Preparatory Study on

Eco-design of Water Heaters

Task 5 Report (FINAL)

Definition of Basecase

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1 INTRODUCTION

1.1 Introduction

Task 5 describes the environmental impacts and life cycle costs (LCC) of water heaters in the EU. It comprises the following items:

- Bill-of-Materials, distinguishing materials fractions / electronics modules (weight) at the level of the EuP EcoReport Unit Indicators as proposed in the VHK Methodology report. This includes packaging materials;
- Primary scrap production during sheet metal manufacturing;
- Volume and weight of the packaged product;
- Annual resources consumption (fuel, electricity) and direct emissions during product life according to the test standards defined in subtask 1.2 [“Standard Base-Case”];
- Annual resources consumption (fuel, electricity) and direct emissions during product life according to the real-life situation as defined in subtask 3.2 [“Real-life Base-Case”];
- Most probably scenario at end-of-life of materials flow for:
  - Disposal (landfill, pyrolytic incineration);
  - Thermal Recycling (non-hazardous incineration optimised for energy recovery);
  - Re-use or Closed-loop Recycling.

The following chapters describe for each category of water heater the base-case(s) which acts as reference case for the calculation of savings from ecodesign options and as basis for the scenario analysis.

For each water heater category the environmental impact of the base-case product life cycle, the product life cycle impacts of new products entering the market in one particular year and the annual impacts of the existing park are described. The subjects are:

- Base-Case Environmental Impact Assessment (subtask 5.3);
- Base-Case Life Cycle Costs (subtask 5.4);
- EU Totals.

For the EU Totals we aggregate the Base-Case environmental impact data (subtask 5.3) and the Life Cycle Cost data (subtask 5.4) to EU-25 level, using market data from task 2, indicating

- The annual (2005) impact of production, use and (estimated) disposal of the product group, assuming post-RoHS and post-WEEE conditions;
- The life cycle environmental impact and total LCC of the new products designed in 2005 (this relates to a period of 2005 up to 2005+product life).

The total system impact (subtask 5.5) entails an analysis including system parameters, such as distribution losses and waste heat recovery. However, because we have followed the systems approach from the start, there is no need for an explicit discussion of this subtask, as it is already incorporated in the subtasks above.

1.2 Task report structure

Chapter 2 introduces the definitions of performance, environmental impact and life cycle costs as well as some fixed input values.

Chapter 3 gives the specific inputs for the standard residential base-cases. Note that further clarification of several base case inputs and values are described in the Annexes A, B, C and D.

During the completion of this Task VHK was asked by the Commission to add two extra performance classes to the base cases: XXXL and XXXXL or 3XL and 4XL as we will call them from now on. These classes describe water heaters sized for a performance of 8 and 16 times the Medium-size performance and are described in Section 3.8.

After that this task report will largely follow the order of the subtasks with Chapter 4 and 5 giving the outputs of the environmental impact and life cycle cost assessment respectively. In Chapter 6 the EU-totals are presented.

2 DEFINITIONS

2.1 Definition of performance

Section 2.1 of Task 1 of the Water Heater study defines a water heater as an appliance designed to provide hot sanitary water. It may (but need not) be designed to provide space heating or other functions as well.

Main performance parameters of the water heater –mentioned in the standards— are specific flow rate (in l/min), typically for instantaneous types, and storage volume (in l.) for storage type water heaters. Furthermore, EN 13203-1 defines marks for the tapping capability (1-4 'taps'), which is also known in other standards as hot water capacity, and the quality of the hot water delivery. This quality is defined through a rating system incorporating waiting time, minimum flow rate, temperature fluctuations during tapping, etc.

A tentative definition for the performance parameter –not based on the technology— could be '*the ability to deliver the desired quantity of hot water of a desired temperature at a desired flow rate and/or time period*[1] *every day of the year at a minimum desired quality level*'.

2.2 Definition of load profiles

The way to make this operational is given in the very recent EN 13203-2 and prEN 50440 standards —the first standards to follow Commission mandate M324- which define several 24 hour tapping patterns that are specific for a performance level. The tapping patterns are not just a way to measure energy efficiency, but specify the performance in terms of :

- flow rate for each draw-off (challenging the capacity of instantaneous types),
- the minimum and maximum temperature level per draw-off (taking into account that e.g. instantaneous water heater types that have a longer waiting time and challenging storage water heaters reheating only once a day),
- the volume per draw-off (challenging the storage capacity, if any),
- the time period available between draw-offs (to reheat in case of a storage water heater),
- the time of day when hot water is required (challenging solar-assisted and possibly heat pump types),
- the total daily hot water consumption (challenging e.g. storage water heaters reheating only once a day).

Furthermore, because the tapping patterns cover 24 hours, an energy consumption measurement appropriately includes any storage losses. All in all, the tapping patterns give a fairly comprehensive coverage of the performance aspects.

Therefore the tapping patterns are used to define the base cases.

[1] The time period would be limited in case of a storage type water heater

Table 2.1. Overview of tapping patterns in EN 13203-2 and prEN 50440 [VHK 2006]

Size	(Unit)	XXS	XS	S	M	L	XL	XXL
No. pattern EN 13203-2	#			1	2	3	4	5
No. pattern prEN 50440	#	1c	1b	1/1a	2/2a	3/3a		
Application [typical, estimate VHK]		kitchen only (dishwasher-owner)	kitchen + manual dishwashing (very small shower)	single person (incl. small shower)	avg. family (2-4 persons)	large family (4-6 persons,)	very large family (>6 persons) and jacuzzi-owners	multi-family
Draw-off types [typical, estimate VHK]		washing hands, cleaning	kitchen, dishwash (very small shower)	kitchen, dishwash (small shower)	kitchen, showers, occasional bath	kitchen, showers, 2 baths a day	kitchen, showers, very large daily baths	kitchen, shower + bath (simultaneous)
Dwelling area [typical]	m2	n.a.	20-60	n.a.	40-150	100-200	150-300	200-400
Hot water volume/24h	litres/day	36	36	36	100	199	325	400
Max. test flow rate	litres/min.	2*	5-6**	4	5-6**	5-10**	10	16
in model	litres/min. ΔT 45K	2	4	5	6	10	10	16
Largest test draw-off	litres	1,8	5,4	9	24	62	75	107
Min. temperatures	oC	25	25/40	25/40	10/25/40	10/25/40	10/25/40	10/25/40
Max. Temperatures	oC	n.a.	55	55	40/55	40/55	40/55	40/55
STORAGE WH								
min storage size (1.66*largest tapping)	L	3.3	8.3	14.9	39.8	102.9	126.2	177.6
Typical storage volume	L		< 40		40 - 100	100 - 130	130 - 180	> 180
INSTANT. WH								
Max.test flow rate (ΔT 45ºC)	L/min	2	4	5	6	10	10	16

* =prEN 50440 mentions 2 litr/min. If storage vessel < 10 litre, otherwise 3-4 litre/min. should apply for dishwashing

**= prEN 50440 mentions 5 litr/min. If storage vessel < 10 litre; EN 13203 mentions 6 litre/min. for shower and 10 litre/min for bath

Note 1: litres mentioned are litres equivalent of 60 oC hot water. For hot water of 40 oC multiply by 1,7 (cold water temperature = 10 oC)

Note 2: 'very small shower' is a 2 minute shower with the most efficient (5 litre/minute of 40 oC water) energy saving showerhead. 'Small shower' is 4 minutes and/or a 2-3 minutes with a less efficient energy saving shower head. A conventional showerhead of 10 litre/minute is assumed for the sizes M, XL and XXL for a shower of 2-3 minutes. The bathtub of tapping pattern 'L' is an older model of 100 litres (40 oC water); modern acrylic bathtubs use 60-80 litres and are often insulated. The 'bath' in sizes XL and XXL are special jacuzzis, hot-tubs, etc. or can be seen as the equivalent of simultaneous showers or small baths.

Note 3: The minimum storage size is based upon a recommended storage size of 1.66 times the largest tapping (see also ECOHOTWATER model, cell X31 - comment on Tank volume Vdhw). This is to take into account preceding and subsequent tappings (one doesn't want the whole tank to be completely emptied after the largest draw off).

Section 2.1 of Task 1 also mentions that although the EN 13203 (for gas-fired appliances) and prEN 50440 (for electric storage water heaters) are similar they are not identical. There are some differences e.g. in flow rate, which perhaps may lead to the necessity of correction factors for Specific Measures.

What is also not taken into account –and which was not part of mandate 341—are

- the distribution energy losses due to longer waiting time (guidance from building standards and/or from recording the total water volume until the minimum temperature is reached, multiplied with an appropriate factor)
- the distribution energy losses because some types have restrictions —i.e. need a chimney— in how close they can be to the tapping points (guidance from building standards) and/or cannot be in the heated area of the house (too big, too noisy),

- the energy losses and emissions of the power generation, fuel preparation and system losses in supplying ambient heat like e.g. over-ventilation of the house in case of heat pump water heaters based on ventilation air (guidance from building standards).
- the environmental impact of production and end-of-life (guidance from the underlying study, e.g. EcoReport)

Finally, EN 13203-2 and prEN 50440 cover the main water heater types, but for smaller market niches such as solar-assisted, heat pump and electric instantaneous water heaters the standards are yet to be adapted. The standard for factory-made solar-assisted water heaters, EN 12976, is already based on a (crude and single) tapping pattern. The standards for heat pump water heaters, EN-255, and electric instantaneous water heaters, EN 50193, both use the steady-state energy efficiency and assess the tapping capability (during a 10 minute operation). The adaption of these test standards to mandate M324 may take some time, but in case the delay would exceed the deadline for the introduction of Specific Measures and given that already some form of performance measurement is available the legislator might consider some temporary evaluation based on current standards. The building standards developed under the EU Energy Performance of Buildings Directive (EPBD) could provide some guidance in that respect.

2.3 Real-life load profiles

Following the calculation of the DHW hot water need in the Task 3 Report the average household has a real-life net heat load of 1246 kWh. This average load is applicable to households with a single (primary) water heater as well as households with both a primary and secundary water heater.

For the households with both a primary and secundary water heater the share of the 1246 kWh that is attributed to the primary respectively secundary water heater is based upon the prEN50440 and EN13203-2 in which the 36 L tapping pattern is considered applicable to secundary water heaters (e.g storage below 50L) and 100L to primary water heaters. In a household that combines the two appliance types 36L of 100L (36%) is thus provided by the secundary water heater and 64% by the primary water heater. We assume these shares remains applicable to the average household that uses only 60 L per day.

The table below gives an overview of the calculation and the average heat load of primary and secundary water heaters.

Table 2.2: Real-life heat load of primary and secundary water heaters

Primary only	Primary + secundary	
68% of hh	32% of hh	
total heat load 1246 kWh, based upon 60 L/day	total heat load 1246 kWh, based upon 60 L/day	
	divided over primary and secundary water heater according:	
	Share primary in load: 64%	Share secundary in load: 36%
	(100L minus 36 L is) 64L of 100L in total	36 L of 100L in total
	64% * 1246 = 797 kWh	36% of 1246 is 449 kWh
Average primary		Average secundary
68% * 1246 is 847 kWh	32% * 797 = 255 kWh	
847 + 255 = 1102 kWh		449 kWh

Furthermore it is assumed that the net heat load of 1246 kWh is the same for both the installed park and new products. Sensitivity analysis is used to trace the effect of increasing heat loads.

The values above represent a "real-life" heat load (the value of 60L of 60°C per day is based upon the average EU DHW consumption). The tender document also describes a "standard" base case (heat load according to what the product standard prescribes) but in this case there is no single standard prescribing a heat load but multiple standards describing at least five heat loads (represented as 36, 100, 200, 325 or even 500 L of 60ºC per day), each related to a tapping pattern. One can recalculate the five heat loads to a single heat load to get an average "standard" base-case water heater load, but this would again lead to a real-life heat load. Therefore no (base case for a) "standard" heat load has been identified. The tapping patterns are however used to determine the product system efficiency.

In order to describe the real-life base-cases the sales data are split up into primary water heater sales and secundary water heater sales where applicable.

2.4 Definition environmental impact

The assessment of the environmental impact follows the MEEUP methodology and more specifically the EcoReport tool. The latter is a spreadsheet calculation tool that helps the user in performing the proper calculations with the Unit Indicators in table 29 of the MEEUP Methodology Report (VHK, Nov. 2005).

The table on the following page presents a selection of this table 29 for Unit Indicators that are relevant for the DHW-systems. For information on all materials indicators we refer to the MEEUP reports and table 29.

Table 2.3 . Selection of relevant Unit Indicators from EcoReport/ MEEUP Methodology Table 29

Row	Mat/process		energy			water		waste		GWP	AD	VOC	POP	Hma	PAH	PM	HMw	EP
nr			tot	el	fd	proc	cool	no	haz	CO2	SOx		i-Teq	Ni	Ni		Hg/20	PO4
		recyc	MJ	MJ	MJ	ltr	ltr	g	g	kg	g	g	ng	mg	mg	g	mg	g
4	PP	0%	73	7	53	5	40	4	28	1,97	6	0,02	0	0	0	1	0	165
5	PS	0%	87	4	48	5	177	1	22	2,79	17	0,00	0	0	121	2	0	55
10	ABS	0%	95	7	46	9	165	10	92	3,32	18	0,00	0	0	2	3	2	630
15	Rigid PUR	0%	104	17	39	60	301	20	427	4,17	31	0,00	0	0	20	7	43	3186
21	St sheet galv.	5%	34	2	0	0		0	1722	2,83	7	0,14	26	4	0	3	4	65
23	Cast iron	85%	10	0	0	1	4	0	315	1,06	3	0,12	6	2	0	14	1	26
25	Stainless 18/8 coil	63%	62	10	4	76	8	0	1000	6,21	56	0,14	8	148	0	8	86	2328
27	Al diecast	85%	55	0	0	0		0	750	3,55	16	0,07	33	1	18	4	6	1
30	Cu tube/sheet	60%	51	0	0	0		0	8014	2,73	63	0,00	10	33	5	1	38	62
31	CuZn38 cast	85%	38	0	0	0		0	3043	1,81	35	0,01	25	57	3	1	9	15
98	avg. controller board		781	579	3	523	106	652	1680	51,53	437	6,45	6	73	60	22	333	4702
54	glass/ mineral		16	13	0	8			14	0,83	3							
34	foundries Fe/Cu/Zn		2	1	0	0	1	0	7	0,12	1	0,00	0	0	0	0	0	1
35	foundries Al		7	4	0	0	2	0	20	0,36	2	0,00	0	0	0	0	0	4
36	sheetmetal plant		15	9	1	0	4	0	47	0,84	4	0,00	0	0	0	1	0	6
37	sheetmetal scrap		12	5	0	0	0	0	180	0,80	4	0,09	11	25	0	1	0	0
53	PWB assembly		128	3	5	12	36	4	107	8,52	49	3,10	0	1	3	15	0	709
60	per m3 appliances		798	3	0	0	0	6	277	46,67	150	15,73	2	14	36	3204	0	7
61	per product		52	0	0	0	0	1	51	4,52	12	0,05	0	3	3	0	0	1
63	per m3 installed product		312	0	0	0	0	4	177	18,60	50	4,91	1	9	8	214	0	5
65	Electricity per MWh		10500	10500	0	700	28000	242	12174	458,21	2704	3,95	69	180	21	58	68	323
68	Gas, η 86%, atmospheric		1163	0	0	0	0	0	0	64,29	19	0,85	0	0	0	0	0	0
69	Gas, η 90%, atmosph.		1111	0	0	0	0	0	0	61,43	18	0,81	0	0	0	0	0	0
70	Gas, η 101%, condens.		990	0	0	-14	0	0	0	54,74	16	0,72	0	0	0	0	0	0
71	Gas, η 103%, condens.		971	0	0	-20	0	0	0	53,68	16	0,71	0	0	0	0	0	0
72	Oil, η 85%, atmosph.		1176	0	0	0	0	0	0	87,76	110	1,52	0	0	0	1,857	0	0
73	Oil, η 95%, condens.		1053	0	0	-14	0	0	0	78,52	98	1,36	0	0	0	1,662	0	0
78	Extra for fossil fuel extraction & transport: **Gas +7%** (row 68-73) , **Oil +10%** (row 72-73)																	
conversion per GJ gas/oil input on GCV																		
	Gas		964	0	0	*	0	0	0	53,30	15	0,66	0	0	0,024	0,252	0	0
	Oil		1038	0	0	*	0	0	0	77,41	97	1,34	0	0	0,028	1,638	0	0
conversion per kWh avg. fuel input on GCV →						gas	88%	oil	12%									
	Fuel		3,50	0	0	NA	0	0	0	0,20	0,09	0,00	0	0	0,000	0,002	0	0
86	Mini-van diesel		2	0	0	0	0	0	0	0,19	0	0,04	0	1	1	9	0	0
88	Landfill		68	0	0	0	0	0	1226	5,10	10	0,28	8	20	0	89	6	325
90	HFC refrigerants & R744		**GWP values: R134a=1300, R404a=3260, R410a=1730, R152a=140, R744= CO2=1**															
91	Incinerated		67	0	0	0	0	1000	0	5,02	10	0,14	0	18	0	85	5,7	325
92	Plastics, re-use, recyc.		7	0	0	0	0	0	3	0,44	2	0,13	0	1	0	30	0,0	0

93 Metals, **WEEE recycling credits already incorporated in production** (e.g. 85% recycling rate instead of 60-65% for cast metal producs)
94 Plastics, Thermal recycling: **credit is 75% of feedstock energy & GWP of plastics used** (displaces oil)
95 Plastics, Re-use/ closed loop recycling: **credit is 75% of all production impact of plastics used**
96 Plastics, Recycling: **credit is 27 MJ** (displaces wood) **+ 50% of feedstock energy & GWP of plastics (less chance heat recovery)**
97 Electronics: if designed for easy separate shreddering **credit is 20% of production impact components and materials**

Unit Indicators nr. 68-73 represent the impact for gas-and oil-fired appliances per GJ heat output. The primary energy values and efficiencies are given in Net Calorific Value. For our purpose, i.e. the link with the ECOHOTWATER Integrated Model it is more convenient to

a. use Gross Calorific Values (divide by 111% for gas and 106% for oil)
b. recalculate –using the given efficiencies in the table—the values per unit of energy input, first in GJ (for gas and oil) then in kWh (for "fuel")
c. use an average "fuel" value with the relative shares of gas and oil (for new boilers 88/12%). [2]

This explains the conversions inserted in the table after Unit Indicators 68-73.

2.5 Definition and fixed inputs Life Cycle Costs

Annex II of the EuP-Directive provides guidance regarding the definition of Life Cycle Costs (LCC). The LCC analysis method *'uses a real discount rate on the basis of data provided from the European Central Bank and a realistic lifetime for the EuP; it is based on the sum of the variation in purchase price (resulting from variations in industrial costs) and in operating expenses, which result from the different levels of technical improvement options, discounted over the lifetime of the representative EuP. The operating expenses cover primarily energy consumption an additional expenses in other resources (such as water or detergent).'*

The relevant equation is

LCC = PP + PWF * OE,

where LCC is Life Cycle Costs, PP is the purchase price (incl. installation costs) and OE is the operating expense.

The PWF (Present Worth Factor) is defined as

PWF= N * 1/(1+ r) ^{N} ,

in which N is the product life and r is the discount (interest-inflation) rate.

In the Task 2 Report, chapter 4 we found an interest rate of 4% and an inflation rate of 2% resulting in a discount rate of 2%. For maintenance costs and electricity with 1,5% per year long-term price increase this is appropriate.

However, also in the same chapter we found a (long-term) annual price increase of 5,6% for gas and 8,2 % for heating oil. This is much higher than inflation and for those two components we have to use Present Worth Factors based on a discount rate of -1,6% (gas) and –4,2% (oil) instead of +2%.

All fixed inputs for the LCC-calculation are give in Chapters 4 and 5 of the Task 2 Report, for the EU-25 average and –whenever possible— per EU Member State.

The table below gives a summary of the running cost parameters that will be used for the Base Case (average EU-25):

[2] In Task 7.2 (scenario analysis) the share in the stock is 78/22 % for gas/oil fired boilers

Table 2.4. Running costs fixed parameters for LCC (EU avg)

Product Life (years) Rlife	17	years
Discount rate Rdis	2%	
Electricity rate per kWhe Rel	0,15	€/ kWhe
Fuel rate per kWh Rgas	0,047	€/ kWh
Oil rate per kWh Roil	0,061	€/ kWh
Avg. Fuel per kWh Rfuel	0,049	€/ kWh
present worth factor (in yrs)-->		PWF (yrs)
Electr.rate increase/ yr. Relinc	1,5%	14,3
Gas rate increase/ yr. Rgasinc	5,6%	19,7
Oil rate increase/ yr. Roilinc	8,2%	25,6
Fuel rate increase/yr Rfuelinc	5,9%	20,3
Repair & maint./ yr. Rmaint	see Annex C	14,3

Rel, Rgas and Roil are respectively the electricity, gas and fuel-oil rate (in euro/kWh) as indicated in the Task 2 Report. The latter two are combined to a Rfuel [3].

The prices of the products and installation costs are based on data in the Task 2 and 4 reports, but as they are direct variables for the design options (Task 6) they will also be discussed in the next chapter.

[3] The average fuel rate is based upon a fixed ratio of gas- and oil-fired appliances and not corrected for gas-/oil-shares per base-case class.

3 SPECIFIC INPUTS

During the completion of this task the Commission asked to include larger base case classes"3XL" and "4XL" - these are described in section 3.8 and included in Chapter 4 to 6 alongside the original 7 base case classes described in section 3.1 to 3.7 below.

3.1 Introduction

This chapter describes the values used as input in the EcoReport (v5) tool for the assessment of environmental impact and Life Cycle Costs of the base cases. For each sales segment an EcoReport is produced and together with other EcoReports in the same base-case class they describe the overall impact for that specific base-case class.

In the table below it is explained as follows: Each blue cell represents an EcoReport for a specific water heater/base-case combination. By multiplying the ecoreport results with the sales data the impact of that product in the base-case is calculated. Vertical addition of these 'EcoReports*sales' delivers the overall EU impact of a specific base-case.

Instantaneous water heaters are assigned to a base-case class according their flowrate (table refers to flowrate at ΔT 45K). Storage water heaters are assigned to a base-case class according the minimal storage size, which is converted to a typical storage volume (see table below).

Table 3.1: Water heater sales per base-case class ('000 units)

STORAGE WH		**XXS**	**XS**	**S**	**M**	**L**	**XL**	**XXL**
typical storage size	L	5-10	10-15	15-30	80	120	150	250
Combi_storage					389	130	73	40
Separate cylinder					522.5	522.5	370.5	268.5
Gas_storage					112	54	33	35
Electric_storage		964	(1927) 482	482	1785	542	473	1179

INSTANT. WH		**XXS**	**XS**	**S**	**M**	**L**	**XL**	**XXL**
Max.test flow rate (ΔT 45ºC)	l/min	2	4	5	6	10	10	16
min.power (100/80% st.st.effi.)	kW	6.3	12.5	15.7	18.8 / 23.3	31.3 / 39	31.3	50.2
Combi_instant					4230			
Gas_instantaneous								
5-10 (9.4 and 17.5kW)	*266*		*133*	*133*				
10-13 (21 kW)	*1253*				*1253*			
>13 (27 and 40 kW)	*330*				*165*	*165*		
Electric_instant								
hydr. (incl. el.showers)		*224*	*1499*	*55*	*250*			
electronic		*49*	*43*	*41*	*268*			
Solar storage (not in Task 5 BC, is option in Task 6)					100	149		

The calculation from sales data to base-case class is further explained in Annex A. The following paragraphs focus on the values that are entered in the EcoReports, following the structure according the life cycle.

3.2 Production phase

3.2.1 Bill-of-materials (BoMs)

The inputs of the production phase in the EcoReport requires a format similar to that of the bill-of-materials of the product (BoM). This paragraph presents the material inputs of water heaters to be used in the calculation of the base-cases. For some types of water heaters the BoM(s) is/are pretty straightforward, for others -especially those with combined water/space heating functionality - a more exhaustive calculation of material input was necessary, which included an allocation of inputs to space heating and hot water functionality. For these products a clarification on this calculation of final material inputs is provided in Annex B. The following sections only provide a summary.

Combined storage water heaters

This paragraph describes the BoMs of gas-/oil-fired storage water heaters: Separate storage cylinders, gas storage water heaters and combi_storage boilers. It comprises a generic storage part, describing only the storage cylinder (basic enamelled steel type) and a product specific part, describing extra inputs related to the type of water heater (separate cylinder, gas_storage or combi_storage). This second parts adds items like heat exchangers, feed pumps, etc. to the generic storage part.

The source for the generic, separate cylinder (ansd solar storage) and gas_storage components are VHK estimates, based upon technical descriptions found in product literature and calculations of component geometry and material. The source for the boiler components of the combi_storage is the MEEUP study (data provided by EHI). A clarification on the calculation of the boiler material input is added in an Annex 2.

The constructed BoMs are relevant for base-case S (30 L storage), M (80 L storage), L (120 L storage), XL (150 L storage) and XXL (250 L storage).

Table 3.2: Material input of gas/oil fired storage water heaters

Typical storage [L]	80	120	150	250
	M	L	XL	XXL
Generic storage tank				
tank	11,6	18,2	20,6	31,8
enamel	2,3	3,3	3,7	5,7
insulation	3,4	6,3	7,2	9,9
mantle	5,6	8,5	9,3	14,5
top/bottom	0,1	0,1	0,2	0,2
diptube	1,2	1,7	1,7	2,6
fitting	1,0	1,0	1,0	1,0
mounting	0,3	0,4	0,5	0,7
TOTAL	25,5	39,6	44,1	66,5
For sep. cylinder add (is also used as BoM for solar storage part, excl. collector)				
Feed pump	2,5	2,5	2,5	2,5
HEx	8,7	11,3	11,3	11,3
3-way valve	1	1	1	1
piping	2	2	2	2
TOTAL	40	56	61	83
For gas_storage add:	80L	120L	150L	250L
Burner	0,8	1,5	1,5	1,5
HEx	3	3,2	3,5	3,7
Flue parts	2,5	2,5	2,7	3,1
Gas valve	1	1,4	1,4	1,4

Brass parts	1	1	1	1
various	9	9	9	9
TOTAL	43	58	63	86
For combi_storage add:				
Storage parts				
HEX	8,7	11,3	11,3	11,3
piping	1,0	1,0	1,0	1,0
boiler mantle	2,0	1,0	1,0	1,0
various	1,0	1,0	1,0	1,0
Subtotal tank	38	54	58	81
Boiler parts (14% allocation)				
Aluminium die cast	268	306	424	351
Stainless steel	363	430	519	440
Electronics	94	113	117	104
Cast Iron	1821	10306	9614	4746
Plastics	427	201	156	313
Plastics ABS	38	213	275	142
Copper	481	107	161	366
Copper (coated)	24	135	175	90
Brass	188	50	64	142
Insulation ceramic	105	124	48	69
Insulation mineral wool	53	298	386	199
Steel - cast iron	719	4076	5275	2717
Steel - galvanized	3375	2093	1295	2418
Others	46	46	60	54
Subtotal boiler	8001	18497	18570	12150
TOTAL boiler+storage	46168	72371	76936	92937

Combined instantaneous water heater

The BoM of the gas-fired combi is based upon the BoM of the 45kg low temperature combi-boiler (presented in MEEUP, source EHI), corrected for typical combi_instantaneous product weight.

Table 3.3: BoM of combi_instantaneous

Base-case		M	
	20 kW Low temperature boiler (material composition)	Combi_instant 24kW (13% of total product weight 40 kg)	
Material			
Aluminium die cast	4,3%	226	27-alu diecast
Stainless steel	5,9%	305	25-stainless steel
Electronics	1,5%	79	98-electronics
Cast Iron	2,6%	134	23-cast iron
Plastics	8,0%	418	10-ABS
Copper	9,4%	488	30-Copper
Brass	3,6%	189	31-brass
Insulation ceramic	1,8%	92	(misc.)
Steel - galvanized	62,1%	3229	21-steel galv.
Others	0,8%	40	(misc.)
Total	100,0%	5200	

Gas-fired instantaneous

The BoMs of dedicated gas_instantaneous water heaters are all based upon the BoM of the 45kg low temperature combi-boiler (presented in MEEUP, source EHI).

Table 3.4: Gas-instantaneous

Base-case		XS	S	M	M	L	
Power		9,4kW	17,5kW	21kW	27kW	40kW	
Materials	% of LT BoM						EcoReport material
Plastics	8,0%	764	1046	1287	1609	1770	10-ABS
Steel - galvanized	62,1%	5899	8073	9936	12420	13662	21-St sheet galv.
Cast Iron	2,6%	245	335	413	516	567	23-cast iron
Ins.ceramic	1,8%	167	229	282	353	388	24-Ferrite
Stainless steel	5,9%	557	762	938	1172	1290	25-Stainless 18/8 coil
Aluminium die cast	4,3%	412	564	695	868	955	27-Al diecast
Copper	9,4%	892	1220	1502	1877	2065	30-Cu tube/sheet
Brass	3,6%	345	473	582	727	800	31-CuZn38 cast
Electronics	1,5%	144	198	243	304	335	98-controller board
Others	0,8%	73	100	123	154	170	not specified
	100%	9500	13000	16000	20000	22000	

Electric_storage

The material inputs for electric storage water heaters of 10, 20, 30, 80, 120, 150 and 250 L are based upon BoMs provided by CECED. Some recalculation according storage size was necessary.

Table 3.5: BoMs of Electric Storage Water Heaters

base-cases	XXS	XS	S	M	L	XL	XXL
	10	20	30	80	120	150	250
3-Ferro	328	5019	9710	23597	24840	31051	51751
2-TecPlastics	79	970	1860	2052	1656	2070	3451
1-BlkPlastics	1700	1762	1823	1186	1279	1599	2665
7-Misc.	757	1208	1658	1678	1603	2004	3341
5-Coating	0	164	327	1215	1537	1922	3203
4-Non-ferro	2571	3235	3899	624	2113	2641	4401
6-Electronics	74	88	101	141	51	64	106
TOTAL	5509	12444	19380	30493	33081	41351	68918
		(10+30)/2			(100+200)/2,5	(100+200)/2	200*1,7

Electric_instantaneous

The material input of electric_instantaneous water heaters is based upon BoMs of two hydraulic and one electronic controlled water heater(s) and weighted for sales per base-case class (for details see Annex B).

Table 3.6: BoMs of Electric Instantaneous Water Heaters

	XXS	XS	S	M
1-LDPE	3	16	16	16
3-LLDPE	8	0	0	0
4-PP	25	146	144	144
5-PS	288	514	630	656
6-EPS	38	64	57	55
8-PVC	93	28	24	23
10-ABS	73	370	318	307
11-PA 6	591	873	843	836

12-PC	0	1	0	0
14-Epoxy	0	0	0	0
19-Aramid fibre	0	1	0	0
21-St sheet galv.	78	87	111	116
22-St tube/profile	3	0	6	7
25-Stainless 18/8 coil	41	47	91	101
29-Cu wire	114	69	114	124
30-Cu tube/sheet	125	314	353	362
31-CuZn38 cast	132	221	311	332
42-LCD per m2 scrn	5	17	22	23
44-big caps & coils	47	7	111	135
45-slots / ext. ports	5	1	12	14
46-IC's avg., 5% Si, Au	0	0	0	0
47-IC's avg., 1% Si	0	0	1	1
48-SMD/ LED's avg.	1	0	1	2
49-PWB 1/2 lay 3.75kg/m2	10	2	24	29
52-Solder SnAg4Cu0.5	1	0	3	3
56-Cardboard	59	136	216	234
57-Office paper	103	13	39	45
89-Controller board	11	82	59	54
not available-ceramics	1	3	5	5
not available -grommet (NBR)	4	3	10	12
not available -sealings (VMQ)	1	3	3	3
not available -O-Rings (EPDM)	1	3	3	3
	0			
TOTAL	1859	2863	3429	3557

3.2.2 *Primary scrap*

For primary sheetmetal scrap used in the production phase VHK assumes the default percentage in Ecoreport_v5 of 25%.

3.3 Distribution Phase

The EcoReport requires the product (transport) volume as an input for transportation and warehouse impacts. The following transport volumes are considered the average for the various products and are entered in the EcoReport (all values in m^3).

Table 3.7: Transport volume [m3]

Base-case	XXS	XS	S	M	L	XL	XXL
combi_instant				0.15			
combi_storage				0.20	0.35	0.45	0.6
sep.cyl.				0.20	0.39	0.45	0.6
gas_storage				0.18	0.39	0.45	0.6
gas_instant		0.06	0.10	0.10 / 0.12	0.12		
el.storage	0.01	0.03	0.10	0.18	0.39	0.45	0.6
el.instant	0.02	0.02	0.05	0.05			

3.4 Use phase

The use phase in the EcoReport requires inputs for energy consumption during use and travel related to maintenance/repairs.

3.4.1 Energy Consumption

The total system energy consumption is described by the total heat load, the efficiency and auxiliairy energy consumption. Renewables (solar and heat pumps) are treated as design options (see also task 6).

The heat load is defined by the applicable base-case tapping pattern. Appliance specifications, features and characteristics including auxiliary energy are inputs to the ECOHOTWATER-model. The efficiency is an output of the model and is calculated at system level which includes unavoidable losses (and gains) related to distribution (and heat recovery).

The overall efficiency and heat load per base-case are a result from applying the respective market shares of each water heater in a specific base-case group. The values entered in the ECOHOTWATER-model are presented in Annex D. For 3Xl and 4Xl see section 3.8.

Table 3.8: Overall system efficiency per product group

	Base-case						
	XXS	XS	S	M	L	XL	XXL
Combi (instant+ storage)				38%	48%	52%	55%
				80L	120L	150L	250L
Sep.cyl.				33%	42%	47%	50%
				80L	120L	150L	250L
Gas_storage				17%	29%	37%	41%
				80L / 5kW	120L / 7.5kW	150L / 9.3kW	250L/15.6kW
Gas_instant		12%	25%	37%	44%		
		9.4 kW	17.5 kW	21 / 27 kW	40 kW		
Electric_storage	25%	23%	21%	27%	27%	29%	30%
	10L	20L	30L	80L	120L	150L	250L
Electric_instant							
hydraulic	30%	30%	30%	33%			
electronic	34%	34%	34%	38%			
combined	31%	30%	32%	35%			
	8 kW	8/12 kW	18 kW	21/24/27 kW			
OVERALL TOTAL	25-27%	25-27%	23%	27%	33%	30%	30%

For GIWH's in the Medium base case the overall efficiency is a construction of heaters of 21 kw (with and without pilot flame) and the 27 kW (with pilot flame). The calculation of the overall GIWH efficiency (sales weighted) is shown below.

Table 3.9: Calcualtion of average efficiency *gas_instant* in BC 'M'

Gas_instant (M)	sales	eff.	kWh/a
21 kW pilot	0,09	25%	5164
21 kW auto.ign	0,05	58%	2217
21 kW combined	0,14	37%	4112
27 kW auto.ign	0,02	41%	3371
total		37%	4019

3.4.2 Maintenance/repairs

VHK assumes a total distance travelled for maintenance and repairs over the product life of 100 km for the combined water heaters. Of this some 14 km (14%) is allocated to the water heating functionality.

For the dedicated water heaters a travel distance over the product life of 35 km is assumed (source EcoReport Electric_instantaneous water heaters by CECED).

Table 3.10: Travel distance maintenance/repair over product life

Maintenance/repairs	distance [km]
combi_instant	14
combi_storage	14
sep.cyl./ solar	14
gas_storage	35
gas_instant <13l/min	35
gas_instant >13l/min	35
el.storage <30L	35
el.storage >30L	35
el.instant <12kW	35
el.instant. >12kW	35

3.4.3 Water consumption / waste water

The water consumption is described by the tapping patterns (see task 2).

As regards waste water: For one part this is taken into account in our methodology indirectly through the distribution losses, whereby extra credits are given for appliances that --through their nature (chimney requirement)/ dimensions/ noise-- can be situated close to the most frequently used tapping point. For another part, e.g. appliance waiting times, it follows from an extra energy requirement in the tapping patterns for those appliances that take longer to reach the minimum tapping temperature. In other words, it is there (in the methodology ie. ECOHOTWATER model) but not expressed in terms of water.

3.5 End-of-life phase

For the End-of-life VHK assumes the EcoReport default scenario for all base-cases. The inputs follow from the EcoReport calculation defaults.

3.6 LCC inputs

3.6.1 Product life

The product life of the combined water heaters is set at 17 years, which is consistent with the Lot 1 study on central heating boilers. For dedicated water heaters like *gas_instantaneous*, *gas_storage* and *electric_storage* a similar product life is applied. For *electric_instantaneous* water heaters CECED assumed a product life of 15 years but in our calculations we used 17 years.

Table 3.11: Product life

Combi_instantaneous	17 years - assumed identical to Lot 1 Ecodesign for Boilers
Combi_storage	17 years - assumed identical to Lot 1 Ecodesign for Boilers
Sep. cylinder / Solar	17 years - assumed identical to Lot 1 Ecodesign for Boilers
Gas_storage	17 years - assumed identical to Lot 1 Ecodesign for Boilers
Gas_instantaneous	17 years - assumed identical to Lot 1 Ecodesign for Boilers
Electric_storage	17 years - indicated by CECED
Electric_instantaneous	17 years - Note: CECED used 15 years in their own calculations, but in order to simplify the calculations for the EU Totals we assume 17 years here. The difference for EU totals is neglible.

3.6.2 Product price

The product prices (new product base case) are based upon the product prices identified in the Water Heater Task 2 and Task 4 Report. Further explanation on the calculation of product prices is described in Annex C.

Table 3.12: Product price EUR

Base-case	XXS	XS	S	M	L	XL	XXL
Combi_instantaneous				243 *			
Combi_storage				360 *	495 *	500 *	485 *
Sep. cylinder				500	700	850	1000
Gas_storage				400	600	750	1250
Gas_instantaneous		240	240	350	600		
Electric_storage		123		253	346	415	647
Electric_instant.hydr.	81	199	245	252			
Electric_instant.electr.	245	318	420	448			

Note: the * indicates the purchase price is based on an allocation to water heating of 13% of the product price (storage is allocated for 100%)

3.6.3 Installation costs

The installation costs are based upon the costs identified in the Water Heater Task 3 and Task 4 Report. They are corrected for small and medium to large base-case classes. Further explanation on the calculation of installation costs is described in Annex C.

Table 3.13: Installation costs EUR

Base-case	XXS	XS	S	M	L	XL	XXL
Combi_instantaneous				160*			
Combi_storage				243*	262*	269*	254*
Separate cylinder				430	430	430	430
Gas_storage				240	360	450	750
Gas_instantaneous		144	144	210	360		
Electric_storage	50	50	50	90	120	144	234
Electric_instantaneous	50	50	100	100			

3.6.4 Energy and water prices

The values are taken from the Task 2 Water heater report.

Table 3.14: Fuel / electricity / water costs EUR

Base-case	EUR		increase		remark
Gas	13	GJ	5.6	%	0.46 EUR/m^3
Household fuel oil	645	1000L	8.2	%	
Electricity	0.15	kWh		%	
Water	2	m^3	4.5	%	

3.6.5 Maintenance/repairs costs

The maintenance/repair costs are based upon the costs identified in the Water Heater Task 3 and Task 4 Report. The costs are explained in Annex C.

Table 3.15: Maintenance/repair costs EUR per year

Service / maintenance costs (EUR/yr)	service contract	storage tank maintenance	TOTAL
Combi_instantaneous	23 *	n.a.	23
Combi_storage	29 *	6	35
Separate cylinder	29	6	35
Gas_storage	58	6	64
Gas_instantaneous	58	n.a.	58
Electric_storage	10 - 30	6	10 - 36
Electric_instantaneous	10 - 15	n.a.	10 - 15

*: allocation applied

3.7 EU Totals: Markets by category

The inputs for the calculation of EU Total impacts is performed on the basis of the sales indicated in Section 3.1 (which are based upon the Task 2 Report). An overview is provided below.

Table 3.16 : Water heater sales per base-case class ('000 units and % of BC)

STORAGE WH		**XXS**	**XS**	**S**	**M**	**L**	**XL**	**XXL**
Combi_storage					389	130	73	40
					4.3%	*9.2%*	*7.7%*	*2.6%*
Separate cylinder					522.5	522.5	370.5	268.5
					5.8%	*37%*	*39%*	*17.6%*
Gas_storage					112	54	33	35
					1.2%	*3.8%*	*3.5%*	*2.3%*
Electric_storage		964	482	482	1785	542	473	1179
		77.9%	*22.3%*	*67.8%*	*19.9%*	*38.3%*	*49.8%*	*77.4%*
INSTANT. WH		**XXS**	**XS**	**S**	**M**	**L**	**XL**	**XXL**
Combi_instant					4230			
					47.1%			
Gas_instantaneous								
5-10 (9.4 and 17.5kW)	*266*		*133*	*133*				
			6.2%	*18.7%*				
10-13 (21 kW)	*1253*				*1253*			
					14%			
>13 (27 and 40 kW)	*330*				*165*	*165*		
					1.8%	*11.7%*		
Electric_instant								
hydr. (incl. el.showers)		*224*	*1499*	*55*	*250*			
		18.1%	*69.5%*	*7.7%*	*2.8%*			
electronic		*49*	*43*	*41*	*268*			
		4.9%	*2%*	*5.7%*	*3%*			
TOTALS	***17116***	***1237***	***2157***	***711***	***8975***	***1414***	***950***	***1523***
		100%	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*

3.8 Base case 3XL & 4Xl

3.8.1 Introduction

During the completion of this Task VHK was asked by the Commission to add two extra water heating performance classes to the base cases: 3XL and 4XL.

Agreed was to size these performance classes at 8 and 16 times the medium size class. Such water heater (systems) would thus be found in larger residential dwellings (apartment buildings) as well as various tertiary/commercial facilities (hotels, sports and leisure, etc.) and even some industrial facilities.

3.8.2 Performance and load profile

As shown in Section 2.1 the medium base case is based upon a flow rate of 6 l/min (at ΔT 45K) and/or a largest tapping of 24L. 3XL and 4XL are based upon 8 and 16 times these performance parameters.

Table 3.17: Performance of base case 3XL and 4XL

		M	3XL	4XL
multiplier		*reference*	*8*	*16*
flow rate (at ΔT 45K)	l/min	6	48	96
minimum power at 80% eff.	*kW*	*23.5*	*188*	*376*
largest draw.off	l	24	192	384
minimal storage size	l	40	319	637
base case storage size	l	80	750	1500

As regards the analysis of environmental impact and definition of fixed inputs to the life cycle cost analysis the same applies as is described in Section 2.4 and 2.5.

3.8.3 Specific inputs for 3XL and 4XL

Production phase

VHK decided to model the 3XL and 4XL base case as a separate cylinder. Market data (table 3.2 in Task 2 Report) shows that sales in 2005 of separate cylinders in the 3Xl and 4XL (500-1000 and >1000L) classes are 112 thousand and 66 thousand units (from a total of 2084 thousand units).

Base case XXL covers already a total of 1684 thousand units (1641 thousand 'separate cylinders' and 43 thousand 'buffer storage cylinders'). The 'gap' of 400 thousand units (the 2084 thousand mentioned above minus 1684 thousand in XXL) is filled by solar tanks (249 thousand tanks not in XXL) and the cylinders in class 3XL and 4XL (112+66 is 178 thousand). This leaves only 27 thousand cylinders unaccounted for, which is only 1.2% on a total of 2084 thousand and neglected.

The bill-of-materials of a 500 and 1000L L cylinder is given below. The total product weight is taken from manufacturers brochures of similar sized cylinders. The shares (in % of total weight) of materials are calculated assuming dimensions similar to units from manufacturers brochures. The smaller material fractions (e.g other plastics, brass) are not indicated since they are obscured by the huge copper and steel fractions.

Table 3.18: Bill-of-materials 3XL and 4XL

			3XL	4XL
Cylinder	69%	Copper	129030	365700
Insulation	12%	PUR	22440	63600
Steel mantle + feet	14%	Steel-galv	26180	74200
(External) heat exchanger + misc.	5%	Steel-galv	9350	26500
TOTAL	100%		187000	530000

For the EcoReport calculation the value of primary scrap is set at default 25%.

3.8.4 *Distribution phase*

The transport volume and product envelope are estimated as indicated below.

Table 3.19: Product envelope

	3XL	4XL
m3	1.5	2.6

Use phase

The impacts of the use phase are calculated using the ECOBOILER-model (developed for Lot 1 Ecodesign of boilers) since the system comprises a DHW storage component linked to an external heating boiler.

The chosen boiler is 115kW for the 3XL and 250kW for the 4XL: These boilers are representative for the XXL respectively the 3XL base case in the Lot 1 study on Ecodesign of Boilers.

The table below lists the input variables in the ECOBOILER model and shows the outputs such as primary heat load and system efficiency. These values are the input values for the Ecoreport which calculates the total environmental impacts.

Table 3.20: Input variables 3XL and 4XL in ECOBOILER model (v5a)

INPUTS DHW		
DHW power class	3XL	4XL
tank volume in ltr	750	1500
tank ref. heat loss	197 W	279 W
smart control ?	no	no
mixingfactor V40	1,65	1,65
heat traps installed?	no	no
boiler characteristics		
CH-power class	7 -XXL	8 -3XL
power input in kW*	115 kW	250 kW
turndown ratio	33%	33%
standby heat loss %	1,00%	1,00%
steady st. efficiency *	5 -eff. 80/80/80/80	5 -eff. 80/80/80/80
fuel (dewpoint)	1-gas	1-gas
air-fuel mix control	2 -pneumatic	2 -pneumatic
circ. pump power	7 -200W	8 -800W
fan power	6 -P=90W	7 -P=150W
CPU power sb/on	8 -P=56/60W	8 -P=56/60W
controls power sb/on	3 -P=0/18W	3 -P=0/18W
comb. air intake	1 -room sealed	1 -room sealed
boiler mass (empty), kg	221 kg	900 kg
water content in kg	20,0 kg	100,0 kg
envelope volume in m3	1,50 m3	2,00 m3
noise level in dB-A	45 dB-A	45 dB-A
RT controllers		
auto-timer control	yes	yes
valve control	2 -RTV 2K	2 -RTV 2K
boiler temp control	6 -on/off RT	6 -on/off RT
electronic optimiser	no	no

Table 3.21: Outputs for 3XL and 4XL

		3XL		4XL	
OUTPUTS HW			TOTAL		TOTAL
HW sys. efficiency	(%)	52%	52%	49%	49%
TOTAL kWh (primary)	kWh/a	19746	19746	41668	41668
load (from tapping pattern)	kWh/a	10268	10268	20537	20537
distribution (from system)	kWh/a	480	480	960	960
storage (from cylinder)	kWh/a	1819		2611	
stby heat (from boiler)	kWh/a	2791		8520	
purge+fuel (from boiler)	kWh/a	204		434	
generator (from boiler)	kWh/a	3891		8266	
el. aux (from boiler)	kWh/a	293		341	
el. back up (n.a.)	kWh/a	0		0	

End-of-life phase

For the End-of-life VHK assumes the EcoReport default scenario for all base-cases. The inputs follow from the EcoReport calculation defaults.

3.8.5 LCC inputs for 3XL and 4XL

The purchase price of a 750L separate cylinder is assessed at 4000 euro and the 1500 cylinder at 6000 euro (interpretation of values in figure 9.16 in Section 9.5 of the Task 4 Report). The product life is assumed to be the same as for other storage cylinders eg. 17 years.

The installation costs are estimated at 860 euro for the 3XL and 1290 euro for the 4XL which is 2 respectively 3 times the installation costs (430 euro) of the standard separate cylinder.

The maintenance costs are difficult to separate from boiler maintenance contracts and are estimated at 100 and 150 euro for the 3XL respectively 4XL cylinder.

The energy rates are as given in Section 3.6.

3.8.6 Environmental impact of 3XL and 4XL

The environmental impact of base case 3XL and 4XL are presented in Chapter 4.

3.8.7 Life Cycle Costs for 3XL and 4XL

The Life Cycle Costs of base case 3XL and 4XL are presented in Chapter 5.

3.8.8 EU Totals for 3XL and 4XL

The EU Totals for environmental impact and Life Cycle Costs of base case 3XL and 4XL are presented in Chapter 6.

4 ENVIRONMENTAL IMPACT

Calculation of the environmental impact per size category of the Base Cases is given in the following table.

Table 4.1. Environmental Impact BaseCases PER UNIT

		XXS		XS		S		M		L		XL		XXL		3XL		4XL	
		BC XXS		*BC XS*		*BC S*		*BC M*		*BC L*		*BC XL*		*BC XXL*		*BC 3XL (sepcyl 750L)*		*BC 4XL (sepcyl 1500L)*	
ENVIRONMENTAL IMPACT PER UNIT OVER LIFE																			
MATERIALS		**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE
TOTAL	kg	**5**		**6**		**16**		**17**		**117**		**60**		**75**		**187**		**530**	
of which																			
Disposal	kg	**2**		**2**		**4**		**3**		**17**		**9**		**11**		**29**		**81**	
Recycled	kg	**3**		**3**		**12**		**14**		**100**		**50**		**64**		**158**		**449**	
OTHER RESOURCES																			
Total Energy (GER)	GJ	**124**	123	**124**	123	**140**	139	**243**	241	**495**	491	**777**	773	**1139**	1133	**1191**	1174	**2514**	2469
of which, electric(in primary)	GJ	**123**	123	**109**	109	**119**	118	**94**	94	**277**	276	**521**	521	**993**	992	**54**	52	**67**	61
Water (process)	m3	**8**	8	**7**	7	**8**	8	**6**	6	**19**	18	**35**	35	**67**	66	**5**	3	**8**	4
Water (cooling)	m3	**329**	329	**291**	291	**316**	316	**251**	250	**738**	737	**1391**	1388	**2647**	2644	**147**	139	**183**	162
Waste, non-haz./ landfill	kg	**4**	3	**4**	3	**5**	3	**4**	2	**11**	6	**17**	12	**29**	23	**21**	1	**57**	1
Waste, hazardous/ incinerated	kg	**161**	143	**140**	126	**179**	137	**139**	109	**400**	320	**698**	604	**1288**	1150	**1193**	61	**3278**	71
EMISSIONS TO AIR																			
GHG in GWP100	tCO2	**5**	5	**6**	6	**6**	6	**12**	12	**24**	24	**37**	37	**51**	51	**65**	64	**138**	136
AP Acidification	kgSOx	**32**	32	**29**	28	**31**	31	**27**	26	**75**	74	**139**	138	**259**	257	**41**	30	**81**	52
VOC Volatile Organic Comp.	kg	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**1**	1	**2**	2
POP Persist.Organic Poll.	mg i-Teq	**1**	1	**1**	1	**1**	1	**1**	1	**3**	2	**5**	3	**8**	6	**3**	0	**8**	0
HMa Heavy Metals	mg Ni	**2**	2	**2**	2	**2**	2	**2**	2	**5**	5	**10**	9	**18**	17	**7**	1	**18**	1
PAHs	mg	**0**	0	**0**	0	**0**	0	**0**	0	**1**	1	**1**	1	**2**	2	**1**	0	**4**	0
PM Particulate Matter	kg	**2**	2	**2**	1	**2**	2	**2**	1	**4**	2	**6**	4	**10**	6	**10**	1	**19**	2
EMISSIONS TO WATER																			
HMw Heavy Metals	g Hg/20	**1**	1	**1**	1	**1**	1	**1**	1	**2**	2	**4**	3	**7**	6	**6**	0	**18**	0
EP Eutrophication	g PO4	**5**	4	**8**	3	**13**	4	**11**	3	**32**	8	**46**	16	**78**	30	**93**	2	**261**	2

5 LIFE CYCLE COSTS

Calculation of the Life Cycle Costs per size category of the Base Cases is given in the following table.

Table 5.1. Life Cycle Costs and Annual Expenditure PER UNIT

	XXS	XS	S	M	L	XL	XXL	3XL	4XL
LCC break down (over product life)									
Product Price	€ 122	€ 187	€ 171	€ 318	€ 530	€ 603	€ 718	€ 4.000	€ 6.000
Installation	€ 50	€ 56	€ 74	€ 173	€ 285	€ 276	€ 281	€ 860	€ 1.290
Fuel energy (gas, oil)	€ 0	€ 224	€ 322	€ 2.474	€ 3.468	€ 4.070	€ 2.275	€ 18.111	€ 38.878
Electricity	€ 1.480	€ 1.309	€ 1.422	€ 1.128	€ 3.202	€ 6.253	€ 11.910	€ 628	€ 731
Repair & Maintenance	€ 144	€ 185	€ 271	€ 468	€ 560	€ 522	€ 520	€ 1.429	€ 2.144
TOTAL LCC	€ 1.797	€ 1.961	€ 2.261	€ 4.560	€ 8.045	€ 11.724	€ 15.704	€ 25.028	€ 49.043
Annual expenditure									
Product Price	€ 7	€ 11	€ 10	€ 19	€ 31	€ 35	€ 42	€ 235	€ 353
Installation	€ 3	€ 3	€ 4	€ 10	€ 17	€ 16	€ 17	€ 51	€ 76
Fuel energy (gas, oil)	€ 0	€ 11	€ 16	€ 122	€ 171	€ 200	€ 112	€ 926	€ 1.954
Electricity	€ 104	€ 92	€ 100	€ 79	€ 224	€ 438	€ 833	€ 44	€ 51
Repair & Maintenance	€ 10	€ 13	€ 19	€ 33	€ 39	€ 37	€ 36	€ 0	€ 0
TOTAL expenditure/a	€ 124	€ 130	€ 149	€ 262	€ 482	€ 726	€ 1.040	€ 1.256	€ 2.434

6 EU TOTALS

Calculation of the EU totals for environmental impact and the Life Cycle Costs per size category of the Base Cases is given in the following tables.

Table 6.1. Environmental Impact BaseCases sold in 2005 over their product life (17 years)

		XXS		XS		S		M		L		XL		XXL		3XL		4XL		NEW TOTAL EU	
Units sales/a * 1000:		1237		2157		711		8975		1414		950		1523		112		66		17143	
IMPACT CATEGORY																					
MATERIALS		TOTAL	USE	TOTAL	USE	TOTAL	USE	TOTAL	USE	TOTAL	USE	TOTAL	USE	TOTAL	USE	TOTAL	USE	TOTAL	USE	TOTAL	USE
TOTAL	kt	6		12		11		150		166		57		114		21		35		572	
of which																					
Disposal	kt	2		5		3		23		24		9		17		3		5		91	
Recycled	kt	3		7		9		127		141		48		97		18		30		481	
OTHER RESOURCES																					
Total Energy (GER)	PJ	153	153	267	266	100	99	2178	2165	699	695	738	734	1734	1725	133	132	166	163	6169	6130
of which, electric(in primary)	PJ	152	152	235	235	84	84	845	843	391	391	495	494	1511	1510	6	6	4	4	3725	3719
Water (process) * mln.	m3	10	10	16	16	6	6	57	56	26	26	33	33	101	101	1	0	1	0	251	248
Water (cooling) * mln	m3	407	406	628	627	225	225	2251	2247	1044	1041	1320	1318	4030	4026	16	16	12	11	9934	9917
Waste, non-haz./ landfill	kt	5	4	10	5	4	2	34	19	15	9	16	11	44	35	2	0	4	0	134	86
Waste, hazardous/ incinerated	kt	199	177	302	273	127	98	1250	977	566	453	663	573	1961	1751	134	7	216	5	5417	4312
EMISSIONS TO AIR																					
GHG in GWP100	MtCO2	7	7	12	12	5	4	111	110	34	34	35	35	78	78	7	7	9	9	298	296
AP Acidification	ktSOx	40	39	62	61	22	22	241	237	106	105	132	131	394	392	5	3	5	3	1006	994
VOC Volatile Organic Comp.	kt	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	3	3
POP Persist.Organic Poll.	g i-Teq	1	1	2	2	1	1	9	6	4	3	4	3	12	10	0	0	1	0	34	24
HMa Heavy Metals	t Ni	3	3	4	4	2	1	17	15	8	7	9	9	27	26	1	0	1	0	73	65
PAHs	t Ni	0	0	1	1	0	0	3	2	1	1	1	1	3	3	0	0	0	0	10	8
PM Particulate Matter	kt	2	2	4	3	2	1	20	13	6	3	6	4	15	10	1	0	1	0	56	36
EMISSIONS WATER																					
HMw Heavy Metals	t Hg/20	1	1	2	2	1	1	7	5	3	3	4	3	11	10	1	0	1	0	30	24
EP Eutrophication	t PO4	7	5	17	7	9	3	101	26	46	12	44	15	119	46	10	0	17	0	369	114

Table 6.2. Life Cycle Costs and Annual Expenditure for BaseCase units sold in 2005 over their product life (17 years)

		XXS	XS	S	M	L	XL	XXL	3XL	4XL	TOTAL
Units sales/a * 1000:		1237	2157	711	8975	1414	950	1523	112	66	17143
LCC break down (product life & sales)											
Product Price	M€	152	403	122	2.855	749	572	1.093	448	396	5.946
Installation	M€	62	120	53	1.555	403	262	427	96	85	2.882
Fuel energy (gas, oil)	M€	0	482	229	22.199	4.902	3.865	3.464	2.028	2.566	35.141
Electricity	M€	1.830	2.824	1.011	10.119	4.526	5.938	18.133	70	48	44.381
Repair & Maintenance	M€	178	400	193	4.199	791	495	792	160	141	7.049
TOTAL LCC	M€	2.223	4.230	1.607	40.926	11.372	11.132	23.910	2.803	3.237	95.400
Annual expenditure (sales)											
Product Price	M€	9	24	7	168	44	34	64	26	23	350
Installation	M€	4	7	3	91	24	15	25	6	5	170
Fuel energy (gas, oil)	M€	0	24	11	1.093	241	190	171	104	129	1.730
Electricity	M€	128	198	71	708	317	415	1.269	5	3	3.105
Repair & Maintenance	M€	12	28	13	294	55	35	55	0	0	493
TOTAL expenditure/a	M€	153	280	106	2.354	681	689	1.584	141	161	5.848

ANNEX A

Calculation of market categories to base-case classes

The following paragraphs provide clarification on how water heater sales are assigned to a specific base-case. The section starts with combi-storage water heaters and continues with other storage water heaters, followed by the instantaneous types.

Combi_ storage

To determine in which base-case the combi_storage appliances belong we need to define the (average) storage size of the tank. The Task 2 BRGC sales data on "combi storage" and "integrated cylinder" (the two categories that comprise combi_storage) does not provide this information. We therefore recontruct storage sizes on the basis of sales data of boiler types and the storage sizes linked to those boilers.

The BRGC Boiler study (also basis for Lot 1 Ecodesign of CH boilers) presented a technical segmentation of boiler sales by product type and water heating function [4]. By combining the boiler groups "*combi-storage*", "*mounted on fs cylinder*" and "*with built-in cyl*" into one water heater category "*combi_storage*" a sales breakdown of 62% gas-wall hung, 12% gas-floor standing and 26% oil-floor standing appears. Applying this to a total of combi_storage water heater sales of 632 thousand units (see table 3.2 in Task 2 report: 248 thousand *Combi Boilers (Storage only)* + 384 thousand *Indirect Cylinders Integrated*) gives 392 thousand gas-wh, 76 thousand gas-fs and 164 thousand oil-fs [5].

Table A.1: Attributing boiler sales per type to combined water heaters

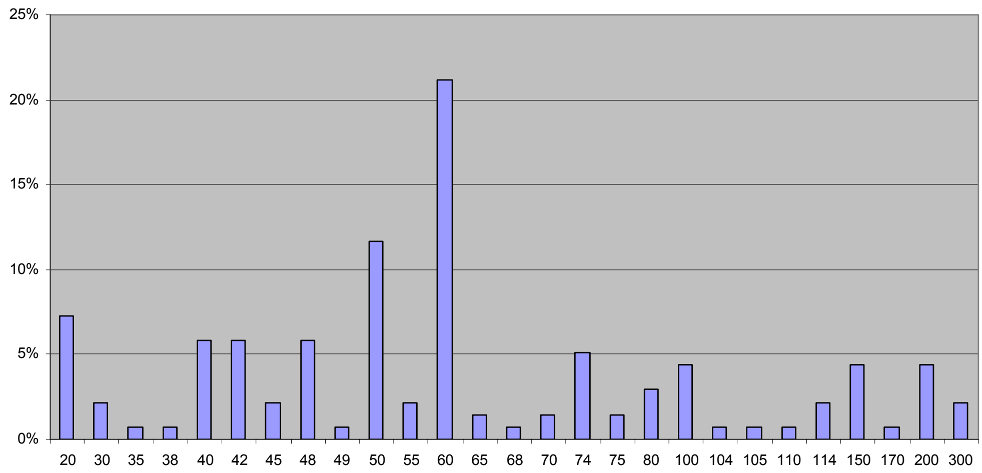
Boiler tech segm 2005 (sales)	gas wh	gas fs	oil fs	TOTAL		Water heater	gas wh	gas fs	oil fs	gas wh	gas fs	oil fs
		['000 units]						%			['000 units]	
combi conv/preheat	3612			3612		combi instant	100%					
combi storage	507	44										
mounted on fs cyl	65			921	➔	combi storage	62%	12%	26%	392	76	164
with built-in cyl		66	239									
with ext.cyl	801	136	363	2042		sep. cylinder	54%	15%	31%			
without cyl	295	171	276									

A further breakdown to storage volume is based upon a product survey of 458 combi-storage boilers from the RT2000 database providing a picture of storage sizes per boiler type.

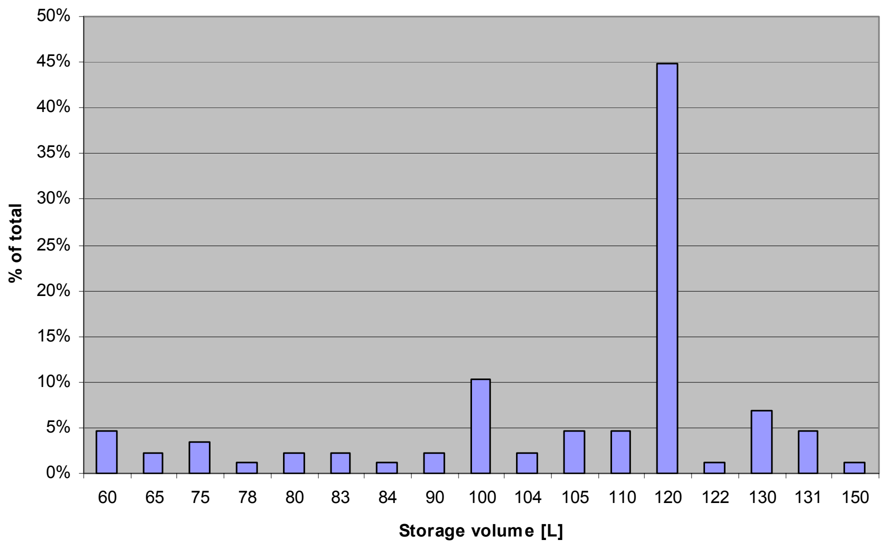
[4] BRG Consult, The Boiler and Heating System Market in the European Union, Final Draft for the European Commission, Canterbury, June 2006.

[5] The difference between 632 thousand storage combi's in water heater sales data and 921 boilers with water heating function in boiler sales data can be explained by some mismatch in applying water heater categories to boiler categories. The difference between storage combi's and separate cylinders sold in conjunction with a heating-only boiler is sometimes hard to spit and largely depends on how it is assessed.

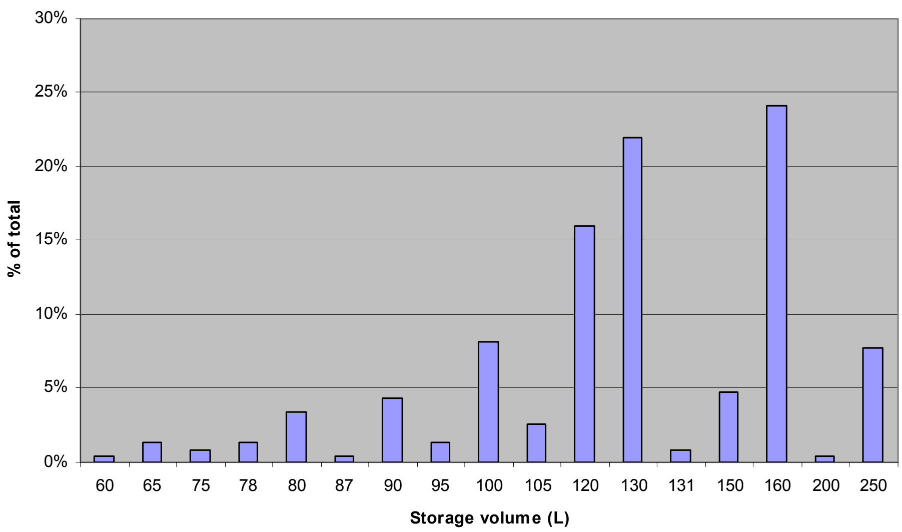
Combi_storage gas-w h (storage volume as % of total)



Combi_storage gas-fs (volume in % of total)



Combi_storage oil-fs (storage as % of total)



The table below presents a summary of the graphs above: The percentages are summed in storage volume classes that are aligned with the typical base-case storage volume.

Table A.2: Storage volume by boiler type (combi_storage)

	M	M	L	XL	XXL
RT 2000 db	< 40 L	30 - 100 L	100 - 130 L	130 - 180 L	> 180 L
Gas wh					
20 tot 40	11%				
40 t/m 100		73%			
104 t/m 114			4.4%		
150 t/m 170				5.1%	
200 t/m 300					6.6%
gas fs					
60 t/m 100		29.9%			
104 t/m 130			64.4%		
131 t/m 150				5.7%	
Oil fs					
60 t/m 100		21.6%			
105 t/m 130			40.5%		
131 t/m 160				29.7%	
200 t/m 250					8.2%

Note that the gas-wh combi-storage range starts at 20L storage volume and almost 11% of sales are less than 40L storage, which puts them (being principally a storage water heater) in the XXS to S class. These smaller storage_combi's are however assigned to class M which is more in line with expected use.

When combined with sales data (table below) the segmentation shows that in base-case M the gas-wh is the dominant boiler type and for base-cases L to XXL the presence of oil-fs increases with XXL as an exception where gas wall hung is combined with large storage vessels. This may be an effect of not using sales-weighted data but at the moment there is no better data available.

Table A.3: Sales and shares by boiler type (combi_storage)

	Sales	M	L	XL	XXL
	'000 units	40 - 100 L	100 - 130 L	130 - 180 L	> 180 L
gas wh	396	332,6	17,4	20,2	26,1
gas fs	72	21,5	46,4	4,1	
oil fs	164	35,4	66,4	48,7	13,4
TOTAL	**632**	**389**	**130**	**73**	**40**
% of units (to be used for material input)					
gas wh		86%	13%	28%	66%
gas fs		5%	36%	6%	
oil fs		9%	51%	66%	34%
Typical BC storage size	(L)	80	120	150	200

The last row of the table above indicates to which typical Base-case storage volume the boilers are assigned to, which results in the overall sales table presented below.

Table A.4: Overview combi_storage by base-case class

Base-case--->	['000]	XXS	XS	S	M	L	XL	XXL
Storage size					80	120	150	250
	TOTAL							
Sales ('000 units)	632				389	130	73	40
% of sales					62%	21%	12%	6%

Separate cylinders

Total sales of separate cylinders was 1641 thousand units, distributed over seven sales categories. To this can be added some 43 thousand *'Gas WH: Indirect Cylinder Buffer Storage'*, giving a total of 1684 separate cylinders. Solar Storage Tanks are treated as a separate category in Task 7 and 8. 'Indirect Cylinders Integrated' are treated in the *Combi_storage* sections.

The sales in each storage volume class are assigned to a specific base-case storage volume according the sales percentages per storage class. Since these sales categories do not exactly match the base-case categories some re-distributing of sales was necessary (see comments in table).

Table A.5: Separate cylinders

Base-case--->			M	L	XL	XXL	
	% of sales	('000)	80	120	150	250	Comments
60-80	14%	236	236				all sales in class M
80-120	34%	573	286.5	286.5			sales 50/50 over class M and L
120-200	28%	472		236	236		sales 50/50 over class L and XL
200-500	16%	269			134.5	134.5	sales 50/50 over class XL and XXL
500-1000	5%	84				84	all sales in class XXL
>1000	3%	50				50	all sales in class XXL
Total	100%	1684	522.5	522.5	370.5	268.5	
			31%	31%	22%	16%	

Gas storage

Total sales of gas storage water heaters was 234 thousand units (condensing and non-condensing combined), distributed over seven sales categories. The sales categories are assigned to a specific base-case storage volume (approximately 1.66 times largest single tapping). Since the sales categories do not exactly match the base-case categories some re-distributing of sales over base-case classes was necessary (see comments in table).

Table A.6: Gas_storage (non-condensing and condensing)

Base-case--->	Sales	M	L	XL	XXL	
Storage [L]		80	120	150	250	Comments
<80L	78	78				All sales <80L into base-case M
80-130L	67	34	34			Sales 80-130L evenly spread over M and L
160L	41		20	21		Sales 130-160L evenly spread over L and XL
190L	12			12		Sales 160-190L all to XL
220L	11				11	Sales 190-220 all to XXL
>220L	24				24	Sales >220 all to XXL
TOTAL ['000]	234	112	54	33	35	
	100%	48%	23%	14%	15%	

Electric storage

Total sales of electric storage water heaters was 5.9 million units, distributed over six sales categories. The sales in each category are assigned to the base-case corresponding to the typical storage volume.

Note that sales in the category <30L are not further specified.

Supporting sales data by BRGC shows that for those countries of which sales data of the smaller groups is available the group 5-10L has a significantly higher share than the group 10-15 and 15-30L (ranging from 1.3 to almost 19 times as much sales).

Table : Sales in class <30L (relative values)

	5-10L	10-15L	15-30L
AU	3	1	1.4
GR	1.3	1	1
IT	?	3.5	1
NL	19	1.3	1
LV	1.75	1	1.5
LIT	1.5	1	1.25

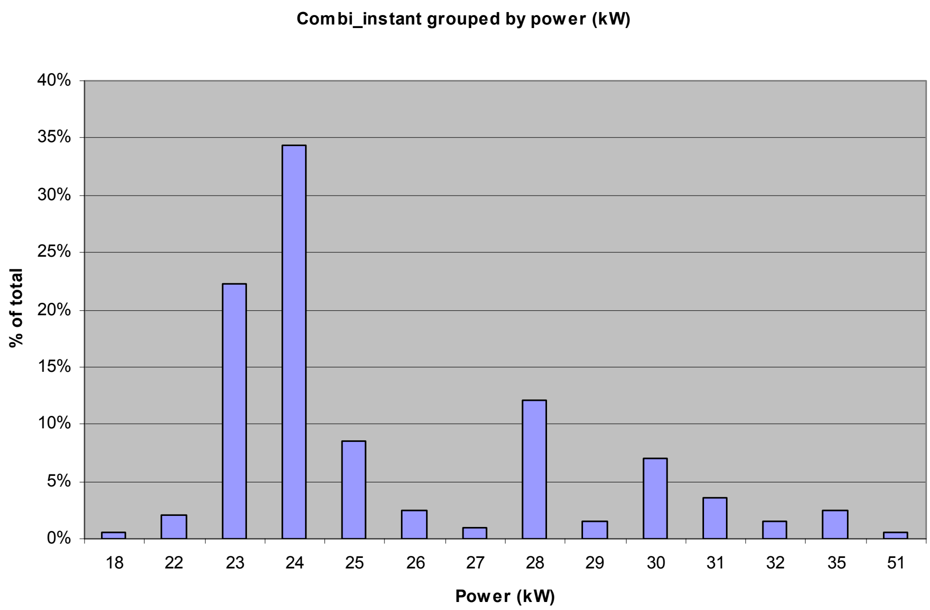
For the EU average we assume 50% of sales <30L to be in class XXS, 25% in class XS and 25% in class S which gives the following overall results.

Table A.7: Electric_storage

Electric-storage		XXS	XS	S	M	L	XL	XXL
Typical storage [L]		<40	<40	<40	40-100	100-130	130-180	>180
<30L	1927		1927					
80L	1785				1785			
100L	542					542		
150L	473						473	
200L	909							909
400L	270							270
TOTAL			1927		1785	542	473	1179
to Base-case ['000]	5906	964	482	482	1785	542	473	1179
[%]	100%	16%	8%	8%	30%	9%	8%	20%

Combi_instantaneous

Most combi_instantaneous (BRGC category "combi-boiler instant") have a power of 18 to 35 kW and the most popular power class is 24 kW (source RT2005 database - see graphh below).



The 24 kW is taken as average which puts the *combi_instantaneous* in the base-case M (flow rate > 6 l/min but less than 10 L/min at ΔT45°). Combi's with flow rate above 10 l/min (17 l/min at 40-45 °C or over 40 kW at steady state efficiency 85%) are rare in market supply and not assigned to a base-case.

Table A.8: Combi_instantaneous

Combi_instant		XXS	XS	S	M	L	XL	XXL
Max.test flow rate (ΔT 45°C)	L/min	2	4	5	6	10	10	16
TOTAL ['000]	4230				4230			
[%]	100%				100%			

Gas_instantaneous

About 1849 thousand gas_instantaneous water heaters are sold in 2005. The BRGC study used sales categories of 5-10, 10-13 and >13 l/min at flow rates of 40 to 45°C outlet temperature which are converted to flow rates at 60°C (ΔT 45K) to allow them to be assigned to a base-case.

Table A.9: Gas instantaneous - from sales categories to base-case categories

BRGC categories				Conversion		To Base-case		
Flowrate at 40°C	sales			Flowrate at 60°C	Equals power class	Base-case	Typical power	Sales
l/min	'000 units			l/min	kW		kW	'000 units
5	266			2.0 - 2.4	8.7 - 9.4	XS	9.4	133
10		1253		5.0	17.5	S	17.5	133
13				6.5 - 7.0	21.4 - 22.6	M	21	1253
>13			330	8.0	27.1		27	165
				10.0	> 40	L	40	165

Note that 50% of sales of water heaters of category "5-10 l/min" are assigned to class XS and 50% to class S. The same goes for ">13 l/min" (8 l/min at 60°C) which is assigned to base-case M and L on 50/50 (respectively 6 and 10 l/min at 60°C).

Table A.10: Gas_instantaneous

Gas_instant		XXS	XS	S	M	L	XL	XXL
Max.test flow rate (ΔT 45°C)	L/min	2	4	5	6	10	10	16
Sales	units							
- 5-10 L/min = 3-6 l/min at 45K = S	266		133	133				
- 10-13 L/min = 6 - 8 l/min at 45K = M	1253				1253			
- >13 L/min = >8 l/min =M+L?	330				165	165		
TOTAL ['000]	1849		133	133	1418	165		
[%]	100%		7%	7%	77%	9%		

Gas_instantaneous water heaters of more than 13 l/min are considered primary and equal or less than 13 l/min are considered secundary (except for Italy and Spain - see notes in the Task 2 report).

Electric_instantaneous

Sales of electric_instantaneous water heaters are 2.4 million units of which 1.452 million (60%) are electric showers. The sales are assigned to base-cases depending on the maximum flowrate that can be achieved by the products.

In the task 2 report (based upon BRGC study) all heaters above 12kW are considered primary water heaters (29% of total), leaving the categories <12kW and electric showers in the group of secundary water heaters (11% and 60% of total).

The electric showers are assigned to base-case XS although it is likely that not all of them achieve the minimum flow rate of 4 L/min of 60°C (simple electric showers are often only 6-8kW). Base-case XXS however does not define a small shower tapping, so all electric showers are put into base-case XS. The rest of the electric_instantaneous water heaters are assigned to a base-case class according maximum flow rate (at ΔT 45K).

If the electric showers are counted as hydraulic controlled water heaters then 83% (1452+576)/(1452+977) of combined sales are hydraulic controlled. If we exclude electric showers than 59% of sales are hydraulic controlled and 41% are electronic controlled.

Table A.11: Electric_instantaneous

Electric_instant		XXS	XS	S	M	L	XL	XXL
Max.test flow rate (ΔT 45ºC)	L/min	2	4	5	6	10	10	16
Hydraulic								
- el.shower (<12kW)			1452					
- <12kW (max 3 l/min)		224						
- 12kW (max 4 L/min)			47					
- 18kW (max 6 L/min)				55				
- 21kW (max 7 L/min)					118			
- 24kW (max 8 L/min)					107			
- 27kW (max 9 L/min)					25			
TOTAL		224	1499	55	250			
Electronic control								
- <12kW (max 3 l/min)		49						
- 12kW (max 4 L/min)			43					
- 18kW (max 6 L/min)				41				
- 21kW (max 7 L/min)					105			
- 24kW (max 8 L/min)					127			
- 27kW (max 9 L/min)					36			
TOTAL		49	43	41	268			
Hydraulic control		82%	97%	57%	48%			
Electronic control		18%	3%	43%	52%			
Overall share of base-case		11%	63%	4%	21%			

ANNEX B

Calculation of material inputs of water heaters

Storage combi's

Combi_storage boilers provide in two functions: space heating and water heating. The impacts associated with production of the combi_boiler should be allocated to these two functions.

Given a net heat load for space heating of 7608 kWh/year for the BaseCase Medium/EU25 (Lot 1 Ecodesign for boilers study - Task 5, table 3.5, p.19) and a net heat load around for BaseCase M water heating of 1284 kWh/year this represents (7608+1284=8892 of which 1284 is) 14%. This will form the basis for the allocation of impacts for combined products.

The material input starts with the share of boilers per base-case class.

Table B.1: Sales and shares by boiler type (combi_storage)

	Sales	M	L	XL	XXL
	'000 units	80 L	120 L	150 L	250 L
% of sales					
gas wh		86%	13%	28%	66%
gas fs		5%	36%	6%	
oil fs		9%	51%	66%	34%
		100%	100%	100%	100%
Material input for allocation					
gas wh	14%	11,1%	1,7%	3,6%	8,6%
gas fs	14%	0,7%	4,6%	0,7%	0,0%
oil fs	14%	1,2%	6,6%	8,7%	4,4%

These shares can now be applied to the original boiler BoMs for gas-wh, gas-fs and oil-fs (as presented in the MEEUP report). The original BoMs of central heating boilers are presented below.

Table B.2: BoMs of boilers

	Gas fired wall hung low temperature boiler	Gas fired floorstanding low temperature boiler	Oil fired low temperature boiler
	20 kW	18 KW	20 kW
Material			
Aluminium die cast	1970		4110
Stainless steel	2660	1440	4790
Electronics	690	730	1010
Cast Iron	1170	70880	105110
Plastics	3650	2970	
Plastics ABS			3210
Copper	4260	740	
Copper (coated)			2040
Brass	1650	470	
Insulation ceramic	800	2370	
Insulation mineral wool			4500
Steel - cast iron			61480

Steel - galvanized	28180	34550	
Others	350	70	550
Total	45380	114220	186800

Applying the allocation of 13% limits the *boiler-only* product weight to approximately 8 to 18.5 kg. To this has to be added the BoM of the storage part (100% allocation to water heating) as shown in the table below.

Table:B.3 Material input of gas/oil fired storage water heaters

Storage [L]	80	120	150	250	EcoReport material
	M	L	XL	XXL	
Generic storage					
tank	11,6	18,2	20,6	31,8	21-steel galv.
enamel	2,3	3,3	3,7	5,7	(misc.)
insulation	3,4	6,3	7,2	9,9	15-rigid PUR
mantle	5,6	8,5	9,3	14,5	21-steel galv.
top/bottom	0,1	0,1	0,2	0,2	4-PP
diptube	1,2	1,7	1,7	2,6	21-steel galv.
fitting	1,0	1,0	1,0	1,0	31-brass
mounting	0,3	0,4	0,5	0,7	21-steel galv.
subtotal storage	25,5	39,6	44,1	66,5	
Boiler parts (13% allocated)					
Aluminium die cast	268	306	424	351	27-alu diecast
Stainless steel	363	430	519	440	25-stainless steel
Electronics	94	113	117	104	98-electronics
Cast Iron	1821	10306	9614	4746	23-cast iron
Plastics	427	201	156	313	11-PA6
Plastics ABS	38	213	275	142	10-ABS
Copper	481	107	161	366	30-Copper tube
Copper (coated)	24	135	175	90	28-Copper wire coated
Brass	188	50	64	142	31-brass
Insulation ceramic	105	124	48	69	24-Ferrite
Insulation mineral wool	53	298	386	199	(misc.)
Steel - cast iron	719	4076	5275	2717	23-cast iron
Steel - galvanized	3375	2093	1295	2418	21-steel galv.
Others	46	46	60	54	(misc.)
Subtotal boiler	8001	18497	18570	12150	
TOTAL boiler+storage	46168	72371	76936	92937	

Combi_instantaneous

The basis of the BoM for the gas-wh *combi_instantaneous* is the 20 kW gas-fired low temperature boiler of 45kg (from MEEUP study) corrected for the typical product weight of a 24 kW *combi_instantaneous*.

The product weight of the *combi_instantaneous* is based upon a product survey [6] of almost 200 *combi_ instantaneous* water heaters (incl. micro-accumulation) which indicates a product weight of 40 kg for a typical 24 kW combi.

[6] The survey is based upon the RT2000 database and includes instantaneous and semi/micro-accumulation combi-boilers with P_nom < 70 kW (n=196).In the graph the one boiler weighing over 85 kg employs a special shaped heat exchanger that contains over 30 liter primary water.

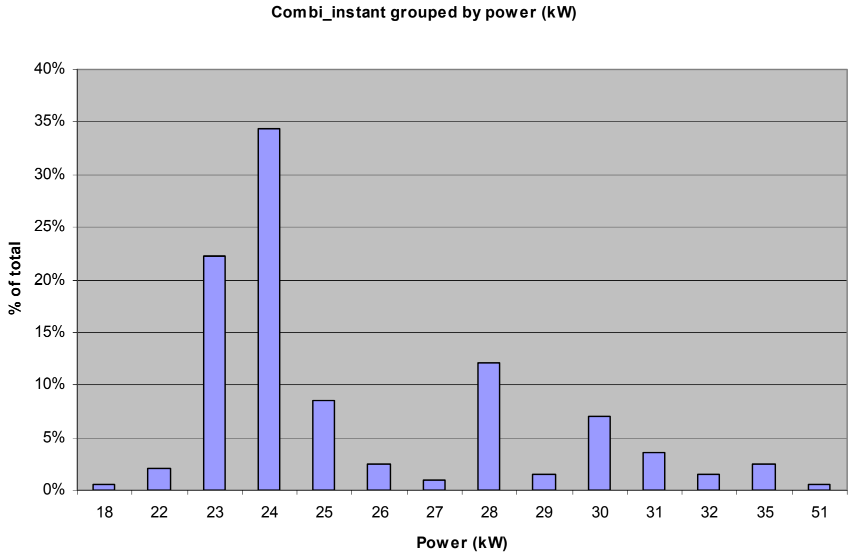
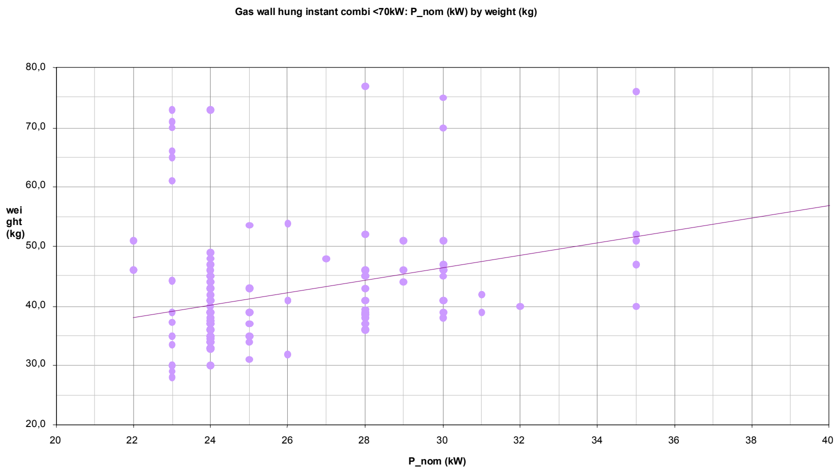


Figure: Scatter-diagram of wall hung gas combi-boiler product weight (kg) by nominal power (kW) (n=196) Source: VHK, 2007



The original boiler BoM is thus corrected for a product weight of 40 kg and then allocated for 13% to water heating (the rest is allocated to space heating).

Table B4: BoM of combi_instantaneous

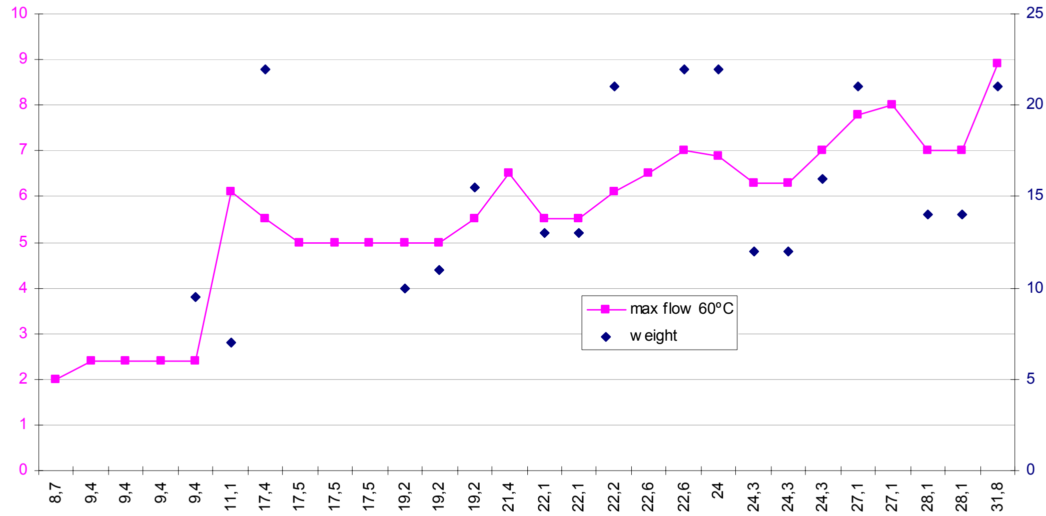
Base-case		M	
	20 kW Low temperature boiler (material composition)	Combi_instant 24kW (13% of total product weight 40 kg)	
Material			
Aluminium die cast	4,3%	226	27-alu diecast
Stainless steel	5,9%	305	25-stainless steel
Electronics	1,5%	79	98-electronics
Cast Iron	2,6%	134	23-cast iron
Plastics	8,0%	418	10-ABS
Copper	9,4%	488	30-Copper
Brass	3,6%	189	31-brass
Insulation ceramic	1,8%	92	(misc.)
Steel - galvanized	62,1%	3229	21-steel galv.
Others	0,8%	40	(misc.)

Total	100,0%	5200

Gas instantaneous

The basis of the BoMs for the gas-fired instantaneous dedicated water heaters is also the 20 kW gas-fired low temperature boiler of 45kg (from MEEUP study) corrected for the typical product weight of gas_instantaneous water heaters.

The product weight of gas_instantaneous water heaters is based upon a product survey of 18 gas_instantaneous water heaters. The graph below shows the product weight (dark-blue) and flow rate (pink) by power.



The product weight is based upon an interpretation of the graph, aimed at identifying an average product weight per power/performance class. This total product weight is indicated in the table below.

Table B.5: Product weight of gas_instantaneous

Base-case		XS	S		M	L
Power	kW	9.4	17.5	21	27	40
Weight	kg	9.5	13	16	20	22

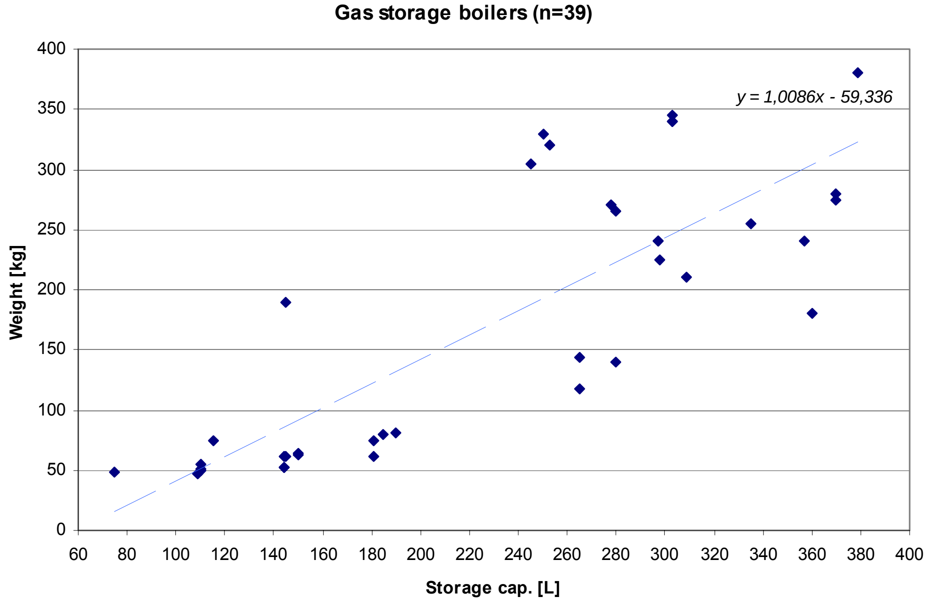
Combined with the material composition (in %) of the 20 kW low-temperature boiler this results in the following BoMs.

Table B.6: Gas-instant

Base-case		XS	S	M	M	L	
Power		9,4kW	17,5kW	21kW	27kW	40kW	
Materials	% of LT BoM						EcoReport material
Plastics	8,0%	764	1046	1287	1609	1770	10-ABS
Steel - galvanized	62,1%	5899	8073	9936	12420	13662	21-St sheet galv.
Cast Iron	2,6%	245	335	413	516	567	23-cast iron
Ins.ceramic	1,8%	167	229	282	353	388	24-Ferrite
Stainless steel	5,9%	557	762	938	1172	1290	25-Stainless 18/8 coil
Aluminium die cast	4,3%	412	564	695	868	955	27-Al diecast
Copper	9,4%	892	1220	1502	1877	2065	30-Cu tube/sheet
Brass	3,6%	345	473	582	727	800	31-CuZn38 cast
Electronics	1,5%	144	198	243	304	335	98-controller board
Others	0,8%	73	100	123	154	170	not specified
	100%	9500	13000	16000	20000	22000	

Gas_storage

A product survey of 39 gas storage boilers of the average product weight by storage volume is the basis for the construction of the BoMs for gas storage water heaters.



Interpretation of the graph learns that the product weight of an 80L gas storage boiler is approximately 50kg, 120 L is 75 kg, 150 L is 95 kg and 250 L is 120 kg (the latter is below the trendline and more in line with a product weight between 120-150 kg for water heaters of 260-280 L storage).

TableB.7: Product weight of gas_storage

base-case	M	L	XL	XXL
Typ. volume	80	120	150	250
kg	50	75	95	120

The complete BoM is constructed from a generic storage cylinder part (identical to other gas-fired storage water heaters) and a burner/heat exchanger/flue-part which is specific for gas_storage water heaters and based upon product geometry and component estimates (no BoM supplied by industry). The final product weight is aligned with the values found above.

Table B.8: Material input of gas/oil fired storage water heaters

Typical storage [L]	80	120	150	250	EcoReport material
	M	L	XL	XXL	
Generic storage tank					
tank	11,6	18,2	20,6	31,8	21-steel galv
enamel	2,3	3,3	3,7	5,7	(misc.)
insulation	3,4	6,3	7,2	9,9	15-rigid PUR
mantle	5,6	8,5	9,3	14,5	21-steel galv.
top/bottom	0,1	0,1	0,2	0,2	4-PP
diptube	1,2	1,7	1,7	2,6	21-steel glav.
fitting	1,0	1,0	1,0	1,0	31-brass
mounting	0,3	0,4	0,5	0,7	21-steel galv.
TOTAL	25,5	39,6	44,1	66,5	
For gas_storage add:	80L	120L	150L	250L	
Burner	0,8	1,5	1,5	1,5	21-steel galv.
HEx	3	3,2	3,5	3,7	21-steel galv.

Flue parts	2,5	2,5	2,7	3,1	21-steel galv.
Gas valve	1	1,4	1,4	1,4	27-alu diecast
Brass parts	1	1	1	1	31-brass
various steel parts	16	26	41	43	21-steel galv.
TOTAL	50	75	95	120	

Electric_storage

BoMs for electric storage water heaters of 30, 80, 100 and 200 L have been supplied by CECED.

Table B.9: Bill-of-materials (supplied by CECED, 23.11.2006)

	30L	80L	100L	200L
Source	CECED	CECED	CECED	CECED
3-Ferro	9710	23597	21621	40480
2-TecPlastics	1860	2052	2649	1492
1-BlkPlastics	1823	1186	1984	1214
7-Misc.	1658	1678	2474	1535
5-Coating	327	1215	783	3061
4-Non-ferro	3899	624	5038	244
6-Electronics	101	141	68	60
TOTAL	19380	30493	34617	48085
to Base-case	**S**	**M**	**L**	**XXL**

A BoM of a small 10L storage heater was produced by VHK. The material dataset is aligned with the CECED dataset (2nd column).

Table B.10: BoM of Inventum EDR10

material	[g]	to material group as with CECED data
cardboard packaging	451	7-misc
paper manual	49	7-misc
EPS protection	28	1-blkplastic
top cover PP	322	1-blkplastic
front cover PP	548	1-blkplastic
back cover PP	544	1-blkplastic
tank insulation EPS	252	1-blkplastic
mount insulation EPS	6	1-blkplastic
mounting plate for elements (st)	308	3-ferro
gasket	17	2-tecplastic
tank	2571	4-non-ferro
screws etc	20	3-ferro
collar for pipe	4	2-tec-plastic
protection for pipe	1	2-tec-plastic
resistance heater	257	7-misc
thermal control	114	50% 6-electronics, 50% 2-tecplastic
wiring	17	6-electronics
TOTAL	5509	

From these data BoMs were developed for electric storage water heaters of 10, 20, 30, 80, 120, 150 and 250 L. The 20L is an intermediate between the 10 and 30L BoM. The 120L and 150L BoM are constructed from the 100 and 200L BoM (("100"+"200")/2.5

respectively ("100"+"200")/2) and the 250L BoM was constructed from the 200L BoM ("200"*1.7).

Table B.11: BoMs of Electric Storage Water Heaters

base-cases	XXS	XS	S	M	L	XL	XXL
	10	20	30	80	120	150	250
3-Ferro	328	5019	9710	23597	24840	31051	51751
2-TecPlastics	79	970	1860	2052	1656	2070	3451
1-BlkPlastics	1700	1762	1823	1186	1279	1599	2665
7-Misc.	757	1208	1658	1678	1603	2004	3341
5-Coating	0	164	327	1215	1537	1922	3203
4-Non-ferro	2571	3235	3899	624	2113	2641	4401
6-Electronics	74	88	101	141	51	64	106
TOTAL	5509	12444	19380	30493	33081	41351	68918
		(10+30)/2			(100+200)/2,5	(100+200)/2	200*1,7

Electric_instantaneous

On average some 83% of the electric instantaneous water heater are hydraulic ontrolled type, but this is mainly due to sales of electric showers which are assumed to be hydraulic controlled.

In the more powerfull classes the share of electronic controlled may rise to 52%. This reflected in the make-up of the base-cases.

Table B.12: Electric instantaneous water heaters sales

	XXS	XS	S	M
electric shower		1452		
<12kW	273			
12kW		90		
18kW			96	
21kW				223
24kW				234
27kW				61
sum	273	1542	96	518
	11%	63%	4%	21%
hydraulic	82%	97%	57%	48%
electronic	18%	3%	43%	52%

For both the hydraulic controlled and the electronic controlled water heaters a BoM has been supplied by CECED. The base-cases are based upon the relative share of these types of water heaters - the BoMs themselves are not corrected for power class.

Table B.13: BoMs of electric instantaneous water heaters

BoM 8.5 kW hydraulic		BoM 13 kW electronic		Bom mini-hydraulic		EcoReport material group	
foil	15,8	folder	15,5	folie	10,3	1-BlkPlastics	**3-LLDPE**
Casing Part 3	146,3	Casing Part 3	141,8	Casing Part 1	176,6	1-BlkPlastics	**5-PS**
Casing Part 1	505,5	Casing Part 1	795,9	filler	36,2	1-BlkPlastics	**6-EPS**
filler	64,3	filler	47,0	isolation Part 1	109,9	1-BlkPlastics	**8-PVC**
Isolation Part 1	28,4	isolation Part 2	17,0	Casing Part 2	36,0	1-BlkPlastics	**10-ABS**
Casing Part 2	373,5	Casing Part 2	244,0	heater casing	545,7	2-TecPlastics	**11-PA 6**
heater casing	875,3	heater casing	799,1			2-TecPlastics	**11-PA 6**
Casing Part 4	0,7					2-TecPlastics	**12-PC**
casting resin	0,0					2-TecPlastics	**14-Epoxy**
Centelen	0,7					2-TecPlastics	**19-Aramid fibre**
bracket / screws	85,6	bracket / screws	145,3	bracket / screws	63,1	3-Ferro	**21-St sheet galv.**
		Casing Part 4	14,1			3-Ferro	**22-St tube/profile**

Clamps	44,4	Clamps	153,4	Clamps	17,0	3-Ferro	**25-Stainless 18/8 coil**
wire	65,8	wire	178,8	wire	99,9	4-Non-ferro	**29-Cu wire**
tubes	311,2	tubes	409,7	tubes	62,7	4-Non-ferro	**30-Cu tube/sheet**
fittings	214,3	fittings	440,9	fittings	65,0	4-Non-ferro	**31-CuZn38 cast**
LCD	17,0	LCD	28,8			6-Electronics	**42-LCD per m2 scrn**
		RCL etc.	260,2			6-Electronics	**44-big caps & coils**
		connector	27,3			6-Electronics	**45-slots / ext. ports**
		IC chip	0,5			6-Electronics	**46-IC's avg.,5%Si,Au**
		IC chip	2,4			6-Electronics	**47-IC's avg., 1% Si**
		SMD	3,5			6-Electronics	**48-SMD/ LED's avg.**
		Printed circuit board	55,8			6-Electronics	49-PWB 1/2 lay 3.75kg/m2
		solder	6,5			6-Electronics	**52-Solder SnAg4Cu0.5**
Printed circuit board	83,3					6-Electronics	**98-controller board**
package	130,2	package	330,3	package	108,0	7-Misc.	**56-Cardboard**
instruction manual	11,0	instruction manual	77,5	instruction manual	7,9	7-Misc.	**57-Office paper**
ceramics	2,9	isolation Part 1	27,2			1-BlkPlastics	
		Ceramics etc.	6,7			4-Non-ferro	
grommet (NBR)	2,8	Grommet (NBR) etc.	20,4				
sealings (VMQ)	2,7	Sealings (VMQ) etc.	4,1				
O-Rings (EPDM)	3,4	O-Rings (EPDM) etc.	2,8				
sum	2823,0		4240,8		1327,7		

For the hydraulic instantaneous water heaters the BoM of the 'mini' is used for class XXS and the BoM of the 'normal' hydraulic water heater for classes XS and higher. For electronic instantaneous water heaters the same BoM is used for all classes.

ANNEX C

LCC Inputs

Purchase prices (product price & installation costs)

Note: Only a part of the total life cycle costs of appliances that combine water heating and space heating functionality should be allocated to the DHW functionality. There are several ways to base this allocation on.

The basis for the allocation can be the annual energy consumption as is done for the material composition: the EU25 net space heating heat load for the medium Base case is 7608 kWh/a. For water heating the Medium net heat load is 1284 kWh/a. Together this is 8892 kWh/a of which 1284 kWh is 14%.

However, one can also argue that the water heating functionality is used throughout the year whereas the space heating functionality is only used 75% of the year.

Another way of allocation is on basis of product price. In Task 2 it is established that the multiplier for combi's is 1.2 (combi's costs 120% compared to a standard boiler).

VHK decided to use the a middle ground approach in that the DHW functionality is assumed to account for 20% of the total price.

Combi_instantaneous

The streetprice (incl. VAT) of the basic boiler (gas wall hung, non-condensing) is 1014 EUR (Water Heater Task 2 Report).

The multiplier for simple instantaneous combi-operation is 1.2, leading to a base-case combi-instantaneous streetprice of 1217 EUR.

The allocation for water heating functionality is 20%, giving 243 euro of the product price (of 1217 euro, not 1014) to be attributed to DHW only.

The installation costs are estimated at 800 euro per installation (standard installation, streetprice incl.VAT) of which (again) 20% is attributed to DHW only, giving 160 euro.

Combi_storage

For combined_storage cylinders and separate cylinders the heat generator (boiler) part is not solely of the gas wall hung type, but also includes gas floor standing and oil-floor standing boiler types (see Annex A).

The basic (solo)boiler product price for *gas wh*, *gas fs* and *oil fs* (all non-condensing) is calculated using the fuel/type multiplier from Task 2. This product price is then multiplied with the combi-multiplier which accounts for the addition of a DHW group (three-way valve, security group, DHW controls, etc.) to the solo-boiler. These prices are the basis for the calculation of the average combi_storage boiler price in each base-case, according the shares of fuel/type in each base-case.

The installation costs are based upon the costs used in the Lot 1 study on Ecodesign of boilers which are 1195 euro for gas- and 1422 euro for oil-fired appliances. To account for the extra work related to connecting the storage-part to the boiler-part an extra factor of 100 euro was added, giving 1295 for gas- and 1522 euro for oil-fired appliances.

To the product price extra costs are added to account for the storage cylinder. These costs are taken from table C.2 regarding separate cylinders. Following the rationale above 20% of the product price and installation costs are attributed to the DHW performance. The resulting purchase price (product price plus installation) is given in the table.

Table C.1: Calculation of product price / installation costs of combi_storage water heaters

	fuel/type multiplier	product price	combi-multiplier	combi-product price	installation costs
gas wh (ref.)	1	1014	1,2	1217	1195
gas fs	1,45	1470,3	1,2	1764	1195
oil fs	1,55	1521	1,2	1825	1422
Shares combi-storage	M	L	XL	XXL	
gas wh	0,86	0,13	0,28	0,66	
gas fs	0,05	0,36	0,06	0	
oil fs	0,09	0,51	0,66	0,34	
average combi-boiler product price	1299	1724	1651	1424	
add storage part price	500	750	850	1000	
total combi_storage price	1799	2474	2501	2424	
installation costs	1215	1311	1345	1272	
total Purchase Price	3014	3785	3846	3696	
20% of total atr. to DHW	0,2	0,2	0,2	0,2	
related to DHW	603	757	769	739	
of which from product price	360	495	500	485	
of which from inst.costs	243	262	269	254	

Separate cylinders

The list price of an average separate cylinder sold in the EU as indicated in the Water Heater Task 2 report (source BRGC) is 756 euro (incl. VAT). The graph in paragraph 9.5 of Task 4 adds more detail as regards prices per storage volume (listprice is taken as street price, 3% error acceptable). The VHK estimates for product prices of cylinders are given in table C.2.

It can be argued that, like storage combi's, separate cylinders are in fact also combi's and, following the rationale above, 20% of the total purchase price can be attributed to DHW heating leading to similar prices as for storage_combi's. However, this would obscure the fact that a single investment in a separate cylinder does not attribute to space heating (contrary to combined appliances) and therefore VHK decided to use the product price without allocation for space heating.

Installation costs are calculated from the product price using a multiplier of 0.6. Since the size of the separate cylinder is assumed to have only limited impact on the total installation costs the multiplier is applied to the average cylinder cost, giving 430 euro.

This is somewhat higher than for storage_combi's which can be explained by the extra work related to the installation of a DHW feed pump, temperature controls, extra piping, etc.

Table C.2: Product price and installation costs of separate cylinder

Base-case	M	L	XL	XXL	average
	80L	120L	150L	250L	
Purchase price	500	700	850	1000	719

share in sales	31%	31%	22%	16%	
Installation costs	430	430	430	430	430
Total Purchase Price	930	1130	1280	1430	

Gas_storage

The product price of the average *gas_storage* water heater (new product base case) as indicated in the Task 2 Water Heater report is 625 euro (list price, incl. VAT). For 80L table 4.2 of Task 2 mentioned 380 EUR (listprice) and 667 EUR for 80-200L.

These values are in line with the table in paragraph 10.5 of Task 4 which adds again more detail as regards prices per storage volume. VHK estimated the following average prices per base-case class (although the price elasticity is large, for reasons indicated in Task 2).

Table C.3: Product price of gas storage water heater

Base-case	M	L	XL	XXL	average
Purchase price	400	600	750	1250	661
share in sales	48%	14%	18%	20%	

Combined with the sales percentage this results in an average price of 661 euro which is close enough to the BRGC average price of 625 euro.

Gas_instantaneous

The product price of the average gas instantaneous water heater (new product base case) as indicated in table 4.1 of the Water Heater Task 2 report is 332 euro (list price, incl. VAT). Table 4.2 of Task 2 mentions prices varying from 105 to 300 for a 5-10l/min appliance, 205 to 355 for a 10-13l/min and 312 to 508 for >13l/min.

The table in paragraph 11.5 of Task 4 adds more detail as regards prices per power class. VHK estimated the following average prices per base-case class.

Table C.4: Product price of gas instantaneous water heater

Base-case	XS	S	M	L	average
Flow rate (sales cat.)		5-10	10-13	>13	
Purchase price	240	240	350	600	358
share in sales	7%	7%	77%	9%	

Combined with the sales percentage this results in an average price of 358 euro which is close enough to the BRGC average price of 332 euro.

Electric_storage

The product price of the average electric storage water heater (new product base case) as indicated in the Water Heater Task 2 report is 278 euro (list price, incl. VAT).

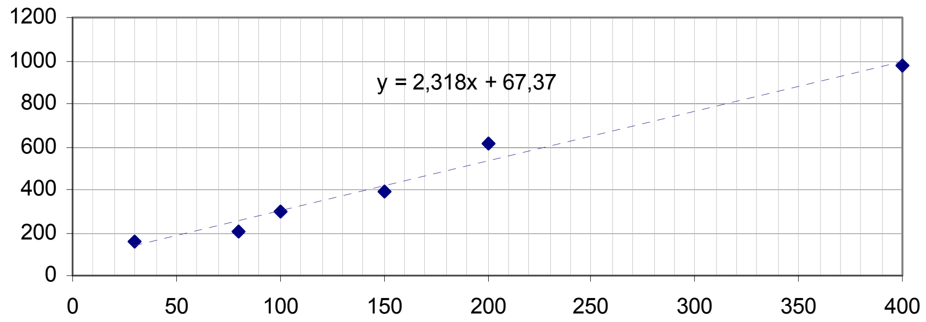
In March 2007 BRGC added more detail by supplying sales weighted RSP (retail selling prices) of electric storage water heaters per storage size. These were combined with sales data (Task 2 - country reports) which resulted in the following sales weighted average purchase prices.

Table C.5: Product price of electric storage water heater (BRGC data)

	RSP incl.VAT sales weighted
< 30 L (Unpressurised)	99
< 30 (Pressurised)	156
80L	202
100L	295
150L	394

200L	610
400L	973

In order to convert the BRGC sales categories to base-case storage size classes the RSP's were plotted and intermediate values for base-case sizes were constructed from the trendline.



The purchase price of 123 EUR for electric_storage <30L is the sales weighted average of the average price for <30L unpressurised storage of 99 EUR and 156 EUR for pressurised <30L.

Table C.6: Product price of electric instantaneous water heater (base case)

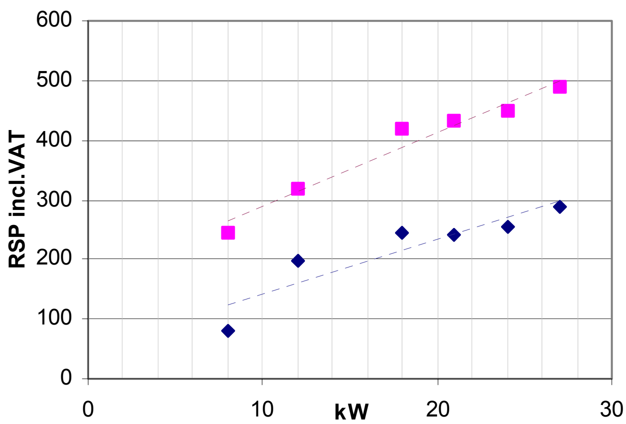
Base-case	XXS	XS	S	M	L	XL	XXL
Storage size	<30	<30	<30	80	120	150	250
Purchase price EUR	123	123	123	253	346	415	647
% of sales		32%		30%	9%	8%	2%

Electric_instantaneous

The product price of the average electric instantaneous water heater (new product base case) as indicated in the Water Heater Task 2 report is 192 euro (list price, incl. VAT).

More recently (March 2007) BRGC added detail by supplying RSP (retail selling prices) of electric instantaneous water heaters per power class. Combined with sales data (Task 2 country reports) this gives the following base-case prices (base-case M is contructed from sales weighted data for 21, 24 and 27 kW appliances).

In the graph the 8 kW values are indicative for the "<12 kW" sales class (could otherwise not be represented in graph).



(dark blue = hydraulic control, pink-purple = electronic control)

Table C.7: Product price of electric instantaneous water heater

Base-case	XXS	XS	S	M
	<12kW	12kW	18kW	21-24-27kW
hydraulic	81	199	245	252
electronic	245	318	420	448
% of sales	11%	64%	4%	21%

Installation costs dedicated water heaters

Gas_storage

Assumed is that the majority of sales are simple replacement sales (without chimney renewal). Applying the multiplier of 0.6 to the *gas_storage* product price gives installation costs for each base case class (sales weighted average is 397 euro).

Table C.8: Installation costs of Gas_storage

	M	L	XL	XXL	
Base-case	80	120	150	250	
p.price	400	600	750	1250	
multiplier	0,6	0,6	0,6	0,6	
Inst.costs	240	360	450	750	
sales	48%	14%	18%	20%	
average					397

Gas_instantaneous

Assumed is that the majority of sales are simple replacement sales (without chimney renewal). Applying the multiplier of 0.6 to the *gas_instantaneous* water heater gives installation costs ranging from 144 to 360 euro (average 214 euro).

Table C.9: Installation costs of Gas_instantaneous

Base-case	XS / S	M	L	
	5-10	10-13	13+	
p.price	240	350	600	
multiplier	0,6	0,6	0,6	
Inst.costs	144	210	360	
sales	14%	77%	9%	
average				214

Electric_storage

Applying the multiplier of 0.6 to the *electric_storage* water heater gives installation costs ranging from 74 euro for a small heater to over 230 for a large heater. The 74 euro for <30L ESWH's is corrected to 50 euro per ESWH (small unpressurised "over-the-sink" appliances require just plugging in and are done by most consumers themselves).

Table C.10: Installation costs of electric storage water heaters

	XXS, XS, S	M	L	XL	XXL	
Base-case	30	80	120	150	250	
p.price	123	150	200	240	390	
multiplier	0,6	0,6	0,6	0,6	0,6	
Inst.costs	50	90	120	144	234	
sales	0,32	0,3	0,09	0,08	0,2	
average						112

Electric_instantaneous

For small EIWH's (XXS and XS) installation costs of 50 euro are assumed (no need for high power electric connection), the same as for ESWH's.

For higher powered EIWH's the costs are estimated at 100 euro per unit. VHK assumes no difference in installation costs for electronic or hydraulic controlled applainces.

Table C.11: Installation costs of Electric instantaneous water heaters

Base-case	XXS	XS	S	M
Installation costs	50	50	100	100

Repair/maintenance

Combi_instant

Annual repair and maintenance costs of (wall hung) gas combi-boilers are set at 115 euro [7] (see Water heater task 2 Report). Of this 20% is allocated to water heating giving 23 euro per year.

Combi_storage

Annual repair and maintenance costs of gas combi-storage boilers are assessed at 115 euro and for oil-boilers at 227.50 euro (see Water heater task 2 Report). The average is 145 euro [8] (77% gas boilers, 26% oil boilers). Of this 20% is allocated to water heating giving 29 euro per year.

For the storage tank maintenance an extra 6 euro is added (see comments under Separate cylinder) giving a total of 35 euro/year.

Separate cylinder

Man-hour service costs are covered by maintenance contracts and in the case of the separate cylinder maintenance is most likely covered by a contract including the central heating boiler (in the range of 115 to 227 euro per year). The costs allocated to water heating are considered equal to that of *combi_storage* appliance at 29 euro per year.

To this are added maintenance costs related to the periodic replacement of the protective magnesium anode (for enamelled steel tanks). According the Task 4 Report such anodes cost 10 to 50 euro, depending on brand, fitting and size. The product life of the anode strongly depends on the local water quality. In this Task 5 Report an average anode price of 30 euro and a product replacement rate of 5 years is assumed, giving annual costs of 6 euro (excluding man-hour costs). Total maintenance costs are then 35 euro/year.

Gas_instantaneous

Anecdotal evidence shows maintenance contracts for gas_instantaneous water heaters are roughly 50% of that for gas_combi's, which results in 50% of 115 is 58 euro per year.

Gas_storage

Man-hour costs for *gas_storage* water heaters are based upon anecdotal data showing maintenance contracts for gas storage water heaters to be half of that of gas-combi contracts. Therefore this study assumes man-hour maintenance costs of (50% of 115 is) 58 euro per year (no allocation of costs to space heating, contrary to the combi's).

[7] This is without the fee for the chimney sweeper (45 euro) which applies in Germany and without material costs (pro memori).

[8] This is without the fee for the chimney sweeper (45 euro) which applies in Germany and without material costs (pro memori).

Material costs are at probably in line with that of separate cylinders at 6 euro per year (periodic replacement of magnesium anode) resulting in total annual repair and maintenance costs of 64 euro.

Electric_storage

VHK estimates annual maintenance costs of electric_storage water heaters to be 10 euro/year for appliances in class XXs to S and 30 euro per year for appliances in class M to XXL (approximately half of that of gas_storage water heaters). To this are added costs related to periodic replacement of the magnesium oxide anode (material costs assessed at 6 euro per year).

Electric_instantaneous

Repair and maintenance costs are minimum for this category of water heaters. A default value of 10 euro per year is used in the LCC calculation for Base Case XXS to XS and 15 euro per year for S and M.

ANNEX D

ECOHOTWATER-model inputs for dedicated water heaters

Table D.1: Base case XXS

	ESWH 10	EIWH H 8	EIWH E 8
	78%	18%	5%
	1	2	3
wh envelope volume	0,01	0,02	0,02
combustion air intake	3 -none (electr)	3 -none (electr)	3 -none (electr)
noise	30,0	30,0	30,0
outdoors?	no	no	no
primary energy factor for Qfuel	2,5	2,5	2,5
Max. heat power (output) **Pmax**	2,00	8,00	8,00
Min. heat power (output) **Pmin**	2,00	4,00	0,10
Steady s. fuel eff. Pmax **ηmax**	99%	99%	99%
Steady s. fuel eff. Pmin **ηmin**	99%	99%	99%
Heat loss off at 50oC **Pbstby**	0,10	0,10	0,10
airfuelmixer	5 -none (elec)	5 -none (elec)	5 -none (elec)
Pilotflame power **Pign** (0= none)	0,000	0,000	0,000
Electricity at Poff **elstby**	0,000	0,000	0,001
Electricity at Pmax **elmaxon**	0,000	0,000	0,002
Electricity at Pmin **elminon**	0,000	0,000	0,002
WH mass extcl. tank **bmass**	0,0	1,3	4,2
Water content **DHWloop**	0,0	0,3	1,5
instant. temperature ctrl. **dhwmix**	1-none	2-hydraulic	3-electronic
Tank volume **Vdhw**	10	0	0
Tank ref. heat loss **Pstbydhw**	114	114	114
smart control factor **dhwsmart**	no	no	no
mixingfactor **dhwV40**	1,60	1,60	1,60
heat traps **dhwtrap ?**	no	no	no
Heat transfer **storeheatex**	3 -direct and/or electric	3 -direct and/or electric	3 -direct and/or electric
OUTPUTS			
System efficiency	25%	30%	34%
Total primary energy	1777	1514	1369
of which el.aux (pump/fan)	-	-	-

Table D.2: Base case XS

	ESWH 20	EIWH H 8	EIWH E 8	GIWH 9,4 P
	22%	70%	2%	6%
	11	12	13	14
wh envelope volume	0,03	0,02	0,02	0,06
combustion air intake	3 -none (electr)	3 -none (electr)	3 -none (electr)	2 -open
noise	30,0	30,0	30,0	30,0
outdoors?	no	no	no	no
primary energy factor for Qfuel	2,5	2,5	2,5	1
Max. heat power (output) **Pmax**	2,00	8,00	8,00	9,40
Min. heat power (output) **Pmin**	2,00	8,00	0,10	5,00
Steady s. fuel eff. Pmax **ηmax**	99%	99%	99%	85%
Steady s. fuel eff. Pmin **ηmin**	99%	99%	99%	85%
Heat loss off at 50oC **Pbstby**	0,10	0,05	0,05	0,10
airfuelmixer	5 -none (elec)	5 -none (elec)	5 -none (elec)	1 -atmospheric
Pilotflame power **Pign** (0= none)	0,000	0,000	0,000	0,080
Electricity at Poff **elstby**	0,000	0,000	0,001	0,000
Electricity at Pmax **elmaxon**	0,010	0,000	0,002	0,000
Electricity at Pmin **elminon**	0,010	0,000	0,002	0,000
WH mass extcl. tank **bmass**	0,0	2,8	4,2	9,5
Water content **DHWloop**	0,0	0,3	0,3	1,5
instant. temperature ctrl. **dhwmix**	1-none	2-hydraulic	3-electronic	2-hydraulic
Tank volume **Vdhw**	20	0	0	0
Tank ref. heat loss **Pstbydhw**	114	114	114	114
smart control factor **dhwsmart**	no	no	no	no
mixingfactor **dhwV40**	1,60	1,60	1,60	1,60
heat traps **dhwtrap ?**	no	no	no	yes
Heat transfer **storeheatex**	3 -direct and/or electric	3 -direct and/or electric	3 -direct and/or electric	3 -direct and/or electric
OUTPUTS				
System efficiency	23%	30%	34%	12%
Total primary energy	2011	1513	1348	3785
of which el.aux (pump/fan)	-	-	-	-

Table D.3: Base case S

	ESWH 30 68% 21	EIWH 18 H 8% 22	EIWH 18 E 6% 23	GIWH 18 I 19% 24
wh envelope volume	0,10	0,05	0,05	0,10
combustion air intake	3 -none (electr)	3 -none (electr)	3 -none (electr)	2 -open
noise	30,0	30,0	30,0	30,0
outdoors?	no	no	no	no
primary energy factor for Qfuel	2,5	2,5	2,5	1
Max. heat power (output) **Pmax**	2,50	18,00	18,00	17,50
Min. heat power (output) **Pmin**	2,50	6,00	0,10	7,00
Steady s. fuel eff. Pmax **ηmax**	99%	99%	99%	85%
Steady s. fuel eff. Pmin **ηmin**	99%	99%	99%	85%
Heat loss off at 50oC **Pbstby**	0,05	0,05	0,10	0,10
airfuelmixer	5 -none (elec)	5 -none (elec)	5 -none (elec)	1 -atmospheric
Pilotflame power **Pign** (0= none)	0,000	0,000	0,000	0,000
Electricity at Poff **elstby**	0,000	0,000	0,001	10,000
Electricity at Pmax **elmaxon**	0,000	0,000	0,002	10,000
Electricity at Pmin **elminon**	0,000	0,000	0,002	10,000
WH mass extcl. tank **bmass**	0,0	2,8	4,2	11,0
Water content **DHWloop**	0,0	0,4	0,3	2,5
instant. temperature ctrl. **dhwmix**	1-none	2-hydraulic	3-electronic	2-hydraulic
Tank volume **Vdhw**	30	0	0	0
Tank ref. heat loss **Pstbydhw**	114	114	114	114
smart control factor **dhwsmart**	no	no	no	no
mixingfactor **dhwV40**	1,60	1,60	1,60	1,60
heat traps **dhwtrap ?**	no	no	no	no
Heat transfer **storeheatex**	3 -direct and/or electric	3 -direct and/or electric	3 -direct and/or electric	3 -direct and/or electric
OUTPUTS				
System efficiency	21%	30%	34%	25%
Total primary energy	2159	1530	1350	1809
of which el.aux (pump/fan)	-	-	-	-

Table D.4: Base case M

	ESWH 80	EIWH 23 H	EIWH 23 E	GIWH 21 l pilot	GIWH 21 l auto.ign.	GIWH 27kW pilot	GSWH 80 P
	20%	3%	6%	9%	5%	2%	1%
	31	32	33	34a	34b	35	36
wh envelope volume	0,18	0,05	0,05	0,10	0,15	0,18	0,18
combustion air intake	3 -none (electr)	3 -none (electr)	3 -none (electr)	1 -room sealed	1 -room sealed	1 -room sealed	2 -open
noise	30,0	30,0	30,0	40,0	40,0	40,0	40,0
outdoors?	no	no	no	no	no	no	no
primary energy factor for Qfuel	2,5	2,5	2,5	1	1	1	1
Max. heat power (output) **Pmax**	2,50	23,00	23,00	21,00	21,00	27,00	5,00
Min. heat power (output) **Pmin**	2,50	6,00	0,10	10.5	10.5	14,0	5,00
Steady s. fuel eff. Pmax **ηmax**	99%	99%	99%	75%	75%	85%	75%
Steady s. fuel eff. Pmin **ηmin**	99%	99%	99%	75%	75%	85%	75%
Heat loss off at 50oC **Pbstby**	0,10	0,10	0,05	0,10	0,10	0,05	0,05
airfuelmixer	5 -none (elec)	5 -none (elec)	5 -none (elec)	1 -atmosferic	1 -atmosferic	1 -atmosferic	1 -atmospheric
Pilotflame power **Pign** (0= none)	0,000	0,000	0,000	0,080	0,000	0,050	0,080
Electricity at Poff **elstby**	0,000	0,000	0,008	0,000	0,010	0,000	0,000
Electricity at Pmax **elmaxon**	0,000	0,000	0,002	0,000	0,010	0,000	0,000
Electricity at Pmin **elminon**	0,000	0,000	0,002	0,000	0,010	0,000	0,000
WH mass extcl. tank **bmass**	0,0	2,8	4,2	15,0	15,0	17,0	10,0
Water content **DHWloop**	0,0	0,5	0,3	1,0	1,0	1,0	0,0
instant. temperature ctrl. **dhwmix**	1-none	2-hydraulic	3-electronic	2-hydraulic	2-hydraulic	2-hydraulic	1-none
Tank volume **Vdhw**	80	0	0	0	0	0	80
Tank ref. heat loss **Pstbydhw**	114	114	114	114	114	114	114
smart control factor **dhwsmart**	no	no	no	no	no	no	no
mixingfactor **dhwV40**	1,60	1,60	1,60	1,60	1,60	1,60	1,60
heat traps **dhwtrap ?**	no	no	no	no	no	no	no
Heat transfer **storeheatex**	3 -direct and/or electric	3 -direct and/or electric	3 -direct and/or electric	3 -direct and/or electric	3 -direct and/or electric	3 -direct and/or electric	3 -direct and/or electric
OUTPUTS							
System efficiency	27%	34%	38%	25%	58%	41%	17%
Total primary energy	4669	3834	3400	5164	2217	3101	7418
of which el.aux (pump/fan)	-	-	-	-	-	-	-

Table D.5: Base case L

	ESWH 120	GIWH 40 I	GSWH 120 P
	38%	12%	4%
	41	42	43
wh envelope volume	0,39	0,21	0,39
combustion air intake	3 -none (electr)	1 -room sealed	2 -open
noise	30,0	44,0	45,0
outdoors?	no	no	no
primary energy factor for Qfuel	2,5	1	1
Max. heat power (output) **Pmax**	2,50	40,00	7,50
Min. heat power (output) **Pmin**	2,50	20,00	7,50
Steady s. fuel eff. Pmax **ηmax**	99%	85%	75%
Steady s. fuel eff. Pmin **ηmin**	99%	85%	75%
Heat loss off at 50oC **Pbstby**	0,10	0,05	0,10
airfuelmixer	5 -none (elec)	1-atmosferic	1 -atmospheric
Pilotflame power **Pign** (0= none)	0,000	0,080	0,080
Electricity at Poff **elstby**	0,000	0,000	0,000
Electricity at Pmax **elmaxon**	0,000	0,000	0,000
Electricity at Pmin **elminon**	0,000	0,000	0,000
WH mass extcl. tank **bmass**	0,0	21,0	15,0
Water content **DHWloop**	0,0	1.0	0,0
instant. temperature ctrl. **dhwmix**	1-none	2-hydraulic	1-none
Tank volume **Vdhw**	120	0	120
Tank ref. heat loss **Pstbydhw**	114	114	114
smart control factor **dhwsmart**	no	no	no
mixingfactor **dhwV40**	1,65	1,65	1,65
heat traps **dhwtrap ?**	no	no	no
Heat transfer **storeheatex**	3 -direct and/or electric	3 -direct and/or electric	3 -direct and/or electric
OUTPUTS			
System efficiency	27%	44%	29%
Total primary energy	9478	5770	8889
of which el.aux (pump/fan)	-	-	-

Table D.6: Base case XL

	ESWH 150 50% 51	GSWH 150 P 4% 52
wh envelope volume	0,45	0,45
combustion air intake	3 -none (electr)	2 -open
noise	30,0	45,0
outdoors?	no	no
primary energy factor for Qfuel	2,5	1
Max. heat power (output) **Pmax**	3,00	9,30
Min. heat power (output) **Pmin**	3,00	9,30
Steady s. fuel eff. Pmax **ηmax**	99%	75%
Steady s. fuel eff. Pmin **ηmin**	99%	75%
Heat loss off at 50oC **Pbstby**	0,10	0,05
airfuelmixer	5 -none (elec)	1 -atmospheric
Pilotflame power **Pign** (0= none)	0,000	0,080
Electricity at Poff **elstby**	0,000	0,000
Electricity at Pmax **elmaxon**	0,000	0,000
Electricity at Pmin **elminon**	0,000	0,000
WH mass extcl. tank **bmass**	0,0	20,0
Water content **DHWloop**	0,0	0,0
instant. temperature ctrl. **dhwmix**	1-none	1-none
Tank volume **Vdhw**	150	150
Tank ref. heat loss **Pstbydhw**	114	114
smart control factor **dhwsmart**	no	no
mixingfactor **dhwV40**	1,65	1,65
heat traps **dhwtrap ?**	no	no
Heat transfer **storeheatex**	3 -direct and/or electric	3 -direct and/or electric
OUTPUTS		
System efficiency	29%	37%
Total primary energy	14320	11227
of which el.aux (pump/fan)	-	-

Table D.7: Base case XXL

	ESWH 250	GSWH 250 P
	77%	2%
	64	65
wh envelope volume	0,60	0,60
combustion air intake	3 -none (electr)	2 -open
noise	30,0	45,0
outdoors?	no	no
primary energy factor for Qfuel	2,5	1
Max. heat power (output) **Pmax**	3,00	15,60
Min. heat power (output) **Pmin**	3,00	15,60
Steady s. fuel eff. Pmax **ηmax**	99%	75%
Steady s. fuel eff. Pmin **ηmin**	99%	75%
Heat loss off at 50oC **Pbstby**	0,10	0,05
airfuelmixer	5 -none (elec)	1 -atmospheric
Pilotflame power **Pign** (0= none)	0,000	0,080
Electricity at Poff **elstby**	0,000	0,000
Electricity at Pmax **elmaxon**	0,000	0,000
Electricity at Pmin **elminon**	0,000	0,000
WH mass extcl. tank **bmass**	0,0	25,0
Water content **DHWloop**	0,0	0,0
instant. temperature ctrl. **dhwmix**	1-none	1-none
Tank volume **Vdhw**	250	250
Tank ref. heat loss **Pstbydhw**	114	114
smart control factor **dhwsmart**	no	no
mixingfactor **dhwV40**	1,70	1,70
heat traps **dhwtrap ?**	no	no
Heat transfer **storeheatex**	3 -direct and/or electric	3 -direct and/or electric
OUTPUTS		
System efficiency	30%	41%
Total primary energy	17860	13266
of which el.aux (pump/fan)	-	-

Table D.8: **ECOBOILER-model inputs for combined water heaters**

Base Case	M	M	M	L	L	XL	XL	XXL	XXL
INPUTS DHW	combi_instant 15l store	combi_storage 80L	sep.cyl 80L	combi_storage 120L	sep.cyl 120L	combi_storage 150L	sep.cyl 150L	combi_storage 250L	sep.cyl 250L
CH-power class	4-M Medium	4-M Medium	4-M Medium	4-M Medium	4-M Medium	4-M Medium	4-M Medium	4-M Medium	4-M Medium
DHW performance class	4-M Medium	4-M Medium	4-M Medium	5-L Large	5-L Large	6-XL (extra large)	6-XL (extra large)	6-XXL (XX large)	6-XXL (XX large)
boiler characteristics									
power input in kW*	24	22	22	22	22	22	22	22	22
turndown ratio	33%	33%	33%	33%	33%	33%	33%	33%	33%
standby heat loss %	1,00%	1,00%	1,00%	1,00%	1,00%	1,00%	1,00%	1,00%	1,00%
steady st. efficiency *	5-eff. 80/80/80/80	5-eff. 80/80/80/80	5-eff. 80/80/80/80	5-eff. 80/80/80/80	5-eff. 80/80/80/80	5-eff. 80/80/80/80	5-eff. 80/80/80/80	5-eff. 80/80/80/80	5-eff. 80/80/80/80
fuel (dewpoint)	1- gas	1- gas	1- gas	1- gas	1- gas	1- gas	1- gas	1- gas	1- gas
air-fuel mix control	2-pneumatic	2-pneumatic	2-pneumatic	2-pneumatic	2-pneumatic	2-pneumatic	2-pneumatic	2-pneumatic	2-pneumatic
circ. pump power	6-95W	6-95W	6-95W	6-95W	6-95W	6-95W	6-95W	6-95W	6-95W
fan power	4-P=45W	4-P=45W	4-P=45W	4-P=45W	4-P=45W	4-P=45W	4-P=45W	4-P=45W	4-P=45W
CPU power sb/on	4-P=12/12W	4-P=12/12W	4-P=12/12W	4-P=12/12W	4-P=12/12W	4-P=12/12W	4-P=12/12W	4-P=12/12W	4-P=12/12W
controls power sb/on	2-P=10/10W	2-P=10/10W	2-P=10/10W	2-P=10/10W	2-P=10/10W	2-P=10/10W	2-P=10/10W	2-P=10/10W	2-P=10/10W
comb. air intake	1-room sealed	1-room sealed	1-room sealed	1-room sealed	1-room sealed	1-room sealed	1-room sealed	1-room sealed	1-room sealed
boiler mass (empty), kg	40 kg	40 kg	60 kg	60 kg	140 kg	60 kg	140 kg	60 kg	180 kg
water content in kg	3.0 kg	3.0 kg	3.0 kg	3.0 kg	3.0 kg	3.0 kg	3.0 kg	3.0 kg	3.0 kg
envelope volume in m3	0,15 m3	0,18 m3	0,18 m3	0,35 m3	0,39 m3	0,45 m3	0,45 m3	0,60 m3	0,60 m3
noise level in dB-A	45 dB-A	45 dB-A	45 dB-A	45 dB-A	45 dB-A	45 dB-A	45 dB-A	45 dB-A	45 dB-A
extra INPUTS DHW									
tank volume in ltr	15 ltr	80 ltr	80 ltr	120 ltr	120 ltr	150 ltr	150 ltr	250 ltr	250 ltr
tank ref. heat loss									
smart control ?	no smart control	no smart control	no smart control	no smart control	no smart control	no smart control	no smart control	no smart control	no smart control
mixingfactor V40	1,65	1,65	1,65	1,65	1,65	1,65	1,65	1,65	1,65
heat traps installed?	no heat traps	no heat traps	no heat traps	no heat traps	no heat traps	no heat traps	no heat traps	no heat traps	no heat traps
OUTPUTS									
DHW system efficiency	39%	34%	33%	48%	42%	52%	48%	55%	50%
Total kWh	3328	3741	3924	5370	6049	8101	8763	9851	10753
electric energy (not primary)	59	59	59	90	90	138	138	129	129