Compounds (VOC)	kg	1.3	1.3	1.3	1.3	1.2	1.2	1.1	0.9	0.9	0.8
	% change with BC	0%	-3%	-5%	-4%	-6%	-8%	-14%	-32%	-35%	-39%
Persistent Organic Pollutants (POP)	µg i-Teq	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	% change with BC	0%	0%	0%	1%	1%	0%	0%	1%	1%	1%
Heavy Metals to air	g Ni eq.	1.0	1.0	1.0	1.1	1.1	1.0	1.0	1.1	1.1	1.1
	% change with BC	0%	0%	0%	5%	5%	0%	0%	5%	5%	5%
PAHs	g Ni eq.	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	% change with BC	0%	0%	-1%	1%	1%	-1%	-2%	-3%	-4%	-5%
Particulate Matter (PM, dust)	kg	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.4	6.4	6.4
	% change with BC	0%	0%	0%	0%	0%	-1%	-1%	-2%	-3%	-3%
EMISSIONS (WATER)											
Heavy Metals to water	g Hg/20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	% change with BC	0%	0%	0%	2%	2%	0%	0%	2%	2%	2%
Eutrophication	kg PO_4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	% change with BC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Life-cycle cost	€	17 321	17 025	17 027	17 008	16 920	16 831	16 739	14 153	14 068	14 393
	% change with BC	0%	-2%	-2%	-2%	-2%	-3%	-3%	-18%	-19%	-17%

Option 1	Option 2	Option 3a	Option 3b	Option 4a	Option 4b
Power control: two stage burner	Power control: modulating burner	Net heat generation efficiency 90%	Net heat generation efficiency 92%	Radiant factor >0.60	Radiant factor >0.70

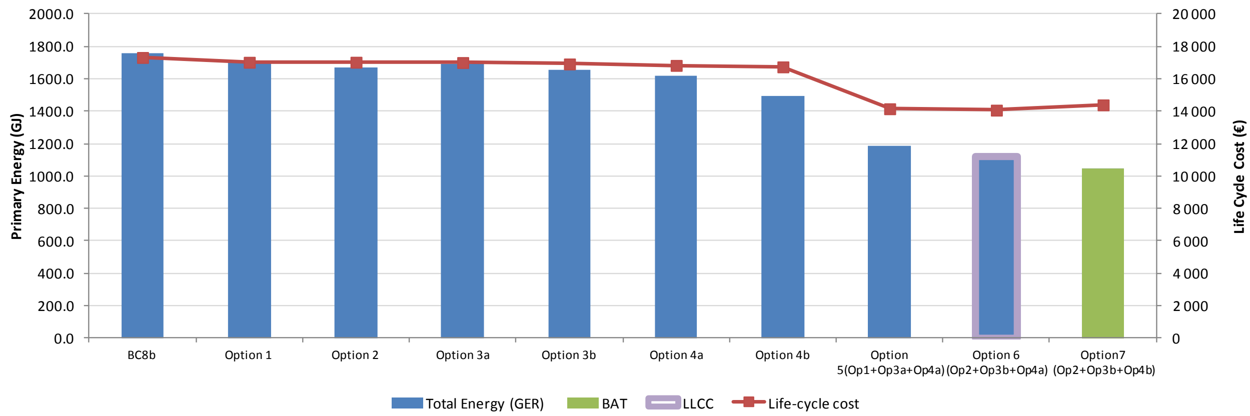
According to Figure 7-21 the life cycle costs of the improvement options for BC 8b, fuel consumption has the highest share of LCC throughout all the options (between 57% to 80%). Purchase price has the second greatest contribution to LCC (varies from 11% to 32%) whereas maintenance and installation/acquisition costs represent only very small shares of LCC.

Figure 7-21: Life cycle cost of the improvement options for BC 8b



As shown in Figure 7-22, LLCC is Option 6, whereas Option 7 leads to the greatest savings of energy. The primary energy consumed in Option 6 is around 36% lower than the Base-Case and the LCC is 19% lower. The highest energy savings is achieved by Option 7 (40%) also leading to the third lowest LCC (around 17% lower).

Figure 7-22: Identification of BAT option and LLCC option for BC 8b



7.2.12 Base-Case 9: Air curtain

According to the assessment of the impacts of the BC 9 presented in the Table 7–24, Option 2 has the same contribution to the reduction of energy consumption and environmental impacts as a combination of Option 1 and Option 2. Option 1 does not result in any reduction of total energy consumption from heating, but it results in energy savings for the building.

Table 7—24: Environmental impacts of the BC 9 and its improvement options

Life-cycle indicators per unit	unit	BC 9	Option 1	Option 2	Option 3
OTHER RESOURCES AND WASTE					
Total Energy (GER)	GJ	295.5	295.5	86.1	86.1
	% change with BC	0%	0%	-71%	-71%
of which, electricity	primary GJ	36.5	36.5	18.6	18.6
	final MWh	3.5	3.5	1.8	1.8
	% change with BC	0%	0%	-49%	-49%
Water (process)	m^3	2.6	2.6	1.4	1.4
	% change with BC	0%	0%	-46%	-46%
Water (cooling)	m^3	95.5	95.5	47.9	47.9
	% change with BC	0%	0%	-50%	-50%
Waste, non-haz./ landfill	kg	166.0	166.0	145.3	145.3
	% change with BC	0%	0%	-12%	-12%
Waste, hazardous/ incinerated	kg	1.1	1.1	0.6	0.6
	% change with BC	0%	0%	-39%	-39%
EMISSIONS (AIR)					
Greenhouse Gases in GWP100	t CO_2 eq.	16.0	16.0	4.6	4.6
	% change with BC	0%	0%	-71%	-71%
Acidification, emissions	kg SO_2 eq.	14.4	14.4	6.7	6.7
	% change with BC	0%	0%	-53%	-53%
Volatile Organic Compounds (VOC)	kg	0.2	0.2	0.1	0.1
	% change with BC	0%	0%	-65%	-65%
Persistent Organic Pollutants (POP)	µg i-Teq	1.8	1.8	1.7	1.7
	% change with BC	0%	0%	-7%	-7%
Heavy Metals to air	g Ni eq.	1.3	1.3	1.0	1.0
	% change with BC	0%	0%	-24%	-24%
PAHs	g Ni eq.	0.2	0.2	0.2	0.2
	% change with BC	0%	0%	-20%	-20%
Particulate Matter (PM, dust)	kg	3.4	3.4	3.2	3.2
	% change with BC	0%	0%	-5%	-5%
EMISSIONS (WATER)					
Heavy Metals to water	g Hg/20	0.7	0.7	0.6	0.6
	% change with BC	0%	0%	-17%	-17%
Eutrophication	kg PO_4	0.0	0.0	0.0	0.0
	% change with BC	0%	0%	-5%	-5%
Life-cycle cost	€	6 977	7 127	5 460	5 610
	% change with BC	0%	2%	-22%	-20%

Option 1	Option 2
Air stream technology	Self-regulating controls

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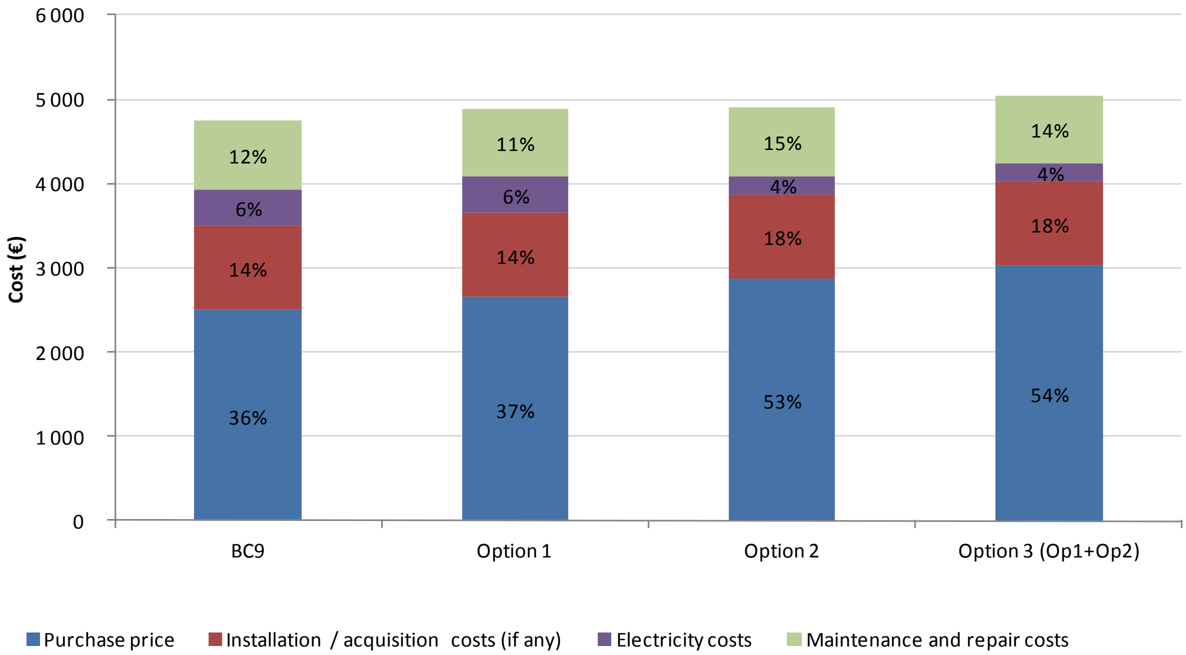
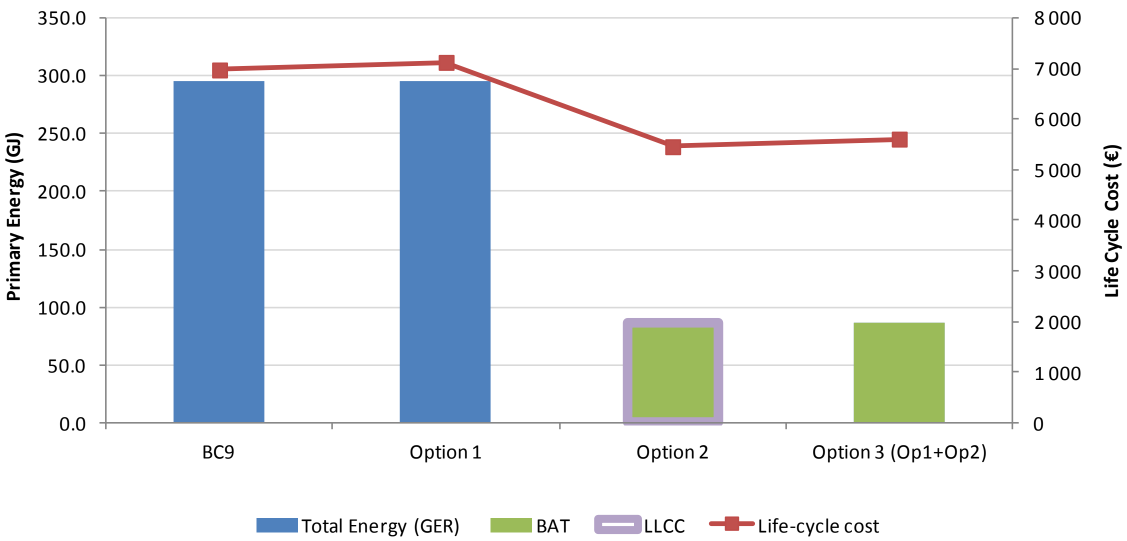
Figure 7-23: Life cycle cost of the improvement options for BC 9



As shown in Figure 7-24, LLCC is Option 2, the LCC is 22% lower than the Base-Case. Option 2 and Option 3 are the options with the greatest energy savings, the primary energy consumption is around 71% lower than the Base-Case. With Option 3 the LCC is 20% lower than the Base-Case.

Figure 7-24: Identification of BAT option and LLCC option for BC 9



7.3 Long-term targets (BNAT)

Not all possible improvement options were considered in the preceding sections. Some are still prohibitively expensive or not yet widely available. Such options can be described as BNAT and considered as long-term targets. Some of these improvement options may therefore only become available in the coming years, and only be applicable to some products on the market. Other improvements are related to the heating system of the building rather than the product itself.

Some manufacturers claim that adaptive room temperature regulation (adaptive learning of user patterns, weather conditions and building characteristics) can potentially result in energy savings as it optimises the heating period from a setback period, to meet the consumer's preference. This technology is however still in R&D phase and therefore a candidate for BNAT.

Several electric heater (in particular electric storage heater) manufacturers commented that smart grids are a potential BNAT candidate for their appliances. Smart Grids, or demand response, allows electricity utility companies to communicate to users and sometimes directly with (smart) appliances to reduce or shift their electricity consumption at different times during the day. Smart Grids need "smart" controls on the demand side in order for electricity utility companies to be able to reduce or shift electricity consumption at different times during the day to match the fluctuating (renewable) power production. Electrical heating with electronic controllers are already able to shift electricity consumption via simple pre-programmed tariff based systems without compromising heat comfort. Electrical heating controllers are able to do this even more intelligently when advanced and dynamic Smart Grids are be deployed. Smart Grids are thought to play a major role in future energy systems – and in particular in relation to renewable energy production such as solar and wind power. However, it is important to note that Smart Grids cannot be seen as an energy saving feature for the consumer. It can possibly reduce the energy costs for the consumer and the total amount of energy generated for the grid, but it does not reduce the energy consumed by the individual heating system[6].

Some manufacturers suggested that user friendliness (e.g. display, user interface, menus, etc.) of the controls (such as programmable thermostats) should be a candidate for BNAT. Qualitative market research conducted by these manufacturers show that advanced and energy reducing features (like setback functionality) may not be used by consumers unless they are easily accessible and easy to use (e.g. one-click holiday mode and setback can result in up to 25 % energy savings).

[6] This is particularly relevant for electrical underfloor and storage heaters, which could play an important role in stabilising the electricity demand and supply gap. These heaters are able to store heat and can be switched off, if the demand for power in the electricity network is too high. This cannot be achieved for many of the other local room heaters, or heat pumps, as thermal mass is missing.

7.4 Conclusions

Several design improvement options are available for each product group, usually with short payback times and only few constraints. Combinations of these improvement options provide potential for significant energy savings, leading to reduced environmental impact and lower life cycle costs.

However, the overall energy savings of local room heaters depends much more on appropriate adjustments of the heat demand and supply than to the energy efficiency of each product. This is particularly true for electric heaters used in residential applications. Here the only design improvement options identified and analysed correspond to controls to regulate the temperature of the heated space.

Based on the energy savings potential of the design options assessed in this task, the following conclusion can be made:

- although it is possible to achieve energy savings from electric local room heaters, their potential is limited (and mostly related to controls)
- the greatest potential for design improvements are for gas (and probably also liquid fuel) heaters. It is reasonable to assume that steadily increasing levels of energy efficiency without significant increase in other environmental impacts should be achievable.
- the improvement potential of air curtains is not related to the energy it consumes itself, but to the potential reduction of energy losses from a building

These results will be discussed further in the context of potential policy options in Task 8.

25 June 2012

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