Energy

Preparatory Studies for Eco-design Requirements of EuPs

(Tender TREN/D1/40-2005)

LOT 13: Domestic Refrigerators & Freezers

Final Report

Draft Version

Tasks 3 -5

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NOTE: according to international standards dealing with quantities and units, the numbers in this study are written according to the following rules:

- the comma “,“ is the separator between the integer and the decimal part of a number
- numbers with more than three digits are divided by a blank in groups of three digits
- in case of monetary values the numbers are divided by a dot in groups of three digits.

0 Brief summary of the Study Tasks

A summary of the tasks included in this second part of the interim report on the cold appliances study (tasks 3-5) is outlined in the following paragraphs

0.3 DESCRIPTION OF TASK 3

The behaviour of the consumer with household appliances influences the environmental impact because of the usage of resources like water and/or energy and/or chemicals.

With the help of an extensive consumer survey (almost 2500 households interviewed from 10 European countries) the task to identify the "real life" consumer behaviour concerning the use/handling with household appliances, especially refrigerators and freezers, is fulfilled and differences from the standard test conditions to real life conditions affecting the environmental impact are identified, including their effect on the real life energy consumption.

In European households refrigerators are available in the local infrastructure for almost 100 % of the households and in even 21 % of the households in this report a secondary refrigerator is available. In average these refrigerators are 1,4 years older than the primary refrigerator. All refrigerators and freezers normally remain in the household for 10 years and more, keeping the status of efficiency of the machine remaining as they were at the production of the gadget. Improvements will therefore take more than 10 years to get fully effective in the market.

Another possible barrier for energy saving innovations for cold appliances is the necessity of food protection. The decrease of energy consumption can only go as far as food safety is ensured. There is common understanding that perishable food should be stored at temperatures below 5 °C in a refrigerator and at -18 °C in a freezer. Other important factors influencing the energy consumption in real life are identified especially by the temperature of the ambient where the refrigerator or freezer stands and the amount of new food loaded into the machines which needs to be cooled down. Recommendations to place the refrigerator and freezer at the lowest possible ambient temperature and not to place hot food into them are important ways to reduce the amount of energy used.

But refrigerators and freezers in consumer homes do not always seem to be set to follow this recommendation. Ambient temperatures go up to 40 °C for a considerable amount of households investigated and down to temperatures of 0 °C. While the higher ambient temperatures are covered by the climate classes as defined, ambient temperatures lower than 10 °C are not foreseen at all. But more than 20 % of the households investigated in 10 European countries report to have minimum ambient temperatures lower than 10 °C where the refrigerator stands. One consequence of this is that the right temperature in the refrigerator and freezer is no longer maintained and the quality of food stored may suffer significant losses. In refrigerators/freezers of category 7 many gadgets do have only one compressor which is used to provide cooling for both compartments. The consequence is, that at lower ambient temperatures these machines may either fail to keep the right storage temperatures or they activate additional heating devices to cause the compressor to provide more cooling. This may cause considerable additional amounts of energy (up to 29 %) used as compared to a similar appliance with two compressor circles.

Consumer behaviour is also characterised by

- average temperature of the refrigerator is set at 5,0 °C at the correct level, but with relevant differences between countries

- average temperature of the freezer is at -16,7 °C again with differences between countries
- the capacity of the refrigerator compartment is used to a good extend by the consumers, but that of the freezer is used even more.

Summarising all of these findings about the consumer behaviour allows estimating the difference between the real life and standard base case energy consumption. Due to the lower ambient temperature in real life compared to the 25 °C used in the standard measurement will considerably reduce the energy taken by the gadgets. Part of this saving is balanced by cooling down food which is loaded and by cooling down the air which is exchanged when opening the door. So all in all the measured consumption following the standard is somehow taking care for this kind of real life behaviour. Not covered are the additional consumptions which may be used by cat. 7 refrigerators/freezers with just one compressor (and one thermostat) not operated within the temperature range of 20 to 30 °C. Here significant amounts of additional energy are used on which the consumer was not informed at the point of sale of the gadget.

0.4 DESCRIPTION OF TASK 4

The eco-design directive is referred to product design and not to systems or installations as a whole. However, Annex VII.4 considers the interaction of the specific EuP with the installation/system where it operates, implicitly stating that the possible effects of the EuP being part of a larger system are to be identified and evaluated. This task includes therefore a functional analysis of the system to which the product belongs, including a rough estimate of the overall impacts, for example from IPP studies like EIPRO and an assessment of how the integration of the product into the system and its design can improve its overall environmental performance.

0.5 DESCRIPTION OF TASK 5

0.5.1 Subtask 5.1: Definition of Base Case for Refrigerators and Freezers

For this assessment average EU product(s) or representative product categories should be defined as the "Base case" for the whole EU 25.

In general, the base case is by definition the average appliance on the European market, where the "Standard Base Case" (STBC) is defined according to the measurement standard or in EU legislation (in terms of appliance category, volume and energy consumption), while for the "Real Life Base Case" (RLBC) the characteristics of the average sold appliance will be considered. **During the development of this Task, it will be evaluated if this differentiation is applicable to cold appliances.**

For refrigerators and freezers ten different categories have been already defined in the existing EU legislation (directive 94/2/EC) and more possibly could be added. In addition, the COLD-II study identified some 13 reference models on which a detailed analysis of the technological improvement was developed, but the time and budget limits of the present study do not allow to deal with such a large amount of base-case models.

Taking into consideration all the available technical information, it was initially proposed to run this Task in two ways:

1) revision of the base-cases defined in previous COLD-II study, to evaluate their representativity of the present market situation, update of the already developed technological impact analysis

and - if necessary - integration with additional options more related to environmental aspects other than energy consumption.

2) as alternative, definition of new average base-case models, maximum four, probably as:

- average European overall appliance
- average European refrigerator
- average European fridge-freezer
- average European freezer.

Under this second option, the selection of base case models will be done on the basis of the analysis of the latest technical database developed by CECED.

CECED database have been developed since 1995 and are regularly presented to the EC and the Regulatory Committee responsible for the management of the EU energy labelling scheme. Cold appliances technical database include the parameters declared for the energy labelling and is therefore structured according to the 10 appliance categories defined in directive 94/2/EC.

Once the overall approach is defined, the selection of the reference models will be mainly based on the analysis of the energy consumption and possibly the appliance volume. The energy consumption characteristics of the models will be expressed through their actual annual consumption values in kWh/year or specific consumption in kWh/litre (or kWh/equivalent_litre), or with their energy efficiency class.

The database analysis will result in the identification of a *virtual average* reference model (or more than one) for each appliance group. This model will be then compared with the real models in the database: the models close to the "virtual average" could be considered as participating in the composition of the average itself, both in terms of technical characteristics and relevant brands & manufacturers. The technical characteristics of the selected real models will be averaged to evaluate how close the *real average* reference model is from the "virtual" one. This analysis will allow the validation of the chosen real average reference appliances, or will suggest the need of selecting a new set of models from the database or to accept more than one set. In addition, outcome of Tasks 2 and 3 will be taken into consideration.

Once the real average reference model(s) is validated, its brand composition will be analysed, in term of number of models per each brand included in the selected real models. The results will be the percentage of each brand (and therefore of each manufacturer) concurring to the real average reference model in each appliance group.

At this point, the identified manufacturers/brands will be asked to select a real appliance model (or more than one model) - possibly[1] among the identified set in the technical database - and to provide the information included in the so called "Environmental Performance Questionnaire" (BOM and inventory data). for this reference model. Once the information is collected, all data will be weighted according to the previously mentioned brand/manufacturer composition, to create the ecological profile of the base case average reference washing machine and dishwasher models. As alternative, a more simple average of the data collected by the manufacturers could be used.

The same procedure will be applied for the identification of the "best case" model(s) or "top of the range model(s)" in each appliance category. Top of the range models will be used to evaluate the gap already existing between the average and the best available appliances in the reference year.

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[1] Since the analysed technical database includes models produced in 2005 or before, manufacturers could select a reference model which is not among the identified set.

0.5.2 Subtask 5.2: Product-specific inputs

Product-specific inputs have been, first of all collected and organised according to the "EuP Eco Report" requirements and taking into account the LCA ISO 14040 norms. Similarly, the methodology used for the LCA analysis has been, at first glance, based on the EuP-Ecoreport settings, but it was, as close as possible, also compared and aligned with the LCA standard methodology, in order to use (in the final version of the report) others LCA software and data (like, i.e. the Simapro tool) and databases).

Primary input data came from direct communication with producers and/or, if not available, collected on sector specific or commercial data base (secondary data). These data have been considered both for the standard and (if identified) the real base cases. The product's specific inputs were thus classified according to the following data sets:

- General information on product type (reference models, efficiency class, volume);
- Production phase (raw materials, components and assembling):
  - Used materials, related working processes (moulding, extrusion, wiring, ...), average distances from production sites, percentage of scrap, …)
  - Energy consumption (electric - kWh, thermal – MJ as Natural Gas, Oil,….or different sources) for assembling
  - Water (and others) consumption for assembling
  - Waste production
  - Waste water quality (BOD, COD, other indicators, …);
- Distribution of products (average distances and types of transport modes);
- Use phase (average life, specific consumption, maintenance and repairs);
- Packaging (type and weight);
- End of Life (disposal, thermal valorisation, incineration, dismantling…).

Production phase: a portion of the data-input inventory table sent to manufacturers for the production phase is:

Material	***from recycling***	***net weight***	***scrap***	***gross weight***	***processing*** *(on gross weight)*	***average distance***	***Mode of transport***
	(%)	(kg)	%	(kg)		(km)	
Ferro metals							
Iron							
Stainless steel							
…..							
Non Ferro Metals							
Aluminium							
Copper							
…..							
Electronic equipments							
Plastics							
ABS							
PP							
PVC							
….							
Glass							
White							
….							
Refrigerating gas							
Rubber							

Others							
Total weight							

Any other specification on material type, specific processes, was required and considered useful to complete the picture. All data were referred to be product specific (allocation procedure).
If preassembled components has been indicated in inventory table, material composition and processing was required and used to define inventory.

Distribution: the following data has been required:
- transport to final user: average distance and transport medium (at least more than one transport medium and specific distances covered);
- packaging management: indication on packaging recovery and disposal (as an alternative medium EU situation has been considered).

Use: the following data has been required:
- Average life
- Efficiency Class
- Energy consumption (kWh/year in case of refrigerators or freezers);
- Refrigerating fluid consumption per year (quantity and type);
- Ordinary Maintenance, as requested by producer for a specified working time;
- Extra-ordinary maintenance (if possible, as suggested by producer or market analysis)
- Noise (dB(A)).

Disposal: the following data has been required:
- indication on typical (or average) disposal system (if existing or known) and % and types of recycled materials.

Manufacturers produced a great amount of data, according to the data inventory sheet, but not always data were complete and congruent with requirements.
Specific questions to producers were made and, according to the received answers, inventory profile of each equipment has been defined.
In any case, as general rules it was stated (and agreed with producers) that if specific data were not available, average EU data have been used and, if only one manufacturer produced a data, that was considered for all the producers.

0.5.3 Subtask 5.3: Base Case Environmental Impact Assessment

The environmental impact assessment has been performed for the Standard Base Case. The methodology used was based on the "EuP EcoReport", specifying emissions and raw material consumption during the whole life cycle of the appliance.

A life cycle assessment will be in parallel also carried out using a different specialised LCA module (as the "Simapro" one) in order to verify and validate the results obtained by the "EuP EcoReport". The methodology used will comply with the ISO 14040 standards and will take into account the whole life cycle of products and their related impacts; results of this comparison will be produced in final report.

According to the EuP methodology, output has been presented disaggregated by each Life Cycle Phase (assembling, use, distribution, end of life, ..), aggregated by damage category (e.g.: global warming, as weighted addition of greenhouse gases), as follow:

- global warming,
- acid rain,
- ozone depletion,
- resource consumption
- energy consumption

It is worth noting that EuP-Ecoreport stops at Characterization phase. In order to evaluate the magnitude of damage among the different life cycle phase and compare the eco-profile outputs between different products and/or scenarios, it will be also analysed and discussed the subsequent LCA phases (normalisation, weighting, damage evaluation) by using tools like SimaPro6.

0.5.4 Subtask 5.4: Base Case Life Cycle Cost

The life cycle costs, or net present value of the costs, to the consumer are calculated for each technological option beginning with the standard and real-life base case. The formula using the real cost of capital, interest – inflation, as suggested in the invitation to tender[2], will be utilized. This implies that the average real (as opposed to nominal) future price of electricity over the next 15 years should be used in this calculation.

To standardize and make the results of the different lots comparable, it was suggested that the DG-TREN set a reference price for electricity to be used in these studies. The DG may also wish to standardize the real cost of capital that also would make all the LCC analysis of the different lots readily comparable. Nevertheless, an initial value between 0,14-0,15 Euro/kWh will be used for this study (the latest consumption weighted average of EU25 electricity prices, for the average household of 3500 kWh annual consumption, with taxes, for July 2006 is 0,1452 Euro/kWh), along with a real cost of capital of about 5%.

Sensitivity analysis will be applied to the main parameters here including purchase price and electricity price and the level of consumption per year of the representative cold appliances.

0.5.5 Subtask 5.5: EU Totals (not yet carried out)

With regard to the total LCC data, the starting point is the individual LCC data for the real life base case (or the standard base case if no real life base case will be found) of the representative cold appliances estimated in Subtask 5.3. In general, the sales for the year 2005 and the cumulative sales from 2005 to 2020 will be estimated for EU25 for the representative models. The product of individual LCC and the 2005 sales gives the total life cycle costs for the base case models in 2005. Instead, the total cumulative sales, 2005 through 2020, cannot be simply multiplied times the LCC for 2005 to give the cumulative total, since LCC refers to the present year (2005) and the LCCs in question occur at each year over the product life. They must be discounted. So the average growth rate in sales for the EU25 is estimated and the total LCC is calculated for each year and discounted accordingly.

An effort will be made to estimate the LCC of representative new models coming to the market after the base case model, depending upon the availability of data. The total calculations will be performed as above.

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[2] We define, for the Standard and Real-Life Base-Case, the Life Cycle Costs. LCC = PP + PWF * OE, where LCC is Life Cycle Costs, PP is the purchase price, OE is the operating expense and PWF (Present Worth Factor) is $PWF = \{1 - 1/(1+r)^N\}/r$, in which N is the product life and r is the discount (interest-inflation) rate.

In addition to the total models sold in 2005, it is necessary to estimate the energy consumption of the existing stock for year 2005. This will allow the environmental impact to be estimated for the existing stock. Adding the impacts for the models of the base case, of the other new models for 2005 and the existing stock(less the new sales) we have the impact environmental impact for 2005 which can be compared to the results of the CEDA EU25 Input Output method, which will require some scaling, as described in Task 4. This comparison can be performed for washing machines which is an explicit product and product service (household laundry washing) in the CEDA model, but not for dishwashers which is not included as a distinct product.

Essentially repeating for each of the future years the calculation of the base case unit sales, other non-base case unit sales and the number of units in stock (minus new sales) along with their respective environmental impacts, the cumulative environmental impact and LCC for the next fifteen years can be estimated. The impact of production, use and disposal of the product group assumes post-RoHs[3] and post-WEEE[4] conditions. This cumulative result will constitute the "Business as Usual" scenario for the lifetime of the product. Actually it makes sense to discount the annual results. Discounting environmental impacts for the cumulative impact may be new to some environmentalists, however certainly most would agree that there is a loss in value from deferring these environmental improvements (the sooner the benefits the better). Total environmental impact without discounting will also be shown.

0.5.6 Subtask 5.6: EU25 Total System Impact (not yet carried out)

For the year 2005 the results of Task 4, the environmental impact of the I/O model for CEDA code 540200 - "use of household refrigerators and freezers", will be compared to the total environmental impacts given in Subtask 5.4 for year 2005, including those for sales of the base case models and for the other new models for year 2005 and for the existing stock in 2005, as previously described.

The steps necessary to make these two results as comparable as possible has been discussed in the description of Task 4. The guiding idea is to have the basic inputs of specific energy consumption and number of unit sales and units in the stock be the same for both methods. With this approach it will be possible to analyze and understand the differences in results, which will be due primarily to the addition of indirect inputs in the input output method and in the possible difference in environmental coefficients. Because we have controlled for inputs this is a good opportunity to better understand the two methods.

The other very important result will be the analysis of the environmental differences in the CEDA outputs between no use of off peak electricity (the normal use) and the use of off-peak electricity through the utilization of more silent machines during the night. While the economic advantages have been studied, the environmental impacts are less well established and constitute an important part of this research. Besides modelling a change in the input energy mix for the production of electricity, an attempt will be made to introduce the changes due to better utilization of the capacity for production and distribution of electricity.

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[3] RoHs directive: Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, O.J. L37, 13.02.2003.

[4] WEEE directive: Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), O.J. L37, 13.02.2003.

3 Task 3: Consumer behaviour and local infrastructure

3.1 Content and basic results of the consumer survey

3.1.1 Data basis and objects of investigation of the survey

The behaviour of the consumer with household appliances influences the environmental impact because of the usage of resources like water and/or energy and/or chemicals.

The aim of the consumer survey within this study is to identify the "real life" consumer behaviour concerning the use/handling with household appliances and to identify differences from the standard test conditions affecting the environmental impact. With the aid of an external market research institute[5] 2 497 European households of 10 European countries were interviewed via an online questionnaire. Suitable households (participants) were chosen following pre-defined criteria. 250 households per country were interviewed (exception: Czech Republic with only 247 households) (Figure 3.1). All in all the countries selected nearly represent 75 % of the European population. The participants were asked about their behaviour with selected household appliances and about their opinion on this topic and energy saving issues in general. Demographic data were recorded additionally.

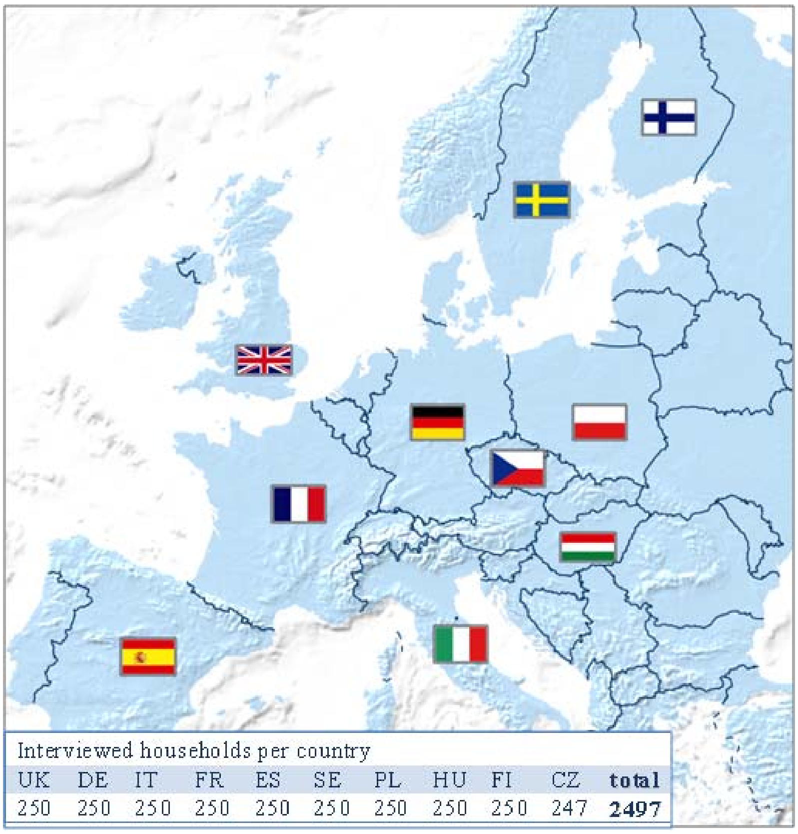


Figure 3.1: geographic coverage and sample size of the survey[6]

[5] ODC Services GmbH, 80636 Munich

[6] Figure created with Map Creator Version.1.0 (free edition)

Households for this survey were selected on the one hand to represent the relevant population in their country as well as possible and on the other hand to fit with the need of this study.

Within the scheduling of the survey following criteria and quotes were chosen:

- Indicator of citizenship: total
- Distribution of gender: not less than 50% female persons
- Selected age groups:
    - between 20 – 39 years
    - between 40 – 59 years
    - between 60 – 74 years
- Household size: 1, 2, 3, 4 and ≥4 persons

Also specific quotes about the existence of selected household appliances were set to be able to achieve a sufficient coverage of interested products and a better comparability of the results. So it was required that

- not less than 50 % of all questioned persons per country should possess a dishwasher,
- 100 % of all questioned persons per country should possess a washing machine,
- 100 % of all questioned persons per country should possess a refrigerator,
- not less than 70 % of all questioned persons per country should possess a freezer.

The quotation of gender and age-groups were made according to the aspect to reach persons which most likely are involved in housekeeping. Eurostat[7] data of the distribution of the population by age group and household size for each country were used to recalculate the population following this quotation (Table 3.1) maximum differences of ± 5 % resulted between the given quotes mentioned before and the real participation in the survey (Table 3.1 and Appendix 3.1- 1).

[7]EUROSTAT: http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1996,45323734&_dad=portal&_schema=PORTAL&screen=welcomeref&open=/popul/popula/cens/cens_n2001/cens_nhou&language=de&product=EU_population_social_conditions&root=EU_population_social_conditions&scrollto=162

Table 3.1: population by household size and age group: comparison of results of own survey vs. Eurostatdata[8] e.g.UK

United Kingdom		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Eurostat [9]	1 person	4 %	5 %	5 %	*14 %*
	2 persons	10 %	13 %	12 %	*36 %*
	3 persons	10 %	9 %	2 %	*21 %*
	4 persons	10 %	8%	1 %	*19 %*
	more than 4 persons	6 %	4 %	0 %	*11 %*
	total	*41 %*	*39 %*	*20 %*	*100 %*
		Age group			total
		20-39 years	40-59 years	60 and 74 years	
results own survey	1 person	3,9 %	7,1 %	4,2 %	15,1 %
	2 persons	11,6 %	12,2 %	10,6 %	34,4 %
	3 persons	11,6 %	10,9 %	1,6 %	24,1 %
	4 persons	8,0 %	8,7 %	1,0 %	17,7 %
	more than 4 persons	4,8 %	3,9 %	0,0 %	8,7 %
	total	*39,9 %*	*42,8 %*	*17,4 %*	*100,0 %*
		Age group			
		20-39 years	40-59 years	60 and 74 years	
Differences	1 person	0,1 %	-2,1 %	0,8 %	-1,1 %
	2 persons	-1,6 %	0,8 %	1,4 %	1,6 %
	3 persons	-1,6 %	-1,9 %	0,4 %	-3,1 %
	4 persons	2,0 %	-0,7 %	0,0 %	1,3 %
	more than 4 persons	1,2 %	0,1 %	0,0 %	2,3 %
	total	*1,1 %*	*-3,8 %*	*2,6 %*	*0,0 %*

3.1.2 Demography

Following the quotation by gender 56 % of all interviewed people are female and 44 % are male. The highest value with nearly 70 % of female persons can be found in our sample in United Kingdom and with over 60 % in Sweden (Figure 3.2). All in all the differences between the actual

[8]Own calculation: Population by household size and age group based on EUROSTAT data.

[9]Own calculation: via crosstabs of EUROSTAT.data of population by household size and age group.

gender distributions in European countries and the results of this survey are between less than 1 % and 18 % (Table 3.2).

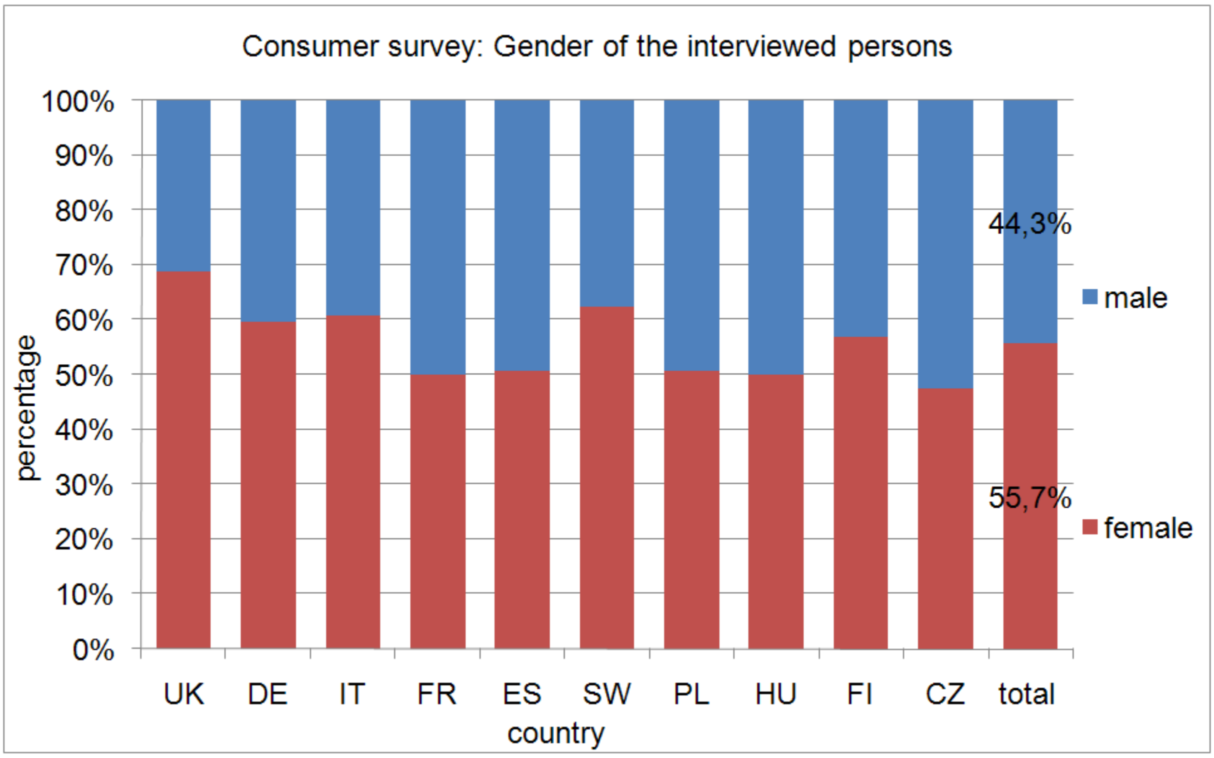


Figure 3.2: distribution: gender of the interviewed persons (per country)

Table 3.2: results consumer survey: share of female persons (per country)

		countries									
		UK	DE	IT	FR	ES	SW	PL	HU	FI	CZ
female	% of country	68,8 %	59,6 %	60,8 %	50,0 %	50,8 %	62,4 %	50,8 %	50,0 %	56,8 %	47,4 %

Because of the self-defined quotation of age groups only people between 20 and 74 years of age were interviewed. People with an age between 20 and 39 years as well as 40 and 59 years amount to nearly 40 % of all interviewees. Between all European countries there are no significant differences; here the values lay between 39 – 42 %. The highest share of young participants could be calculated for Italy (47,6 %), Spain (46 %) and Poland (44,8 %) (Figure 3.3). Of all interviewed persons 19 % are between 60 and 74 years old. The highest share of people of this age-group can be found in our sample in Sweden (22 %), Hungary (20,8 %) and Germany (19,6 %).

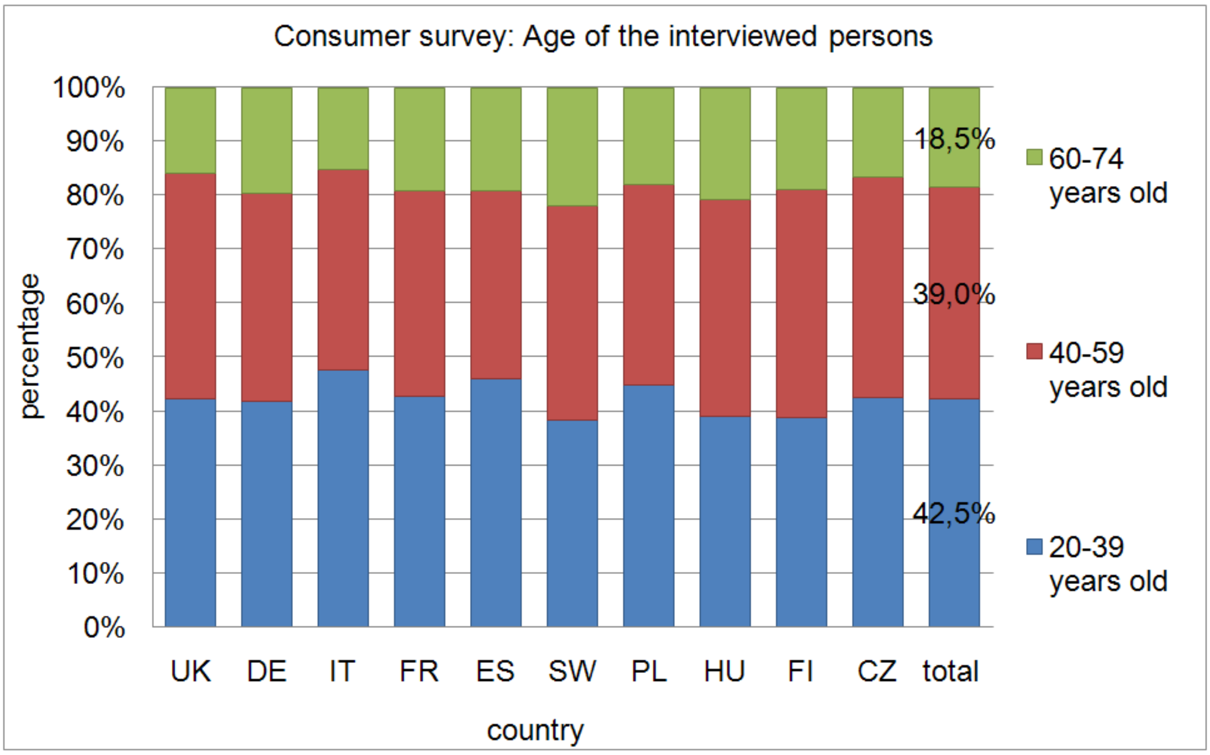


Figure 3.3: distribution: age of the interviewed persons (per country)

3.1.3 Living conditions

Within this survey people were also asked to describe their kind of habitation. When the consumers were asked about this point 52 % of all European households (n = 2.497) said that they *live in a city*. Nearly 80 % of all Polish interviewed persons live in a city (Figure 3.4). This is the highest share of all European countries. Also over 60 % of all Spanish participants are city dwellers. A fourth of all households live *in the suburbs of a city* (25 %). Mostly British (42 %) and Czech (39 %) interviewees live at this place. The other countries show percentages between 14 and 28. The remaining European households (23 %) answered that they *live in a rural area*, especially a high share of British participants (40 %). Furthermore German (33 %), French (29 %) and Hungarian (28 %) households follow.

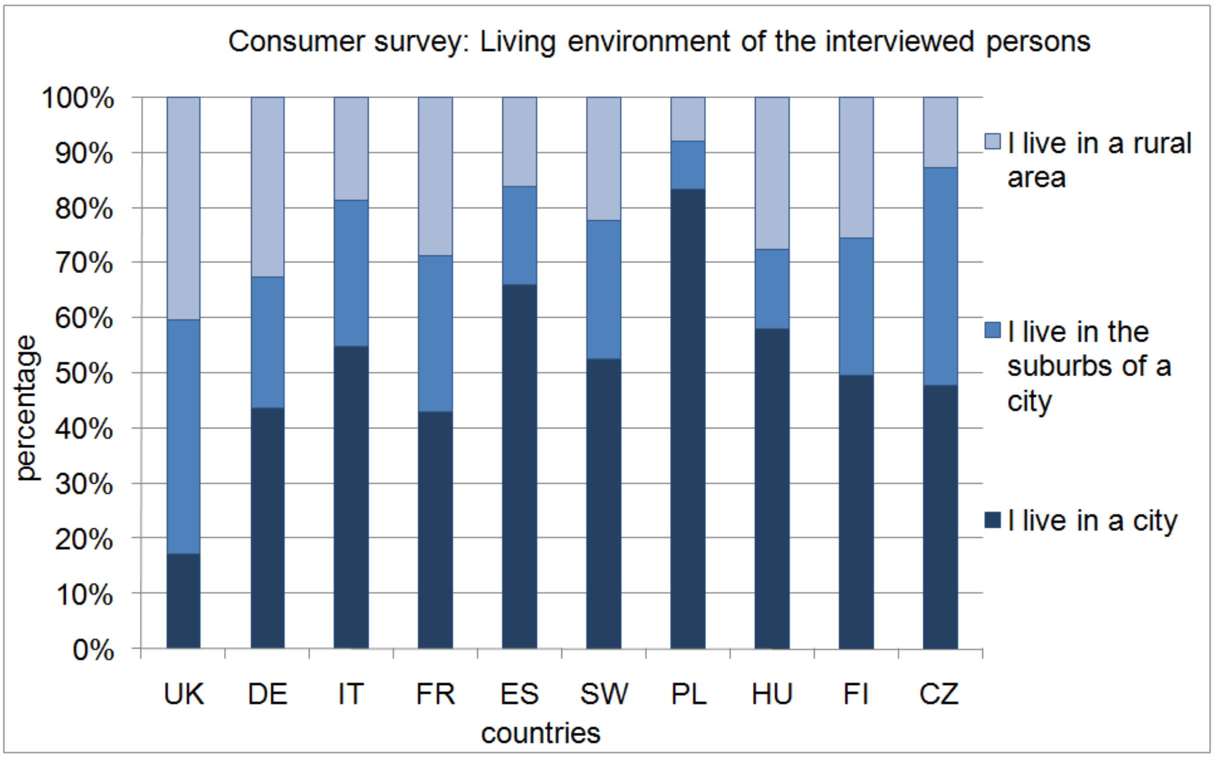


Figure 3.4: living environment of the interviewed persons (per country)

Nearly 60 % of all interviewed people live in a family household (Figure 3.5). This household type could be found mostly in our sample in Italy and Czech Republic with over 70 % and also in Poland and Hungary with over 66 % (Figure 3.6). Approximately 40 % of all family households consist of 3 or 4 persons and even 10 % over 4 persons (Figure 3.7).

Almost a fourth of all interviewed consumers (22 %) live in couple households, which are mostly represented by 2 -person households (18 %) (Figure 3.7). Especially in Finland and France this type of household could be determined with over 30 % (Figure 3.6).

Over 14 % of all participants live in a single-/one-person household. Particularly in Sweden 27,6 % and in Finland 18,4 % of all households are single-households.

With only 3,5 % the multi-person non family household was mentioned least frequently (Figure 3.5). With the exception of Italy, in all European countries the share in this type of household is marginal and shows values between 0,8 % and 5,2 % (Figure 3.6). Because of possible misunderstandings of the notation of the different types of households is it necessary to take a look at the number of persons in the households too.

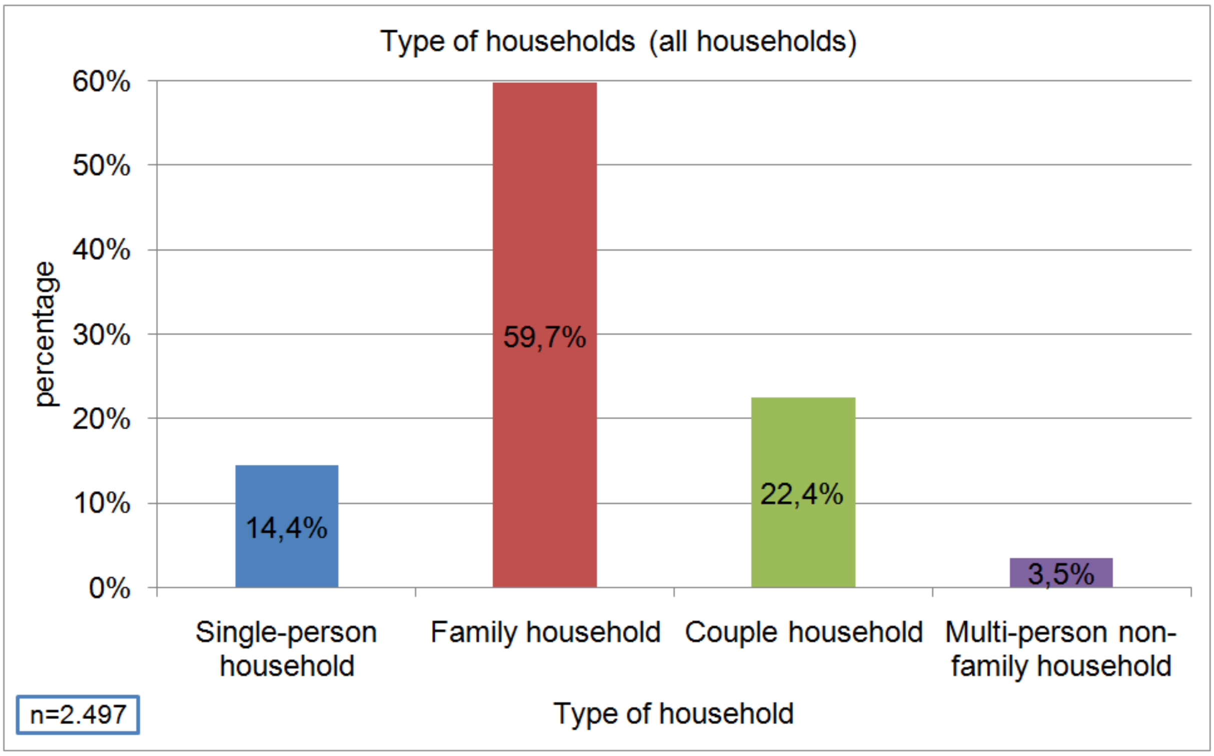
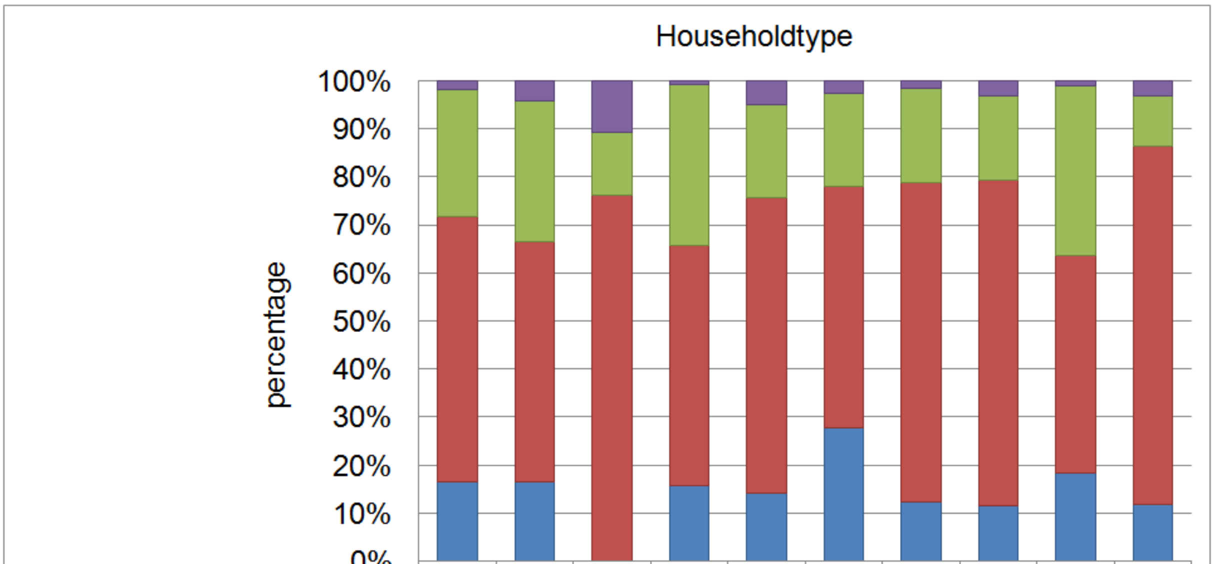
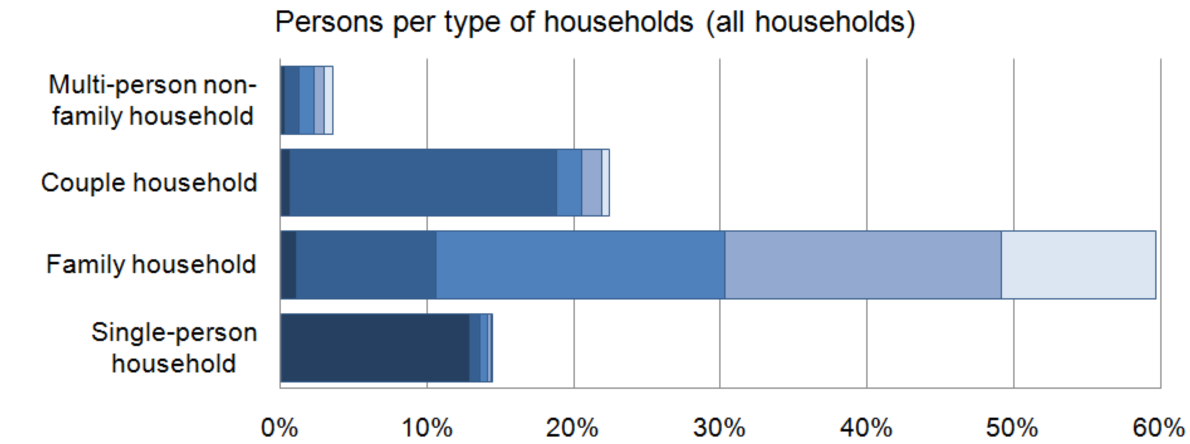


Figure 3.5: distribution: type of household (all households)



	UK	DE	IT	FR	ES	SW	PL	HU	FI	CZ
Multi-person non-family household	2,0%	4,4%	10,8%	0,8%	5,2%	2,8%	1,6%	3,2%	1,2%	3,2%
Couple household	26,4%	29,2%	13,2%	33,6%	19,2%	19,2%	19,6%	17,6%	35,2%	10,5%
Family household	55,2%	50,0%	76,0%	50,0%	61,6%	50,4%	66,4%	67,6%	45,2%	74,5%
Single-person household	16,4%	16,4%	0,0%	15,6%	14,0%	27,6%	12,4%	11,6%	18,4%	11,7%

Figure 3.6: distribution: type of household (per country)



	Single-person household	Family household	Couple household	Multi-person non-family household
1 person	12,9%	1,1%	0,6%	0,2%
2 persons	0,7%	9,5%	18,1%	1,0%
3 persons	0,5%	19,7%	1,7%	1,0%
4 persons	0,2%	18,8%	1,4%	0,7%
more than 4 persons	0,1%	10,6%	0,6%	0,6%

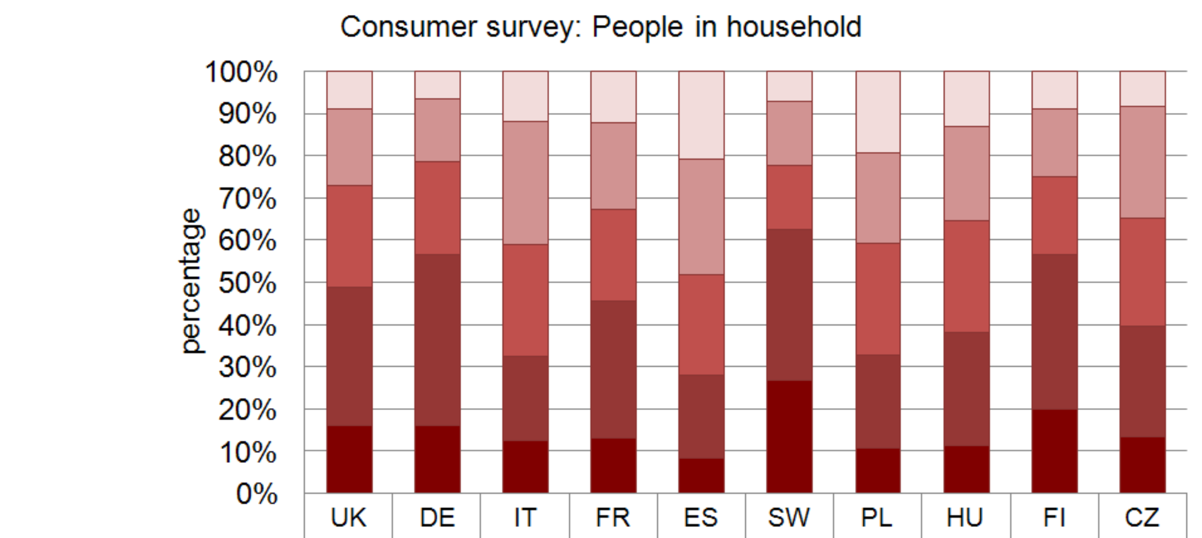
Figure 3.7: distribution: by type of household and person per household (all households)

The detailed analysis of the answers to the question how many people are living in the household results an average of 2,9 people per household. In comparison with the average household size published by UNECE[10], for those countries investigated here, an average difference of -0,3 people per household could be calculated (Table 3.3). The highest number of people with more than 4 persons could be determined in nearly 20 % of the Spanish and Polish households in our survey (Figure 3.8). Also nearly 30 % of all Italian, Spanish, Czech and Polish interviewees stated that there are 4 persons in their households. Following the consumer survey analysis the most single households could be calculated with nearly 30 % for Sweden and with 20 % for Finnish households. For the other analysed European countries between 8 and 16 % of singles could be calculated (Figure 3.8 & Appendix 3.1-2).

[10] The Statistical Yearbook of the Economic Commission for Europe 2003. Online: http://www.unece.org/stats/trends/ch2/2.1.xls

Table 3.3: average household (countries of this survey) (source: UNECE (2004))

	EUROSTAT		Consumer survey		Δ Average household size (EUROSTAT – Consumer survey)
Countries	**Average household size**	**Year**	**Average household size**	**Year**	
Czech Republic	2,7	1998	2,9	2006	-0,2
Finland	2,1	2001	2,6		-0,5
France	2,4	2001	2,9		-0,5
Germany	2,2	2001	2,6		-0,4
Hungary	2,6	2001	3,0		-0,4
Italy	2,6	2001	3,1		-0,5
Poland	3,1	1995	3,2		-0,1
Spain	2,9	2001	3,3		-0,4
Sweden	2,9	2001	2,4		0,5
United Kingdom	2,3	2001	2,7		-0,4



	UK	DE	IT	FR	ES	SW	PL	HU	FI	CZ
more than 4 persons	9,2%	6,8%	12,0%	12,4%	20,8%	7,2%	19,6%	13,2%	9,2%	8,5%
4 persons	18,0%	14,8%	29,2%	20,4%	27,6%	15,2%	21,2%	22,4%	16,0%	26,3%
3 persons	24,0%	22,0%	26,4%	21,6%	23,6%	15,2%	26,4%	26,4%	18,4%	25,5%
2 persons	32,8%	40,4%	20,0%	32,4%	19,6%	35,6%	22,0%	26,8%	36,4%	26,3%
1 person	16,0%	16,0%	12,4%	13,2%	8,4%	26,8%	10,8%	11,2%	20,0%	13,4%

Figure 3.8: number of people in households (per country)

In nearly 38 % of all European households of our survey at least one person is younger than 18 years. Figure 3.9 shows that in 17 % of all households lives one and in nearly 14 % live two persons under this age, mostly in France (46 %), Hungary (44 %), Poland (42 %) and Italy (41 %).

Households with the least share of people under 18 years could be found in Czech Republic (29,6 %), Sweden (33,6 %) and Spain (32,4 %) (Appendix 3.1- 3).

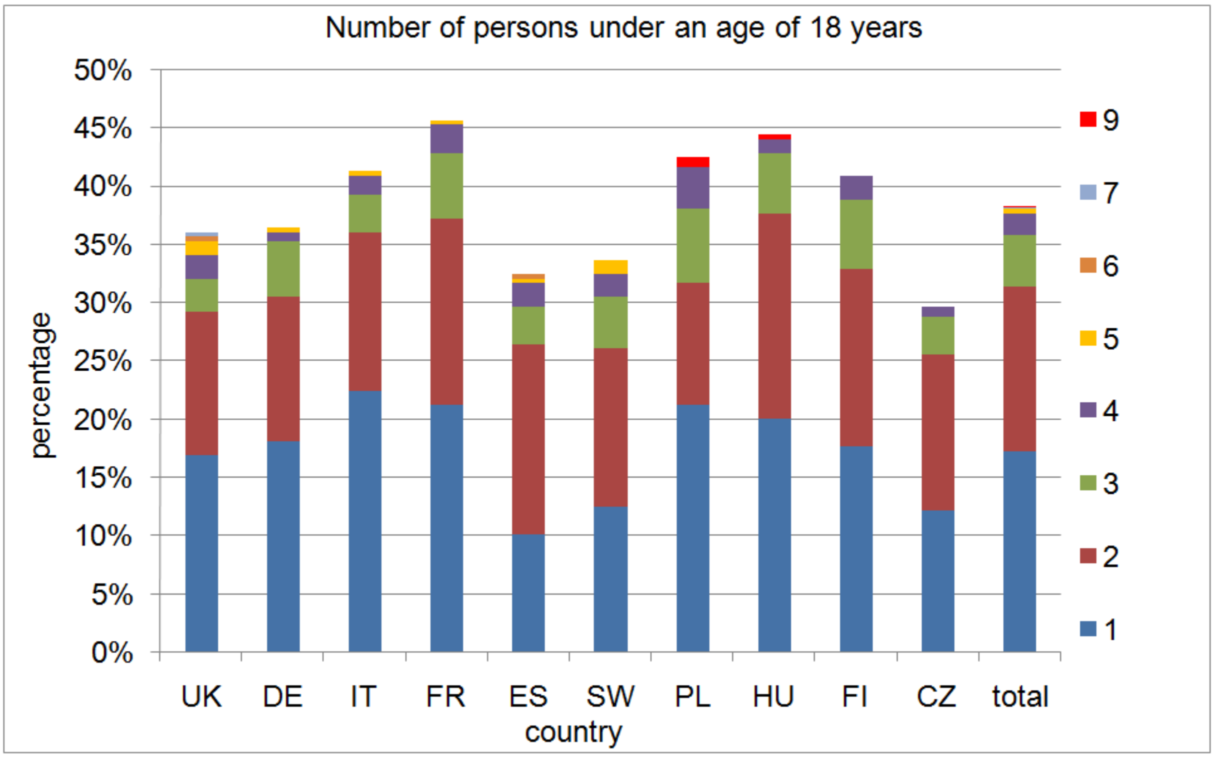


Figure 3.9: number of people under an age of 18 years (per country) living in household

<u>Stock of household appliances</u>

A total of 10 044 household appliances exist in all interviewed households (n = 2 497). Refrigerators and washing machines were reported with an ownership of 100 %, because of the predefined quota. 69 % (n = 1 722) of all households possess an automatic dishwasher and over 35 % (n = 893) a tumble dryer.

From the group of cold appliances approximately 75 % (n = 1 871) of all households own an upright freezer and nearly a fourth of all households own a chest freezer (22,6 %; n = 564). 14.2 % (n = 355) of all interviewees even mentioned to have both (Figure 3.10).

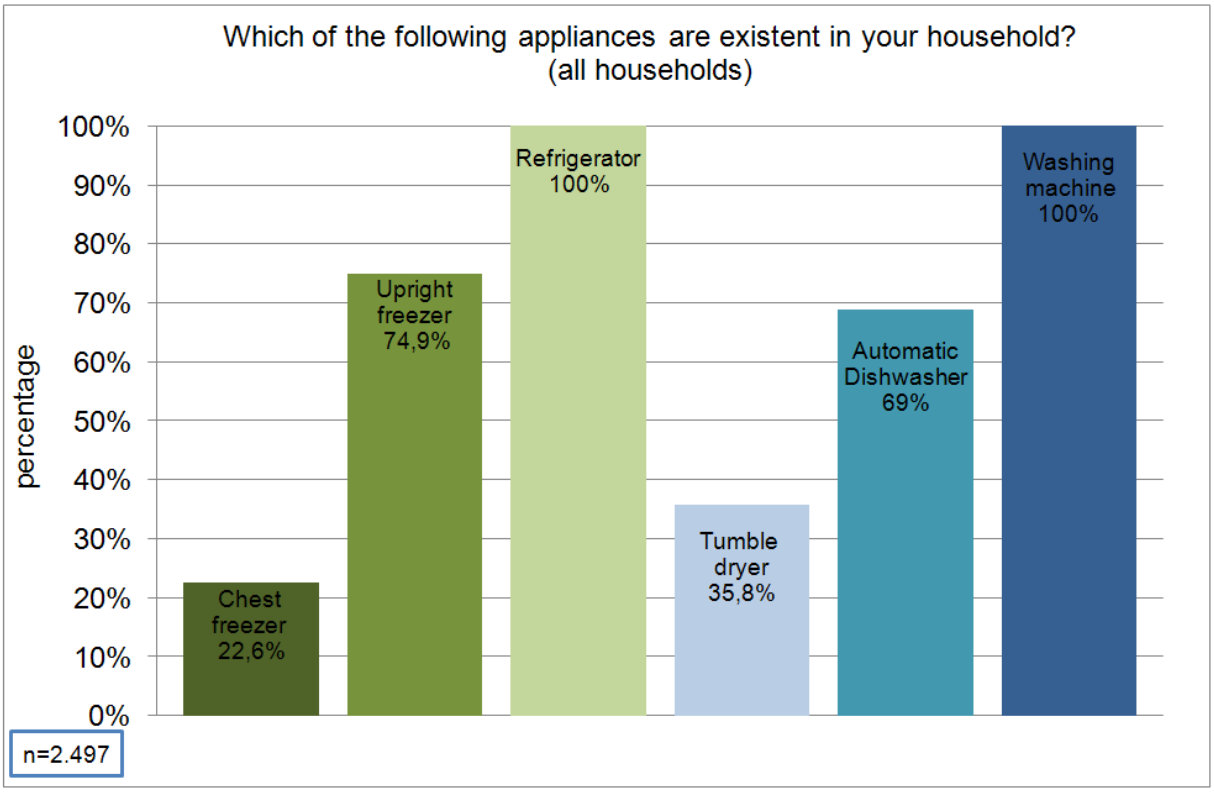


Figure 3.10: equipment of household appliances in % (all households)

Nearly all Swedish household possess an upright freezer (99,2 %) but only 4 % a chest freezer. For British households (91,2 %) a high share of freezers can be mentioned also. Additionally 33 % of all British participants mentioned that they have a chest freezer too. Only Finnish households show a higher share of chest freezers with nearly 40 %. Concerning the equipment with freezers values between 71 and 78 percentages for the other countries were calculated with the exception of Polish and French households. Here only approximately 57 % possess a freezer. The share of chest freezers is also very low in Polish households and in Czech households in comparison with the other countries with nearly 9 % respectively 11 %.

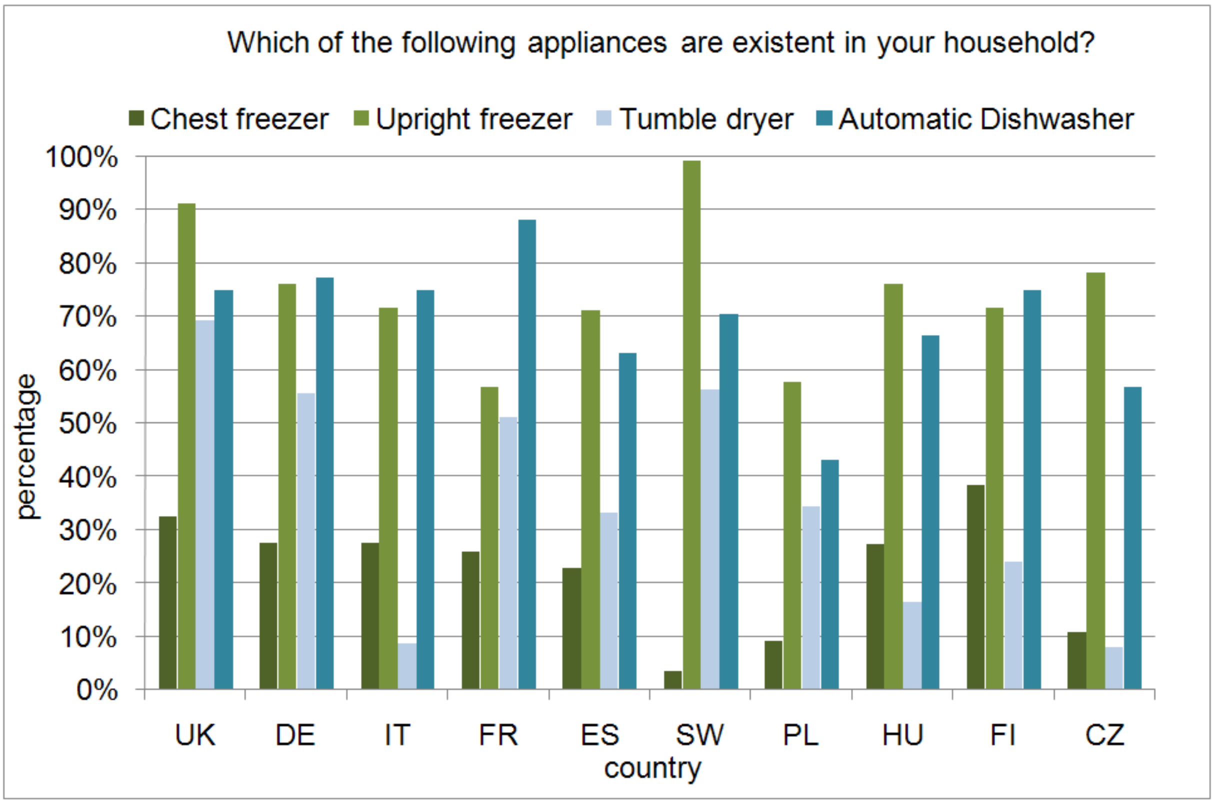


Figure 3.11: equipment of household appliances in % (per country)

One fourth of couple and family households have a chest freezer and over 70 % an upright freezer (Figure 3.12). One person households only show an equipment level of 10 % of chest freezers. The reason might be not enough space or that this appliance is unnecessary.

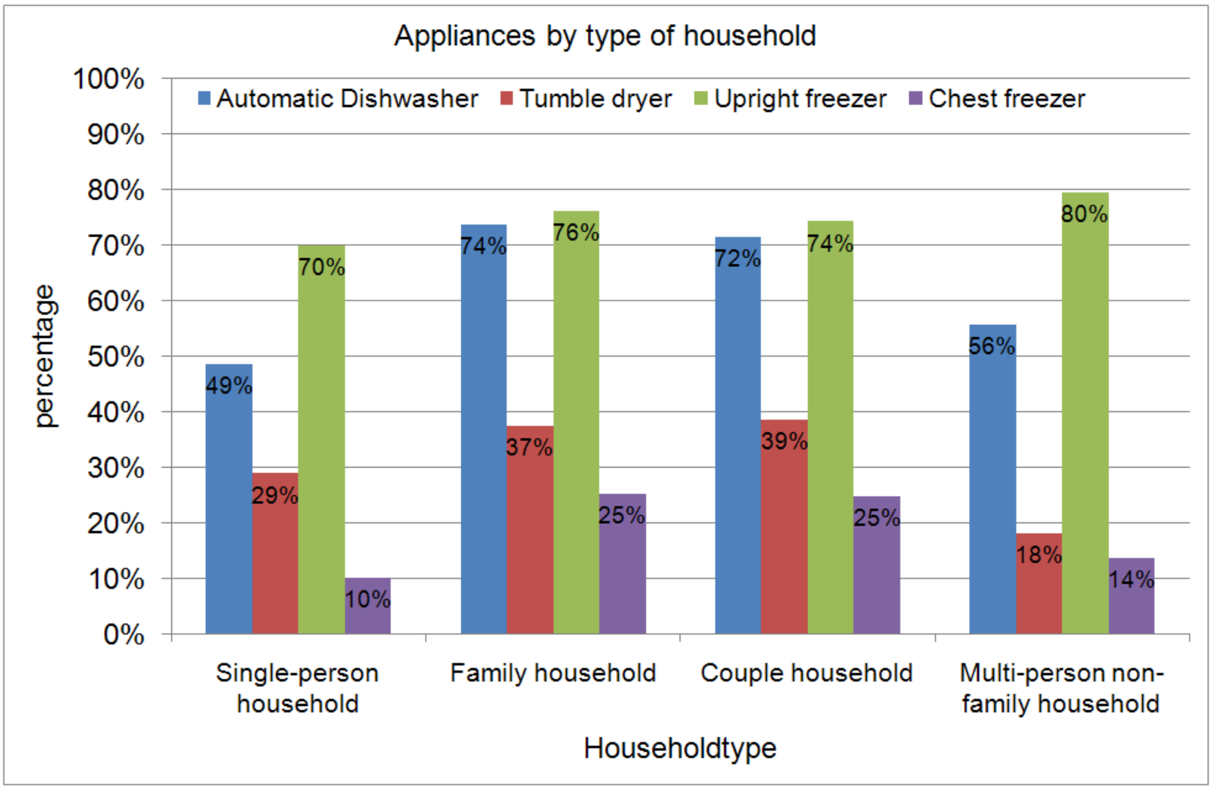


Figure 3.12: equipment of household appliances by type of household

3.1.4 Consumer opinion about the topic "Household appliances"

For a possible general estimation how consumers use their appliances or how they evaluate their influences on the environmental impact with their behaviour they were confronted with some general statements.

Nearly all interviewed consumers stated that appliances should *just do a perfect job* (Figure 3.13) so that the consumer does not need to worry about it (53,9 %) (Figure 3.14). Ecological aspects are very important for the consumers too. Most of the consumers know that their *behaviour plays a role for the environmental impact*. Consequently nearly 90 % of all interviewed persons mentioned that it's very important for them *to be able to protect the environment with their behaviour* (Figure 3.13) and they agree with the statement that *a correct use of their machines would save energy* (94,7 %) (Figure 3.14). So it is also a high priority for the interviewees that household *appliances show very good economical consumptions* (39,7 %) (Figure 3.13) and that they *work economically* too (38,3 %) (Figure 3.14). Aspects like design or the price seem to play a minor role for the consumers. Approximately 40 % of all consumers disagree and even 7,9 % strongly disagree with the statement that an *appliance should reflect their lifestyle or match the interior of their home* (Figure 3.13). Also nearly 30 % disagree that they primarily pay attention to an *attractive price of the appliances* (Figure 3.14).

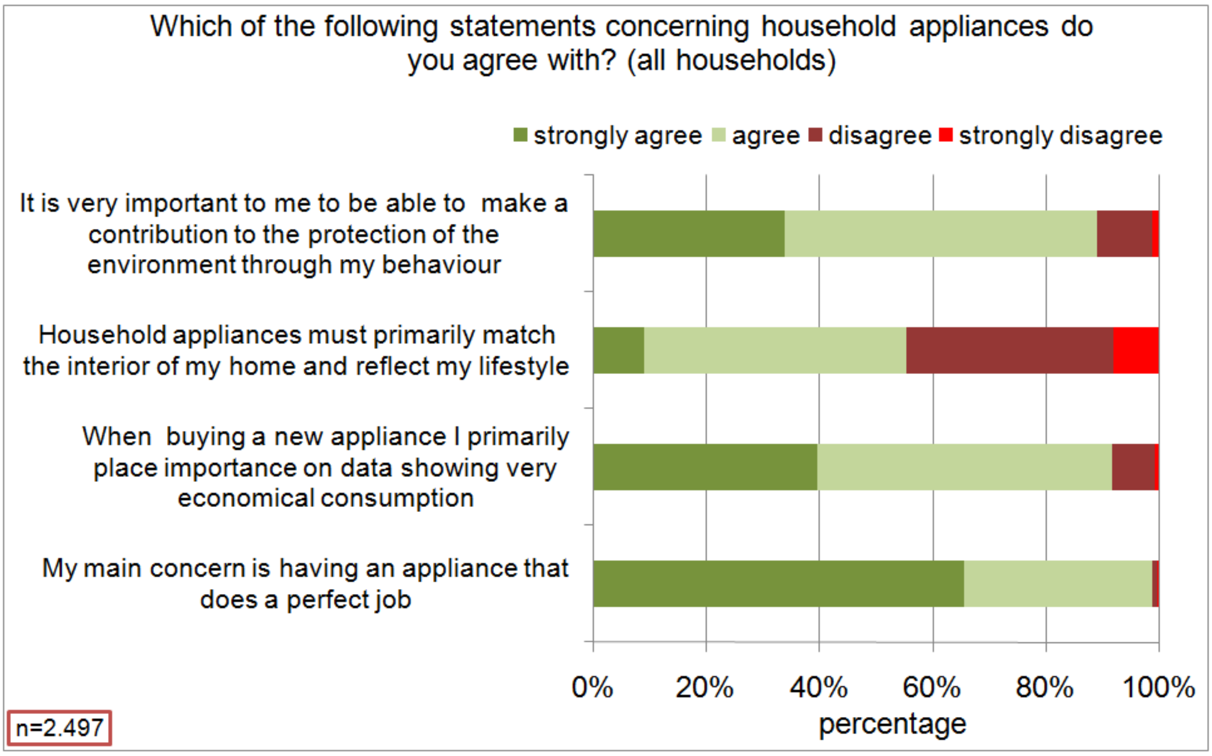


Figure 3.13: consumer statements – part I

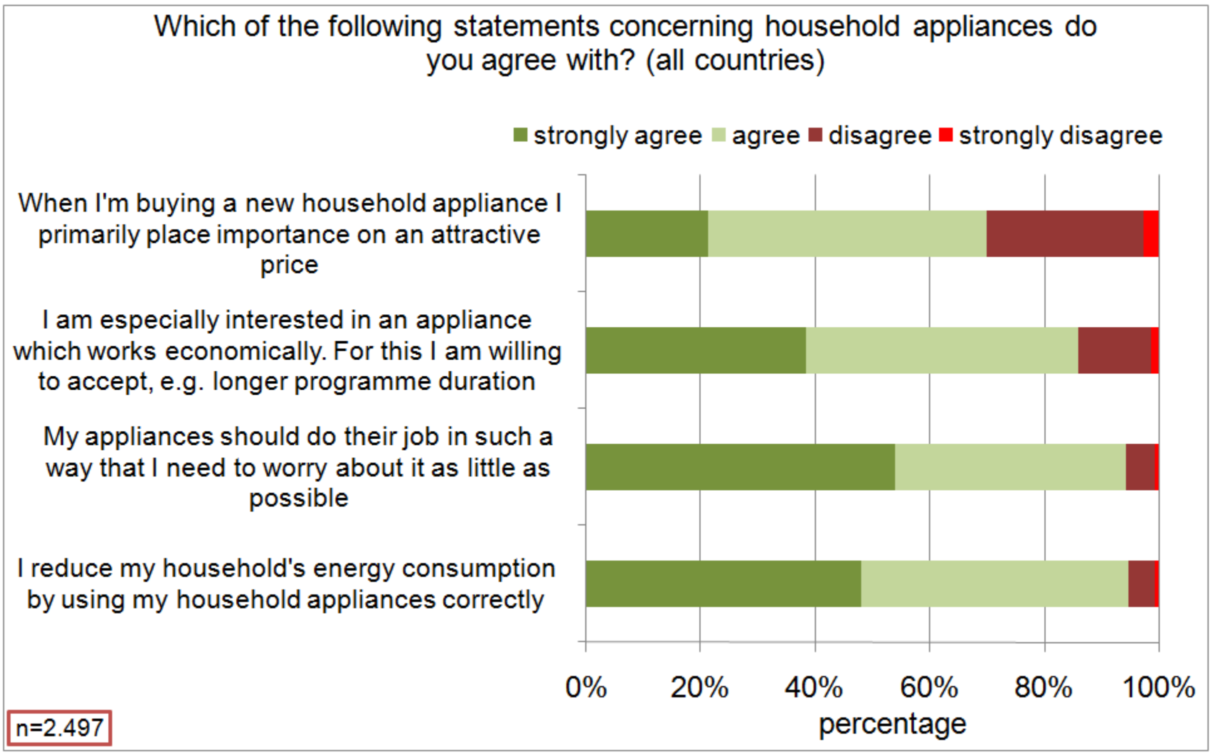


Figure 3.14: consumer statements – part II

The consumers were also asked which sources of information they would consult when they plan on buying a new appliance (multiple answers allowed). The main source of information for the consumer when buying a new appliance is his *own experience* (55,7 %) (Figure 3.15). The second main source of information is *internet sites of the manufacturers* (52,2 %). *Information on the energy label* is important for nearly 52 % of all interviewed consumers. Approximately equally quoted are *advices and experiences of friends* and *test reports from consumer organizations* (50,5 %; 50,8 %) (Figure 3.15). In comparison with the results of a study of a German magazine (STERN)[11] (Figure 3.16) concerning information when purchasing an electrical domestic appliance the importance of *information in trade* is quoted lower (Figure 3.16). These *advices from sales representatives in a shop* (46,4 %) are less relevant for the interviewees of our survey. But similar are the results for the importance level of "information *by manufacturers' brochures"*. Here in our study and the STERN study nearly 30 % of the consumers choose this source of information when they consider buying a new appliance (Figure 3.15; Figure 3.16).).

[11] STERN (2005): TrendProfil "Elektronische Haushaltsgeräte". Online: http://www.gujmedia.de/_content/20/50/205011/TP_0505_Elektr_HHG.pdf?PHPSESSID=3d884f1d5fee754e7b0e5320766a6ab2

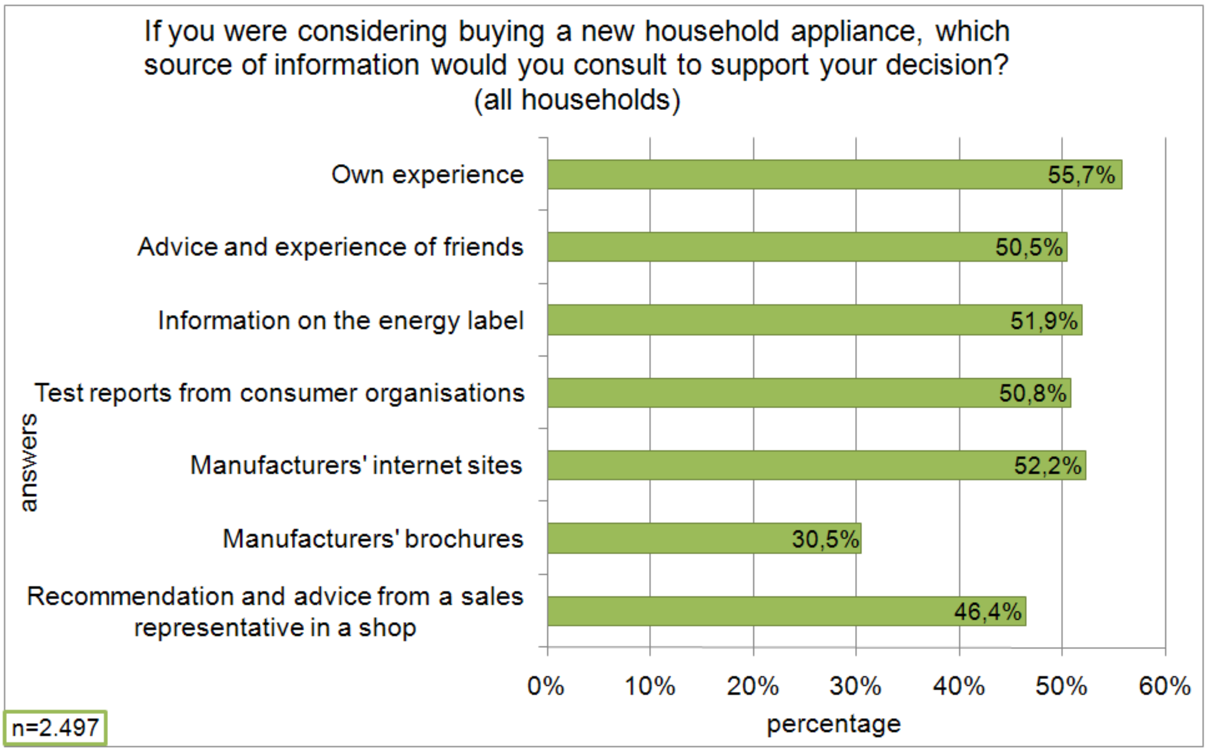


Figure 3.15: sources of information when purchasing a new appliance

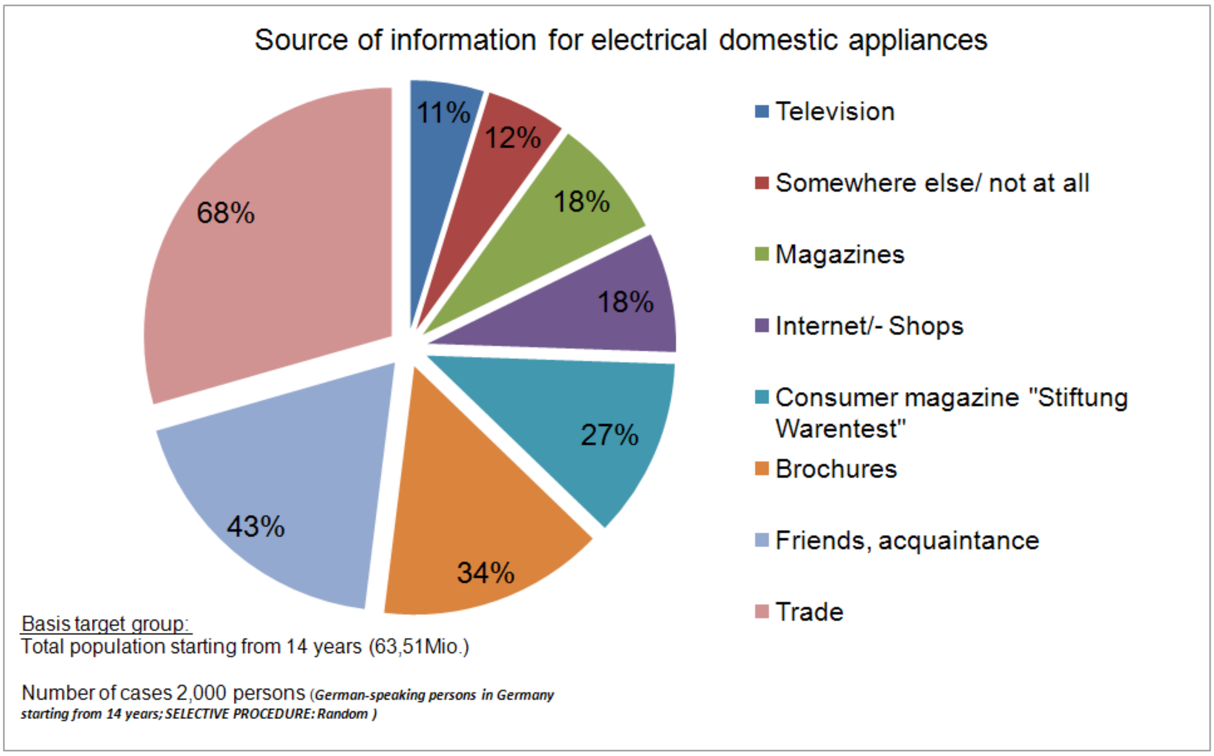


Figure 3.16: results study STERN: sources of information when purchasing an electrical domestic appliance (STERN (2005)[12]

[12] STERN (2005): TrendProfil "Elektronische Haushaltsgeräte". Online: http://www.gujmedia.de/_content/20/50/205011/TP_0505_Elektr_HHG.pdf?PHPSESSID=3d884f1d5fee754e7b0e5320766a6ab2

For approximately 52 % of all participants of this survey *information on the energy label* is important for their buying decision (Figure 3.15). Within this survey the consumers were asked in more detail what information on the energy label they would expect (list of options was provided). For over 80 % the *energy efficiency class* and information about the *water consumption* are rated as very important (Figure 3.17). More than about 50 and 60 % of all interviewees mentioned and chose points which are already listed on the energy label today, like e.g. *cleaning/washing performance* (58,1 %), *capacity* (57,5 %), *noise emission* (55,4 %) or *spin/drying performance* (50,5 %). A bit lower in the reply quota information on the *programme duration* (45,2 %) is requested.

Referring to the *energy consumption* the consumer expects more information on the consumption *per cycle per day* (56,4 %) than on the *annual consumption* (34,1 %). Other detailed information on all *programmes or features of the appliance* or on *programme and temperature used for the assessment* are only wished by approximately 28 % of the consumers. Financial aspects like *yearly* or *running cost (per cycle)* are also requested by only about 32 % to 34 %.

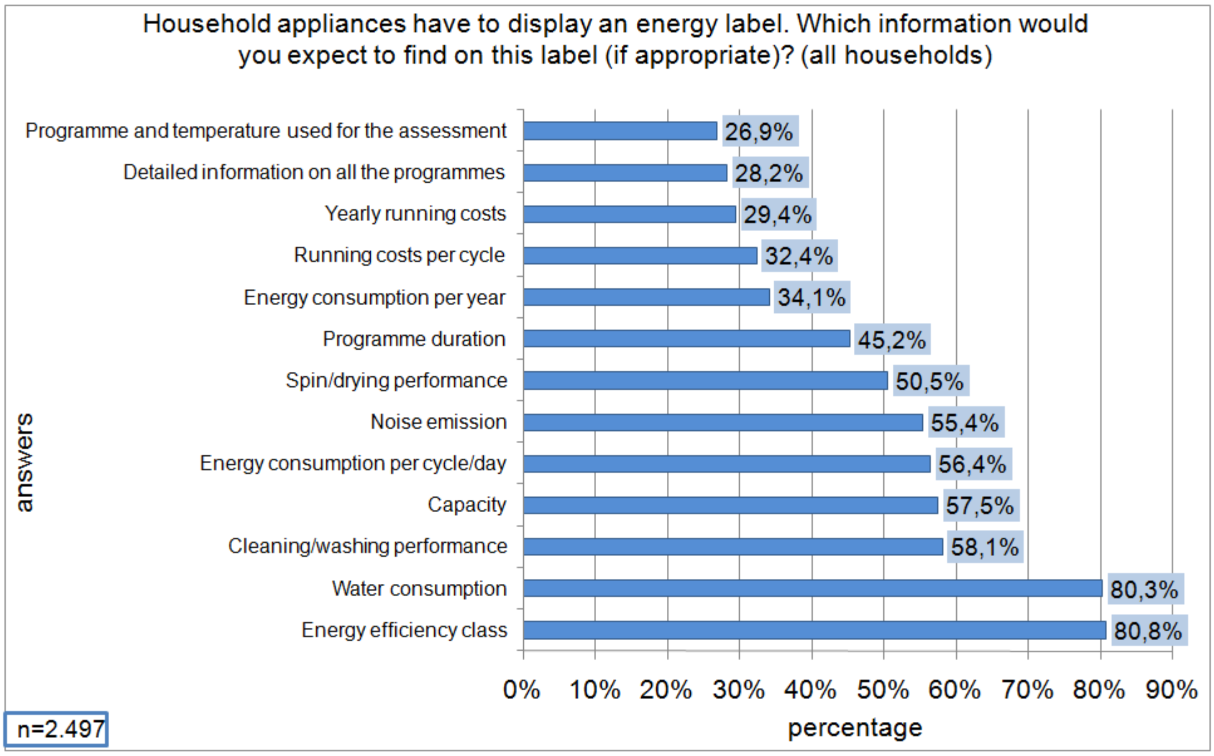


Figure 3.17: energy label – expected information

A very *low consumption of resources like water and/or energy* is the most important aspect for the consumers when they plan on buying a new appliance (83,9 %) (Figure 3.18). Also for over 70 % of all interviewed persons a *very good cleaning/washing performance* has a high priority. More than half of all participants of this study pay attention to a *low operating noise emission* of the appliance. Accordingly a lot of consumers not only look at the *purchase price of the machine* (38,2 %) but also for a very *good result on the energy label* (36 %). More than one fourth of the consumers attend to a *good dishes-/textile protection* too. The other criteria like *shorter programme duration*, *low detergent consumption* or a *large number of different programmes* are only mentioned by between 15 and 18,5 % of the consumers. The least values are reached by a *higher capacity* (10,2 %) and an *innovative aesthetic design* (7,2 %).

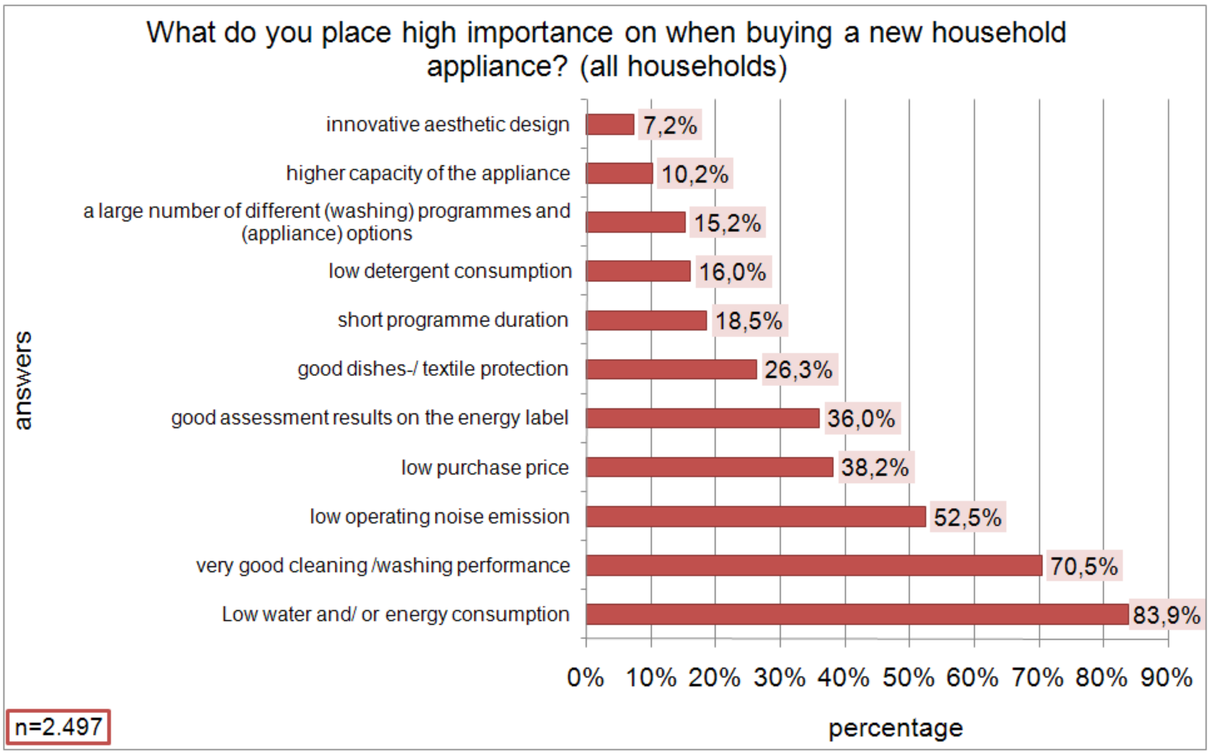


Figure 3.18 : criteria when purchasing a new appliance

3.2 IDENTIFICATION OF POSSIBLE BARRIERS TO ECO DESIGN INNOVATIONS

After development it takes some time for new energy efficient appliances to penetrate the market. It depends on how often consumers buy new refrigerators/ freezers, this in turn is depended on the life time of the appliance, on repairs and the second-hand market. Another possible barrier for energy saving innovations for cold appliances is the necessity of food protection. The decrease of energy consumption can only go as far as food safety is ensured.

First available data on these subjects is presented followed by results of the conducted survey of consumers of the EU.

3.2.1 Life time of the appliances

Consumers normally purchase an appliance and use it until it breaks before buying a new one. This implies that new refrigerator/ freezer models with innovative eco-designs only enter the households when an old appliance is replaced.

According to CECED[13] the life time of refrigerators is 14 years and 17 years for freezers.

A study conducted by S.A.F.E.[14] showed that 2 % of the participating households owned refrigerators manufactured between the years 1970 and 1979, 11 % owned appliances from the years 1980 to 1989, 37 % had refrigerators manufactured between 1990 and 1999, the remaining 50 % have appliances produced after 2000. The situation is similar for freezers. The same study showed that 2 % of the freezers owned were manufactured between 1970 and 1979, 15 % in the 1980s, 38 % were produced between 1990 and 1999 and 45 % after 2000.

MTP[15] estimated the life times of different old appliances by using the stock model and optimising estimated sales data with actual sales (Table 3.4).

Table 3.4: assumed life span of different cold appliances (source: MTP[15])

	Chest freezer	Upright freezer	Fridge	Fridge-freezer
Lifetime (years)	16.7	15.5	12.8	17.5

The consumer survey conducted for this study showed that more than 10 % of the main refrigerators in EU households are older than 10 years, with ages up to 25 years (Figure 3.19). Approximately 55 % of the appliances are less than 5 years old and therefore unlikely to be replaced in the near future.

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[13] CECED (2006): White Paper: Energy efficiency a shortcut to Kyoto targets. The vision of European home appliance manufacturers, S.18 Online: http://www.ceced.org/IFEDE//easnet.dll/GetDoc?-APPL=1&DAT_IM=20429D&DWNLD=White Paper_Energy efficiency_Feb 2006_Final.pdf

[14] S.A.F.E. SCHWEIZERISCHE AGENTUR FÜR ENERGIEEFFIZIENZ/ SWISS AGENCY FOR EFFICIENT ENERGY USE (2005): www.energy box.ch – Auswertung der Nutzerdatenbank, Online: http://www.energieeffizienz.ch-/files/auswertung_energybox.pdf

[15] MTP MARKET TRANSFORMATION PROGRAMME (2006): BNC08: Assumptions underlying the energy projections for domestic cold appliances. Online: http://www.mtprog.com/ApprovedBriefingNotes/PDF-/MTP_BNC08_2006October31.pdf

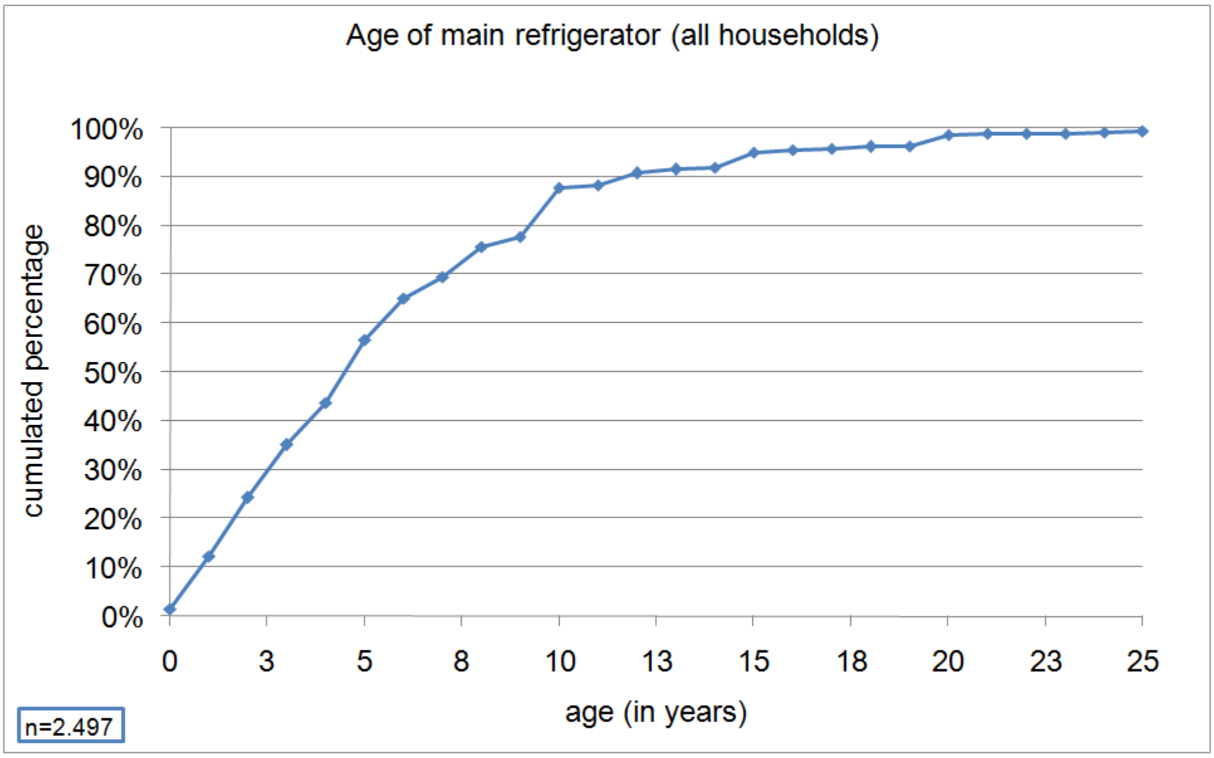


Figure 3.19: cumulated age of the main refrigerators of all questioned households

A separated look at the average refrigerator ages in the different countries shows that they are similar. 50 % of the appliances are less than 3,5 to approx. 5 years old. 10 % of the cold appliances are older than 9 to 15 years (Figure 3.20). The average ages of main refrigerators in the different countries only differ by 1,7 years, the youngest being found in the UK (5,1 years), the oldest in Sweden and Finland with 6,8 years and 6,7 years, respectively (Figure 3.21).

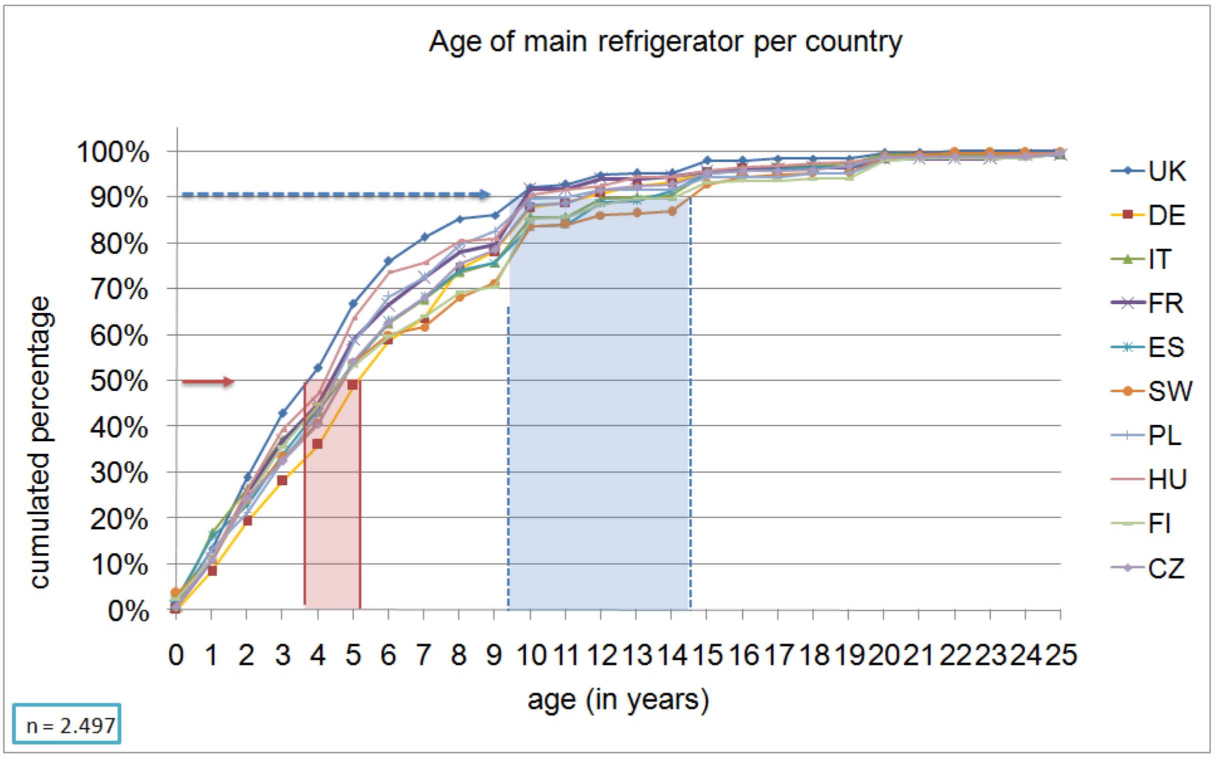


Figure 3.20: cumulated age of the main refrigerators of all questioned households per country

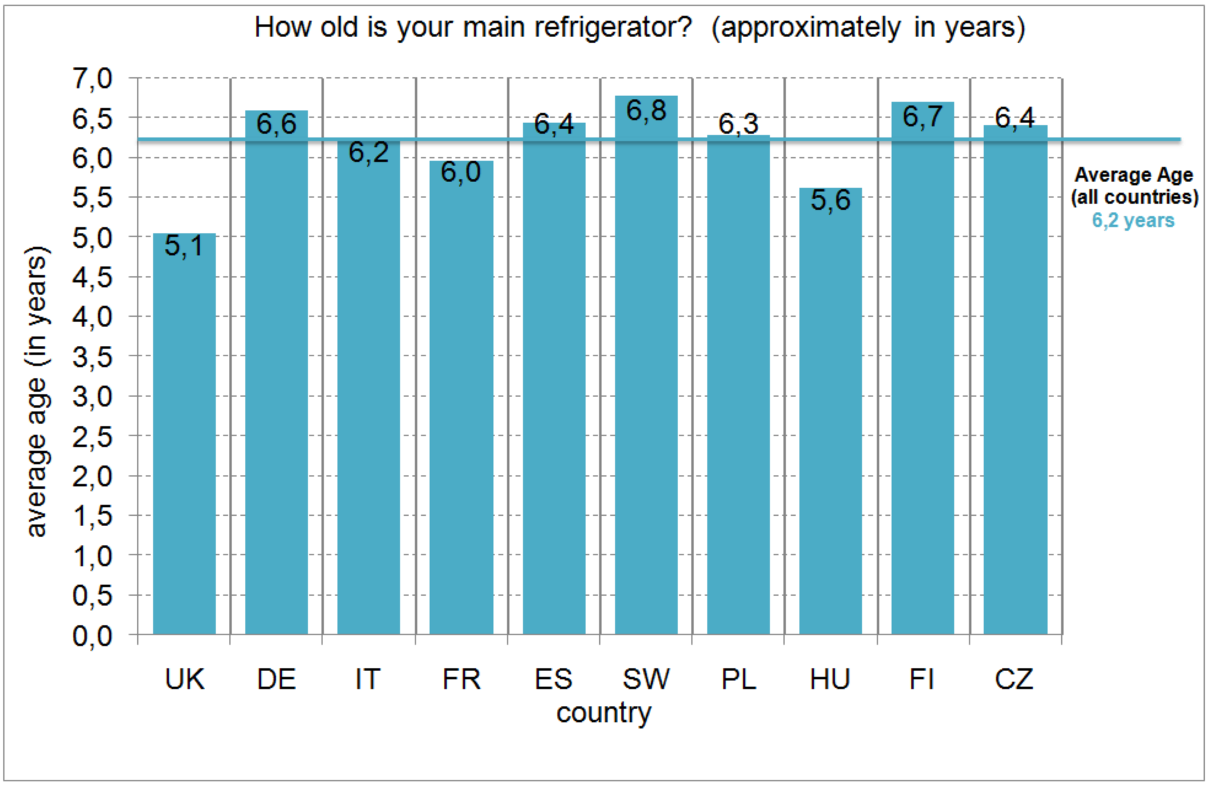


Figure 3.21: average age of the main refrigerators of all questioned households per country

About 21 % of the participating households own a second refrigerator, particularly approximately 30 % of all Italian and Hungarian households (Figure 3.22).

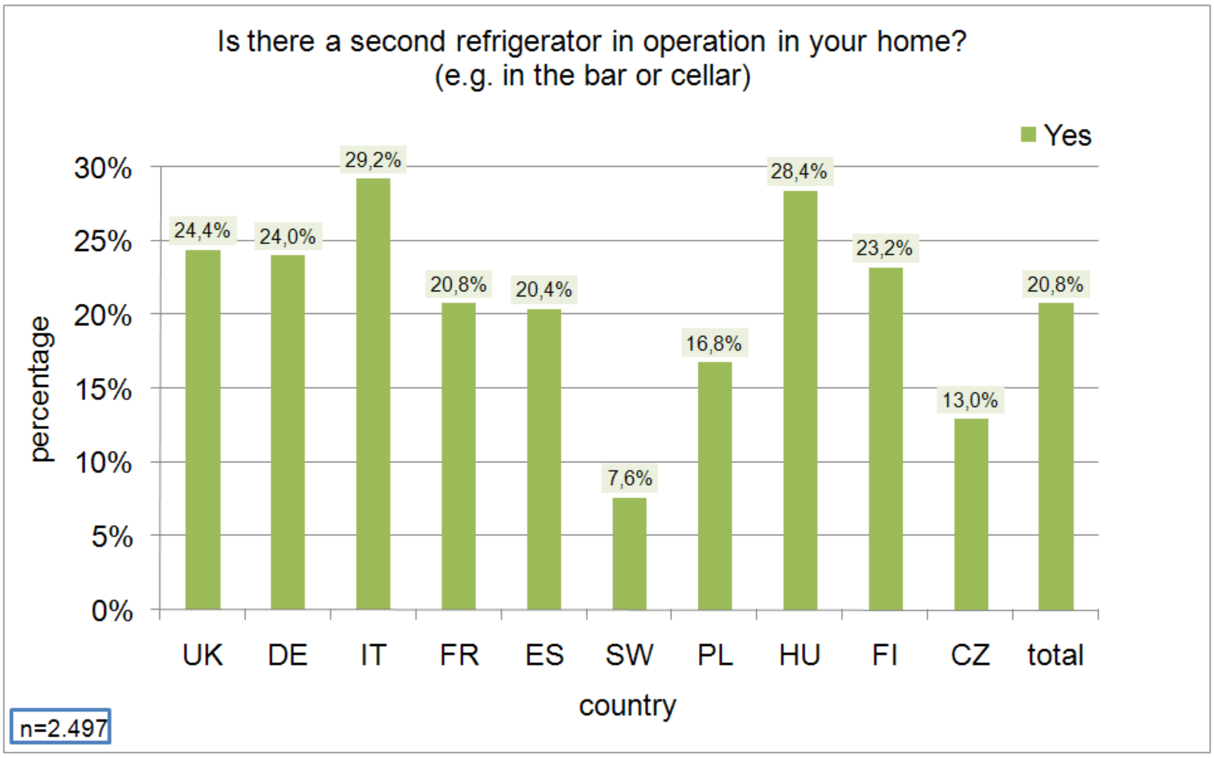


Figure 3.22: share of second refrigerators in all questioned households

50 % of the second refrigerators are less than 5 years old and 10 % are more than 15 years old (Figure 3.23).

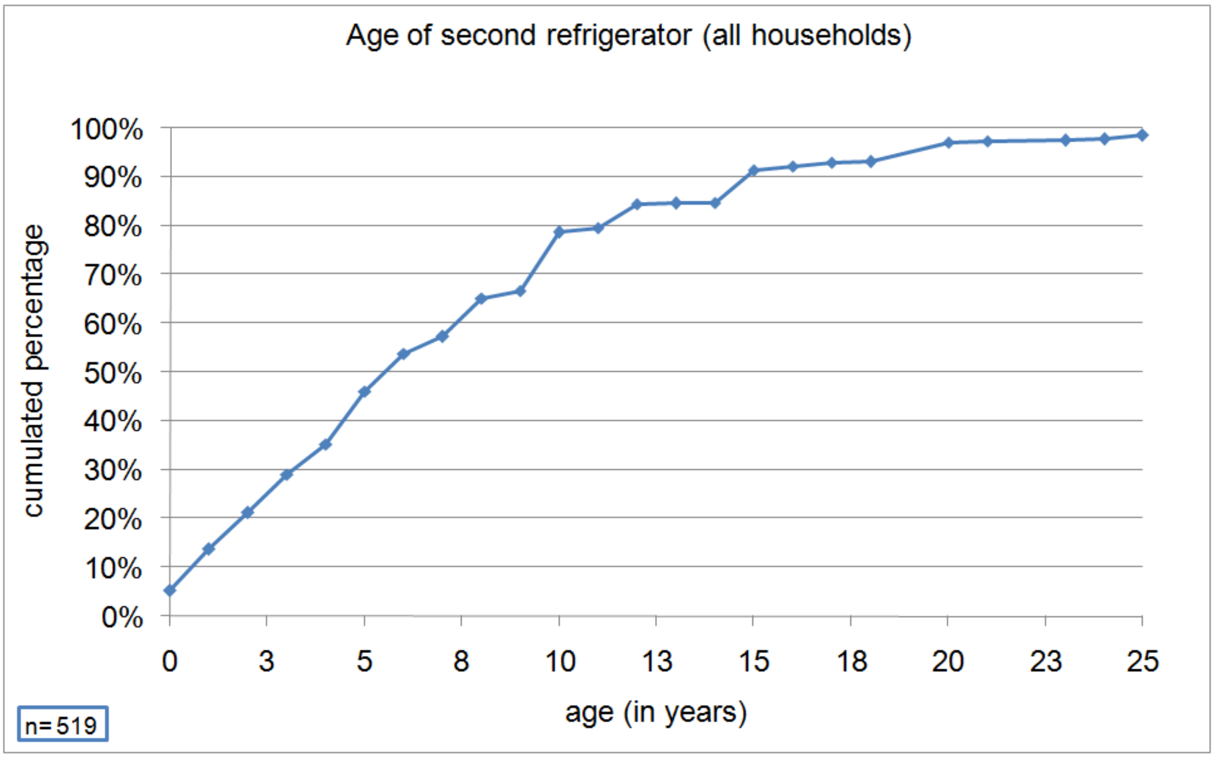


Figure 3.23: cumulated age of the second refrigerators of all questioned households

The age variations of the second appliances between the countries have a greater spread than age variations of main appliances (Figure 3.24). The average ages in comparison of countries range from 4,8 years (Spain) to 11,1 years in the Czech Republic (Figure 3.25). In the average of all countries second appliances tend to be older than the main refrigerator, but only by 1,4 years.

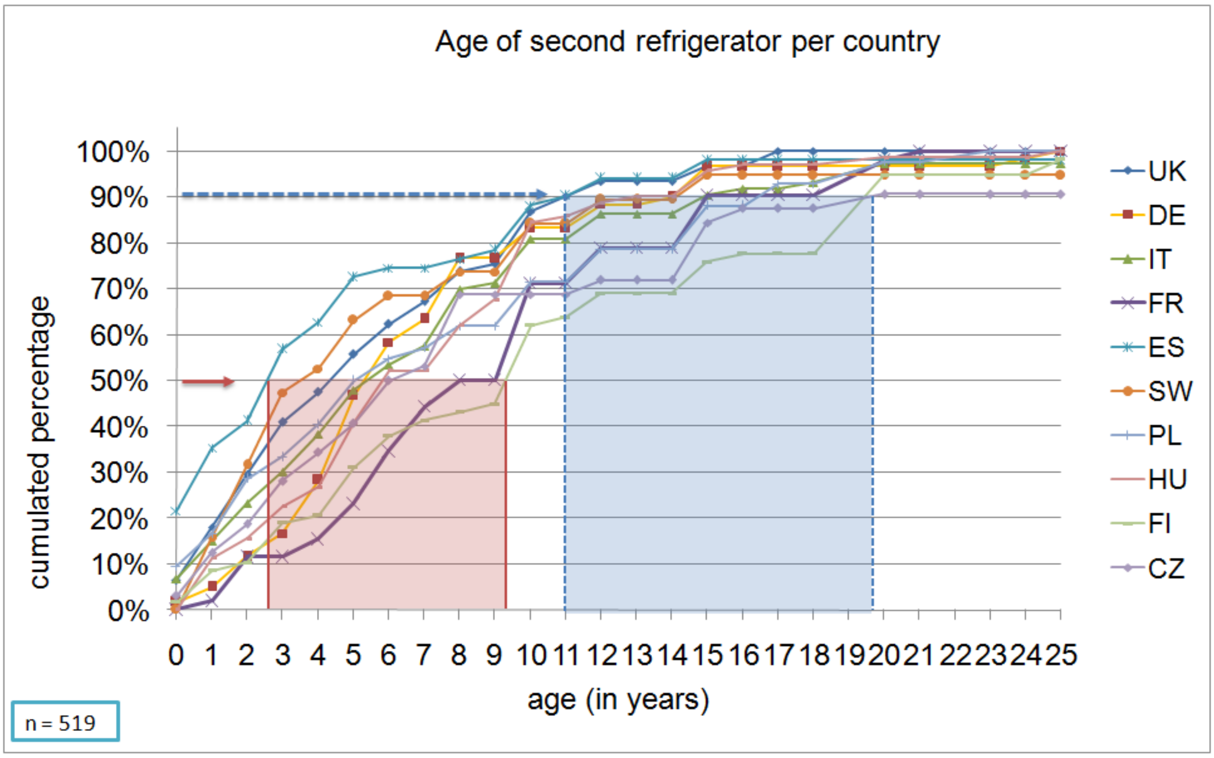


Figure 3.24: cumulated age of the second refrigerators of all questioned households per country

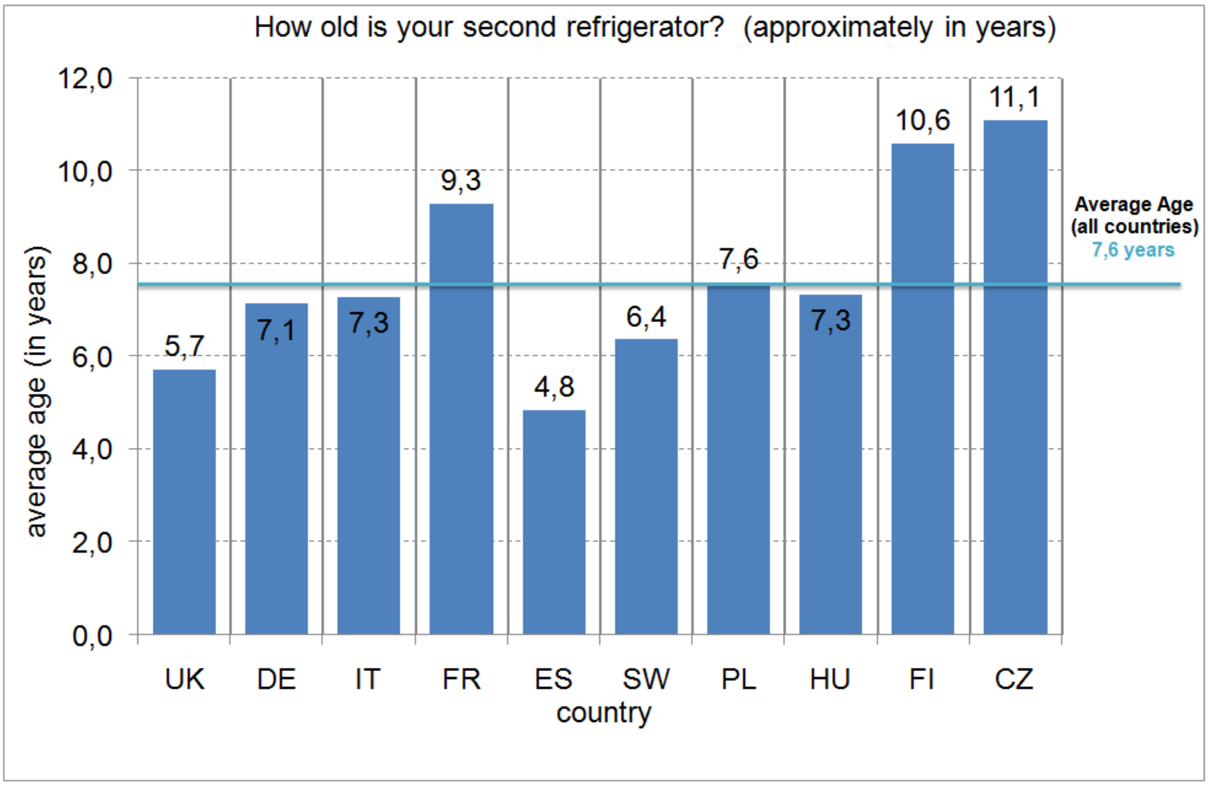


Figure 3.25: average age of the second refrigerators of all questioned households per country

Also the age of freezers was evaluated. The answers of all consumers which posses a chest freezer or upright freezer (n = 2 081) were analysed. The survey shows that 50 % of the freezers in all countries are younger than 5 years and 10 % older than approx. 15 years (Figure 3.26).

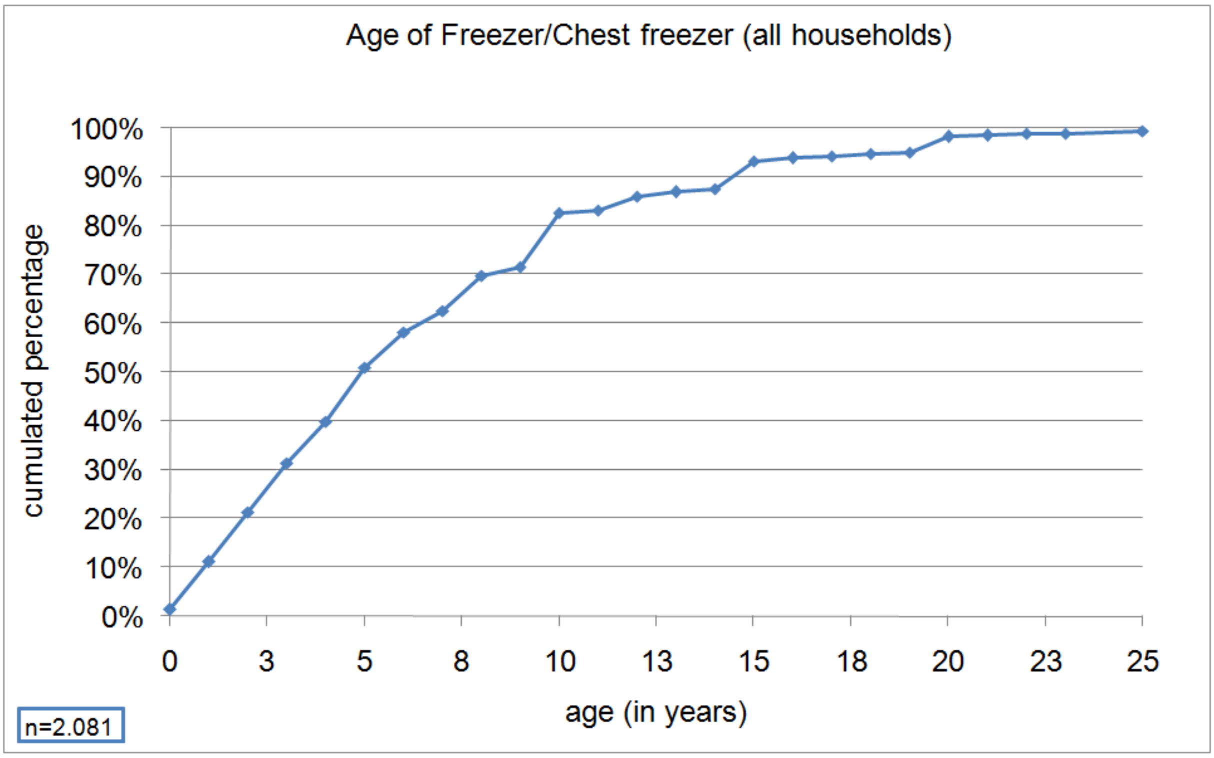


Figure 3.26: cumulated age of upright freezers/ chest freezers of all questioned households

A separated look at the average freezer ages in the different countries shows that they are very similar. 50 % of the appliances are less than 4 to approx. 6,5 years old. 10 % of the cold appliances are older than approx. 11 to 15 years (Figure 3.27).

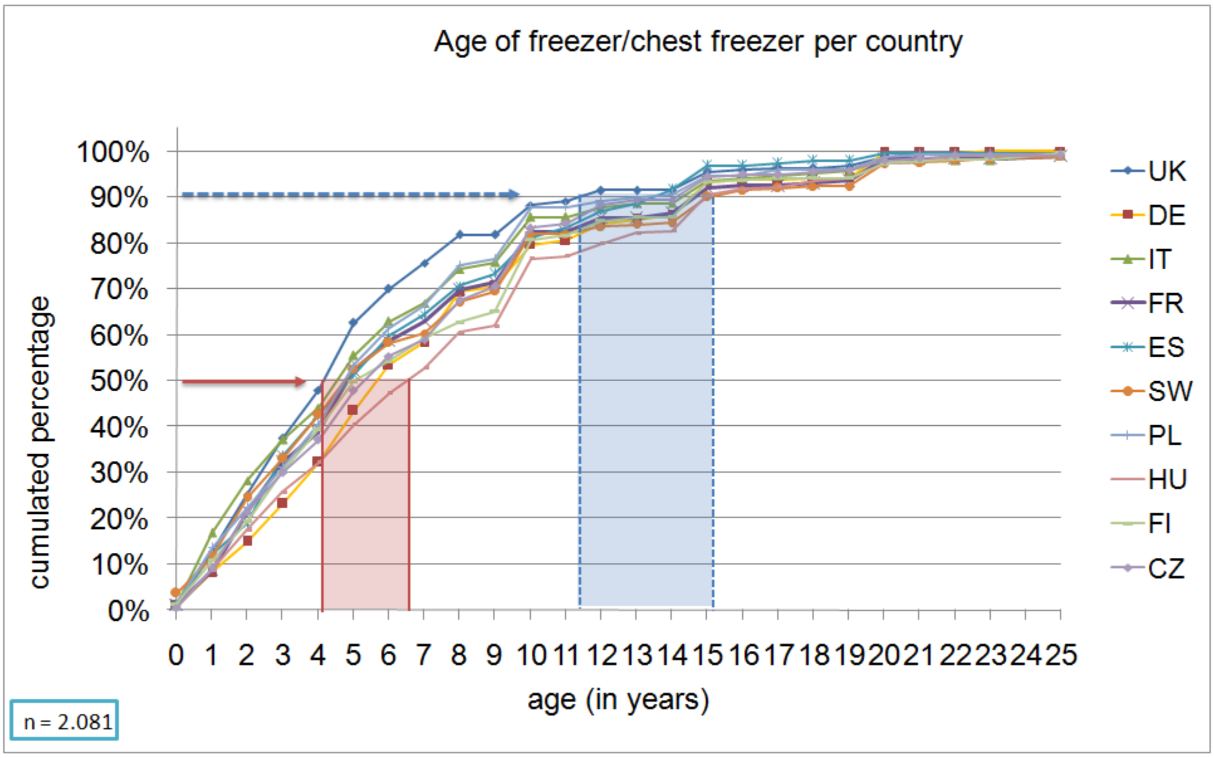


Figure 3.27: cumulated age of upright freezers/ chest freezers of all questioned households per country

The average age of upright freezers/ chest freezers in comparison between countries is very similar. The youngest freezers can be found in Italy (6,5 years), Spain (6,6 years) and Poland (6,7 years), the oldest are found in Hungary (8,0 years) (Figure 3.28).

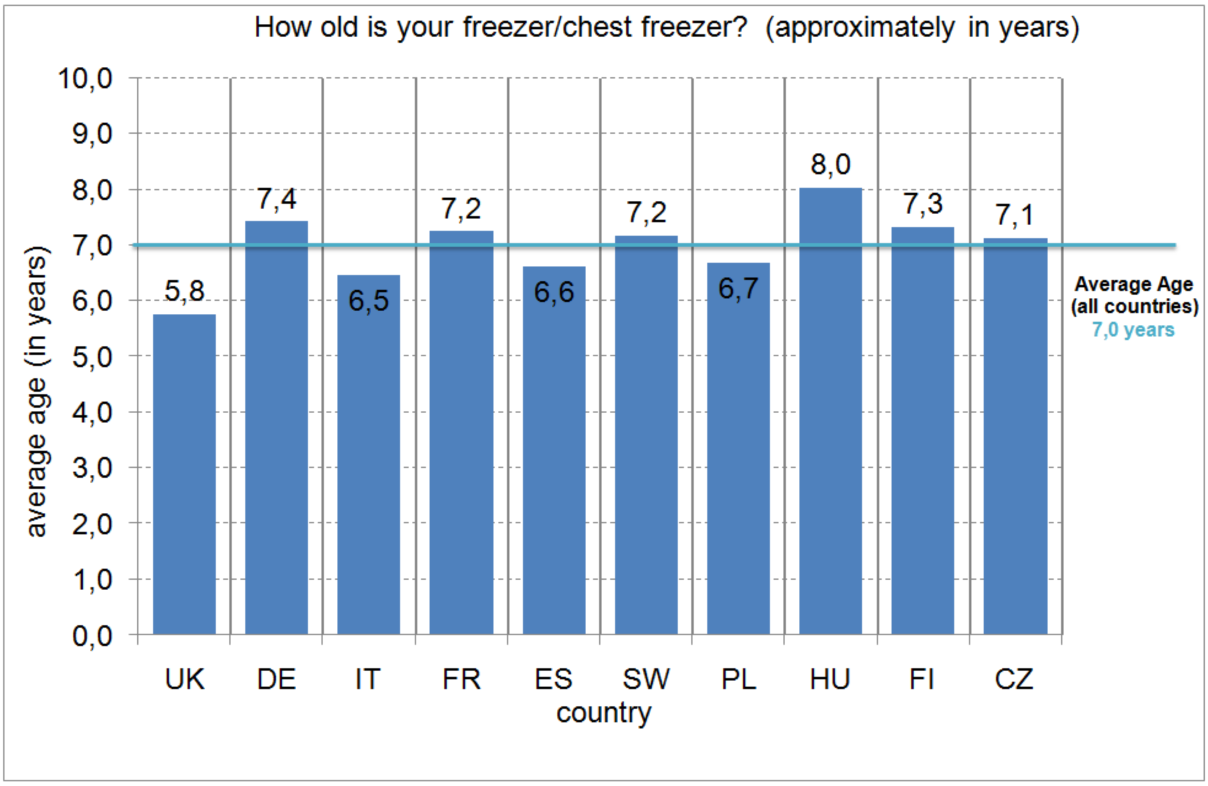


Figure 3.28: average age of the freezers of all questioned households per country

3.2.2 *Repairs*

In the survey consumers were asked whether their household appliances have been repaired or serviced. The analysis shows that 16 % (n = 1 611) of all appliances (n = 10 044) in all interviewed households have been repaired or serviced (Figure 3.29).

When looking at all countries the following figures show that only few cold appliances have been serviced. Approx. 12 % of the refrigerators (Figure 3.30) and 6,2 % and 4,2 % of the chest freezers and upright freezers, respectively have been repaired.

	total	**repaired/ serviced**
Dishwasher	1.722	309
Washing machine	2.497	750
Tumble-dryer	893	133
Refrigerator	**2.497**	**306**
Freezer	**1.871**	**78**
Chest freezer	**564**	**35**
Sum (repaired/serviced)		**1.611**
all appliances		10.044
% of all appliances		**16,0**

Figure 3.29: overview: repaired or serviced appliances

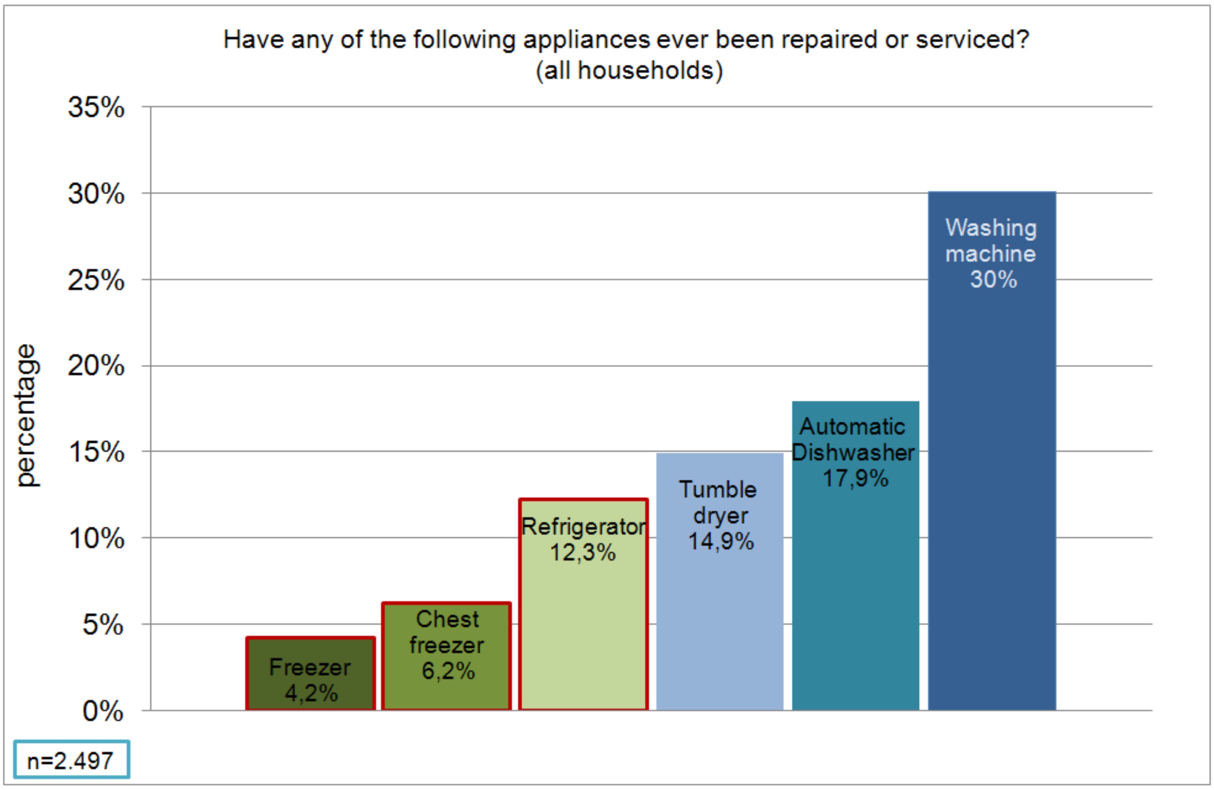
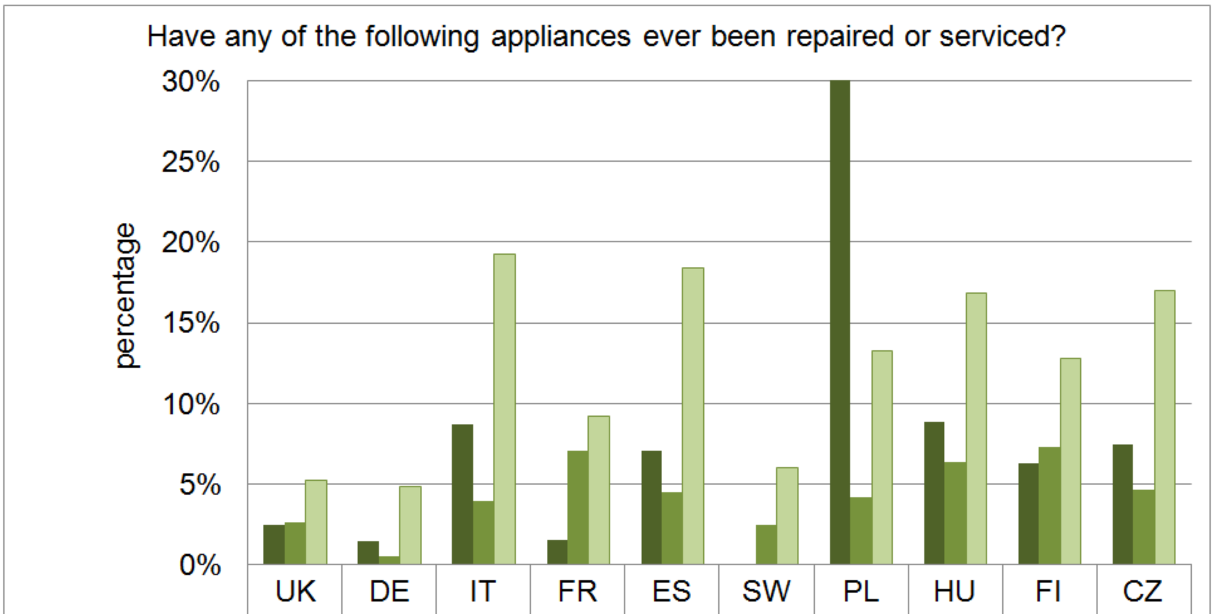


Figure 3.30: repaired or serviced appliances – cold appliances

Between 15 % and 20 % of refrigerators in Italy, Spain, Hungary and the Czech Republic have been repaired or serviced. The least share of appliances which have been repaired or serviced are determined in Germany and the UK followed by Sweden with less than or little more than 5 % (Figure 3.31).



	UK	DE	IT	FR	ES	SW	PL	HU	FI	CZ
Chest freezer	2%	1%	9%	2%	7%	0%	30%	9%	6%	7%
Freezer	3%	1%	4%	7%	4%	2%	4%	6%	7%	5%
Refrigerator	5%	5%	19%	9%	18%	6%	13%	17%	13%	17%

Figure 3.31: cold appliances repaired or serviced per country

The average age of repaired or serviced refrigerators in Europe is 7,5 years. 50 % of these appliances are younger than 5,5 years and 90 % are younger than 15 years (Figure 3.32).

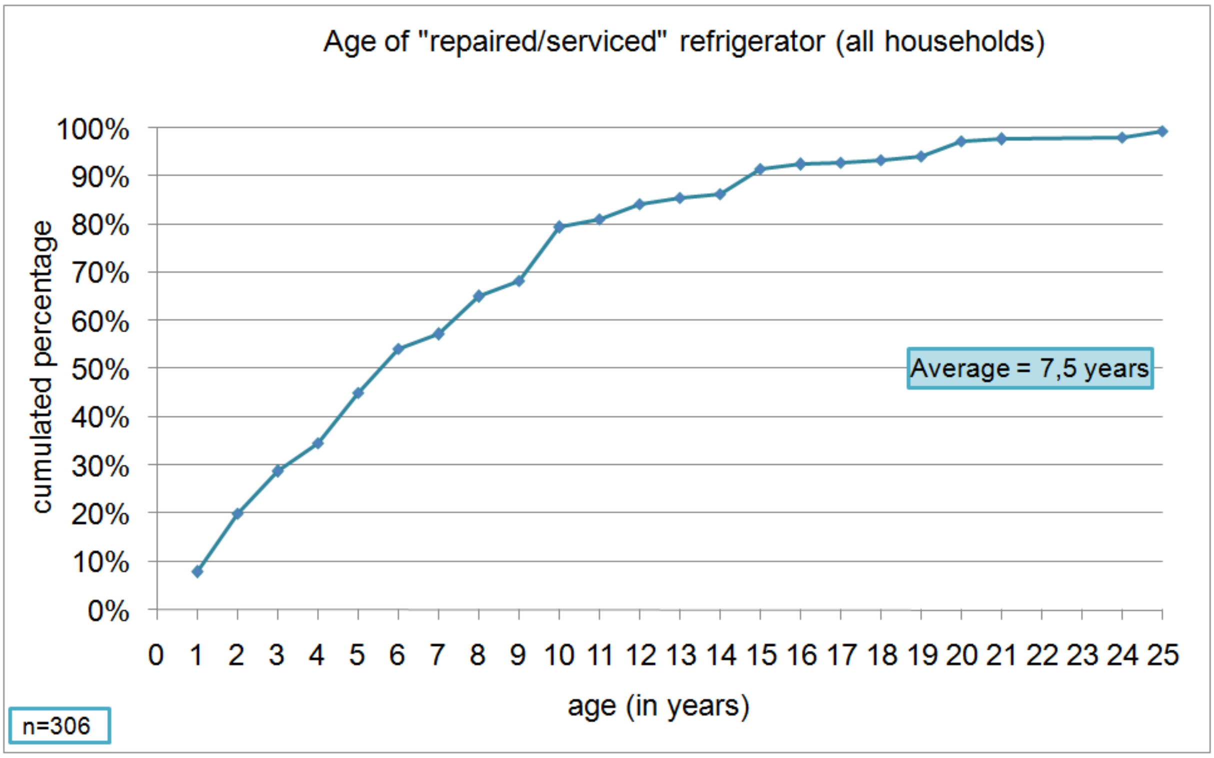


Figure 3.32 : age of repaired or serviced refrigerators in all households (EU)

The average age of repaired or serviced freezers in Europe is 8,5 years. 50 % of these appliances are younger than 6 years and 90 % are younger than 15 years (Figure 3.33).

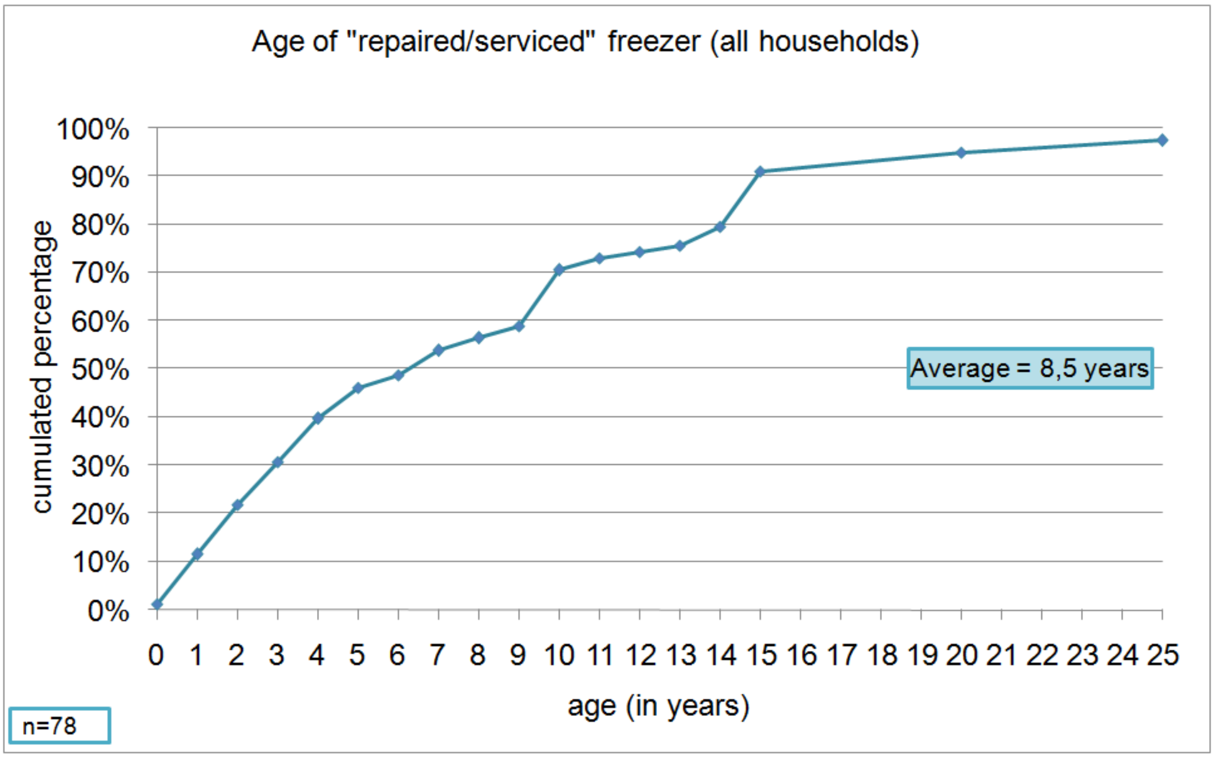


Figure 3.33: age of repaired or serviced freezers (chest/upright freezer) in all households (EU)

3.2.3 Second-hand market

Another possible barrier for the implementation of eco-design innovations is the stock of second-hand purchased appliances in households. Often consumers choose to replace broken or missing apparatuses by second-hand appliances. These are often older refrigerators/freezers with worse performances in comparison with new appliances on the market.

It is also possible that there is an existent kitchen with refrigerator/ freezer in the new apartment/ house when moving.

30 % of the questioned households in the study by LEPTHIEN[16] had a kitchen including a refrigerator already installed when they moved into their apartment/ house.

The survey shows that refrigerators are the appliances least frequently purchased second-hand of those evaluated. Only 4,9 % of the purchased refrigerators were pre-owned (Figure 3.35).

	total	**second hand**
Dishwasher	1.722	114
Washing machine	2.497	140
Tumble-dryer	893	59
Refrigerator	**2.497**	**122**
Freezer	**1.871**	**118**
Chest freezer	**564**	**80**
Sum (second hand)		**633**
all appliances		10.044
% of all appliances		**6,3**

Figure 3.34: overview: second hand appliances

[16] LEPTHIEN K. (2000): Umweltschonende Nutzung des Kühlgerätes im privaten Haushalt, Bonn, Rheinische Friedrich-Wilhelms-Universität, Diss. oec.troph

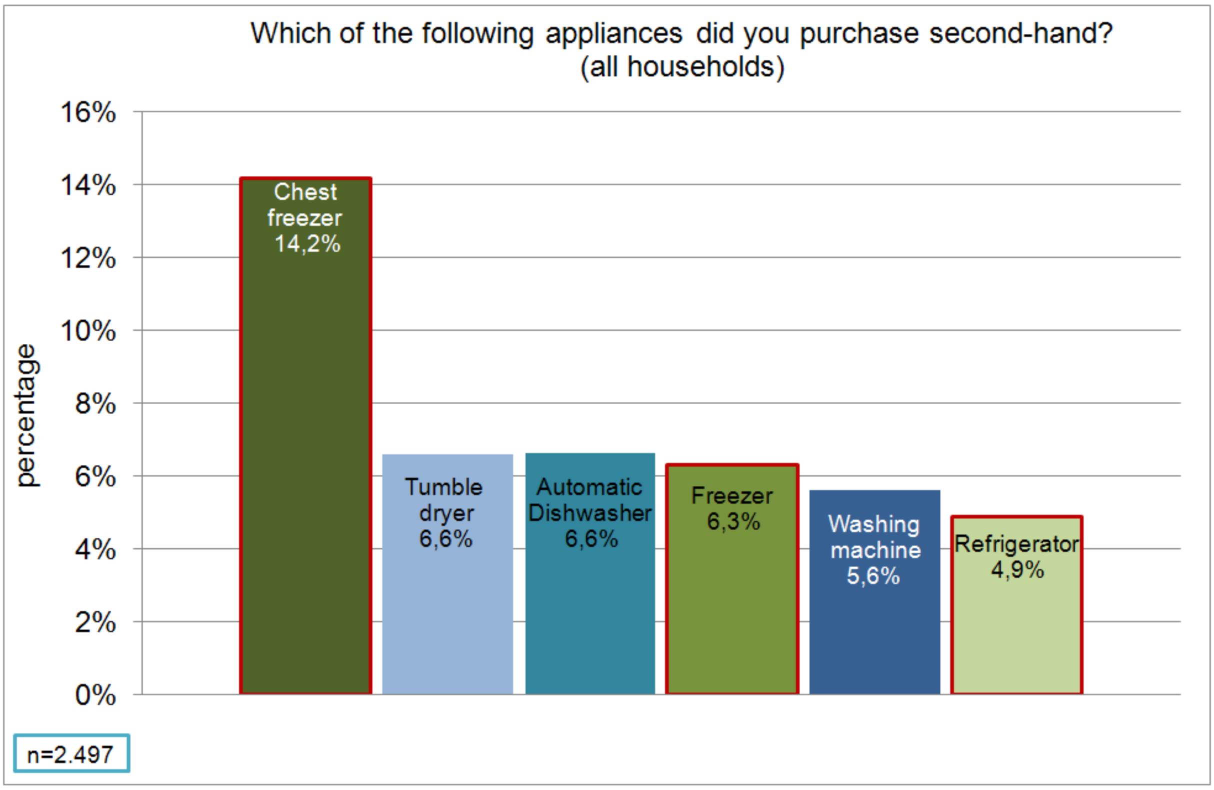
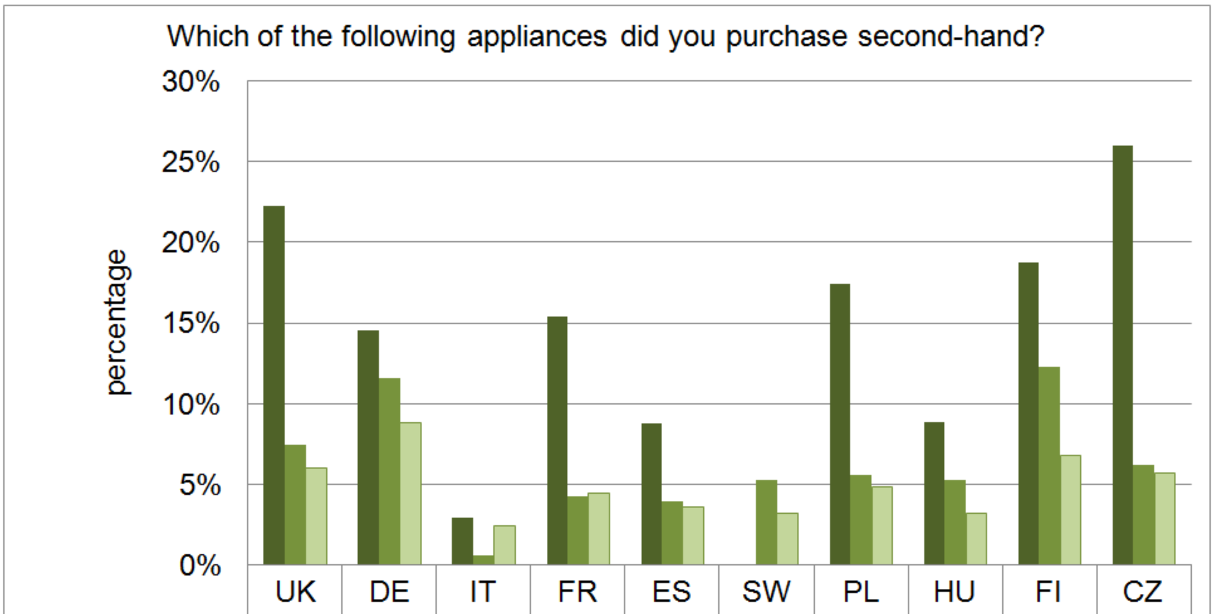


Figure 3.35: appliances purchased second-hand

Chest freezers are the appliances most frequently purchased second-hand 14,2 %. 6,3 % of all freezers were previously owned before purchase (Figure 3.35).

When comparing countries it can be seen that chest freezers are most often bought second-hand in the Czech Republic, with 25 % of the appliances, and the UK, with more than 20 %. In Sweden none of the chest freezers are purchased second-hand. Upright freezers are most often bought pre-owned in Finland and Germany (more than 10 %), and least frequently in Italy. German households are the ones with the most second-hand refrigerators (approx. 9 %) followed by Finnish and British households (Figure 3.36).



	UK	DE	IT	FR	ES	SW	PL	HU	FI	CZ
Chest freezer	22%	14%	3%	15%	9%	0%	17%	9%	19%	26%
Freezer	7%	12%	1%	4%	4%	5%	6%	5%	12%	6%
Refrigerator	6%	9%	2%	4%	4%	3%	5%	3%	7%	6%

Figure 3.36: cold appliances purchased second-hand per country

The average age of second-hand main refrigerators is 7 years. 50 % of the appliances are younger than 5 years, 90 % are younger than 13 years (Figure 3.37).

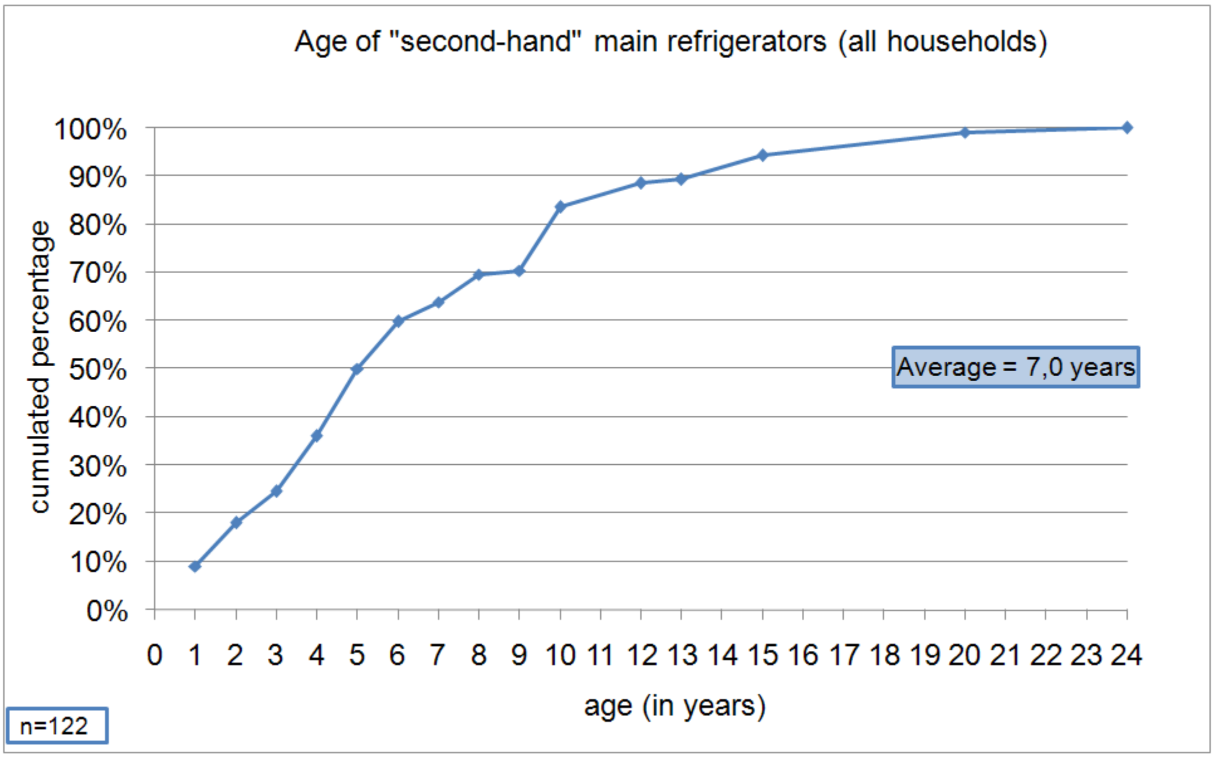


Figure 3.37: age of „second-hand“ main refrigerators in all households (EU)

The average age of second-hand freezers is 9 years. 50 % of the appliances are younger than 7,5 years, 90 % are younger than 17 years (Figure 3.38).

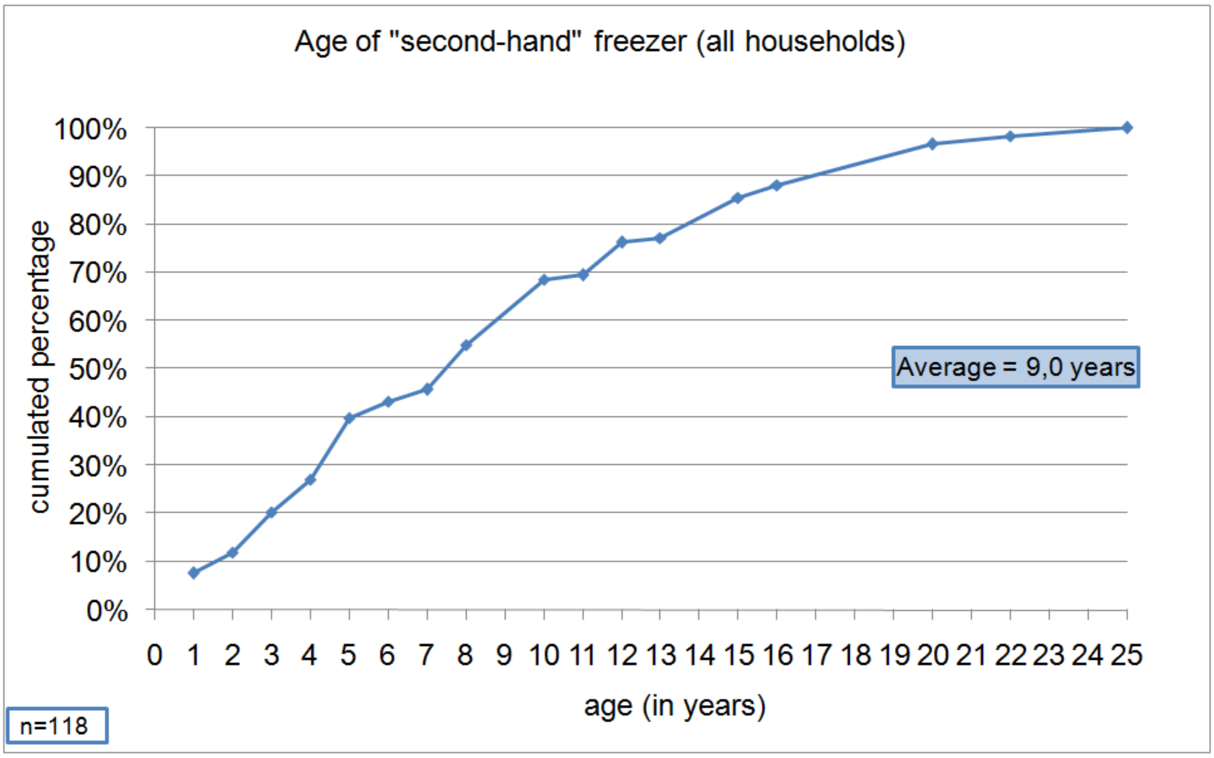


Figure 3.38: age of „second-hand" freezers (chest/upright freezer) in all households (EU)

3.2.4 Food safety

Another possible barrier for energy saving innovations for cold appliances is the necessity of food protection. The decrease of energy consumption can only go as far as food safety is ensured.

This means that temperatures of 3 to 5 °C need to be accomplishable so that perishable food stuffs can be stored safely. Refrigeration temperatures for perishable foods for food businesses are regulated by different institutions. According to the (UK) Food Hygiene (Amendment) Regulations 1990[17], for instance, Listeria-sensitive food should be kept at a temperature below 5 °C, less sensitive foods should be kept below 8 °C. The BGVV[18] (1999) stated that perishable foods ought to be kept at temperatures below 7 °C to reduce microbial growth. In France it is regulated by decree no. 2002-478[19] from April 2002 that every domestic refrigerator has to offer a designated zone which maintains a temperature of max. 4 °C. The refrigerators need to be equipped with a binary thermometer with a gradation of max. 0,5 °C.

Some pathogenic micro-organisms can survive and reproduce at refrigeration temperatures (the lower the less) and are able to cause food borne diseases. Between 1992 and 1999 35,9 % of all

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17 MINISTRY OF AGRICULTURE, FISHERIES AND FOOD, THE SECRETARY OF STATE FOR HEALTH & THE SECRETARY OF STATE FOR WALES (1990): Food Hygiene (Amendment) Regulations 1990; Online: http://www.opsi.gov.uk/si/si1990/Uksi_19901431_en_1.htm [11/26/06]

18 BGVV BUNDESINSTITUT FÜR GESUNDHEITLICHEN VERBRAUCHERSCHUTZ UND VETERINÄR-MEDIZIN (1999): Temperaturanforderungen und -empfehlungen für Lebensmittel Online: http://www.obersllgaeu.orgse_data-/_filebank/luew/temperatur.pdf [11/28/06]

19 Décret no. 2002-478 (2002): DECRET NO 2002-478 DU 3 AVRIL 2002 RELATIF AUX REFRIGERATEURS A USAGE DOMESTIQUE, AUX THERMOMETRES ET AUTRES DISPOSITIFS DESTINES A INDIQUER LA TEMPERATURE DANS CES APPAREILS. FRANCE

registered intoxications were linked to consumption of contaminated food at home[20]. The WHO Surveillance programme for Germany evaluated the treatment of food which had been the cause of infection. It was found that in 1999 and 2000 the most frequently indicated treatment of the food was wrong storage in the refrigerator with 13 % and 23 %, respectively[21].

According to the WHO inadequate temperatures were the cause for 44 % of food borne diseases in Europe. This includes insufficient cooling[22].

3.3 USER DEFINED PARAMETERS

3.3.1 Consumer behaviour in terms of energy consumption and saving

a) Refrigerator

Different institutions have dealt with the questions of how consumer behaviour with refrigerators influences energy consumption and how to alter this behaviour to save energy.

Consumer organisations give information on this matter through their consumer magazines. In Germany these are, i.e. STIFTUNG WARENTEST, ÖKOTEST and the AGV (Arbeitsgemeinschaft Verbraucherverbände e.V.). In the USA this is, i.e. the US DEPARTMENT OF ENERGY, and in Canada the MINISTRY OF ENERGY. Different Universities also research this matter, i.e. the University of Bonn, Germany, the Mississippi State University and University of Florida, USA.

The factors said to influence the energy consumption of a refrigerator are:

- interior temperature of the refrigerator
- room temperature
- loading of refrigerator/ insertion of goods
- door openings
- location near a heat source
- possibility of ventilation
- condition of gasket seals

Refrigerator temperature

The interior temperature has a great influence on the energy consumption of the refrigerator. According to BÖHMER & WICKE[23] (1998) a 13 % reduction of energy consumption is possible by

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[20] Kraemer J. (2002): Lebensmittelmikrobiologie, Verlag Eugen Ulmer, Stuttgart

[21] WHO Surveillance Programme for Control of Foodborne Infections and Intoxications in Europe 8th Report 1999-2000 Country Reports: Germany, Online: http://www.bfr.bund.de/internet/8threport/CRs/deu.pdf

[22] WHO (2004): Food and health in Europe: a new basis for action, WHO Regional Publications, European Series, No. 96

[23] BÖHMER T. & WICKE L. (1998): Energiesparen im Haushalt – So schonen Sie Umwelt und Geldbeutel, Deutscher Taschenbuch Verlag

keeping the interior temperature at 7 °C instead of 5 °C. LEPTHIEN[24] (2000) showed that by increasing the refrigerator temperature from 5 °C to 7-7,5 °C energy use can be reduced up to 28 %.

Different European studies[25, 26, 27] show that the mean interior temperature of refrigerators lies between 6 and 7 °C. A study in New Zealand[28] evaluated a mean temperature of 4,5 °C and a study in Malaysia[29] found a mean temperature of 2 °C (Figure 3.39).

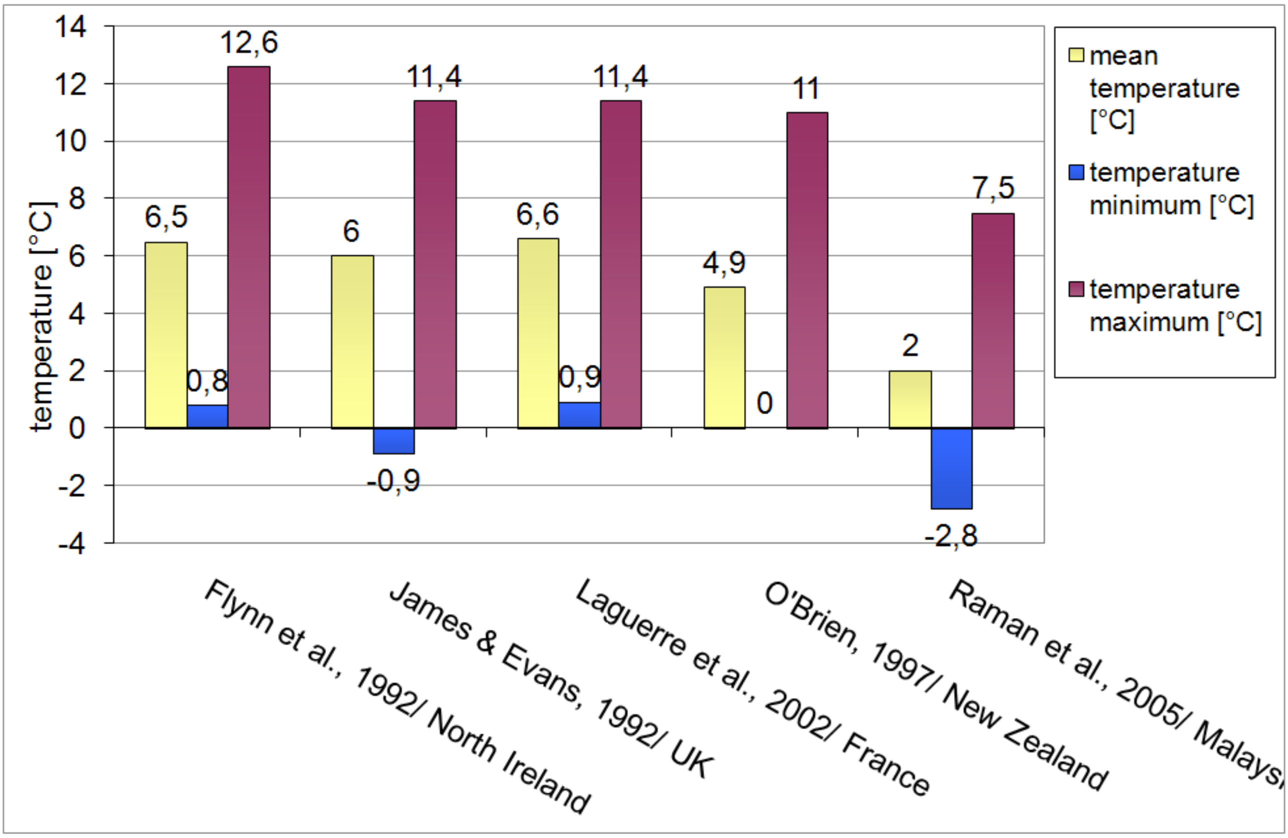

Figure 3.39: mean refrigerator temperature evaluated in different studies

According to JAMES & EVANS[30] (1992a) 32,8 % of the 252 study participants adjust their refrigerator temperature according to the weather, lowering the temperature in summer. A survey[31]

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[24] LEPTHIEN K. (2000): Umweltschonende Nutzung des Kühlgerätes im privaten Haushalt, Bonn, Rheinische Friedrich-Wilhelms-Universität, Diss. oec.troph

[25] FLYNN O.M.J., BLAIR I. & MCDOWELL D. (1992): The efficiency and consumer operation of domestic refrigerators, *Int. J. Refrig.* **15**, 307-312

[26] JAMES S.J. & EVANS J. (1992a): Consumer handling of chilled foods: Temperature performance, *Int. J. Refrig.* **15**, 299-306

[27] LAGUERRE O., DERENS E. & PALAGOS B. (2002): Study of domestic refrigerator temperature and analysis of factors affecting temperature: a French survey, *Int. J. Refrig.* **25**, 653-659

[28] O'BRIEN G.D. (1997): Domestic refrigerator air temperatures and the public's awareness of refrigerator use, *Int. J. Environ. Health Res.* **7**, 141-148

[29] RAHMAN S., MOHD SIDIK N., HASSAN M.H.J., MOHD ROM T. & JAUHARI I. (2005): Temperature Performance and Usage Conditions of Domestic Refrigerator-freezers in Malaysia, *Transactions* **12,** 30-35

[30] JAMES S.J. & EVANS J. (1992a): Consumer handling of chilled foods: Temperature performance, *Int. J. Refrig.* **15**, 299-306

in the UK showed that 50 % of the 1 093 questioned people adjust their refrigerators according to ambient temperature, whereas 35 % never alter the setting.

Adequate temperature for food preservation

In France it is regulated by decree no. 2002-478[32] from April 2002 that every domestic refrigerator has to offer a designated zone which maintains a temperature of max. 4 °C. The refrigerators need to be equipped with a binary thermometer with a gradation of max. 0,5.

BEM & HECHELMANN[33] (1994) as well as KREYENSCHMIDT[34] (2003) show that the shelf life of poultry is highly reduced when kept at higher temperatures. When stored at 4 °C the quality of the meat samples was still acceptable after approx. 5-6 days whereas the same state of quality was reached after as little as 2-3 days at storage temperatures of 10 °C. According to ALMONACID-MERINO & TORRESE[35] (1993) shelf-life of foods can be reduced significantly (20-30 %) when stored at room temperature even when this period is only a small fraction of total storage time (2-3 %). GILL[36] (1986) reported that microbial growth is bisected when temperature is reduced by 10 °C.

Room temperature

Room temperature also influences the energy use of refrigerators.

The HESSIAN MINISTRY OF ECONOMY, TRANSPORT, URBAN AND REGIONAL DEVELOPMENT[37] (HMWVL 2005) stated that keeping a room temperature of 21-23 °C instead of 25 °C can save 16 % of energy use. As reported there a room temperature of 17-21 °C can save 32 % and a temperature of 13-17 °C can save 53 % of energy use. STIFTUNG WARENTEST[38] (1994) indicates a reduced energy consumption of 47 % when the refrigerator is located in a room with a temperature of 16 °C instead of 25 °C whereas a higher temperature of 32 °C instead of 25 °C increases energy use by 55 %. According to PEART[39] (1993) setting the house thermostat at approx. 18 °C in winter instead of 21 °C would save 12 kWh/ year. The Study of LEPTHIEN[40] (2000) shows that refrigerators use 18 to 19 % less energy in a room which has a temperature of 20 °C instead of 25 °C. According

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[31] SPRIEGEL G. (1991): Food Safety in the Home, *Nutr. Food. Sci.* **133**, 14-1

[32] Décret no. 2002-478 (2002): DECRET NO 2002-478 DU 3 AVRIL 2002 RELATIF AUX REFRIGERATEURS A USAGE DOMESTIQUE, AUX THERMOMETRES ET AUTRES DISPOSITIFS DESTINES A INDIQUER LA TEMPERATURE DANS CES APPAREILS. FRANCE

[33] BEM Z. & HECHELMANN H. (1994): Kühlung und Kühllagerung von Fleisch – Mikrobiologische Vorgänge, *Fleischwirtschaft* **74**, 916-924

[34] KREYENSCHMIDT J. (2003): Modellierung des Frischeverlustes von Fleisch sowie des Entfärbeprozesses von Temperatur-Zeit-Integratoren zur Festlegung von Anforderungsprofilen für die produktbegleitende Temperaturüberwachung, Diss. Universität Bonn, Agrimedia Verlag, Bergen Dumme

[35] ALMONACID-MERINO S.F. & TORRESE J.A. (1993): Mathematical models to evaluate temperature abuse effects during distribution of refrigerated solid foods, *J. Food. Eng*. **20**, 223- 245

[36] GILL C.O. (1986) The Control of Microbial Spoilage in Fresh Meats, In: Pearson A.M., T.R. (eds.): Advances in Meat Research – Meat and Poultry Microbiology, Macmillian Publishers LTD, 49-88

[37] HMWVL HESSISCHES MINISTERIUM FÜR WIRTSCHAFT, VERKEHR UND LANDESENTWICKLUNG (Hrsg.) (2005): Strom effizient nutzen – Wegweiser für Privathaushalte zur wirtschaftlichen Stromeinsparung ohne Komfortverzicht

[38] STIFTUNG WARENTEST (1994): Umwelt geschont – Strom gespart, In: *Test* **3**, 36-39

[39] PEART V. (1993): The Refrigerator Energy Use Story, EES 51, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida

[40] LEPTHIEN K. (2000): Umweltschonende Nutzung des Kühlgerätes im privaten Haushalt, Bonn, Rheinische Friedrich-Wilhelms-Universität, Diss. oec.troph

to BÖHMER & WICKE[41] (1998) a reduction of the kitchen temperature of 1 °C decreases the energy consumption by 8 % (Figure 3.40).

When reducing the surrounding temperature of a refrigerator-freezer it is important to know whether the appliance has two compressors or one compressor with a magnet valve controlling two separate circulations. If this is not the case, the compressor will stop cooling when the surrounding temperature is below about 16 °C and the freezing compartment will defrost. Some appliances have a so called "winter switch" with causes the refrigerator light to burn even with closed door to heat up the refrigerator compartment. This energy input into the cooling compartment will cause the compressor to start again, keeping the freezer compartment cold. This mechanism increases energy consumption[42, 43].

JAMES & EVANS[44] (1992a) found that 72,2 % of the 252 surveyed kitchens had an ambient temperature between 17 and 23 °C (mean 20,6 °C).

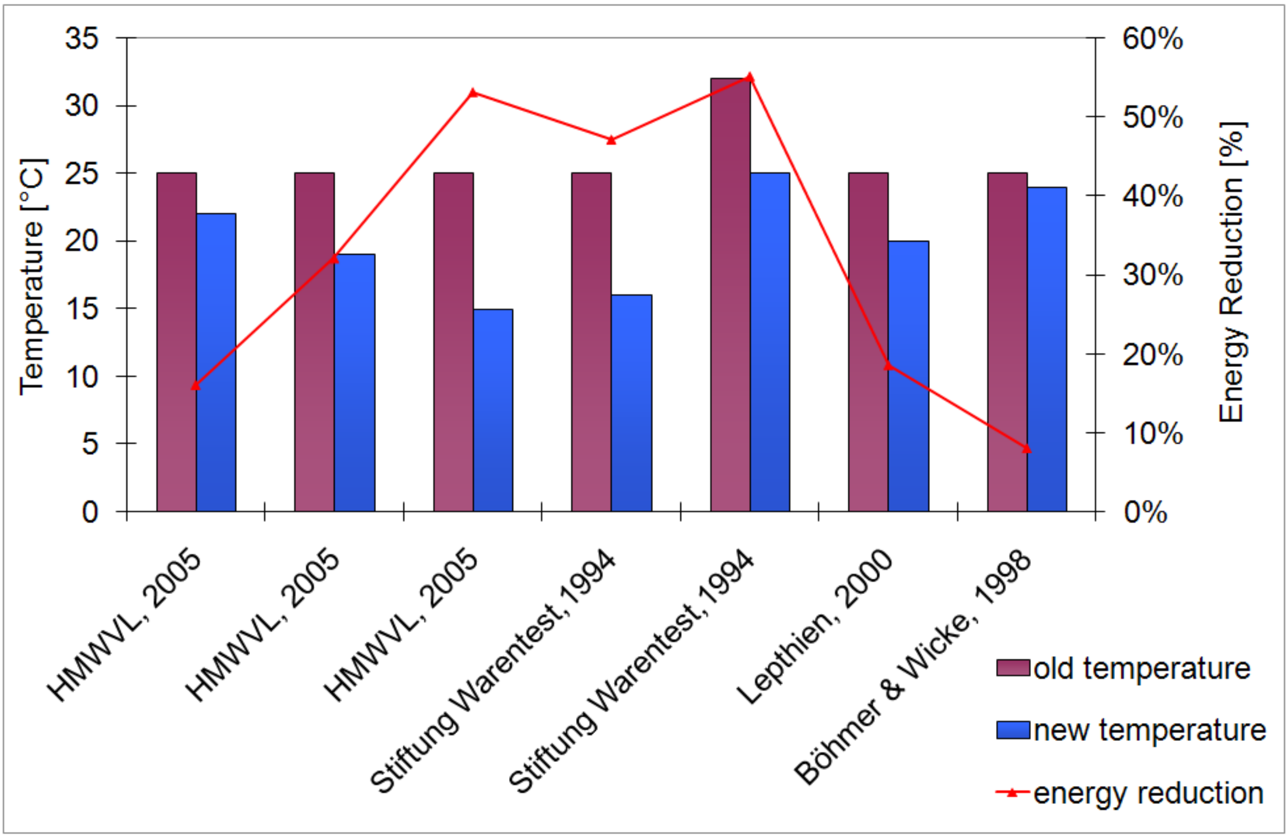

Figure 3.40: possible energy decrease after reduction of room temperature as evaluated in different studies

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[41] BÖHMER T. & WICKE L. (1998): Energiesparen im Haushalt – So schonen Sie Umwelt und Geldbeutel, Deutscher Taschenbuch Verlag

[42] PLATZ B. (2007): Kühlgefrierkombinationen - heimlich brennt das Licht, broadcast from 03.02.2007 17:03 Uhr (NDR) http://daserste.ndr.de/ardratgebertechnik/archiv/haushalt_garten/t_cid-3646502_.html [02/20/2007]

[43] NIPKOW J. (2002): Klimaklassen von Haushalt-Kühl-/Gefriergeräten, S.A.F.E Schweizerische Agentur für Energieeffizienz/ Swiss agency for efficient energy use (www.energieeffizienz.ch)

[44] JAMES S.J. & EVANS J. (1992a): Consumer handling of chilled foods: Temperature performance, *Int. J. Refrig.* **15**, 299-306

Insertion of goods

The insertion and storage of hot or cold goods in the refrigerator is also reported as having influence on the energy consumption of the refrigerator. BÖHMER & WICKE[45] (1998) stated that the insertion of food or storage containers into the refrigerator uses 10 % of the energy consumption. Bisecting the insertion can only save 5 % of energy use. On the other hand a lot of energy can be wasted by setting hot goods into the refrigerator. Cooling of food with a temperature of 50 °C uses thrice the energy than cooling of food with a temperature of 20 °C. LEPTHIEN[46] (2000) found that thawing frozen food in the refrigerator can reduce energy consumption up to 26 %. Thawing of frozen foods inside the refrigerator also protects food from getting to warm and from increased bacterial growth[47].

A Study in New Zealand[48] shows that 48 % of the 50 questioned people rarely and 30 % never place hot foods into the refrigerator and that 70 % always cool their foods adequately before placing them into the refrigerator.

Door openings

Consumer information given by Ministries or Universities advises people to open the refrigerator door as infrequently as possible. According to PEART[49] (1993) forty door openings per day can add 50 to 120 kWh per year to the energy bill. GRAHAM[50] (1997) gives advice to install vinyl flaps to the refrigerator to keep cool air from escaping to save up to 10-20 % of energy use. BÖHMER & WICKE[51] (1998) report that losses through air change make up 3 % of the total energy consumption of a refrigerator. The study by LEPTHIEN[52] (2000) showed that 20 door openings per day generate an increase of energy consumption of 1 to 6 %. According to LIU et al.[53] (2004) 50 five second door openings within 10 hours generate an increase in energy consumption of 5-10 % at an ambient temperature of 15 °C. JAMES & EVANS[54] (1992b) evaluated the effect of door openings on the refrigerator temperature and found that after a 3-minute door opening it took one hour to reduce the temperature within 1 °C of the original temperature.

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[45] BÖHMER T. & WICKE L. (1998): Energiesparen im Haushalt – So schonen Sie Umwelt und Geldbeutel, Deutscher Taschenbuch Verlag

[46] LEPTHIEN K. (2000): Umweltschonende Nutzung des Kühlgerätes im privaten Haushalt, Bonn, Rheinische Friedrich-Wilhelms-Universität, Diss. oec.troph

[47] SØRENSEN L.B.: Frozen Food Legilation, Bulletin of the IIR, No 2002-4

[48] O'BRIEN G.D. (1997): Domestic refrigerator air temperatures and the public's awareness of refrigerator use, *Int. J. Environ. Health Res.* **7**, 141-148

[49] PEART V. (1993): The Refrigerator Energy Use Story, EES 51, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida

[50] GRAHAM F. (1997): Refrigerators & Freezers, Mississippi State University Extension Service, Online: http://msucares.com/newsletters/housing/19970411.html (last modified 31-Aug-01) [11/03/2006]

[51] BÖHMER T. & WICKE L. (1998): Energiesparen im Haushalt – So schonen Sie Umwelt und Geldbeutel, Deutscher Taschenbuch Verlag

[52] LEPTHIEN K. (2000): Umweltschonende Nutzung des Kühlgerätes im privaten Haushalt, Bonn, Rheinische Friedrich-Wilhelms-Universität, Diss. oec.troph

[53] LIU D.-Y., CHANG W.-R. & LIN J.-Y. (2004): Performance comparison with effect of door opening on variable and fixed frequency refrigerator/freezers, *Appl. Therm. Eng.* **24**, 2281-2292

[54] JAMES S.J. & EVANS J. (1992b): The temperature performance of domestic refrigerators, *Int. J. Refrig.* **15**, 313-319

LIU et al.[53](2004) also evaluated the effect of door openings of the freezer compartment on the energy consumption of refrigerator-freezers with an ambient temperature of 30 °C. Depending on the model 15 door openings within 10 hours increase the energy consumption by 0,5-4 %.

According to the study by LAGUERRE et al.[55] (2002) 19 % of the 143 questioned people open their refrigerator less than 10 times a day, 43 % open the refrigerator 10 to 20 times a day and 38 % open it more than 20 times. A study in Malaysia[56] found that 8 % of 26 questioned households open their refrigerator less than 10 times a day, 73 % 10 to 20 times a day and 19 % open the refrigerator more than 20 times a day (Figure 3.41).

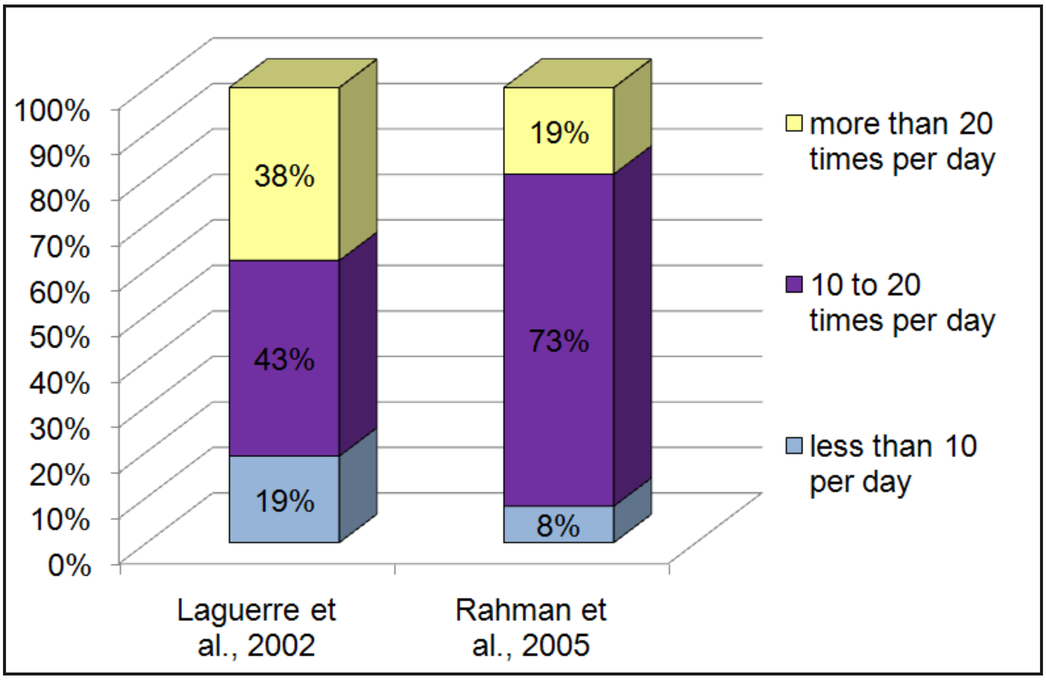

Figure 3.41: frequency of door openings per day as evaluated in two studies

Location

Another common advice is not to set the refrigerator next to a heat source, like an oven, dishwashing machine etc. or into direct sunlight[57, 58, 59]. LEPTHIEN[60] (2000) evaluated the effect of an oven next to the refrigerator on the energy consumption. It was found that the increase in energy use was very little (approx. 1 %).

[55] LAGUERRE O., DERENS E. & PALAGOS B. (2002): Study of domestic refrigerator temperature and analysis of factors affecting temperature: a French survey, *Int. J. Refrig.* **25**, 653-659

[56] RAHMAN S., MOHD SIDIK N., HASSAN M.H.J., MOHD ROM T. & JAUHARI I. (2005): Temperature Performance and Usage Conditions of Domestic Refrigerator-freezers in Malaysia, *Transactions* **12,** 30-35

[57] PEART V. (1993): The Refrigerator Energy Use Story, EES 51, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida

[58] BÖHMER T. & WICKE L. (1998): Energiesparen im Haushalt – So schonen Sie Umwelt und Geldbeutel, Deutscher Taschenbuch Verlag

[59] HMWVL HESSISCHES MINISTERIUM FÜR WIRTSCHAFT, VERKEHR UND LANDESENTWICKLUNG (Hrsg.) (2005): Strom effizient nutzen – Wegweiser für Privathaushalte zur wirtschaftlichen Stromeinsparung ohne Komfortverzicht

[60] LEPTHIEN K. (2000): Umweltschonende Nutzung des Kühlgerätes im privaten Haushalt, Bonn, Rheinische Friedrich-Wilhelms-Universität, Diss. oec.troph

JAMES & EVANS[61] (1992a) evaluated how frequently the refrigerator is placed near a heat source. Results are that in 25,5 % of the 252 surveyed households the refrigerator had potential heat sources on one side and in 1,2 % a potential heat source on both sides. 13,6 % of the refrigerators were free standing and 59,8 % were located away from heat sources but had a kitchen unit or wall on either one or both sides. In France[62] 30 % of the 143 questioned households had a refrigerator located near a heat source and 14 % were built-in. RAHMAN et al.[63] (2005) found that 77 % of the surveyed refrigerators were positioned near a heat source (oven, rice cooker, microwave, kettle, etc.) and 23 % were standing away from a heat source.

There is not much literature on the availability of space for ventilation so the heat can be transported away from the back of the refrigerator. LEPTHIEN[64] (2000) found that a complete inhibition of air circulation did not alter the energy consumption although the temperature between the condenser and the wall increased 3 to 5 °C. O'BRIEN[65] (1997) found that 62 % of the 50 households questioned had inadequate space around the refrigerator, accordingly 38 % left adequate space.

Condition of gasket seals

The condition of gasket seals is another characteristic which is pointed out to consumers[66, 67, 68, 69]. Heat losses of refrigerators depend – amongst others – on the quality of the door seals[70].

JAMES & EVANS[71] (1992a) found that 60 % of the refrigerator door seals in the 252 observed households were in excellent or good shape while 10 % were described as poor (torn and perished).

Consumer attitudes towards buying an energy saving refrigerator model

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[61] JAMES S.J. & EVANS J. (1992a): Consumer handling of chilled foods: Temperature performance, *Int. J. Refrig.* **15**, 299-306

[62] LAGUERRE O., DERENS E. & PALAGOS B. (2002): Study of domestic refrigerator temperature and analysis of factors affecting temperature: a French survey, *Int. J. Refrig.* **25**, 653-659

[63] RAHMAN S., MOHD SIDIK N., HASSAN M.H.J., MOHD ROM T. & JAUHARI I. (2005): Temperature Performance and Usage Conditions of Domestic Refrigerator-freezers in Malaysia, *Transactions* **12,** 30-35

[64] LEPTHIEN K. (2000): Umweltschonende Nutzung des Kühlgerätes im privaten Haushalt, Bonn, Rheinische Friedrich-Wilhelms-Universität, Diss. oec.troph

[65] O'BRIEN G.D. (1997): Domestic refrigerator air temperatures and the public's awareness of refrigerator use, *Int. J. Environ. Health Res.* **7**, 141-148

[66] PEART V. (1993): The Refrigerator Energy Use Story, EES 51, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida

[67] KNIGHT P.A. (1996): Your energy savings – a resident's handbook – Midwest edition, sponsored by U.S. Department of Energy, Illinois, Department of Commerce and Community Affairs, Chicago Rehab Network, Bickerdike Redevelopment Corporation, ComEd, and Argonne National Laboratory.

[68] GRAHAM F. (1997): Refrigerators & Freezers, Mississippi State University Extension Service, Online: http://msucares.com/newsletters/housing/19970411.html (last modified 31-Aug-01) [11/03/2006]

[69] ONTARIO MINISTRY OF ENERGY (2006): Refrigerator, Online: http://www.energy.gov.on.ca-/index.cfm?fuseaction=conservation.tips_refrigerator (© 2006) [11/03/2006]

[70] COLD II – The revision of energy labelling and minimum energy efficiency standards for domestic refrigeration appliances – FINAL REPORT 2000

[71] JAMES S.J. & EVANS J. (1992a): Consumer handling of chilled foods: Temperature performance, *Int. J. Refrig.* **15**, 299-306

A survey[72] of 1 000 Italian and 1 000 German consumers showed that 84 % of Italians and 63 % of Germans preferred a refrigerator with energy class A rather that class C, 8 % of Italian respondents and 21 % of German respondents indicated they did not. According to this evaluation between 76 and 80 % of the Italian consumers and 53 - 56 % of German consumers were interested in buying an energy efficient refrigerator for a higher purchasing price when this meant that they could save on the electricity bill.

LEPTHIEN[73] (2000) asked 100 people whether energy consumption and environmental compatibility of a refrigerator were important to them when buying a new appliance. This was considered very important to 58 % and 54 %, respectively.

Summary/ conclusion

Studies and literature show that a change of behaviour can help decrease energy consumption of cold appliances. From what has been found, the following recommendations can be given to consumers for energy saving purposes:

- Increasing of interior temperature of the refrigerator to approximately 7 °C, if no perishable food is stored,
- Place the refrigerator in a room of 20 °C temperature (or lower where applicable),
- Cooling of prepared food to room temperature before placing into refrigerator,
- Defrosting frozen food inside the refrigerator,
- Replacement of old by new and more efficient refrigerator or freezer,
- Selection of a refrigerator/freezer unit with two compressors or one compressor with a magnet valve controlling two separate circulations,
- Exchanging loose or torn gaskets to ensure leak-proof closing of the door.

Advising consumers to open the refrigerator door less frequently or to relocate the appliance further away from potential heat sources does not seem necessary because the influence of these factors is little.

b) Freezer

Because there is not much literature available dealing with the consumer behaviour with freezers in terms of energy consumption, it can only be assumed that consumers handle their freezers in a similar manner as their refrigerators.

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[72] COLD II – The revision of energy labelling and minimum energy efficiency standards for domestic refrigeration appliances – FINAL REPORT 2000

[73] LEPTHIEN K. (2000): Umweltschonende Nutzung des Kühlgerätes im privaten Haushalt, Bonn, Rheinische Friedrich-Wilhelms-Universität, Diss. oec.troph

3.3.2 *Results of the consumer survey*

a) Refrigerator

An important role for the performance and energy consumption of a refrigerator plays the ambient temperature of the room where the appliance stands. Accordingly the participating household of the consumer survey in 10 European countries were asked what the minimum and maximum temperatures are of the room where the refrigerator is placed. The analysis of the answers of all households (n = 2 497) shows that the *average <u>maximum</u> temperature* is 24,4 °C (Figure 3.42). In approximately 30% of all households the maximum room temperatures is between 20 and 23 °C, especially in Germany more than 65 % of all consumers answered that the ambient temperature reached maximal 23 °C, and additional 24 % less than 31 °C. But in some countries like in Spain (10,8 %) or in Italy (6,0 %) the ambient room temperature in the room where the refrigerator stands reached values of over 36 °C (Figure 3.42).

The *average <u>minimum</u> ambient temperature* is 14,6 °C (Figure 3.43).

Approximately 44 % of all households have minimum temperatures in the room where the refrigerator stands of between 16°C - 19°C. In United Kingdom and Spain between 40 % up to over 50 % of all households have an ambient room temperature of under 11 °C and even in some countries like UK, Germany, Italy or Spain over 20 % of the consumers answered that the minimum ambient temperature lies at less than 7 °C.

Especially Italian, Spanish and Hungarian households presented the highest temperatures which also had the lowest temperatures (Figure 3.42). Interesting are also the results of northern countries. Here e.g. in Finnish and Swedish households the minimum temperature is higher in comparison with the other countries while these countries have the coldest maximum temperatures (Figure 3.42).

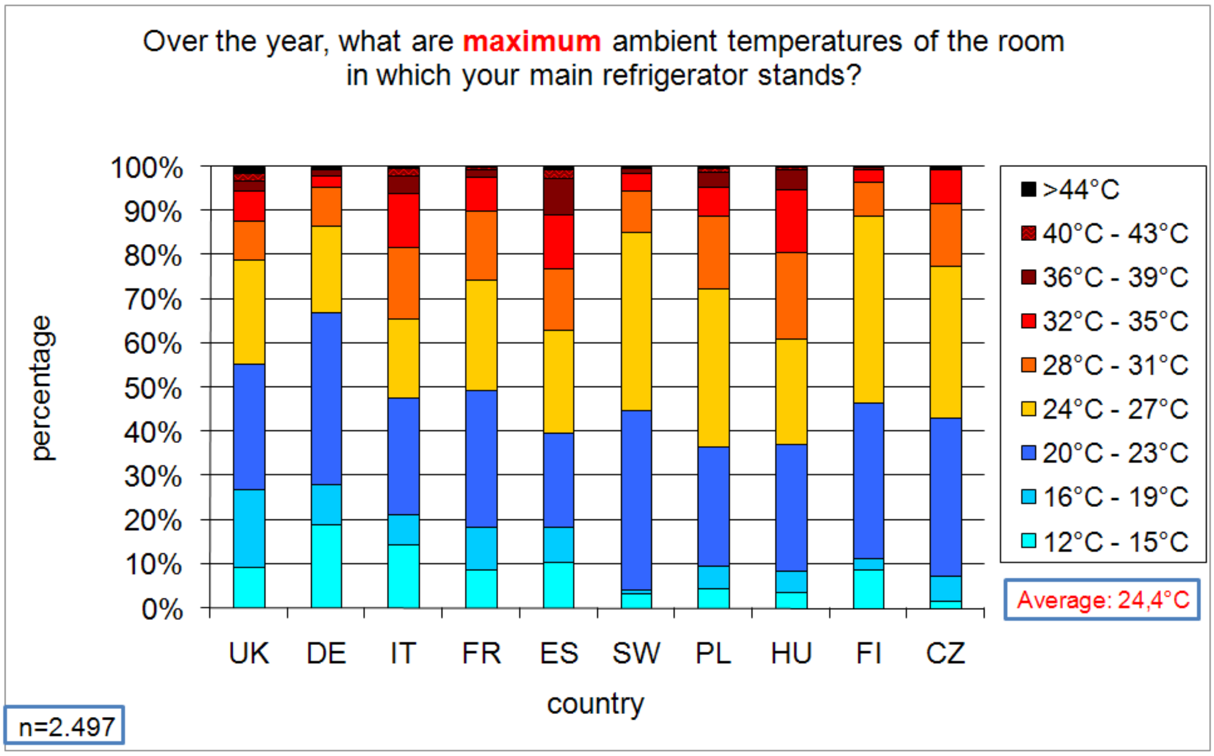


Figure 3.42: refrigerator: maximum ambient room temperature per countries

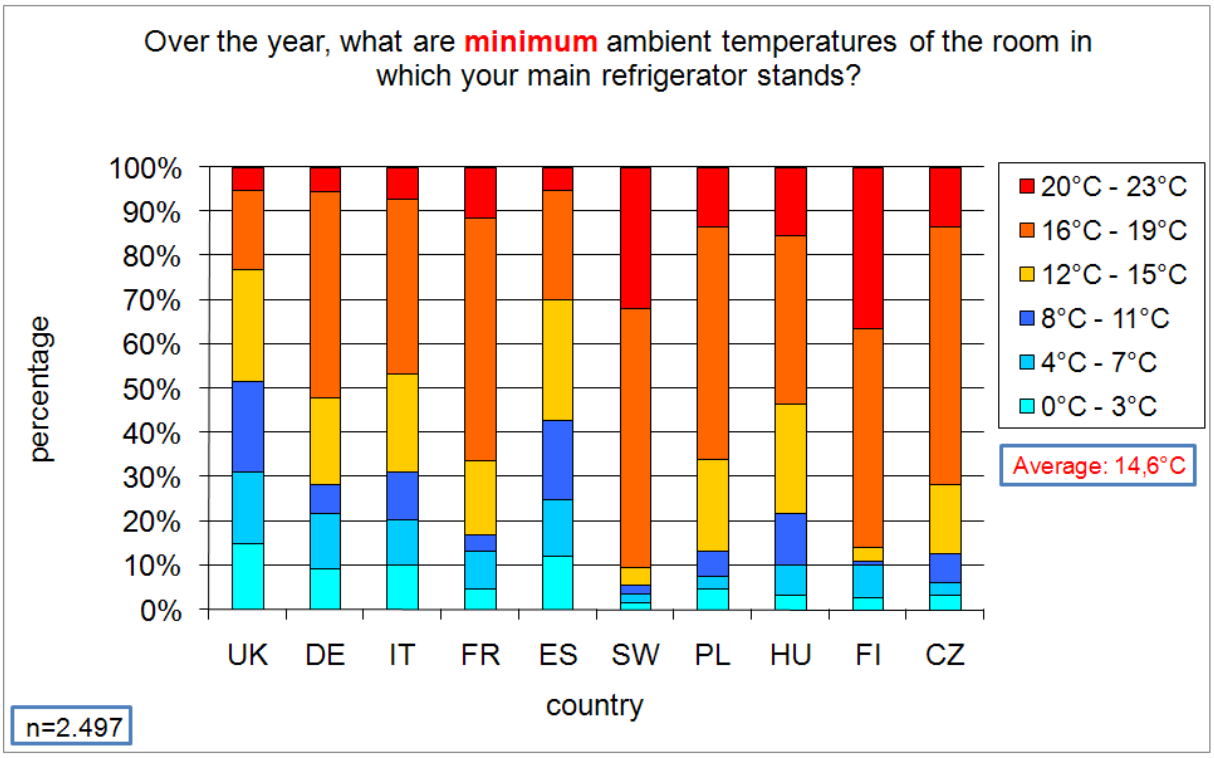


Figure 3.43: refrigerator: minimum ambient room temperature per countries

When the results of the data/statements of maximum and minimum ambient room temperatures are set in contrast with each other an average room temperature in all households of 19,5 °C can be calculated (Figure 3.44).

Furthermore a total of 49,7 % of all consumers said that they have a minimum respectively maximum room temperature of 15 °C or lower (Figure 3.44). Actually in 23,5 % of all households temperatures of 11 °C or lower are reached. On the other hand in 3,6 % of all interviewed households the room temperature lies at 36 °C or higher (Figure 3.44).

More than 40 % of all households mentioned a minimum temperature between 16 and 19 °C and over 30 % a maximum temperature of between 20 and 23 °C. But although a high share of consumers (28,6 %) answered that the maximum temperature of the room where the refrigerator stands reached more than 24 °C up to 27 °C.

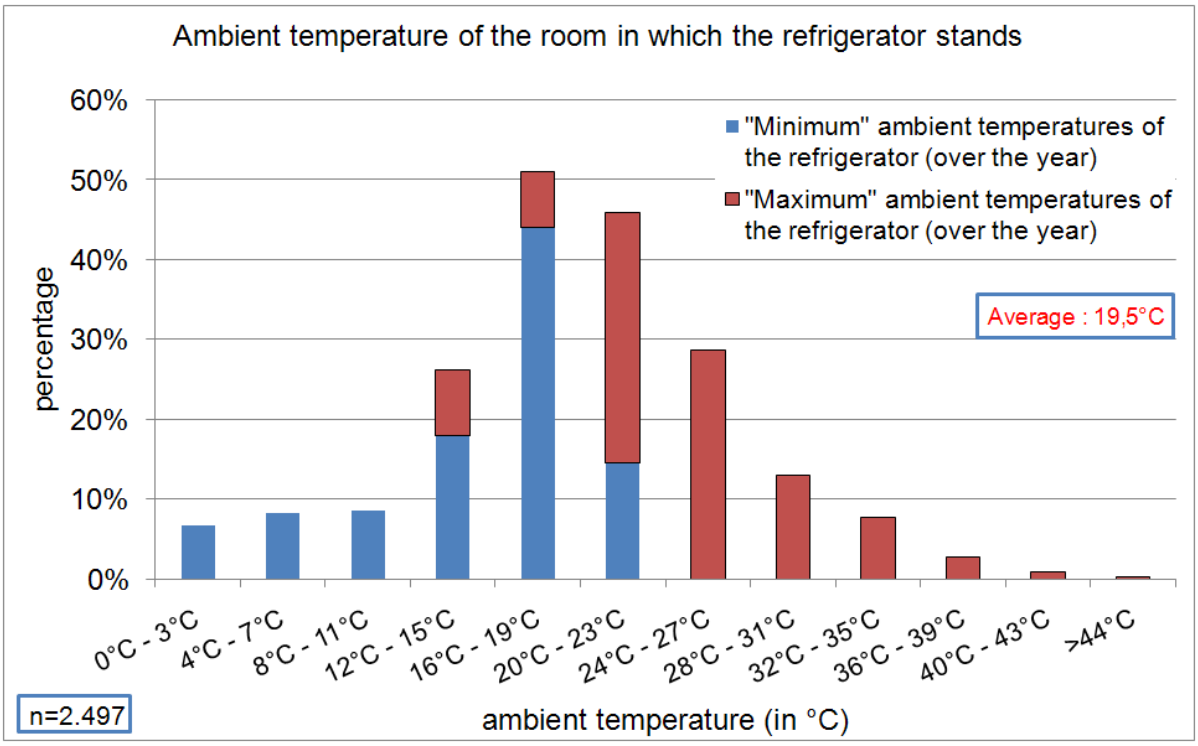


Figure 3.44: refrigerator: comparison of minimum and maximum ambient room temperature

A detailed look at the ambient room temperature differences of each individual household shows that especially in Spanish, British and Italian households the differences are higher than in other countries. Especially in Spain and United Kingdom differences of over 28 K could be determined in nearly 5 % up to 7 % of all households (Figure 3.45). The smallest temperature differences show the results of the statements of Swedish, Finnish, German, French and Czech households. From these countries, especially households of the northern countries (SW, FI), about 80 % of the households reached a temperature difference of maximally 8 K.

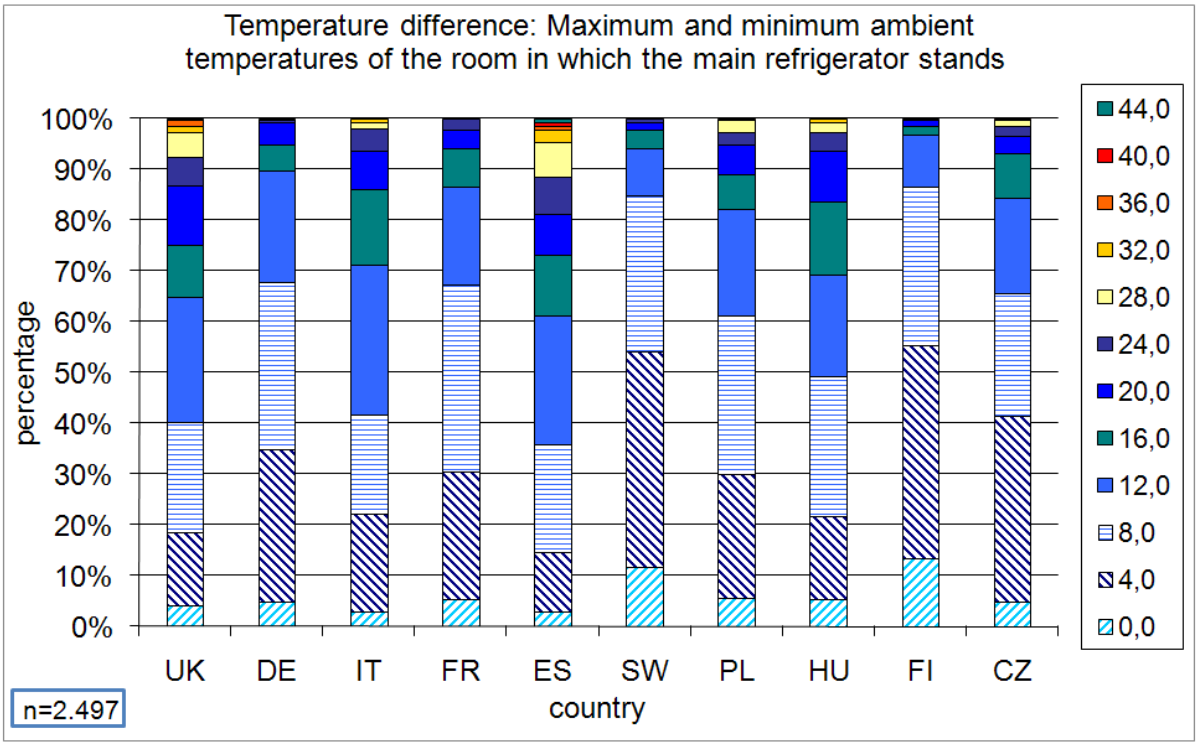


Figure 3.45: refrigerator: temperature differences - Location of the appliances

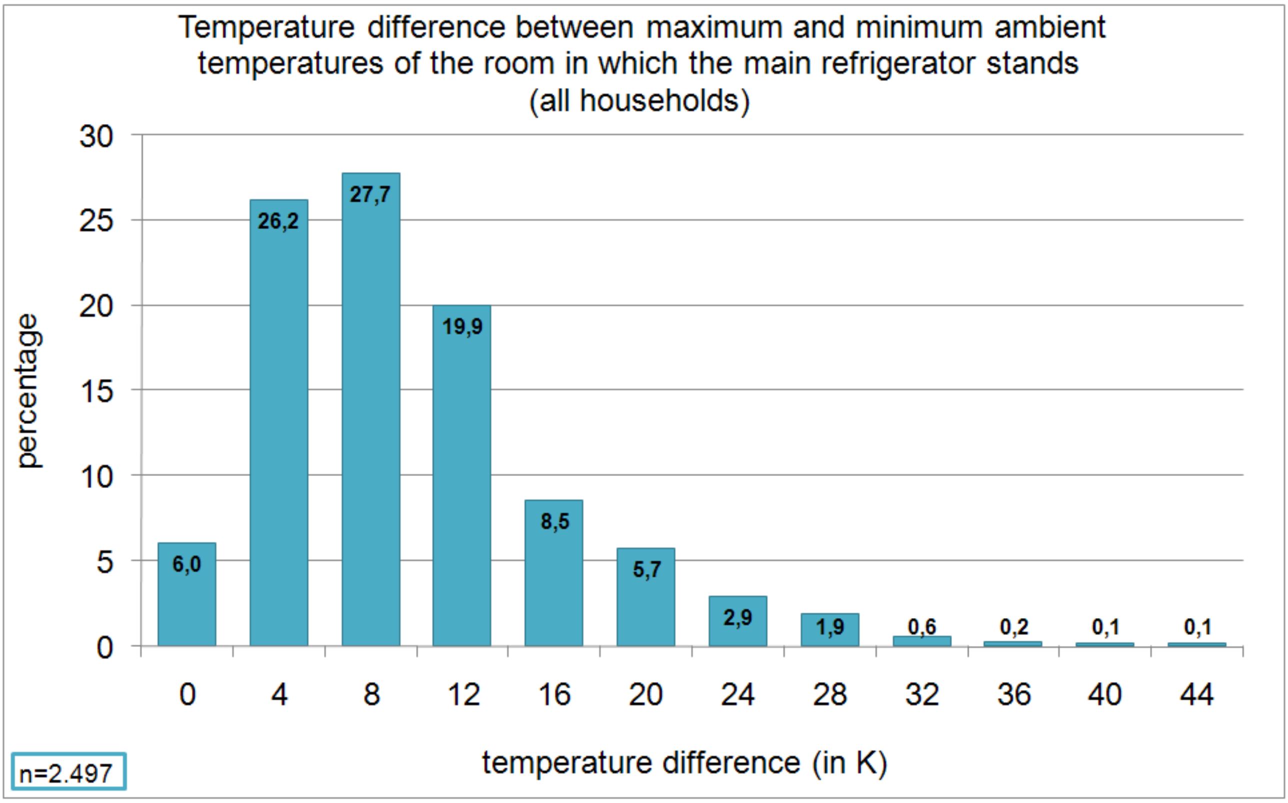


Figure 3.46: refrigerator: frequency of temperature differences - location of the appliances

About 32 % of all households can be characterized by a temperature difference of the ambient room temperature where the refrigerator stands of less than 8 K and about 80 % of all interviewed households show temperature differences of ≤ 12 K. In approximately 20 % of all participating households temperature differences are ≥ 16 K (Figure 3.46). These data can be interpreted as two different placements of refrigerators: either it is placed in a heated room (e.g. kitchen) with relatively constant temperatures over the year or it is placed in an unheated room (e.g. garage, balcony, household working room or cellar) with temperatures following more or less the ambient temperature change during the year.

To represent the real life behaviour of consumers in using a refrigerator, data about the actual temperature setting of the refrigerator were collected too. In average the actual temperature setting, when possible, adjusted in degree Celsius, is 5,0 °C (Figure 3.47). 20 % of all participants adjust their refrigerator to temperatures from 6,5 up to12 degree Celsius (Figure 3.48).

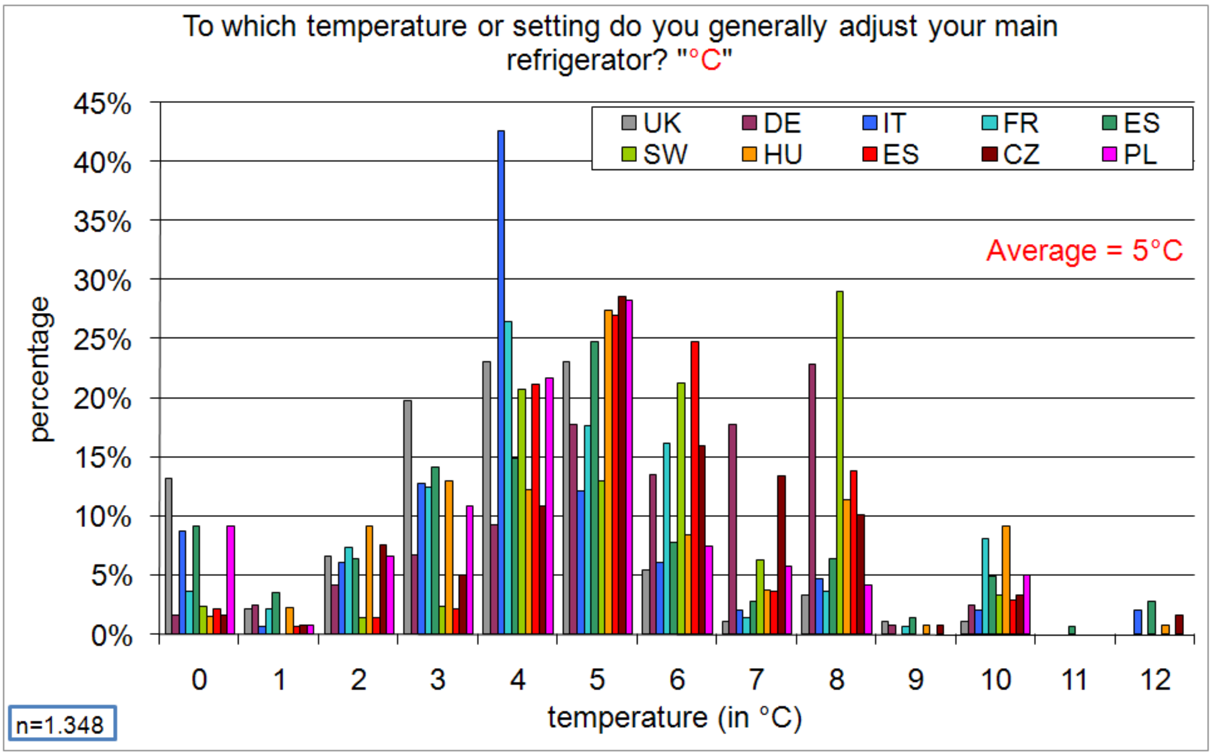


Figure 3.47: refrigerator: temperature adjustment in °C

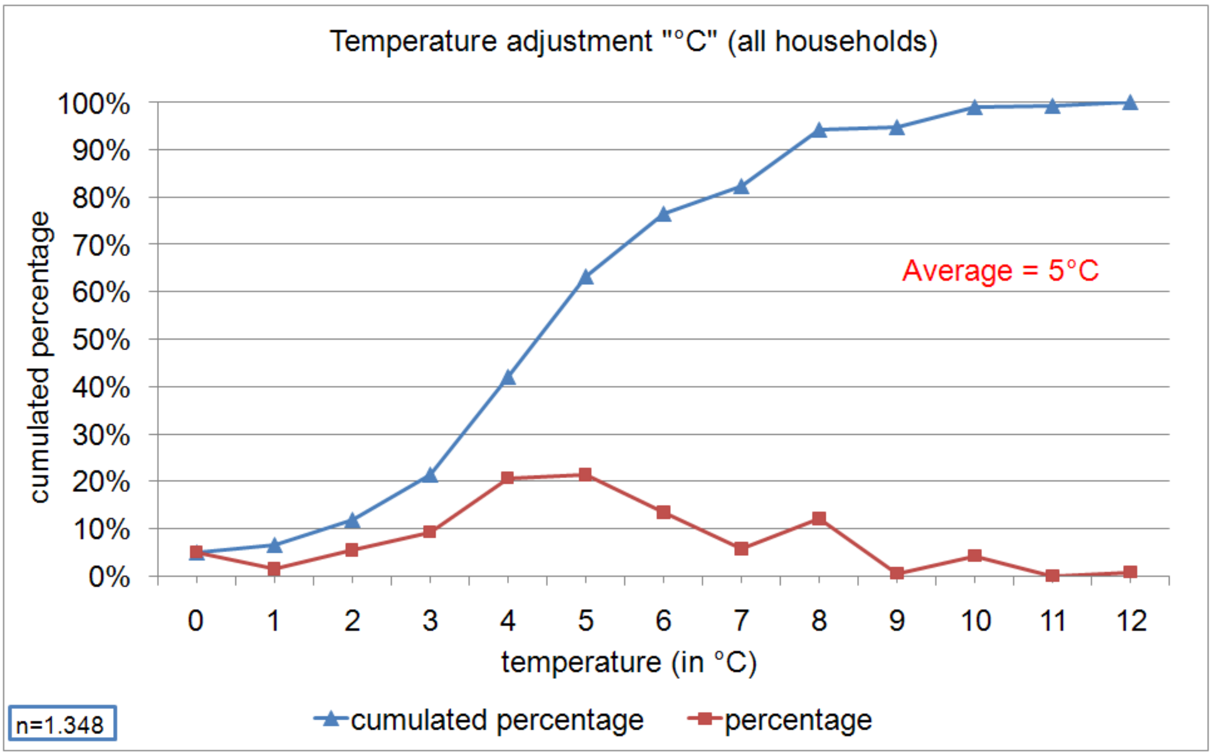


Figure 3.48: refrigerator: temperature adjustment in °C (all households)

The detailed analysis of the temperature adjustment of those consumers which could adjust their temperature in degree Celsius in all countries shows that the average values range between 3,7 °C of British and 6,0 °C of Swedish refrigerators (Figure 3.49). These average temperatures show that the adjustment in all countries is set mostly following recommended values. But anyhow a detailed look at the distribution of setting in all countries (Figure 3.47) shows that between nearly 5 % up to 30 % (e.g. Swedish households) choose temperatures in a critical range higher than 8 °C.

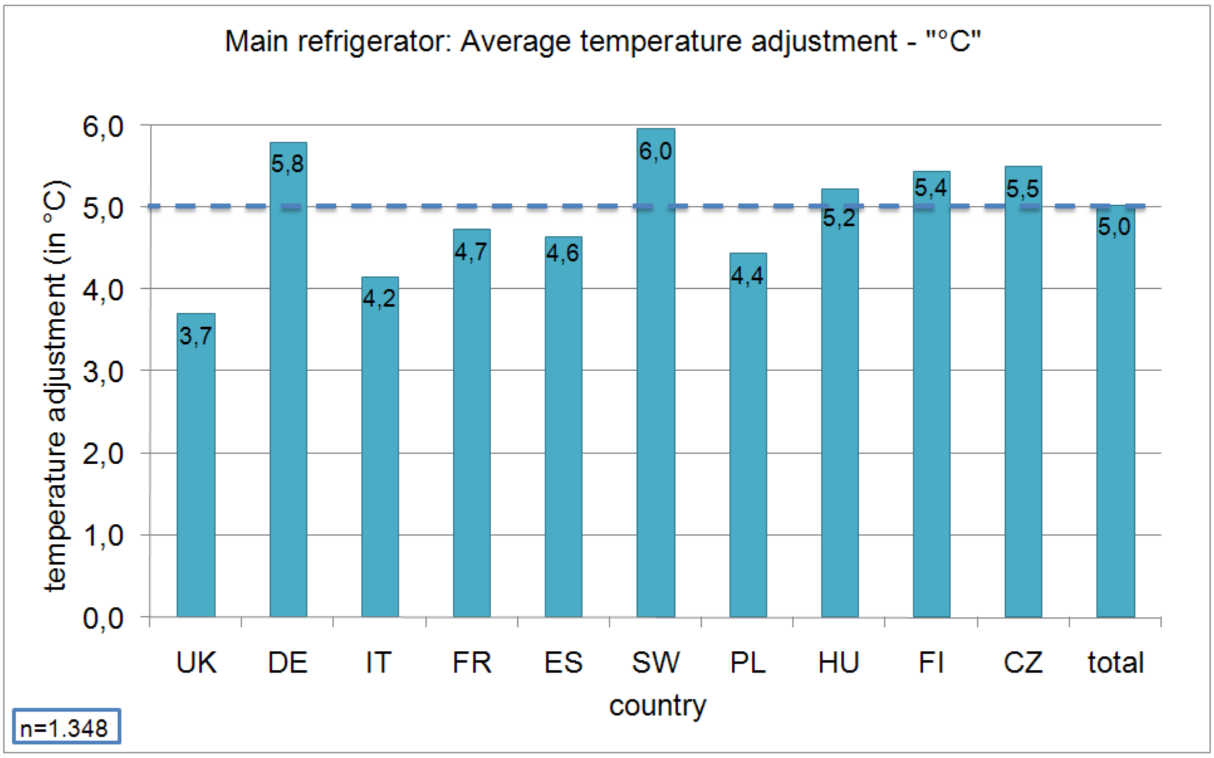


Figure 3.49: refrigerator: average temperature adjustment in °C (per country)

Those consumers which did not have the possibility to adjust the temperature by degree Celsius setting were asked to quote the number of their adjustment possibilities together with the minimum and maximum setting. Unfortunately a high share couldn't give an answer because they *don't know* (53,2 %) or they answered uncertainly (Figure 3.51). 32,2 % (n = 803 of 2 497 hh) of all interviewed consumers answered that they have a temperature and a number adjustment. The reason could be that these consumers didn't understand the questions.

48,5 % of all participating households owning a refrigerator mentioned that they change the temperature setting of the appliance (Figure 3.50). Especially Italian and French households show this behaviour with nearly 60 %. At least nearly 40 % of Swedish households (38 %) and German (39,6 %) and Czech (39,7 %) participants take care about changing the temperature setting conditions. The main reason for the consumers for changing the setting is the *outside temperature* (57 %) (Figure 3.51). Also the *grade of filling* (45,7 %) of the appliances plays an important role for the consumer when they vary the Celsius or numbered setting. One fourth mentioned that the *type of food* influences their behaviour too. Only a minor share of the interviewees (12,5 %) answered that they act *intuitively*.

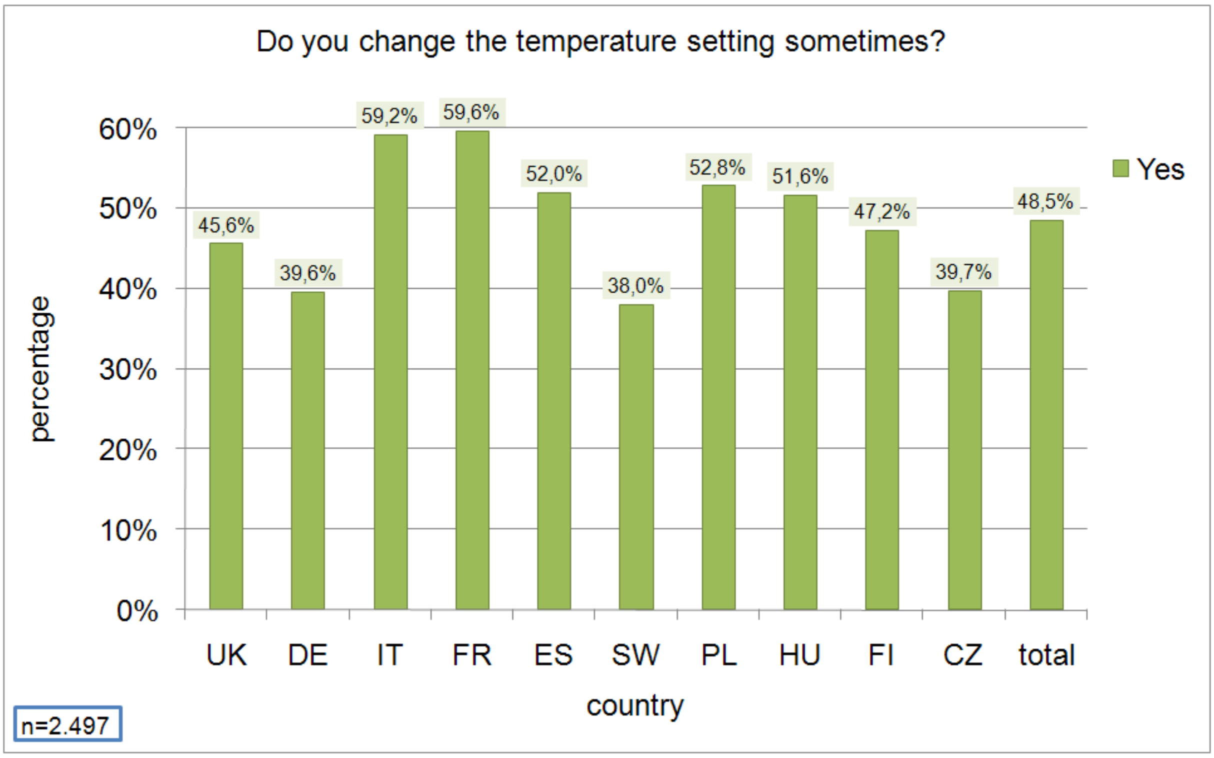


Figure 3.50: refrigerator: temperature changing (per country)

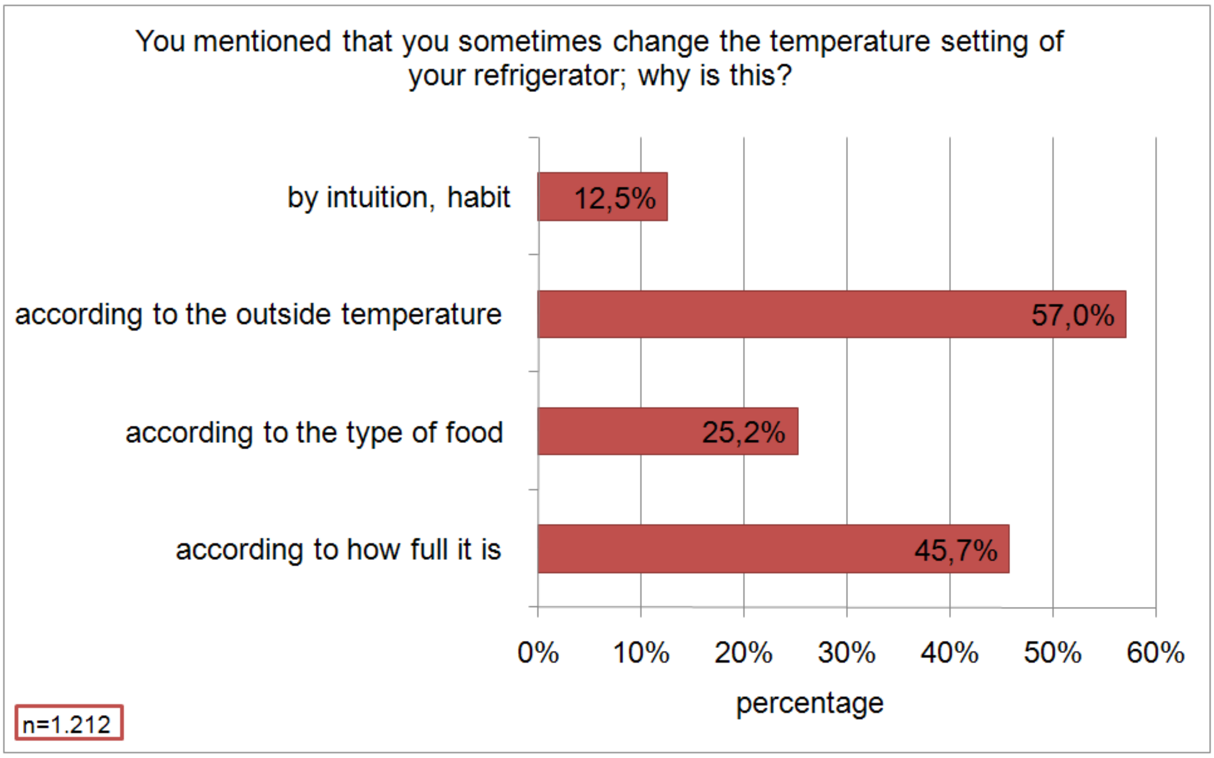
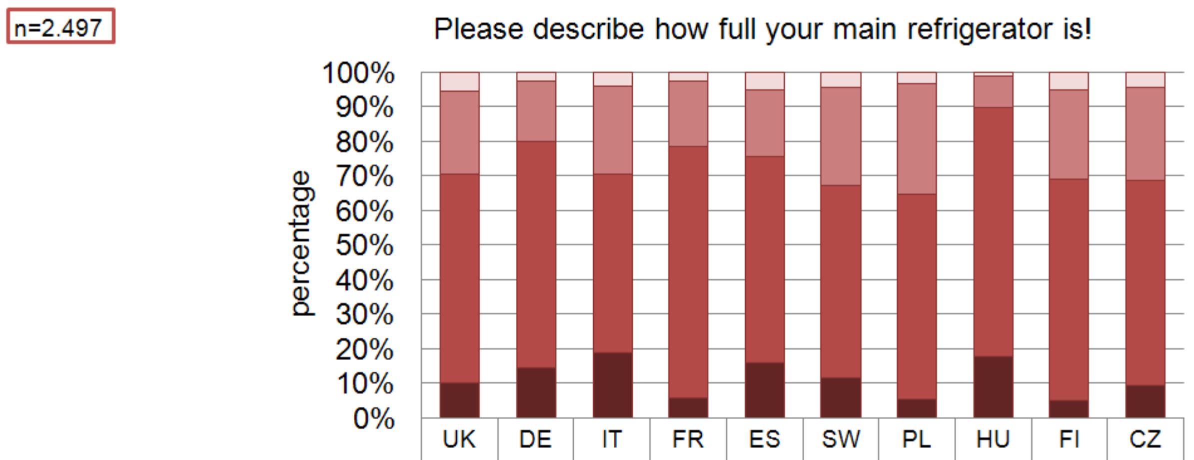


Figure 3.51: refrigerator: reasons for temperature changing (per country)

The most consumers described their charging of the refrigerator as *sometimes completely full and sometimes less full* (62 %) (Table 3.5). Especially the results for Spanish and Hungarian households show that here about over 70 % of all those interviewed agree with this statement (Figure 3.52). These households and additionally Italian households show the highest share of households which describe the refrigerator as *full most of the time*. Their values lie about 8 percentages above the average of all participating households with 11,3 %. Nearly a quarter of all households say that their refrigerator is *more or less half full all the time* (Table 3.5), varying between 17 and 32 %. An exception is the result of Hungary where only 9 % of all households fill their refrigerator *more or less full all the time* (Figure 3.52).

Table 3.5: refrigerator: load size (n = 2.497)

My refrigerator is completely full most of the time	11,3 %
My refrigerator is sometimes completely full and sometimes less full	62,0 %
My refrigerator is more or less half full all the time	22,7 %
My refrigerator is often only partly full	3,9 %



	UK	DE	IT	FR	ES	SW	PL	HU	FI	CZ
My refrigerator is often only partly full	6%	3%	4%	3%	5%	4%	4%	1%	5%	4%
My refrigerator is more or less half full all the time	24%	17%	26%	19%	19%	28%	32%	9%	26%	27%
My refrigerator is sometimes completely full and sometimes less full	60%	66%	52%	73%	60%	56%	59%	72%	64%	59%
My refrigerator is completely full most of the time	10%	14%	19%	6%	16%	12%	5%	18%	5%	9%

Figure 3.52: refrigerator: load size per country

The analysis of the different household structures shows that especially in single-/one person households (35,4 %) only the half capacity of the refrigerator is used all the time (Figure 3.53). With increasing number of persons in households this behaviour decreases and the space of the refrigerator is used more completely. The share of households which described the charge of their refrigerator as *completely full most of the time* grows from 6,5 % in one-person household up to 16,5 % in a more than 4 person household. The same positive correlation can be noticed for the description of a *sometimes completely full and sometimes less full* refrigerator. Here the growth between single households and more person households which described their charge of refrigerator in this way reached nearly 22 %. If more people are living in the household probably also more exchange of food will happened.

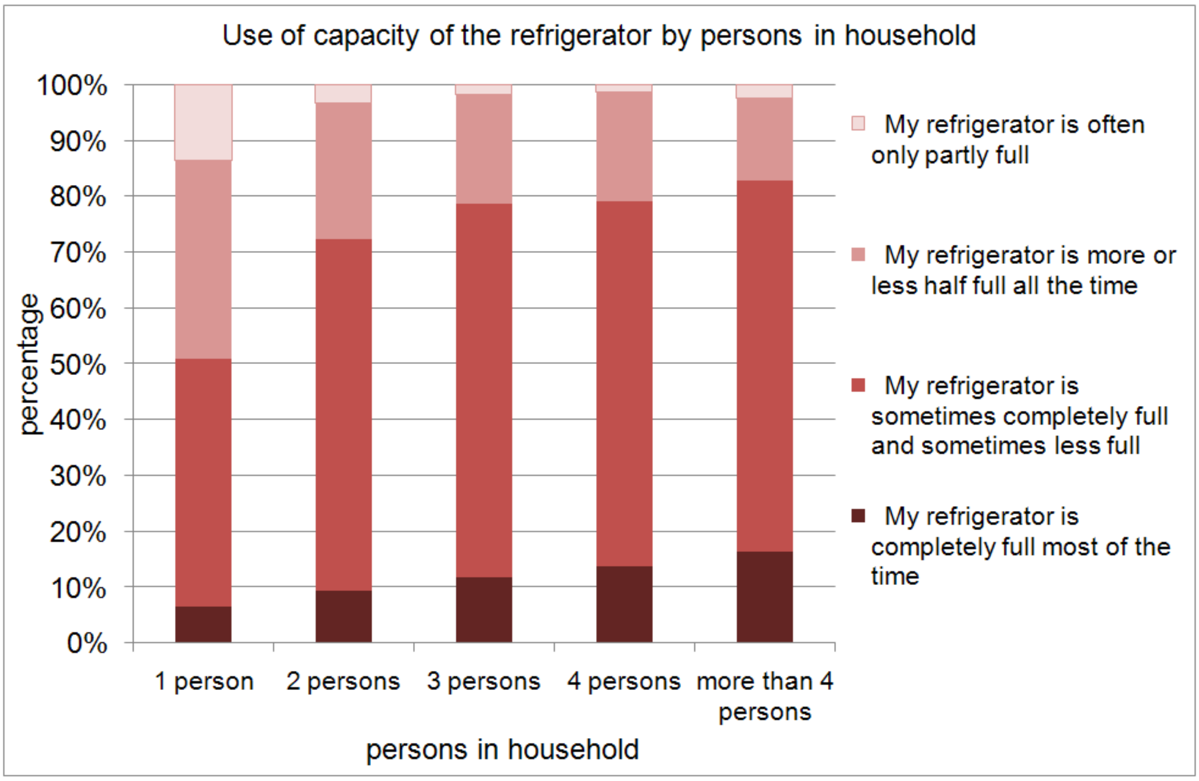


Figure 3.53: refrigerator: load size per number of persons in household

Concerning the object of investigation of "loading" a refrigerator the consumers were asked if they cool prepared food down before placing it into the refrigerator. Approximately 80 % of all consumers mentioned that they cool down prepared food, especially Hungarian consumers act in this way (93,2 %) (Figure 3.54). Most carelessly according to their answers behave Swedish, Polish and Spanish participants because of their lower agreement to this statement. Even 10 % of them answered that they never cool down food before placing it into the refrigerator (Figure 3.54).

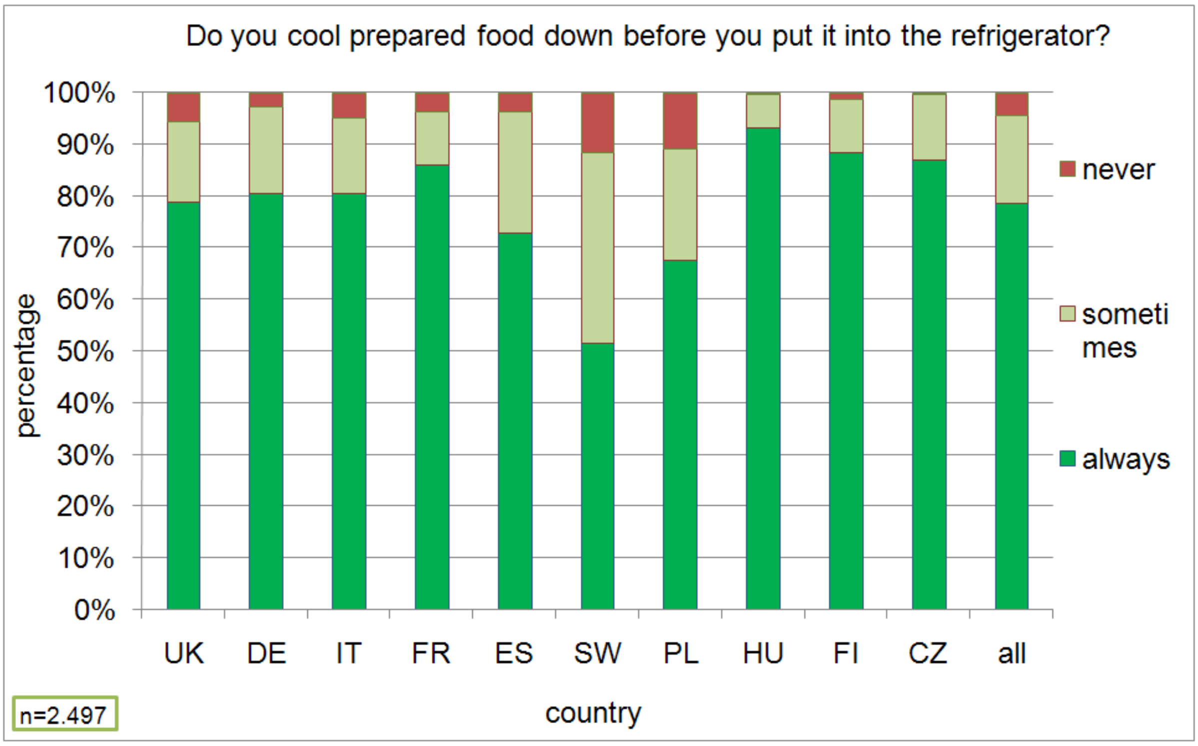


Figure 3.54: refrigerator: cool down of prepared food

b) Freezer

All participating households with a freezer (n = 2 081) were asked what the maximum and minimum temperature of the room is in which their freezer stands.

Following the analysis of all answers an average temperature of 18,1 °C could be calculated (Figure 3.55) as the arithmetic mean of the maximum and minimum temperature quoted. Over 30 % of all households have their freezers standing in a room with temperatures between 16 and 19 °C. In over the half of all households the freezer stands in a room with a maximum ambient room temperature between 20 °C and 27 °C (Figure 3.55). Together 38,6 % of all households mentioned that the minimum room temperature where their freezer stands reaches values below 11 °C down to 0 °C. Furthermore a total of 66,8 % of all consumers said that they have a minimum respectively maximum room temperature under 16 °C (Figure 3.55). Actually in 38,6 % of all households temperatures of 11 °C or lower are reached. On the other hand in 4,6 % of all interviewed households the room temperature lies at 36 °C or above (Figure 3.44).

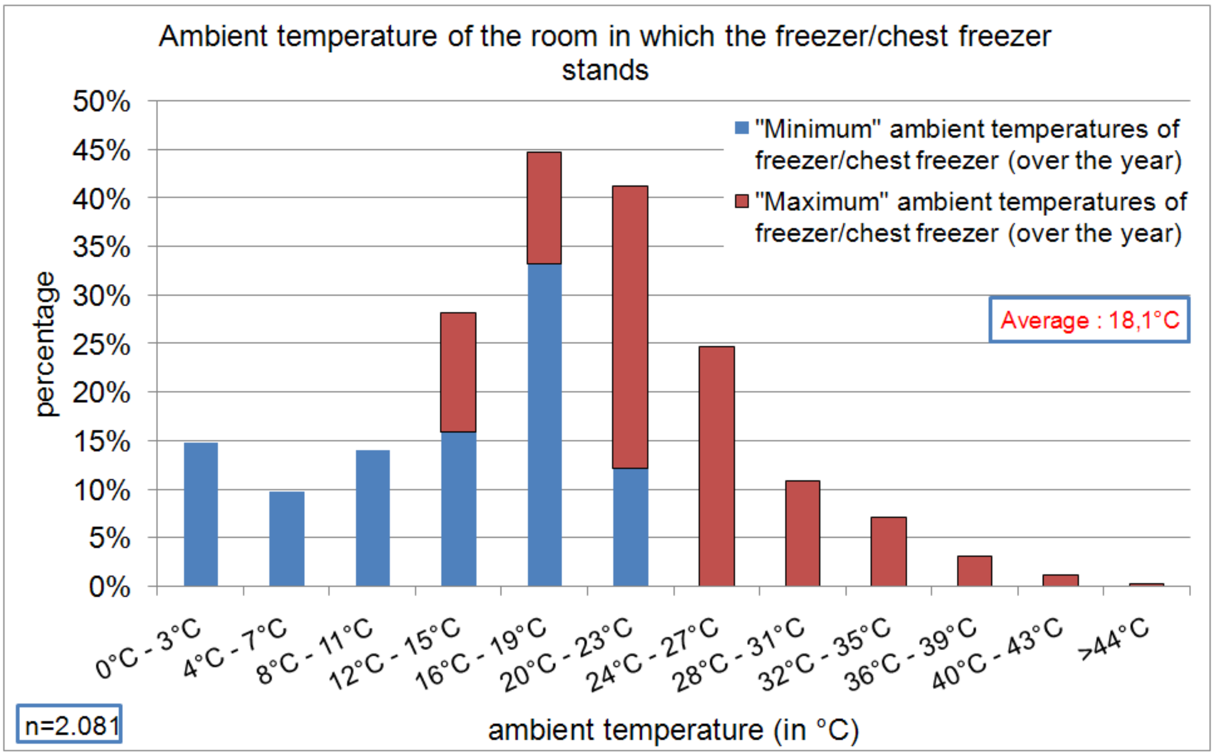


Figure 3.55: freezer: comparison of minimum and maximum ambient room temperature

The *average minimum temperature* reached 12,7 °C (Figure 3.56).

In some countries, especially United Kingdom or Spain, in over 50 % of all households the minimum temperature is below 11 °C. Interesting are the results for the northern countries like Sweden and Finland, where the minimum ambient temperatures in nearly 80 % of all households lay above 12 °C and even 30 % between 20 to 23 °C (Figure 3.56).

The analysis of the answers of all consumers to the question what the ***maximum*** ambient room temperature is results an *average temperature* of 23,6 °C (Figure 3.57). Especially in nearly 13 % of all Spanish households the maximum room temperature is even above 36 °C.

In contrast to that in one fourth of all German households a maximum temperature of 15 °C is reached.

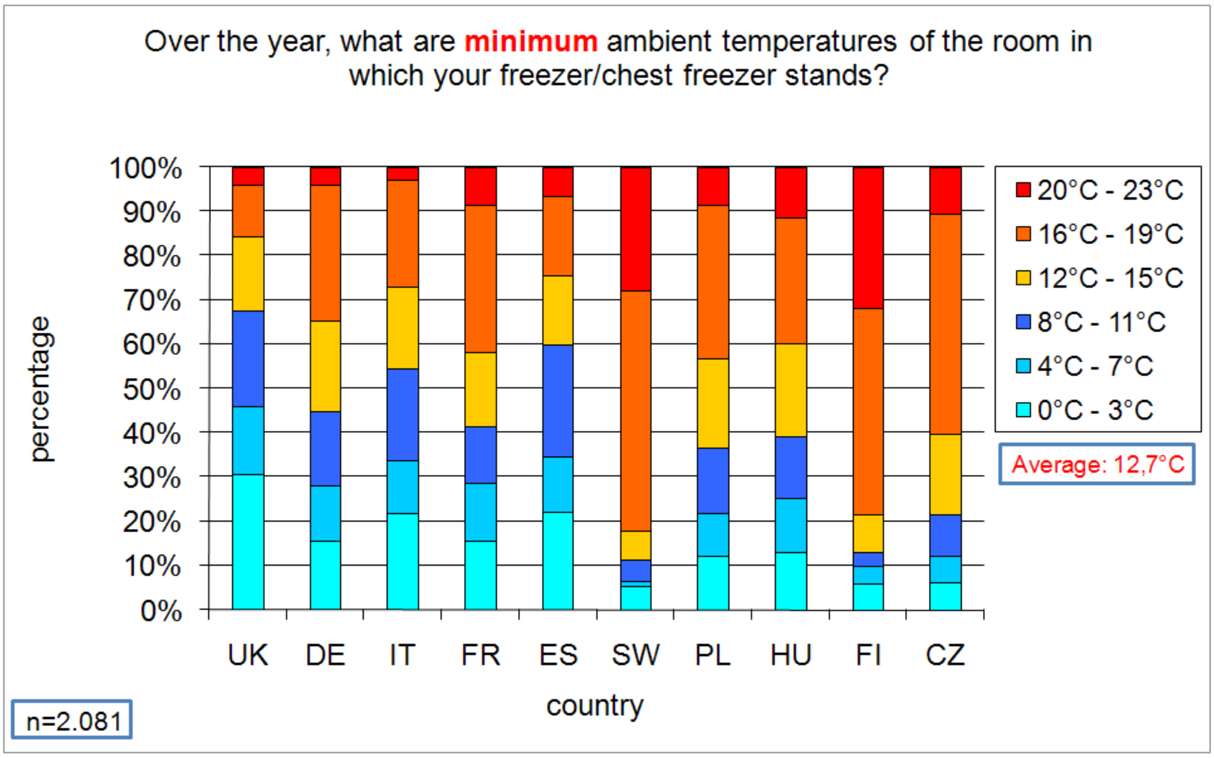


Figure 3.56: freezer: minimum ambient room temperature per countries

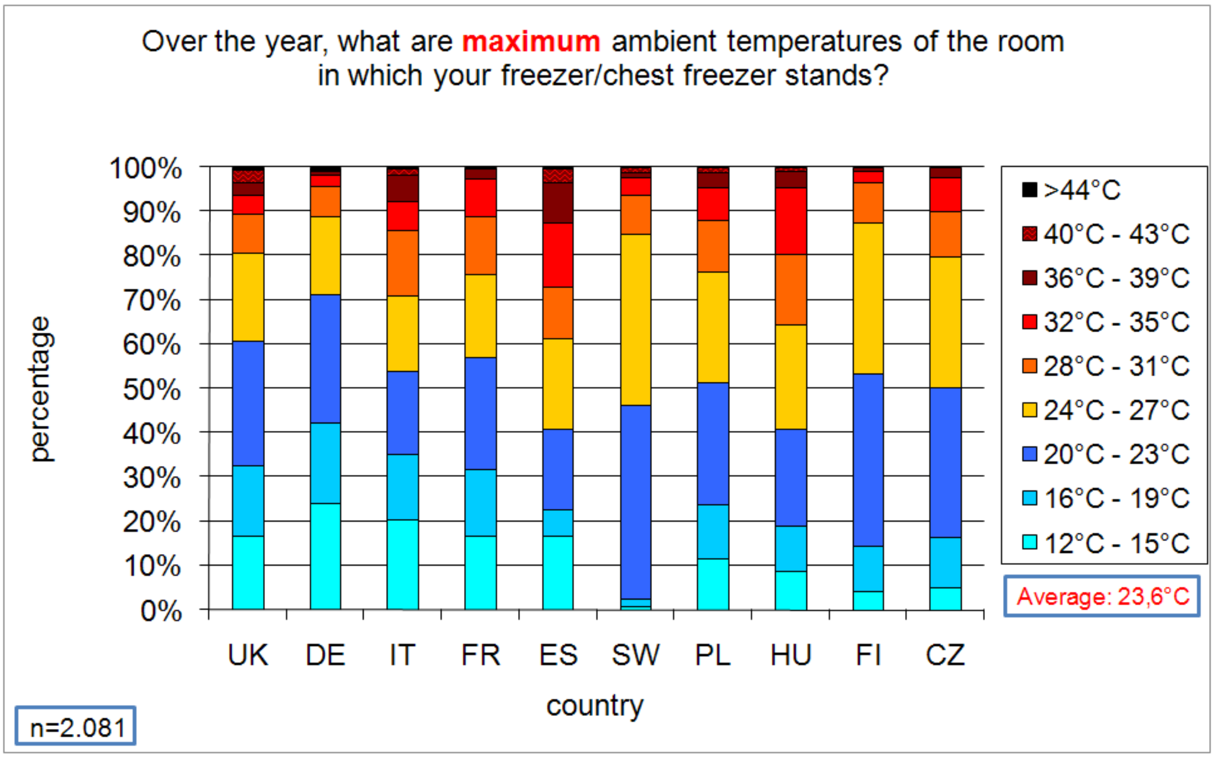


Figure 3.57: freezer: maximum ambient room temperature per countries

About 52 % of all households can be characterized by a temperature difference (Figure 3.58) of the ambient room temperature where the freezer stands of less than 12 K. In approximately 16 % of all participating households temperature differences are > 16 K.

The smallest differences could be calculated for northern countries like Sweden or Finland, where in approximately 80 % of all rooms temperature differences were maximally 8 K (Figure 3.59). The comparison with the results for southern households shows that e.g. in nearly 70 % of all Spanish households the differences between the minimum and maximum room temperature reached between 12 K and even 44 K (Figure 3.59).

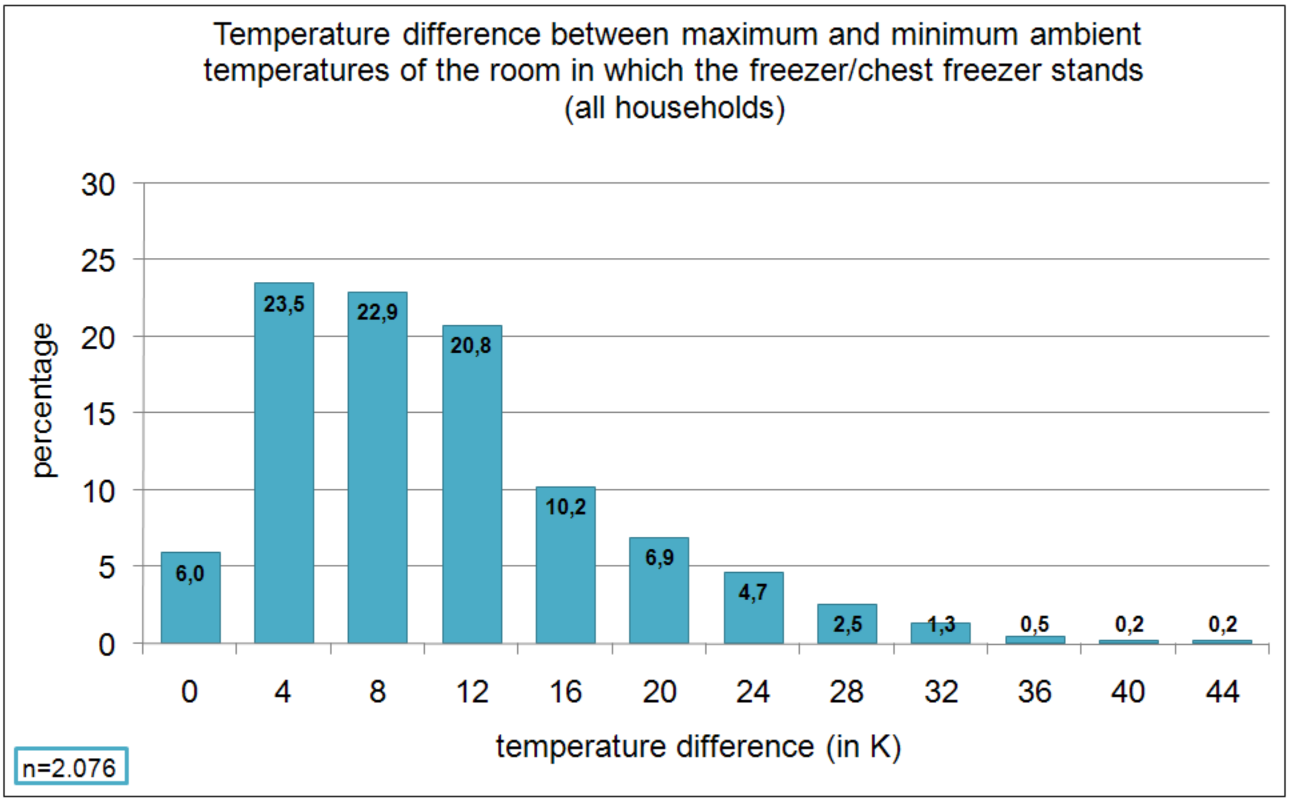


Figure 3.58: freezer: frequency of temperature differences - location of the appliances

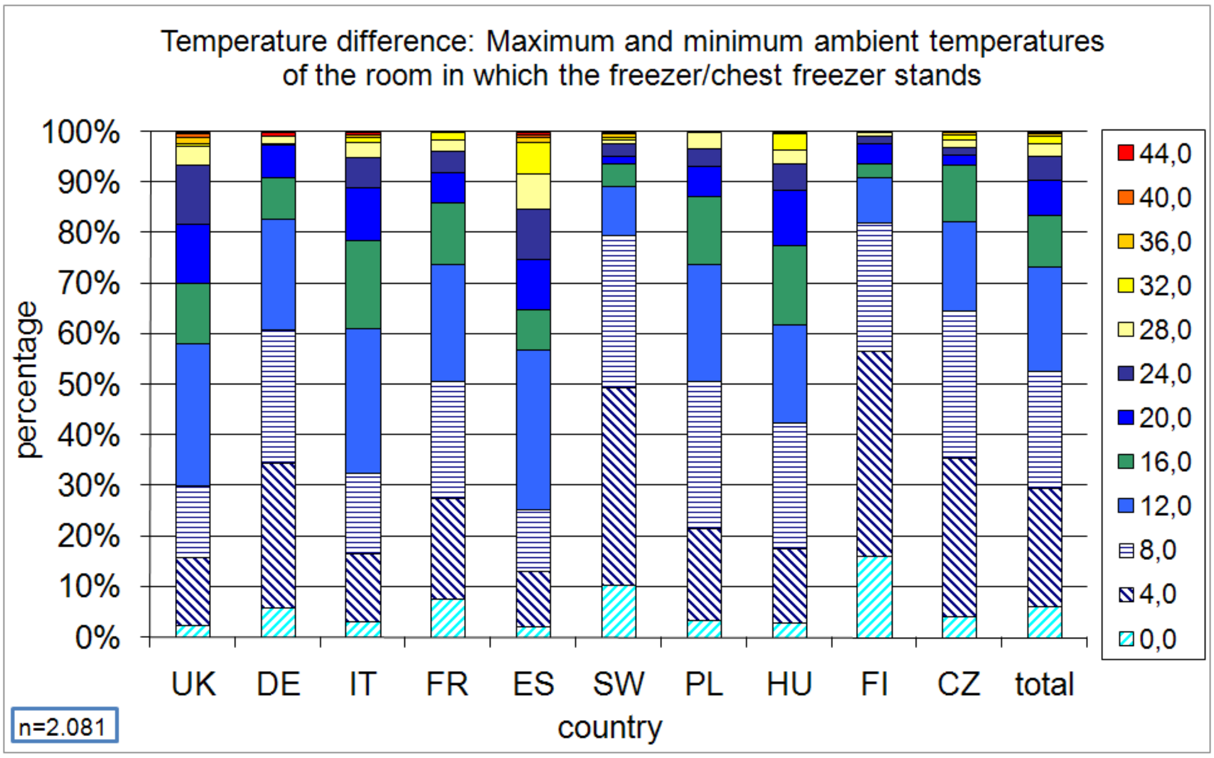


Figure 3.59: freezer: temperature differences - location of the appliances

These data can be interpreted as two different placements for the freezers: either it is placed in a heated room (e.g. kitchen) with relatively constant temperatures over the year or it is placed in an unheated room (e.g. garage, balcony, household working room or cellar) with temperatures following more or less the ambient temperature change during the year.

In addition to the room temperature also the adjustment of the cool appliances plays an important role for the energy performance and efficiency. The analysis of the question what the actual temperature adjustment in degree Celsius of the freezer is results an average of -16,7° C (Figure 3.60). Between the interviewed countries only differences plus or minus one degree on the average temperature setting can be noticed. Just French consumers state a very low temperature setting with in average nearly -19 °C (Figure 3.60).

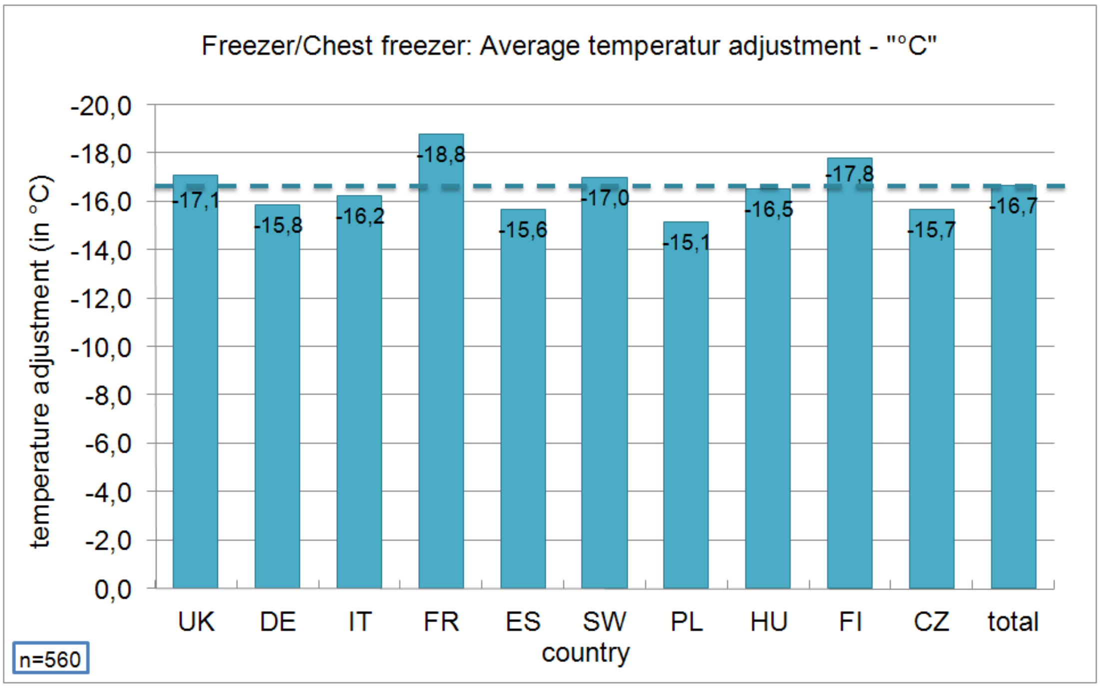


Figure 3.60: freezer: average temperature adjustment in °C (per country)

For consumers which have an appliance without an indicator showing centigrade the adjustment in numbered setting was asked too. Approximately 50 % of the participants *don't know* what possible settings their appliance has. Therefore this question was not analysed any further.

Only 23,4 % of all participating households say that they change their temperature setting sometimes (Figure 3.61). Mostly Finnish consumers change their temperature adjustment (39,5 %). Least frequently German and British households act in this way, with approximately 12,5 %. The share of the remaining countries lay between 22,1 and 28 %. Approximately 75 % of all asked consumers say that they change the temperature of their freezer according to how full it is (Figure 3.62). Also the outside temperature plays an important role for changing the adjustment for 35 % of all participants. Only nearly 10 % act by intuition or/and their habit.

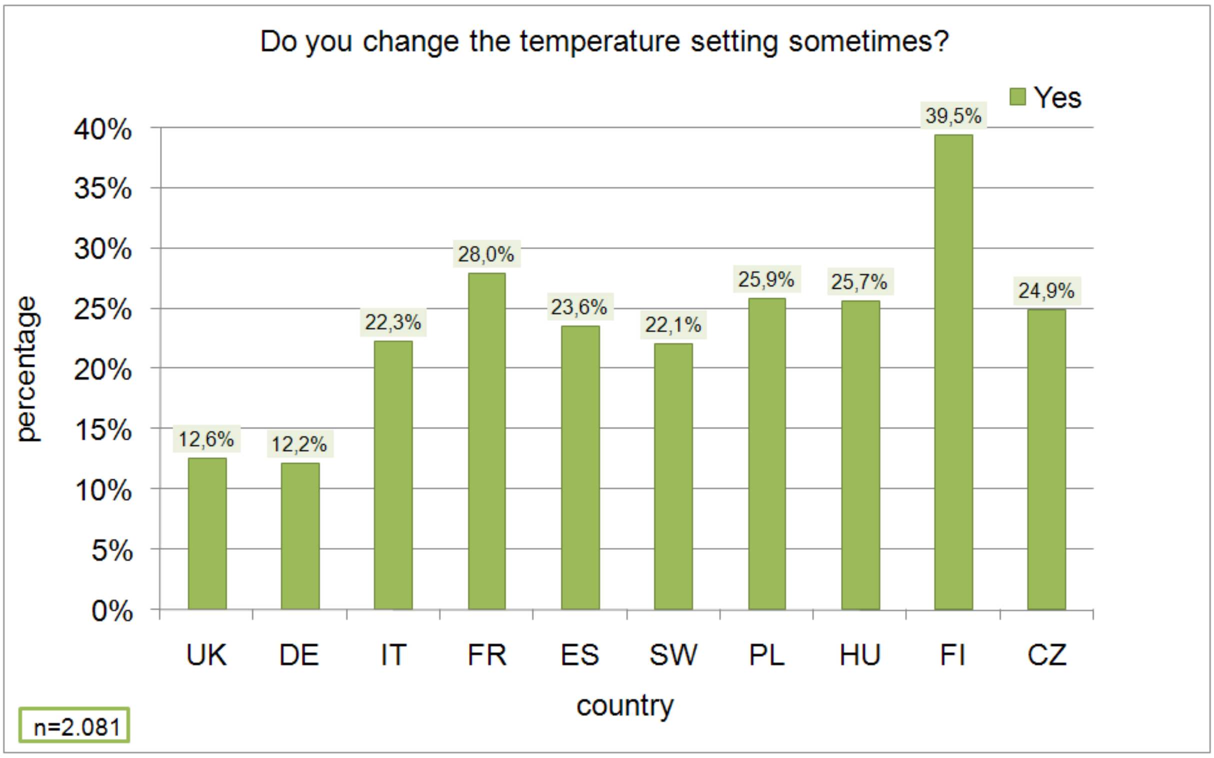


Figure 3.61: freezer: temperature changing (per country)

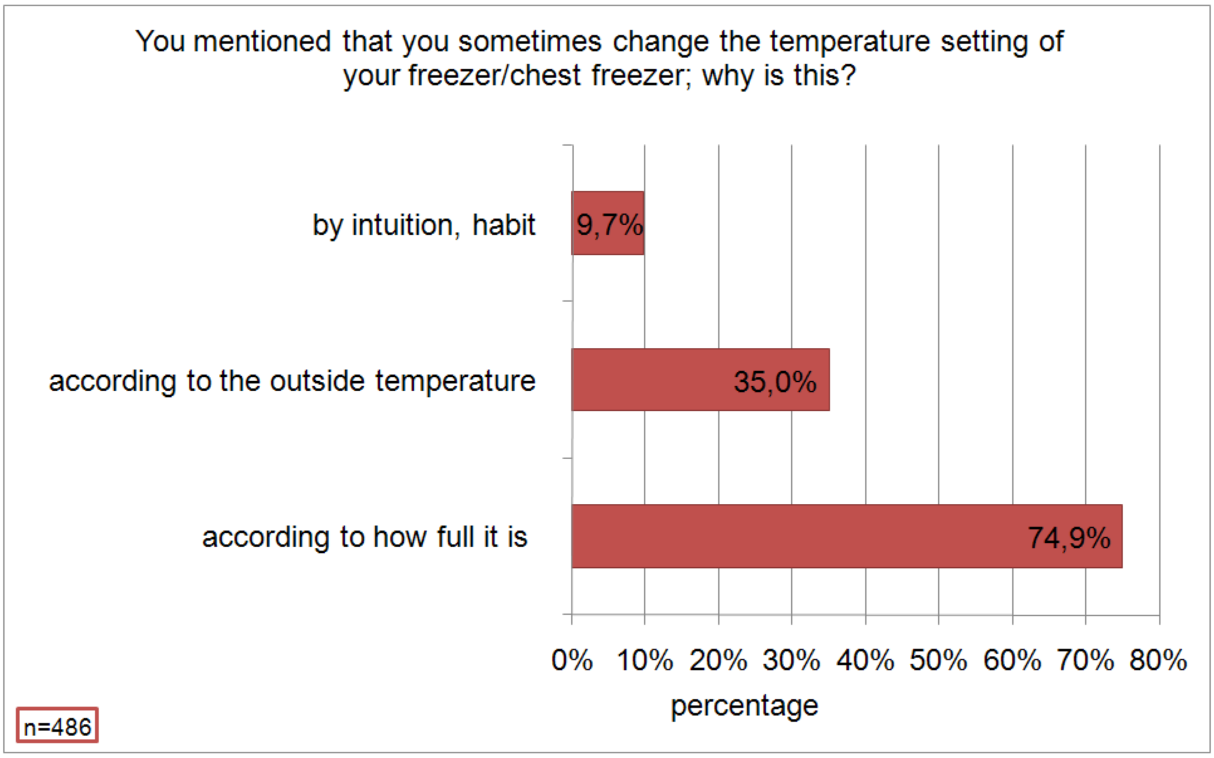


Figure 3.62: freezer: reasons for temperature changing (per country)

About half of all households describe the charge of their freezer as *sometimes completely full and sometimes less full* (Table 3.6). Also a high share of nearly 35 % of all asked consumers says that their *freezer is completely full all the time*. For nearly 20 % of the consumers the freezer seems to be oversized because they *used only a part* (3,5 %) *or the half size* (13,6 %) of the freezer.

Table 3.6: freezer: load size (n=2.081)

My freezer/chest freezer is completely full most of the time	34,6 %
My freezer/chest freezer is sometimes completely full and sometimes less full	48,4 %
My freezer/chest freezer is more or less half full all the time	13,6 %
My freezer/chest freezer is often only partly full	3,5 %

Especially in Hungarian and Czech households the most space of the freezer is used (*completely full most of the time* ~50 %) (Figure 3.63). The shares of households which used *only a part of the freezer* are marginal with between 1 % (UK) and 9 % (IT). French and Hungarian consumers never use the capacity of a freezer in this way (0 %).

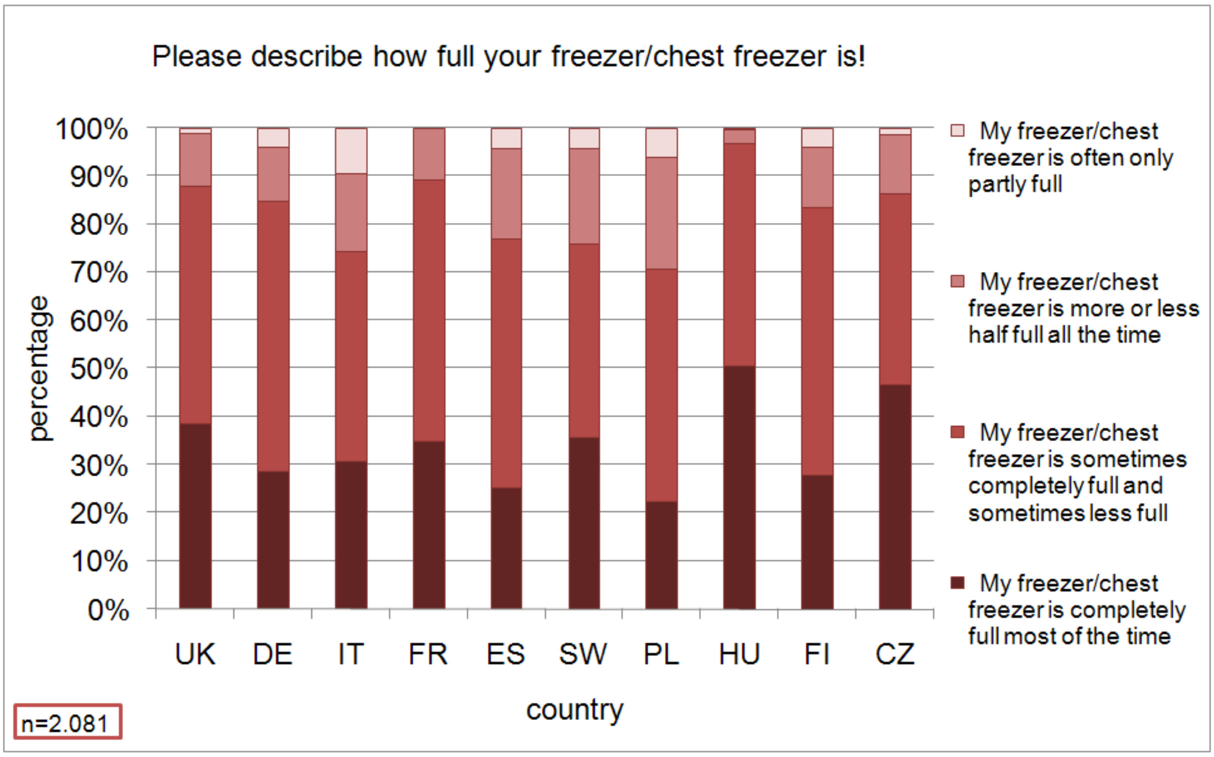


Figure 3.63: freezer: load size per country

In single-/one person households the share of freezers which are only filled partly reached nearly 8 %, more than thrice of the results of the other household types (Figure 3.64). 19,3 % of all single households also only use the half size of the freezer. With increasing number of persons in a household the share of freezers which are often *completely full and sometimes less full* grows. In comparison with this the share of *completely full freezers* decreases if more people live in the household. Maybe the exchange of food in households with a lot of people is higher than in only two or three person households, where the duration of storage may be longer.

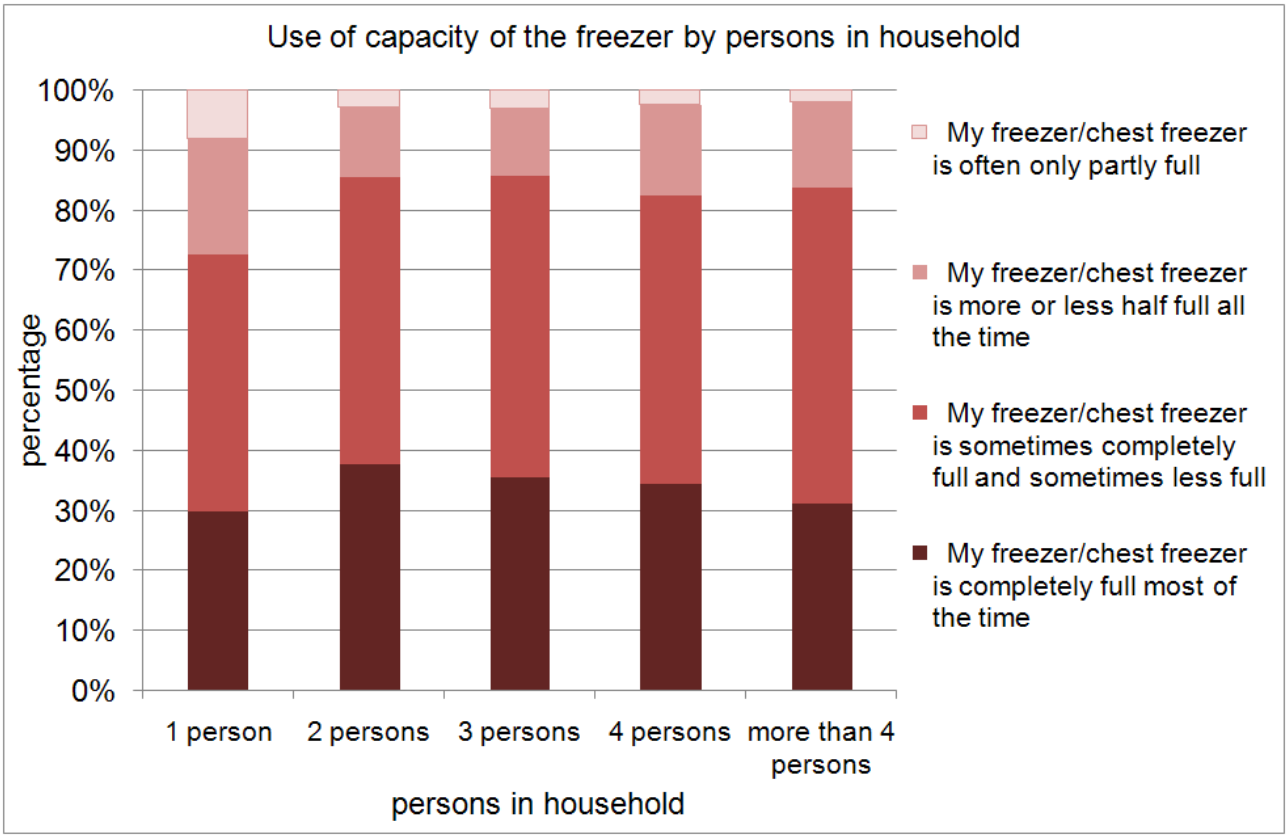


Figure 3.64: freezer: load size per number of persons in household

3.3.3 *Definition of the real life base case*

As it has been shown (s. chap 3.3.2) consumers' behaviour and usage is very different between themselves, but also between their behaviour and usage and what is defined in the standard base case, used for calculating the energy efficiency and energy saving. These differences are summarised here as far as they effect the energy consumption of refrigerators or freezers.

a) Refrigerator

All calculations and assumptions are based on the criteria of cold appliances of cat.7 and the behaviour of a 2,9 person household, which was the average household size of this consumer survey.

The factors which are seen as relevant for the energy consumption and which are not included in the standard base case but representative for the real life consumer behaviour are:

- Room/ambient temperature,
- The "cooling performance",
    - exchange of food
    - storage/insertion of hot items
    - door openings.

<u>Room/ambient temperature</u>

In real life the consumer survey (s. chap. 3.3.2) has shown that the average ambient room temperature where the refrigerator stands is 19,5 °C which is lower than the temperature used in the standard base case test (25 °C). The effect of a reduction of the room temperature examined in several studies and the results are summarised in Table 3.7. In average an energy reduction of 5,8 % per degree can be calculated. For a temperature difference of 5,5 K between the results of the consumer survey and standard base case conditions an energy reduction of 31,9 % can be calculated. Based on the annual energy consumption of the standard base case of cat.7 (= 324,4 kWh) the energy consumption in this 'real life base case situation' will be reduced to 220,9 kWh/year (Table 3.12).

Table 3.7: change of ambient temperature – effect on energy reduction

study	original ambient temperature in °C	new ambient temperature in °C	temperature difference in K	energy reduction	energy reduction per K
HMWVL, 2005	25	22	3	16 %	5,3 %
HMWVL, 2005	25	19	6	32 %	5,3 %
HMWVL, 2005	25	15	10	53 %	5,3 %
Stiftung Warentest,1994	25	16	9	47 %	5,2 %
Stiftung Warentest,1994	32	25	7	55 %	7,9 %
Lepthien, 2000	25	20	5	18,50 %	3,7 %
Böhmer & Wicke, 1998	25	24	1	8 %	8,0 %
Peart, 1993	*21*	*18*	*3*	*12 kWh/year*	*4 kWh/year*
average energy reduction per K					5,8 %
temperature difference (standard base case - consumer survey)					5,5 K
energy reduction					31,9 %

Regarding the ambient temperature the result of the consumer survey shows that nearly half of all households have temperatures below 16 °C (Figure 3.65). In detail 18 % of all households mentioned that the ambient minimum temperature reaches values between 12 and 15 °C (Figure 3.65). These temperatures are below the lower limit temperature of the climatic classes N, ST and T. Also approximately 24 % of the participants said that the room has a minimum temperature between 0 °C and 11 °C (Figure 3.65) what is below the lower limit of climatic class N.

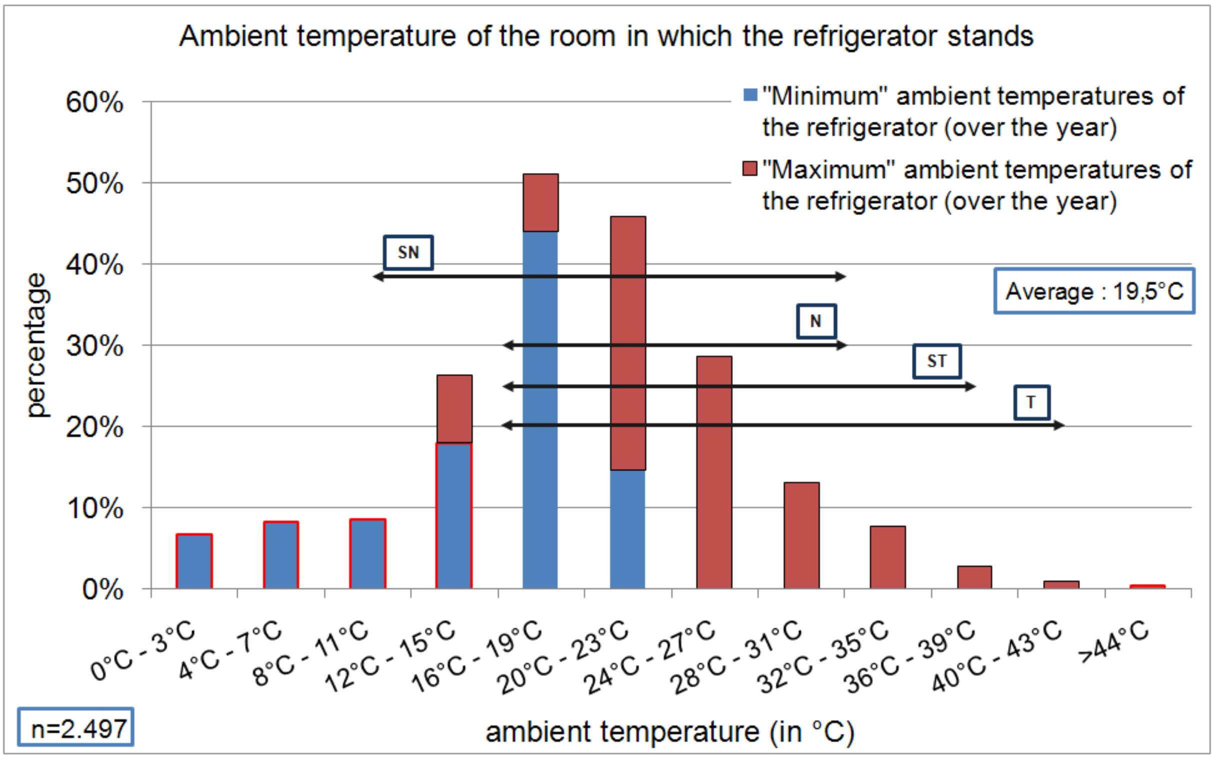


Figure 3.65: ambient temperature where the refrigerator stands (all households)

For appliances of cat.7 the climatic class ST (room temperature: + 16 to + 38 °C) is used for the standard base case calculations. As nearly 50 % of all households have minimum temperatures below 16 °C (Figure 3.65) these appliances would not fit their needs. If such an appliance would be operated under these conditions the consumer would risk to de-frost his frozen goods or have perishable goods stored under inadequate conditions. Consequently the food quality would suffer or even more serious food poisoning could happen. The same will happen with appliances of climate class SN placed at ambient conditions which allow temperatures below 10 °C, which is mentioned by the consumers to happen in 24 % of the cases.

In chapter 3.3.1 the function of an "ambient temperature switch" so called "winter switch" is mentioned, which is one solution to solve the problem of low ambient temperatures especially for appliances of cat.7 with only 1 compressor and 1 thermostat (one cooling cycle). As at low ambient temperatures the temperature difference between the ambient and the storage temperature in the fridge compartment is low, this would cause the compressor to only rarely operate. Consequently, in those gadgets with just one compressor and one thermostat, also the freezer compartment would get supplied with cold only rarely and would therefore not be able to maintain the required temperature of -18 °C. To avoid this, it is necessary to get the compressor to operate which is done, e.g. by having the indoor light of the fridge compartment switched on or by activating an internal heating device. By that heat, the temperature in the fridge compartment will raise and will cause the compressor to start. One disadvantage of this application is some additional energy consumption. Another point is that the consumer has to know when to switch it on and, more importantly, not to forget to switch it "off" when the ambient temperature is higher again. Not all appliances possess this application, but the negative effect of defrosting should be classified more critically than an additional energy consumption of an extra application. If it is assumed that light bulbs of 8, 10 or 15 Watt are used, additional energy consumptions can be calculated for periods during the year when the room would usually be heated. For the calculation the heating degree days[74] respectively heating days of each country are used. When the average temperature of the day is under the "heating limit temperature" of 15 °C this day is called "heating day". Heating degree days are summations of negative differences between the mean daily temperature and room (base) temperature of 18 °C. With published data[75] of average temperatures per month for each country the average temperature of the heating period was determined. As heating period these months are chosen which reached only temperatures ≤ 15 °C. For example for United Kingdom an average temperature of the heating period (outside temp. ≤ 15 °C) of 8,6 °C could be calculated using the changes of temperatures during the year (Table 3.8).

Table 3.8: e.g. calculation: heating days and average temperature of the heating period (e.g. UK)

Month	°C
JANUARY	4
FEBRUARY	4
MARCH	6
APRIL	8
MAY	12
JUNE	15
JULY	17
AUGUST	17
SEPTEMBER	14
OCTOBER	11
NOVEMBER	7
DECEMBER	5
average temp. heating period	**8,6**

The number of heating days Z [d] is calculated by the following formula:

$$Z\,[d] = G / (ti - tz)$$

G [Kd] = number of heating degree days

ti = 18°C (base temperature)

tz = average outside temperature during the heating period

With the heating degree days' data published by the World Resources Institute (2003) the heating days were determined (

[74] World Resources Institute: Kevin Baumert and Mindy Selman (2003): Data Note - Heating and Cooling Degree Days. Online: http://cait.wri.org/downloads/DN-HCDD.pdf

[75] http://www.eurometeo.com/english/climate

Table 3.9).

Table 3.9: heating degree days and heating days

	2006		
	heating degree days[76]	heating days	average temp. outside (heating period)[77]
countries	G	Z	tz
	[Kd]	[d]	[°C]
Czech Republic	3569	270	4,8
Finland	5212	345	2,9
France	2478	253	8,2
Germany	3252	264	5,7
Hungary	3057	233	4,9
Italy	1838	167	7,0
Poland	3719	277	4,6
Spain	1431	154	8,7
Sweden	4375	319	4,3
United Kingdom	2810	299	8,6

Accordingly the additional energy consumption of the "winter switch application" can be estimated. Assuming the heating device (lamp or heater) is 'on' for 24 hours per day when the average ambient temperature is below 15 °C, an 8 Watt light bulb causes an average additional energy consumption of nearly 15 % (49,6 kWh) (Table 3.10) and a 15 Watt light bulb even nearly 29 % (92,2 kWh) of the energy consumption per year of the standard base case appliances of cat.7 (Table 3.10).

[76] World Resources Institute: Kevin Baumert and Mindy Selman (2003): Data Note - Heating and Cooling Degree Days. Online: http://cait.wri.org/downloads/DN-HCDD.pdf

[77] Own calculations based on data from http://www.eurometeo.com/english/climate

Table 3.10: additional energy consumption – „winter switch“-option

* *based on cat.7: 324,4 kWh*	winter - switch (15 watt light bulb)		winter - switch (10 watt light bulb)		winter - switch (8 watt light bulb)	
	kWh	**additional energy consumption (%*)**	**kWh**	**additional energy consumption (%*)**	**kWh**	**additional energy consumption (%*)**
Czech Republic	97,2	30,0 %	64,8	20,0 %	51,8	16,0 %
Finland	124,3	38,3 %	82,8	25,5 %	66,3	20,4 %
France	91,2	28,1 %	60,8	18,7 %	48,7	15,0 %
Germany	94,9	29,3 %	63,3	19,5 %	50,6	15,6 %
Hungary	83,7	25,8 %	55,8	17,2 %	44,7	13,8 %
Italy	60,2	18,5 %	40,1	12,4 %	32,1	9,9 %
Poland	99,6	30,7 %	66,4	20,5 %	53,1	16,4 %
Spain	55,5	17,1 %	37,0	11,4 %	29,6	9,1 %
Sweden	115,0	35,4 %	76,6	23,6 %	61,3	18,9 %
United Kingdom	107,6	33,2 %	71,7	22,1 %	57,4	17,7 %
average	**92,9**	**28,6 %**	**61,9**	**19,1 %**	**49,6**	**15,3 %**

In those appliances which only have one compressor and one thermostat unneeded energy is consumed also when the appliance is placed at an ambient temperature which is higher than the measurement temperature of the standard base case. As under these conditions the compressor will tend to operate more frequently than under the standardized testing conditions, the freezer compartment will get considerably cooler than -18 °C and may therefore have higher energy losses. No published studies are available which would allow estimating this effect in terms of additional energy consumption.

The “cooling performance”

Refrigerators are used to cool down food (used in general terms here for everything stored in a refrigerator) and to keep them at these conditions. The standard base case only covers the storage of food under a constant temperature. The daily exchange of food under the conditions of ambient temperature and temperature adjustment of the refrigerator plays an important role for the energy consumption too.

Important aspects, which are not covered in the standard base case, are the

- exchange of food,
- storage/insertion of hot items,
- door openings.

With the assumption of a daily exchange of food of 2 kg (here represented by water) per person and per household, a total amount of 5,8 kg needs to be cooled down from ambient condition to the storage temperature for an average household of 2,9 persons. The consumer survey analysis resulted an average storage temperature setting of 5 °C of the refrigerator and an average ambient temperature of 19,5 °C (Figure 3.65). A necessary energy of **23,8 kWh/year for a 2,9 person household** can be calculated by the following formula:

Energy needed = Heat load per day / COP[78] · 365 days/year

Heat load = 5,8 kg · 14,5 K · 4,19 kJ/kgK = 352,4 kJ
= 0,0979 kWh

Energy needed = 0,0979 kWh/day / 1,5 · 365 days/year
= 23,8 kWh/year

For single- and four persons households the necessary energy consumption for cooling down inserted food would result in 8,2 kWh and 65,6 kWh per year, respectively.

Storage of hot items:

The consumer survey analysis shows that nearly 20 % (Figure 3.54) do not always cool down hot items or cooked food before inserting them in the refrigerator *(15 % "sometimes", 5 % "never").* This behaviour causes an additional energy increase.

With the assumptions of an amount of 0,25 kg hot food (represented by water) at 40 °C inserted per person and per household, the refrigerator additionally has to cool this down about ΔT = 20,5 K to the ambient temperature of 19,5 °C. Accordingly this allows to estimate an extra energy consumption for a **2,9 person household of 4,2 kWh/year** (1,4 kWh/year for a single person household and 5,8 kWh/year for a four persons household).

Calculation: Insertion hot items - Energy consumption per year

Energy needed = Heat load per day / COP[79] · 365 days/year

Heat load = 0,725 kg · 4,19 kJ/kgK · 20,5 K= 62,27 kJ
= 0,0173 kWh

Energy needed = 0,0173 kWh/day : 1,5 · 365 days/year
= 4,2 kWh/year

[78] COP (coefficient of performance) assumed to be 1,5

[79] COP (coefficient of performance) assumed to be 1,5

Door openings

With insertion and storage of food the door has to be opened and will be left open for some time. This will mainly cause cold air to pour out and to be replaced by air from the ambient. This effect and the additional energy needed to cool down the replaced air are not covered by the standard base case, as tests are done with closed door only. Table 3.11 summarises the results of studies which investigated the energy consumption increase depending on the door opening.

In average an additional energy consumption of 0,002903 kWh per door opening can be calculated.

Table 3.11: energy consumption studies with door opening

study	door opening/ household(/person))	increase energy consumption		energy consumption (standard base case)*	kWh/door opening
	[do]	[kWh/year]		[kWh/year]	[kWh/do]
PEART (1993)	40/hh	50-120 kWh/year	= 85	-----	0,005822
LEPTHIEN (2000)	20/hh	1-6 % (aver.3,5 %)	= 11,35	324,4	0,001555
LIU (2004)	50/hh	5-10 % (aver.7,5 %)	= 24,33	324,4	0,001333
THOMAS (2007)	8,2/p				
(cat.7)* **average energy consumption per door opening					**0,002903**

A recent consumer behaviour study about the storage of food in Europe[80] observed an average door opening of a refrigerator of 8,2 times per day per person. With the average energy consumption per opening and this frequency the **energy consumption for a 2,9 person household is 25,2 kWh/year (**single household: 8,7 kWh/year – four person household: 34,8 kWh/year).

The comparison of the energy consumption of the real-life base case (RLBC) and the standard base case (STBC) shows that the total amount of energy used is surprisingly similar (Table 3.12). This is especially due to the lower ambient temperature of the location of the refrigerator in the households, where the energy consumption is considerably reduced. All other factors not considered in the measurement according to the standard are not so relevant as to balance the high ambient temperature of the measurement conditions. Only for refrigerators/freezers of category 7 with mainly one compressor and one thermostat a considerable additional amount of energy is needed when they are placed in an unheated room and are therefore affected by low and high ambient temperatures. As this depends on the local conditions no definite answer about the additional energy can be given. It may even be much higher than estimated here. Unfortunately the consumer is

[80] Thomas, Simone (2007): Diss.: Erhebung des Verbraucherverhaltens bei der Lagerung verderblicher

Lebensmittel in Europa [*Consumer behavior with the storage of perishable food in Europe*]. (will be published) Online: http://www.shaker.de/online-gesamtkatalog/booklist.asp?ID=1707429&CC=54012&Reihe=423

hardly aware of this situation as at the point of sale of the gadget he is not informed about the limitations regarding ambient temperatures and an eventual additional energy consumption. This may be changed either by including real life ambient temperature spans into the standard measurement procedure, in minimum by informing the consumer on the Energy Label about the range of temperatures under which the gadget is supposed to be operated and the declared energy consumption is a representative figure.

As all the additional energy consumptions caused by the actual use of the refrigerator are independent of the size or the energy efficiency of the gadget, the relevance of these additional amounts of energy used will increase as much as the absolute values of the energy consumption of the standard base case is reduced. This reduction happens as soon as more efficient appliances are compared or just in considering refrigerators with smaller volumes.

Table 3.12: refrigerator: annual energy comparison of real-life versus standard base case

Activity	Effect	Real-life base case (RLBC)	Standard base case (STBC)*
Average ambient temperature	19,5 °C vs. 25 °C ΔT = 5,5 K → Energy reduction of 31,9 %	220,9 kWh	324,4 kWh
Ambient temperature < 16 °C (Cat.7 with 1 compressor, 1 thermostat)	Heating on (light or heating element, e.g. 10 W) when heating day	61,9 kWh	
Ambient temperature > 25 °C (Cat.7 with 1 compressor, 1 thermostat)	Losses due to too low freezer temperature	???	
Temperature setting	Average temperature setting 5 °C / numbered setting 3,2	0 kWh	
Exchange of food	Exchange : 2 kg (represented by water)/day/person	23,8 kWh	
Cooling down of hot food	Insertion of hot food (40 °C): 0,25 kg (represented by water) per household/person/day	4,2 kWh	
Door openings	8,2 door openings per day per person	25,2 kWh	
	kWh per year	**336,0 kWh**	**324,4 kWh**

**of cat. 7*

b) Freezer

All calculations and assumptions are based on the criteria of cold appliances of cat.8 and 9 and the behaviour of a 2,9 person household, which was the average household size of this consumer survey.

The factors which are seen as relevant for the energy consumption under real life conditions and which are not included in the standard base case are the:

- Room/ambient temperature
- Temperature setting of the appliances
- Insertion of goods/loading of freezer

<u>**Room/ambient temperature and setting of the appliance**</u>

The average ambient room temperature where the freezer stands was reported to be 18,1 °C (Figure 3.66) which is lower than the ambient temperature used in the standard base case test with 25 °C. Taking a linear dependency between the temperature difference (ambient – storage) and the energy consumption an energy reduction of 2,3 % per degree can be calculated. For the ambient temperature difference of 6,9 K between the results of the consumer survey and standard base case conditions an energy reduction of 16 % would be reached. As the temperature setting in the freezer compartment was found to be at -16,7 °C (Figure 3.60) an additional reduction of the energy consumption of 3 % compared to the standard base case has to be incorporated.

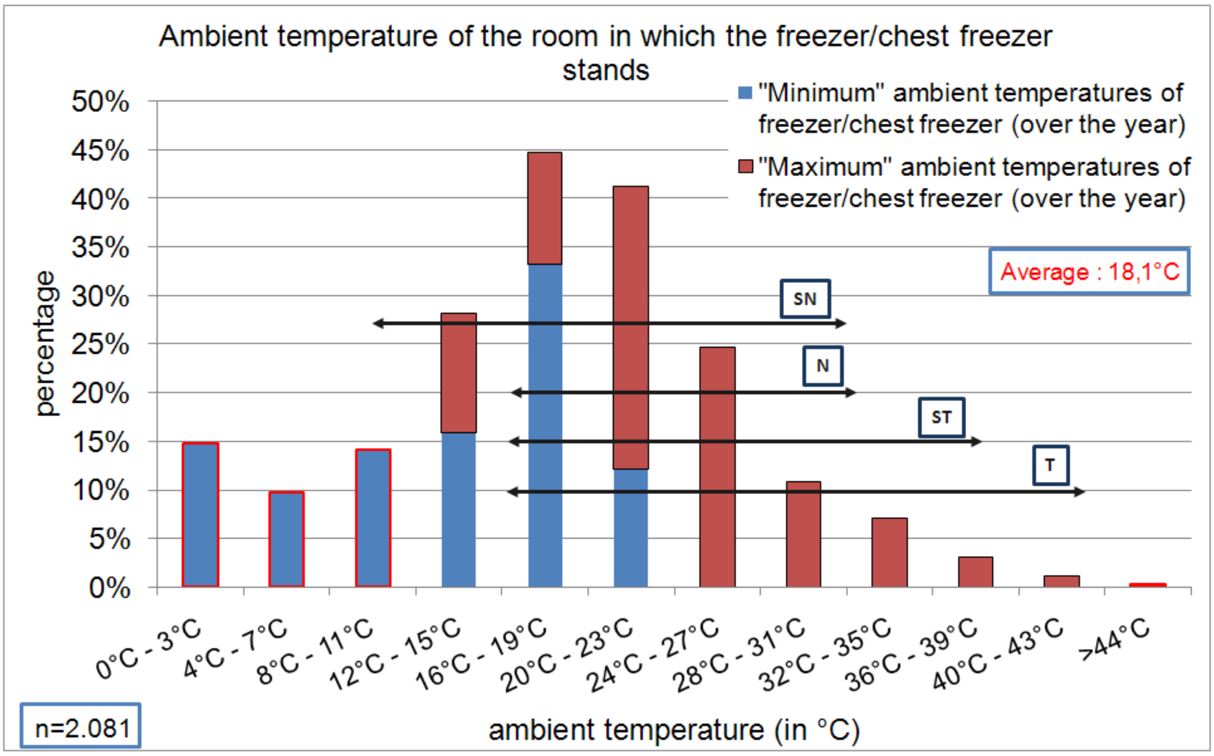


Figure 3.66: ambient temperature where the freezer stands (all households)

For appliances of cat.8 and 9 the average energy consumption, based on the values of the standard base cases, is 287,5 kWh/year. Under the circumstances of the results of the consumer survey with an average ambient temperature of 18,1 °C and a temperature setting of the freezer of -16,7 °C an energy consumption of 232,7 kWh could be determined (see calculation below) in comparison with the standard base case settings with an ambient temperature of 25 °C and a temperature setting of the appliance of -18 °C. On inspection of only the temperature difference of 6,9 K between the results of the consumer survey and standard base case conditions of the ambient temperature an energy reduction of 16% would lower the annual consumption to 241,4 kWh/year (Table 3.13).

Calculation: Energy reduction per degree

<u>Standard base case (cat.8 & 9)*:</u>

- Room temperature = 25 °C
- Temperature setting = -18 °C
- ΔT = 25 °C - (-18 °C) = 43 K
- Energy consumption/degree: 287,5 kWh* / 43K = **6,7 kWh/K**

<u>Results consumer survey:</u>

- Average room temperature = 18,1 °C
- Average temperature setting = -16,7 °C
- ΔT = 18,1 °C – (-16,7 °C) = 34,8 K
- Energy consumption: **6,7 kWh**/K 34,8 K = **232,7 kWh**

Insertion of food / Loading of freezer

In assuming a daily exchange of food of 0,125 litre (represented by water) per day and person the additional energy needed to freeze this food (heating capacities for water assumed) from ambient temperature to average freezer temperature **for a 2,9 person household** can be calculated as follows:

Energy needed/year = Heat load/day / COP (coefficient of performance) · 365 days/year

Heat load:

1). 0,3625 kg · 18,1 K · 4,19 kJ/kgK = 27,5 kJ

2). 0,3625 kg · 16,7 K · 2,10 kJ/kgK = 25,4 kJ

3). 0,3625 kg · 332,5 kJ/kg = 120,5 kJ *(Freezing energy)*

Heat load/day = (27,5 kJ + 25,4 kJ +120,5 kJ)/day = 173,4 kJ/day = 0,0481 kWh/day

Energy needed/year = Heat load/day : COP[81] · 365 days/year

= 0,0481 kWh/day : 1,5 · 365 days/year

= 11,7 kWh/year

Regarding **door opening** of a freezer no real life consumer behaviour data were available. As this is assumed to be done seldom, no effect on the total energy consumption was considered.

Table 3.13: freezer: annual energy comparison of real-life versus standard base case

Activity	Effect	Real-life base case (RLBC)	Standard base case (STBC) aver. Cat 8/9
Average ambient temperature	18,1 °C vs. 25 °C ΔT = 6,9 K → Energy reduction of 16 %	241,4 kWh	287,5 kWh
Average temperature setting	-16,7 °C vs. – 18,0 °C ΔT = 1,3 K → Energy reduction of 3 %	-8,6 kWh	
Exchange of food (“Cooling performance”)	Exchange (assumption): 0,125 kg (represented by water)/day/person	+11,7 kWh	

[81] COP (coefficient of performance) assumed to be 1,5

kWh per year	**244,5 kWh**	**287,5 kWh**

Considering all effects (Table 3.13), the annual energy consumption under real life conditions seems to be somewhat lower than measured in the standard base case. This is based mainly on the lower ambient temperature in real life compared to standard conditions. It is only partly balanced by the extra energy needed to freeze loads exchanged in the fridge. As this was not measured anywhere but just assumed to be at 0,125 litres per day and per person, no real judgement about a significant difference can be made. Other factors like door opening were not considered, but seem to be of even less importance for freezers.

3.4 SUMMARY OF CONSUMER BEHAVIOUR

Consumer investigations done within this study on an almost representative sample of people from 10 European countries covering 75 % of the population reveal a very high level of awareness of the consumer towards the environmental aspects of household appliances. This is also reflected when buying decisions are done and the energy label as an informational tool is seen almost as important as the own experience and as the information available on the Internet.

In European households refrigerators are available in the local infrastructure for almost 100 % of the households and in even 21 % of the households in this report a secondary refrigerator is available. These refrigerators are in average 1,4 years older than the primary refrigerator. All refrigerators and freezers remain in the household for normally 10 years and more, keeping the status of efficiency of the appliance remaining as it was at the production of the gadget. Improvements will therefore take more than 10 years to get fully effective in the market. This time is even prolonged when second-hand appliances are used. As this investigation has shown, this second –hand market takes only a minor part of the market.

Another possible barrier for energy saving innovations for cold appliances is the necessity of food protection. The decrease of energy consumption can only go as far as food safety is ensured. There is common understanding that perishable food should be stored at temperatures below 5 °C in a refrigerator and at -18 °C in a freezer. Other important factors influencing the energy consumption in real life are identified especially by the temperature of the ambient where the refrigerator or freezer stands and the amount of new food loaded into the devices which needs to be cooled down. Recommendations to place the refrigerator and freezer at the lowest possible ambient temperature and not to place hot food into them are important ways to reduce the amount of energy used.

But refrigerators and freezers in consumer homes not always seem to be set to follow this recommendation. Ambient temperatures go up to 40 °C for a considerable amount of households investigated and down to temperatures of 0 °C. While the higher ambient temperatures are covered by the climate classes as defined, temperatures lower than 10 °C of the ambient are not foreseen at all. But more than 20 % of the households investigated in 10 European countries report to have minimum ambient temperatures lower than 10 °C where the refrigerator stands. One consequence of this is that the right temperature in the refrigerator and freezer is no longer maintained and the quality of food stored may suffer significant losses. In refrigerators/freezers of category 7 many gadgets only have one compressor which is used to provide cool for both compartments. These systems are optimised to provide the required temperatures under standard conditions, but will fail if the constant ambient temperature of 25 °C is not met. The consequence is, that at lower ambient temperatures these appliances may either fail to keep the right storage temperatures or activate additional heating devices to cause the compressor to provide cool. This may cause considerable additional amounts of energy (up to 29 %) used than compared to a similar appliance with two compressor circles. At higher ambient temperatures these machines will – while keeping the temperature in the refrigerator compartment at the right value – provide more cool to the freezer compartment as needed to keep the desired temperature. Also this may cause unnecessary energy consumptions. Only about one quarter of the consumers adjust their temperature setting according to the outside temperature to somehow balance this effect.

Consumer behaviour is also characterised by

- an average temperature of the refrigerator set at 5,0 °C at the correct level, but with relevant differences between countries,
- an average temperature of the freezer at -16,7 °C, again with differences between countries,
- the capacity of the refrigerator compartment which is used to a good extent by the consumers, but that of the freezer is even more filled.

Summarising all of this information about the consumer behaviour allows estimating the difference between the real life and standard base case energy consumption. Due to the lower ambient temperature in real life compared to the 25 °C used in the standard measurement will considerably reduce the energy taken by the gadgets. Part of this saving is balanced by cooling down food which is loaded and by cooling down the air which is exchanged when opening the door. So all in all the measured consumption following the standard is somehow taking care of this kind of real life behaviour.

Not covered are the additional consumptions which may be used by cat. 7 refrigerators/freezers with just one compressor (and one thermostat) not operated within the temperature range of 20 to 30 °C. Here significant amounts of additional energy are used about which the consumer was not informed at the point of sale of the gadget.

APPENDIX

Appendix 3.1- 1 population by household size and age group: comparison results own survey vs. Eurostat data[82]

United Kingdom		Age group 20-39 years	Age group 40-59 years	Age group 60 and 74 years	total
results own survey	1 person	3,9%	7,1%	4,2%	15,1%
	2 persons	11,6%	12,2%	10,6%	34,4%
	3 persons	11,6%	10,9%	1,6%	24,1%
	4 persons	8,0%	8,7%	1,0%	17,7%
	more than 4 persons	4,8%	3,9%	0,0%	8,7%
	total	*39,9%*	*42,8%*	*17,4%*	*100,0%*
		Age group 20-39 years	Age group 40-59 years	Age group 60 and 74 years	total
Eurostat*	1 person	4%	5%	5%	*14%*
	2 persons	10%	13%	12%	*36%*
	3 persons	10%	9%	2%	*21%*
	4 persons	10%	8%	1%	*19%*
	more than 4 persons	6%	4%	0%	*11%*
	total	*41%*	*39%*	*20%*	*100%*
		Age group 20-39 years	Age group 40-59 years	Age group 60 and 74 years	
Differences	1 person	0,1%	-2,1%	0,8%	-1,1%
	2 persons	-1,6%	0,8%	1,4%	1,6%
	3 persons	-1,6%	-1,9%	0,4%	-3,1%
	4 persons	2,0%	-0,7%	0,0%	1,3%
	more than 4 persons	1,2%	0,1%	0,0%	2,3%
	total	*1,1%*	*-3,8%*	*2,6%*	*0,0%*

[82]Own calculation: Population by household size and age group based on EUROSTAT data.

* Own calculations: crosstabs with EUROSTAT data of population by age group and household size

France		Age group			total
		20-39 years	40-59 years	60 and 74 years	
results own survey	1 person	5,9%	3,9%	3,9%	13,8%
	2 persons	9,1%	11,0%	11,8%	31,9%
	3 persons	9,8%	9,8%	2,0%	21,7%
	4 persons	11,0%	7,9%	1,2%	20,1%
	more than 4 persons	7,5%	5,1%	0,0%	12,6%
	total	*43,3%*	*37,8%*	*18,9%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Eurostat*	1 person	6%	4%	4%	*15%*
	2 persons	9%	11%	12%	*32%*
	3 persons	10%	9%	2%	*22%*
	4 persons	11%	8%	1%	*19%*
	more than 4 persons	7%	5%	0%	*12%*
	total	*42%*	*38%*	*20%*	*100%*
		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Differences	1 person	0,1%	0,1%	0,1%	1,2%
	2 persons	-0,1%	0,0%	0,2%	0,1%
	3 persons	0,2%	-0,8%	0,0%	0,3%
	4 persons	0,0%	0,1%	-0,2%	-1,1%
	more than 4 persons	-0,5%	-0,1%	0,0%	-0,6%
	total	*-1,3%*	*0,2%*	*1,1%*	*0,0%*

Czech Republic		Age group			total
		20-39 years	40-59 years	60 and 74 years	
results own survey	1 person	4,0%	5,3%	4,0%	13,4%
	2 persons	6,1%	10,9%	9,3%	26,3%
	3 persons	12,1%	11,3%	2,0%	25,5%
	4 persons	15,0%	10,1%	1,2%	26,3%
	more than 4 persons	5,3%	3,2%	0,0%	8,5%
	total	*42,5%*	*40,9%*	*16,6%*	*100,0%*

		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Eurostat*	1 person	5%	5%	5%	*14%*
	2 persons	6%	11%	10%	*27%*
	3 persons	12%	11%	2%	*25%*
	4 persons	15%	10%	1%	*25%*
	more than 4 persons	5%	3%	0%	*9%*
	total	*42%*	*40%*	*18%*	*100%*

		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Differences	1 person	1,0%	-0,3%	1,0%	0,6%
	2 persons	-0,1%	0,1%	0,7%	0,7%
	3 persons	-0,1%	-0,3%	0,0%	-0,5%
	4 persons	0,0%	-0,1%	-0,2%	-1,3%
	more than 4 persons	-0,3%	-0,2%	0,0%	0,5%
	total	*-0,5%*	*-0,9%*	*1,4%*	*0,0%*

Germany		Age group			total
		20-39 years	40-59 years	60 and 74 years	
results own survey	1 person	6,3%	6,0%	4,8%	17,2%
	2 persons	11,8%	14,8%	12,7%	39,3%
	3 persons	10,3%	9,4%	1,8%	21,5%
	4 persons	9,4%	6,0%	0,0%	15,4%
	more than 4 persons	3,9%	2,7%	0,0%	6,6%
	total	*41,7%*	*39,0%*	*19,3%*	*100,0%*

		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Eurostat*	1 person	7%	5%	5%	*18%*
	2 persons	8%	14%	16%	*38%*
	3 persons	9%	9%	2%	*21%*
	4 persons	9%	7%	0%	*17%*
	more than 4 persons	4%	3%	0%	*7%*
	total	*38%*	*38%*	*24%*	*100%*

		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Differences	1 person	0,7%	-1,0%	0,2%	0,8%
	2 persons	-3,8%	-0,8%	3,3%	-1,3%
	3 persons	-1,3%	-0,4%	0,2%	-0,5%
	4 persons	-0,4%	1,0%	0,0%	1,6%
	more than 4 persons	0,1%	0,3%	0,0%	0,4%
	total	*-3,7%*	*-1,0%*	*4,7%*	*0,0%*

Spain		Age group			total
		20-39 years	40-59 years	60 and 74 years	
results own survey	1 person	3,1%	2,0%	3,1%	8,2%
	2 persons	6,3%	5,5%	7,8%	19,5%
	3 persons	10,9%	7,8%	5,1%	23,8%
	4 persons	13,7%	11,7%	2,0%	27,3%
	more than 4 persons	11,7%	7,8%	1,6%	21,1%
	total	*45,7%*	*34,8%*	*19,5%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Eurostat*	1 person	3%	2%	3%	*7%*
	2 persons	7%	5%	8%	*20%*
	3 persons	11%	8%	5%	*24%*
	4 persons	14%	12%	2%	*28%*
	more than 4 persons	11%	8%	2%	*21%*
	total	*45%*	*35%*	*20%*	*100%*
		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Differences	1 person	-0,1%	0,0%	-0,1%	-1,2%
	2 persons	0,8%	-0,5%	0,2%	0,5%
	3 persons	0,1%	0,2%	-0,1%	0,2%
	4 persons	0,3%	0,3%	0,0%	0,7%
	more than 4 persons	-0,7%	0,2%	0,4%	-0,1%
	total	*-0,7%*	*0,2%*	*0,5%*	*0,0%*

Finland		Age group			total
		20-39 years	40-59 years	60 and 74 years	
results own survey	1 person	7,6%	7,2%	5,2%	19,9%
	2 persons	10,0%	13,9%	12,4%	36,3%
	3 persons	7,6%	9,6%	1,6%	18,7%
	4 persons	8,4%	7,6%	0,0%	15,9%
	more than 4 persons	5,2%	4,0%	0,0%	9,2%
	total	*38,6%*	*42,2%*	*19,1%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Eurostat*	1 person	7%	7%	5%	*20%*
	2 persons	10%	14%	11%	*35%*
	3 persons	8%	9%	2%	*19%*
	4 persons	8%	7%	0%	*16%*
	more than 4 persons	5%	4%	0%	*10%*
	total	*38%*	*43%*	*19%*	*100%*
		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Differences	1 person	-0,6%	-0,2%	-0,2%	0,1%
	2 persons	0,0%	0,1%	-1,4%	-1,3%
	3 persons	0,4%	-0,6%	0,4%	0,3%
	4 persons	-0,4%	-0,6%	0,0%	0,1%
	more than 4 persons	-0,2%	0,0%	0,0%	0,8%
	total	*-0,6%*	*0,8%*	*-0,1%*	*0,0%*

Hungary		Age group			total
		20-39 years	40-59 years	60 and 74 years	
results own survey	1 person	1,9%	3,9%	5,1%	10,9%
	2 persons	6,2%	10,9%	9,7%	26,8%
	3 persons	11,7%	10,9%	3,1%	25,7%
	4 persons	11,7%	9,3%	1,6%	22,6%
	more than 4 persons	7,8%	5,1%	1,2%	14,0%

	total	*39,3%*	*40,1%*	*20,6%*	*100,0%*

		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Eurostat*	1 person	2%	4%	5%	*11%*
	2 persons	6%	11%	10%	*27%*
	3 persons	11%	11%	3%	*25%*
	4 persons	12%	9%	1%	*23%*
	more than 4 persons	8%	5%	1%	*15%*
	total	*40%*	*40%*	*20%*	*100%*

		Age group			**total**
		20-39 years	40-59 years	60 and 74 years	
Differences	1 person	0,1%	0,1%	-0,1%	**0,1%**
	2 persons	-0,2%	0,1%	0,3%	**0,2%**
	3 persons	-0,7%	0,1%	-0,1%	**-0,7%**
	4 persons	0,3%	-0,3%	-0,6%	**0,4%**
	more than 4 persons	0,2%	-0,1%	-0,2%	**1,0%**
	total	***0,7%***	***-0,1%***	***-0,6%***	***0,0%***

Italy		Age group			total
		20-39 years	40-59 years	60 and 74 years	
results own survey	1 person	4,2%	4,5%	3,2%	12,0%
	2 persons	8,4%	5,8%	7,5%	21,8%
	3 persons	12,0%	10,4%	4,2%	26,6%
	4 persons	14,9%	11,4%	1,6%	27,9%
	more than 4 persons	6,5%	4,5%	0,6%	11,7%
	total	*46,1%*	*36,7%*	*17,2%*	*100,0%*
Eurostat*	1 person	3%	3%	4%	*9%*
	2 persons	7%	6%	10%	*23%*
	3 persons	12%	10%	5%	*27%*
	4 persons	13%	12%	2%	*27%*
	more than 4 persons	6%	5%	1%	*13%*

	total	*41%*	*36%*	*23%*	*100%*
		Age group			**total**
		20-39 years	40-59 years	60 and 74 years	
Differences	1 person	-1,2%	-1,5%	0,8%	**-3,0%**
	2 persons	-1,4%	0,2%	2,5%	**1,2%**
	3 persons	0,0%	-0,4%	0,8%	**0,4%**
	4 persons	-1,9%	0,6%	0,4%	**-0,9%**
	more than 4 persons	-0,5%	0,5%	0,4%	**1,3%**
	total	***-5,1%***	***-0,7%***	***5,8%***	***0,0%***

Poland		Age group			total
		20-39 years	40-59 years	60 and 74 years	
results own survey	1 person	3,2%	4,0%	3,6%	10,7%
	2 persons	4,0%	8,3%	7,9%	20,2%
	3 persons	9,9%	10,3%	3,2%	23,4%
	4 persons	11,9%	9,9%	1,2%	23,0%
	more than 4 persons	11,9%	9,1%	1,6%	22,6%
	total	*40,9%*	*41,7%*	*17,5%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Eurostat*	1 person	3%	4%	4%	*10%*
	2 persons	4%	8%	8%	*20%*
	3 persons	10%	10%	3%	*23%*
	4 persons	12%	10%	1%	*23%*
	more than 4 persons	12%	9%	2%	*23%*
	total	*42%*	*41%*	*18%*	*100%*
		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Differences	1 person	-0,2%	0,0%	0,4%	**-0,7%**
	2 persons	0,0%	-0,3%	0,1%	**-0,2%**
	3 persons	0,1%	-0,3%	-0,2%	**-0,4%**
	4 persons	0,1%	0,1%	-0,2%	**0,0%**
	more than 4 persons	0,1%	-0,1%	0,4%	**0,4%**

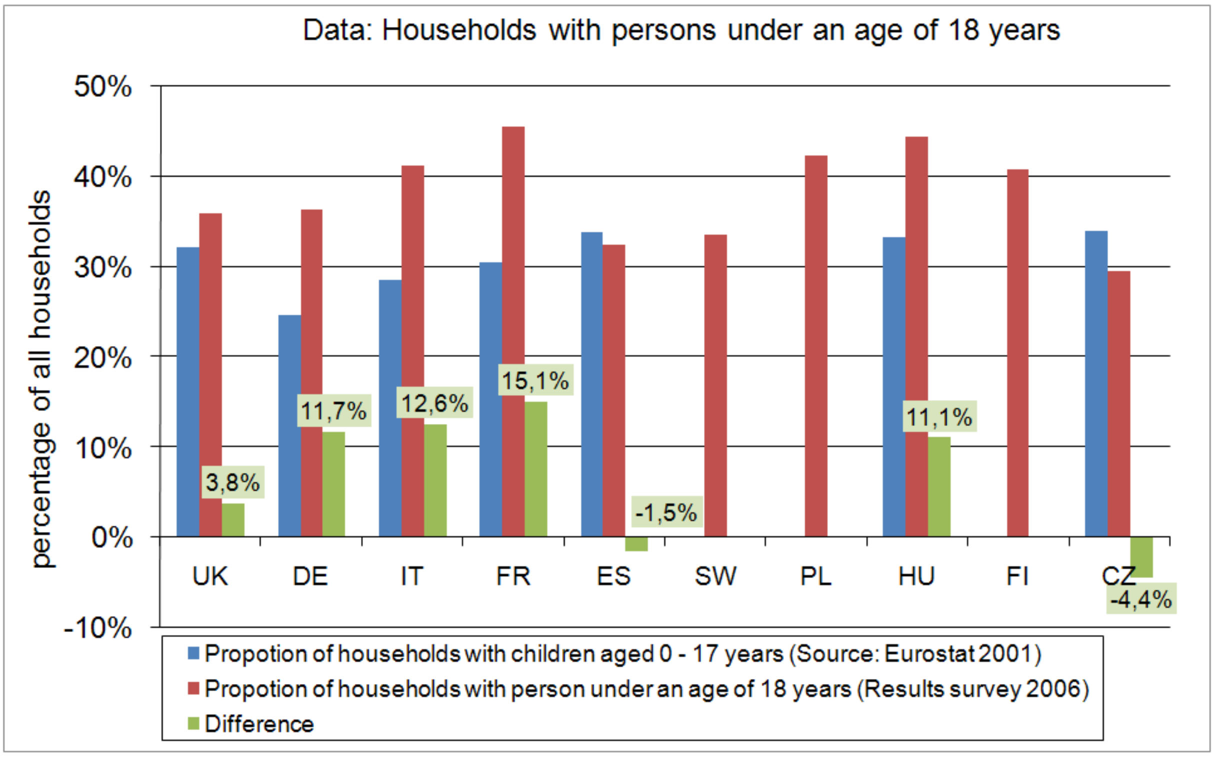
	total	*1,1%*	*-0,7%*	*0,5%*	*0,0%*

Sweden		Age group			total
		20-39 years	40-59 years	60 and 74 years	
results own survey	1 person	12,5%	8,6%	5,9%	27,0%
	2 persons	7,8%	12,1%	15,2%	35,2%
	3 persons	7,0%	7,0%	1,2%	15,2%
	4 persons	7,4%	7,8%	0,0%	15,2%
	more than 4 persons	3,5%	3,9%	0,0%	7,4%
	total	*38,3%*	*39,5%*	*22,3%*	*100,0%*
		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Eurostat*	1 person	12%	9%	6%	*27%*
	2 persons	8%	12%	15%	*35%*
	3 persons	7%	7%	1%	*15%*
	4 persons	8%	8%	0%	*16%*
	more than 4 persons	3%	4%	0%	*7%*
	total	*38%*	*40%*	*23%*	*100%*
		Age group			total
		20-39 years	40-59 years	60 and 74 years	
Differences	1 person	-0,5%	0,4%	0,1%	**0,0%**
	2 persons	0,2%	-0,1%	-0,2%	**-0,2%**
	3 persons	0,0%	0,0%	-0,2%	**-0,2%**
	4 persons	0,6%	0,2%	0,0%	**0,8%**
	more than 4 persons	-0,5%	0,1%	0,0%	**-0,4%**
	total	***-0,3%***	***0,5%***	***0,7%***	***0,0%***

Appendix 3.1- 2 Population by household size (results of this survey vs. Eurostat data)

	People per household	CZ	DE	ES	FR	IT	HU	PL	FI	UK	SW
Source: EUROSTAT (2005)[83]	1 person	30,3%	35,8%	20,3%	31,0%	24,9%	26,2%	24,8%	37,3%	30,2%	no data
	2 persons	28,2%	33,8%	25,2%	31,1%	27,1%	28,8%	23,2%	31,5%	33,9%	
	3 persons	18,9%	14,5%	21,2%	16,2%	21,6%	19,7%	19,9%	13,6%	15,5%	
	4 persons	17,5%	11,5%	21,5%	13,8%	19,0%	16,5%	18,0%	11,1%	13,4%	
	more than 4 persons	5,2%	4,4%	11,8%	7,9%	7,5%	8,7%	14,1%	6,5%	7,0%	
Results survey		**CZ**	**DE**	**ES**	**FR**	**IT**	**HU**	**PL**	**FI**	**UK**	**SW**
	1 person	13,4%	16,0%	8,4%	13,2%	12,4%	11,2%	10,8%	20,0%	16,0%	26,8%
	2 persons	26,3%	40,4%	19,6%	32,4%	20,0%	26,8%	22,0%	36,4%	32,8%	35,6%
	3 persons	25,5%	22,0%	23,6%	21,6%	26,4%	26,4%	26,4%	18,4%	24,0%	15,2%
	4 persons	26,3%	14,8%	27,6%	20,4%	29,2%	22,4%	21,2%	16,0%	18,0%	15,2%
	more than 4 persons	8,5%	6,8%	20,8%	12,4%	12,0%	13,2%	19,6%	9,2%	9,2%	7,2%
Differences		**CZ**	**DE**	**ES**	**FR**	**IT**	**HU**	**PL**	**FI**	**UK**	
	1 person	-17%	-20%	-12%	-18%	-12%	-15%	-14%	-17%	-14%	
	2 persons	-2%	7%	-6%	1%	-7%	-2%	-1%	5%	-1%	
	3 persons	7%	7%	2%	5%	5%	7%	6%	5%	8%	
	4 persons	9%	3%	6%	7%	10%	6%	3%	5%	5%	
	more than 4 persons	3%	2%	9%	4%	5%	4%	6%	3%	2%	

83 http://epp.eurostat.ec.europa.eu/extraction/retrieve/en/theme3/cens/cens_nheco?OutputDir=EJOutputDir_1244&user=unknown&clientsessionid=2D0572A025FB02509B4413EF05D8A0DC.extraction-worker-1&OutputFile=cens_nheco.htm&OutputMode=U&NumberOfCells=72&Language=en&OutputMime=text%2Fhtml&



Appendix 3.1- 3 Population: Households with persons under an age of 18 years (results of this survey vs. Eurostat data. For Sweden, Finland, Poland no data available)

4 Task 4: Product system analysis

4.1 DESCRIPTION OF TASK 4

The eco-design directive is referred to product design and not to systems or installations as a whole. However, Annex VII.4 considers the interaction of the specific EuP with the installation/system where it operates, implicitly stating that the possible effects of the EuP being part of a larger system are to be identified and evaluated. This task includes therefore a functional analysis of the system to which the product belongs, including a rough estimate of the overall impacts, for example from IPP studies like EIPRO and an assessment of how the integration of the product into the system and its design can improve its overall environmental performance.

Apparently, refrigerators and freezers do not have a strong impact on the installation system that would require modification to the inputs of other subsystems or sectors. Some heat is transferred to the kitchen environment, however a much larger amount comes from other appliances (stoves and ovens) and is in any case already considered through thermostatic control of temperature set in space heating requirements.

As such, the existing results of the CEDA EU25 Product and Environmental Model as applied to the use of refrigerators and freezers can be used directly. This is taken as an opportunity to make a controlled comparison between the CEDA top down and LCC bottom up approaches.

The environmental impact for use of refrigerators and freezers is given for the EU-25 in vector – A332, CEDA code 540200 – the use of household refrigerators and freezers, which involves both new unit sales and the consumption of electricity for using the new and existing units. What is required is a normalization for inputs between CEDA and LCC methods. Namely unit sales, that is the total new sales for 2005 estimated in Task 5.4, should be scaled to the number of units used in CEDA EU-25. Average prices will make possible this conversion.

The sales from production to households of "pure" products such as refrigerators and freezers are given in matrix A_{12} of the CEDA model. Dividing these sales by the average price should give us unit sales and permit scaling to achieve comparison with the bottom up results to be performed in Subtask 5.6.

Also in the CEDA EU-25 model, electricity consumption for these products is given as electricity services (utilities) to the household sector for refrigerators and freezers. This energy consumption, given by dividing by average electricity price, must be normalized for both new purchased units and existing units of the stock. The idea is that the same specific consumption (kWh/year per appliance) should be used for the new sales in 2005 in the CEDA EU25 model and the bottom up LCC approach. The same should be attempted for the existing stock consumption; a different, greater specific consumption will result for existing stock. Also the number of units: base case sales, other sales in 2005 and those in the existing stock (less new sales) for 2005 should be the same inputs for the two methods.

If the inputs can be made to be the same, then the differences in results will be due to considering the direct and indirect effects of the input output matrix. Since the input output approach is more complete in its inclusion of the secondary input, such as those materials (and other goods), transport (and other services) and capital inputs to utilities production. With the inversion of the matrix in the input output approach all of the indirect inputs are included. These secondary and tertiary inputs are not always included in LCC analysis and to the extent that they are excluded we would expect more environmental impacts from the input output model. Of course, this assumes that environmental parameters are similar.

If the specific energy parameters and the units sold and being used in the stock cannot be scaled to render the inputs comparable between the two methods, either a new simulation with the CEDA EU25 model or a new simulation of the base case, other new models and the stock should be made to enable the correct comparison, using the same units and electricity inputs. In the case of a simulation with CEDA EU25, a minimum amount of support by the authors or the EC will be required.

4.2 SYSTEM BOUNDARY

The eco-design directive is referred to product design and not to systems or installations as a whole. However, Annex VII.4 considers the interaction of the specific EuP with the installation/system where it operates, implicitly stating that the possible effects of the EuP being part of a larger system are to be identified and evaluated. This Task includes therefore a functional analysis of the system to which the product belongs, including an assessment of how the integration of the product into the system can change overall energy and environmental performance. Particular attention is given to the actual ambient conditions in which the refrigerators and freezers are used and the other aspects of utilization that that are not included in base cases described in Task 5, such as load and door opening. Probably the most important element in the system is man himself, in the form of user of the appliance and electric utility.

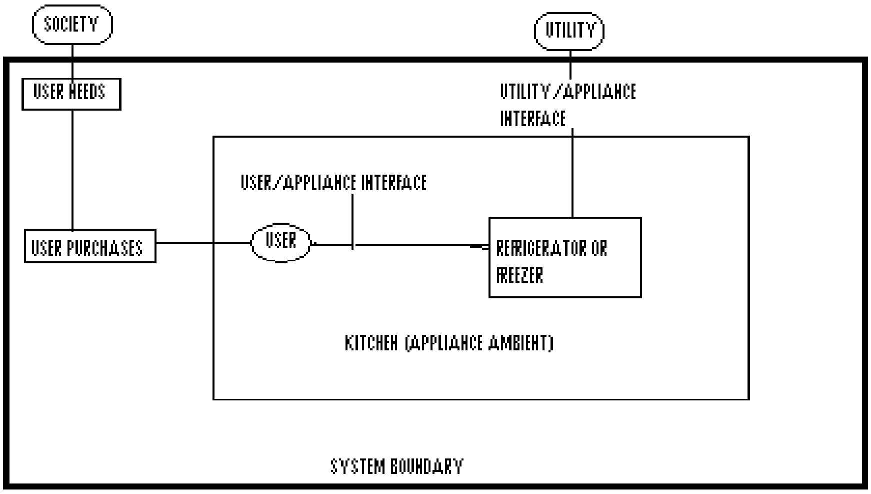
The primary objective of this Task is to explore from a systematic point of view the elements, not considered in the base cases, which influence the present and future energy/environmental impact of appliances. Thus we briefly review the results of the consumer use of cold appliances, fully presented in Task 3, and then proceed to the analysis of changing consumer needs, the enriched user/appliance interface and finally the new utility/appliance interface.

The part of the task regarding the use of the CEDA EU25 Product and Environmental Model is in a preliminary phase and not yet presented. It was preferred to give priority to specific systems issues that emerged in real use of the appliance and future needs and trends of the consumer. This was necessary for a better understanding of the base cases and long-term scenarios.

Apparently, refrigerators and freezers do not have a strong impact on the installation system that would require modification to the inputs of other subsystems or sectors. Some heat is transferred to the kitchen environment, however a much larger amount comes from other appliances (stoves and ovens) and is in any case already considered through thermostatic control of temperature set in space heating requirements.

Undoubtedly, this is a very reductive interpretation of the system boundary, characteristic of the 1990's but not taking into consideration of the advances made in consumer electronics in the last decade. The system boundary we consider is widened to include: i) the kitchen or place of use within the home; ii) the product user, in particular how he/she actually uses the appliance and his/her changing needs for refrigeration and freezing; iii) the enriched user/appliance interface made possible by less and less expensive electronics, displays and Internet; and finally the possibility of a new utility/appliance interface regarding demand side management. This is illustrated in Figure 4.1.

Figure 4.1: System elements and boundary



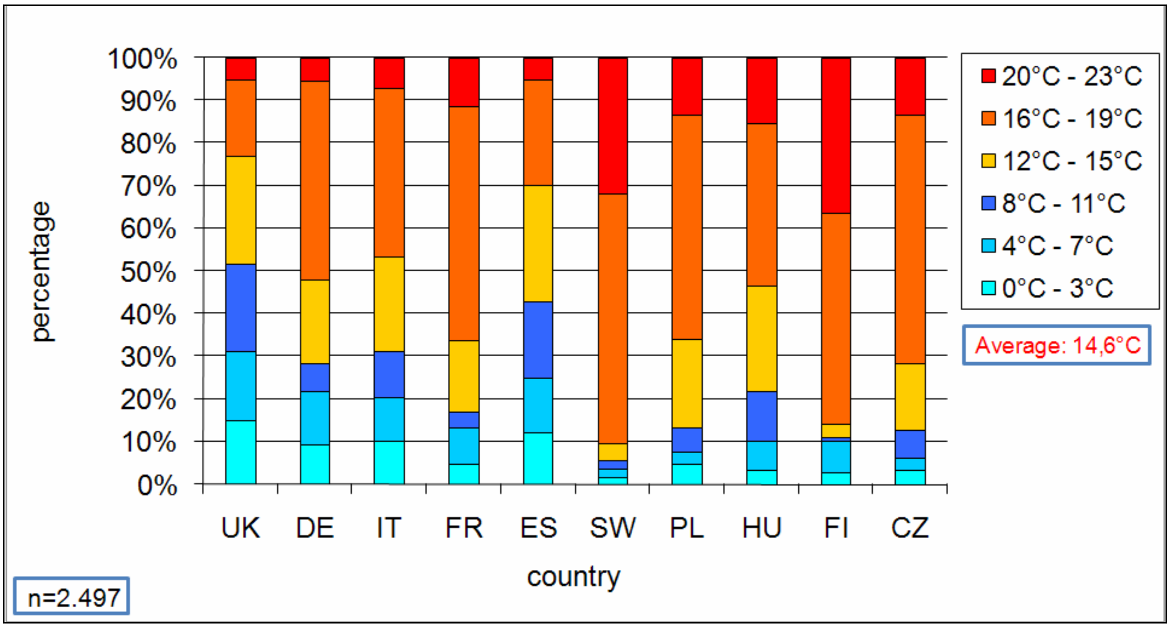
4.3 REAL CONSUMER USE OF REFRIGERATORS AND FREEZERS

The results of the study on consumer base case are summarised here, for the complete presentation and discussion of this subject refer to Task 3.

4.3.1 Ambient temperature

A surprising result from the survey undertaken in this study for the description of the consumer behaviour - and involving 2 500 European households - was that the average minimum ambient temperature given by respondents was reported at a quite low 15 °C. Seventy percent of households declared to have minimum temperatures below 18 °C; twenty to thirty percent of the households reported to have minimum temperatures below 7 °C, as shown in Figure 2 concentrated in the UK, Italy and Spain.

Figure 4.2: Minimum ambient temperatures of the kitchen (or where the refrigerator is located)



The average temperature reported was 19,5 °C considerably below the 25 °C used in the standard test procedures (described in Task 1). The consumer may not accurately represent the temperature behind the **refrigerator** where the heat exchange is occurring, which might be somewhat higher than the average ambient temperature given that the exchanger is warm and some installations may not have completely free air flow. The maximum temperatures are also surprisingly high: some of the same countries, Spain and Italy (along with Hungary), representing 20% of the households surveyed, had maximum temperatures over 32 °C.

In any case, the average temperature is very likely considerably below 25° C the standard test temperature on which the European energy consumption measurements are based. Energy consumption is very sensitive to the ambient temperature: a 1°C reduction in ambient temperature produces a 6% decrease in electricity consumption.

The concern is that some users may purchased appliances in an inappropriate climate class[84], underestimating their room temperature, which in some cases may not be the kitchens. This is of particular concern with the combination refrigerator-freezers with one compressor and one thermostat, which under extreme cold conditions, outside the range of their climate class, could require extra heating to keep the freezer above the minimum temperature (at which the compressor can function). More detailed surveys and measurements are appropriate to address this situation. In any case increased emphasis should be given to the choice of appropriate climate class of appliances – included in all the forms of consumer information/advice before the purchase, on the appliance, on web sites and in the store.

Also for **freezers** the ambient temperatures were reported much lower than the standard; specifically the average room temperature for category eight and nine freezers was 18 °C, slightly less than that of refrigerators possibly due to the fact that freezers are opened less frequently and thus can be kept in more remote places such as a basement. Forty percent of the household reported rooms with minimum temperatures less than 12 °C, outside the N climatic range, but included in the

[84] Climate classes: SN from 10° C to 32° C; SN from 16° C to 32 ° C; ST from 16° C to 38° C; and T from 18° C to 38°C.

SN range. Again there is concern that consumers may have purchased freezers for an inappropriate climate class and further field research is necessary.

As reported the consumption of cold appliances is very sensitive to the ambient temperature and such large negative differences between the standard temperature of 25 °C and these reported averages would lower consumption some 33% in the case of refrigerator-freezers and could be nearer 40% for freezers. Naturally this lower consumption is compensated in part by the consumers' real use of the appliance including loading, introducing warm food, door openings, and possible substandard performance in the case of operation outside of the climate class.

4.3.2 Temperature settings, loading and door opening

4.3.2.1 Actual settings

Setting of the internal temperature for the main refrigerator is reported in the consumer survey at an average of 5 °C in keeping with the standard setting. Also for freezer/chest freezer the reported average internal setting is at 17 °C not very far from the 18 °C standard temperature. Therefore these settings should not induce energy consumption substantially different from that measured according to the European standard.

4.3.2.2 Higher temperature settings (storage life and health issues)

Occasionally the issue is raised about the appropriate standard internal temperatures with the idea of increasing the internal temperatures a small amount (several degrees) thereby achieving a substantial energy savings. With a 2°C increase, about 12% energy savings could be realized. However, the effect of food storage in various conditions have been explored and tested thoroughly at international level, as illustrated in Task 1. In general there is no motivation to raise the established internal temperatures.

With regard to freezing, although bacteria do not grow substantially below -10°C, enzymes and other chemicals are active. As a result, the storage life of frozen foods decreases dramatically above -18 °C as shown in the already mentioned Task 1, where in 60% of the cases presented, the storage life is reduced by more than half in going from -18°C to -12°C.

Instead with refrigeration the question of storage time is even more critical since many of the most valuable refrigerated foods last only one or two days, such as fish/shell fish, leftover eggs, and left over cooked meats. Any increase in the standard +5°C temperature would make these items particularly vulnerable. In general there is no reason for the consumer to risk lower storage times and spoilage of food and thus no incentive for manufacturers to raise the established internal temperature settings.

4.3.2.3 Loading and door opening

In the case of refrigerator, 62% of households surveyed are interpreted to have their appliance more or less half full at all times; 11% percent reported that their refrigerator was full most of the time. The refrigerator does not appear to be underutilized.

The repetitive loading of food is not taken into consideration in the standard testing method for refrigeration and preliminary calculations are given in Task 3. Also studied is the impact of occasionally inserting warm food and the opening of the refrigerator door, which also has been studied internationally.

The result of all these loadings and opening of the door, which is certainly much more near true consumer usage of the refrigerator, results in an increase over the base case energy consumption of 16%. It is recalled that operating in much lower ambient temperatures was estimated to decrease the base case consumption by 33%. Given that some appliances may occasionally operate outside their correct climatic class would increase consumption. These compensating factors appear to make the characteristics of the base case measured according to the European standard fairly realistic in the case of refrigerators.

Results for freezers (both upright and chest) are analogous. Users report in 34% of the households that the freezer is completely full most of the time and in 48% report it is sometimes completely full and sometimes less full, indicating high utilization on the whole. As in the previous situation the estimates were made for normal loading (hot foods were not introduced into the freezer) and door openings. These resulted in a smaller correction than the refrigerator case due to the fact that amount of the loadings are less and door openings are much less frequent.

The additional consumption for this more realistic use of freezers is in the order of one or two percent compared to the energy consumption measured according to the EN standard.

4.3.3 Consumer needs and trends

There is a trend to toward slightly larger refrigerators and freezers internal volumes. This trend can be seen from an analysis of the CECED database over the last decade in Table 4.1. The arithmetic average over all cold appliance models produced is shown. Since the number of models for each category is approximately proportional to the number of unit produced and consumed, this average over all models is near the average of all models sold for each year. The average net volume over all categories has gone from 229 to 252 litre, an increase of 10% or 24 litre over the decade.

This increase in volume has been widespread: in every appliance category (underlined) where there has been relative frequency growth, there was volume growth. And the converse is true: in the declining categories, volumes have been decreasing.

An examination of the equivalent volume reveals that the growth of 24 litre of net volume produced an increase of 32 litre in equivalent volume. Thus the volume growth came from both an increase in freezer volume and refrigeration volume.

This trend is thought to represent the changing need of the consumer to engage in less frequent food shopping; and thus the need for buying and storing more food products. It could also be due to a change in family size, but this is declining. Higher incomes might imply a little more food, but more of the income usually goes to discretionary spending. Less time and fewer trips for food shopping could also be a choice by consumer to increase time for other activities.

Table 4.1: Frequency of Models in the CECED Data Bank and Volumes of Cold Appliances

Category	Measure	Year 1995	Year 2005	Percent Change	Change in Volume (l.)
Cat. 1:	Frequency of Models	724	2146		
	Percent of Total Models	11,1%	13,7%	23,4%	
	Average Net Volume	197	230	16,8%	33
	Average Equiv. Vol.	199	245	22,8%	45
Cat. 2:	Frequency of Models	21	97		
	Percent of Total Models	0,3%	0,6%	92,4%	
	Average Net Volume	292	314	7,4%	22
	Average Equiv. Vol.	276	283	2,6%	7
Cat. 3:	Frequency of Models	189	107		
	Percent of Total Models	2,9%	0,7%	-76,4%	
	Average Net Volume	140	123	-11,9%	-17
	Average Equiv. Vol.	143	125	-12,4%	-18
Cat. 4:	Frequency of Models	69	46		
	Percent of Total Models	1,1%	0,3%	-72,2%	
	Average Net Volume	154	91	-41,0%	-63
	Average Equiv. Vol.	163	98	-39,8%	-65
Cat. 5:	Frequency of Models	244	78		
	Percent of Total Models	3,7%	0,5%	-86,7%	
	Average Net Volume	184	145	-21,4%	-40
	Average Equiv. Vol.	200	158	-20,8%	-42
Cat. 6:	Frequency of Models	481	23		
	Percent of Total Models	7,4%	0,1%	-98,0%	
	Average Net Volume	159	150	-5,7%	-9
	Average Equiv. Vol.	181	170	-6,3%	-11
Cat. 7 & 10:	Frequency of Models	2865	9822		
	Percent of Total Models	44,0%	62,8%	42,8%	
	Average Net Volume	271	278	2,4%	7
	Average Equiv. Vol.	359	378	5,4%	19
Cat. 8:	Frequency of Models	1065	2441		
	Percent of Total Models	16,4%	15,6%	-4,5%	
	Average Net Volume	154	177	15,1%	23
	Average Equiv. Vol.	332	417	25,6%	85
Cat. 9:	Frequency of Models	855	879		
	Percent of Total Models	13,1%	5,6%	-57,2%	
	Average Net Volume	280	254	-9,4%	-26
	Average Equiv. Vol.	598	582	-2,8%	-17
All Categories:	Frequency of Models	6513	15639		
	Percent of Total Models	100,0%	100,0%	0,0%	
	Average Net Volume	228,6	252,1	10,3%	23,5
	Average Equiv. Vol.	340,4	372,7	9,5%	32,2

Under the hypothesis that this increase in volume of refrigeration has allowed for making fewer trips to the food store, the possible tradeoffs between refrigeration and transport can be compared. The increased energy consumption (for this 10% increase in volume) of a Categories 7&10 refrigerator-freezer is about 6-8% and the annual consumption increases, 23 kWh/year considering the average refrigerator-freezers consumption in 2005. At the current EU27 average price of 0,14 €/kWh, this amounts to an additional energy cost of 3,18 €/year for the larger appliance. Add to this about 50% for the annualized price increase of the larger appliance and we have annualized cost of 4,80 €.

Suppose the transport savings is in the form of a car trip to the store at one kilometre distance. This If one saves one such trip each week, the transport savings more than compensate the increased refrigerator-freezer energy consumption. With the European average automobile consuming 6,5 litre petrol/km., this amounts to 6,9 litre of petrol/year or 8,30 € at an average price of 1,20 €/litre.

In general, as illustrated in Figure 4.3, the consumer can save: travelling less and cooling more, although the real motivation is probably more satisfactory use of his time. The economic breakeven is about 60 km of trips (30 round trips of 2 km) not taken per year. This would imply one less trip every 12 days. In terms of primary energy, there is the same type of advantage as shown in Figure 4.4. Surprisingly the primary energy breakeven is at about the same point around 60 kilometres.

Figure 4.3: Cooling and driving tradeoffs: comparison of cost of extra cooling volume vs. savings in fewer trips to food store

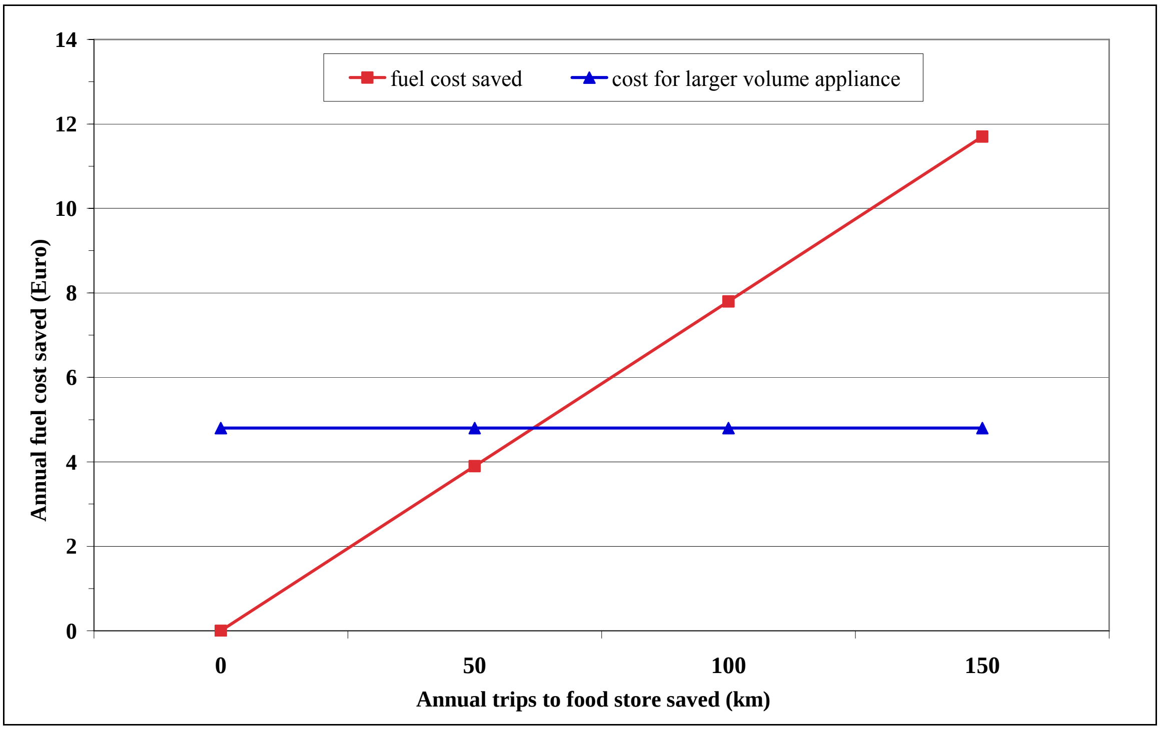
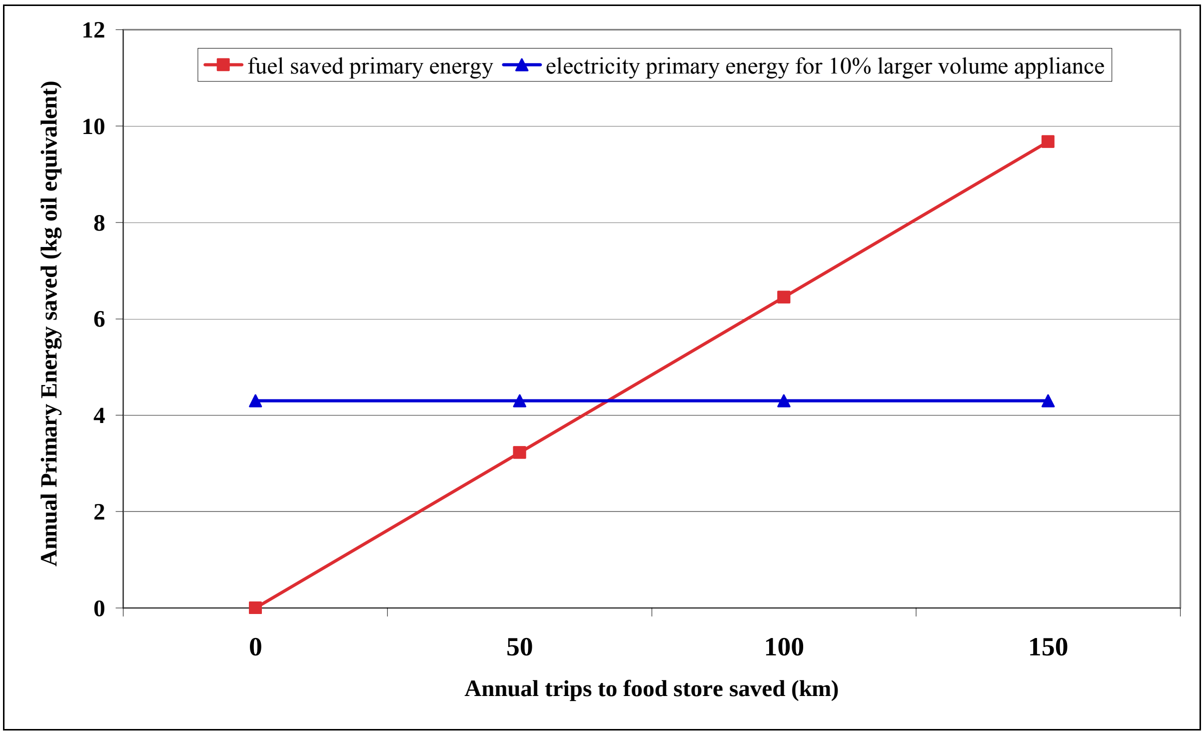


Figure 4.4: Comparison of primary energy used for increased volume of refrigerators vs. primary energy saved by reducing the kilometres of trips driven to the food store



4.4 ENRICHED USER/APPLIANCE INTERFACE

Less and less expensive displays, consumer electronics and Internet make possible a much fuller user/cold appliance interface. More measuring devices are incorporated for better control. The consumer is gradually expecting more information about the operation of all his/her products, from automobiles to appliances.

In the case of refrigerators and freezers there can be a green light to indicate everything is operating properly and more models are beginning to give information about internal temperatures. Another simple feature would be a display reminding the user that he/she had made certain special settings such as fast freezing, or set the internal temperatures at some exceptional setting considerably different from the standard one. If user is reminded of these exceptional settings he/she can better manage their prompt normalization to standard operating conditions, saving energy.

Taking the intelligence of the appliance one step further, the refrigerator or the freezer can manage itself this normalization procedure, setting the internal temperature settings back to normal after a certain amount of time or after the work of additional cooling has become much smaller (and the food reached the proper temperature). The status of seasonal summer/winter switches could be indicated or managed by the appliance based on external temperatures or time.

Another area of obvious interest is the indication of abnormal conditions. Courteous or humorous reminders of abnormal conditions, such as prolonged opening of the appliance door would be appreciated and would save energy. An indication of abnormal ambient temperatures could be of help, for example a high temperature near the area of the heat exchanger possibly indicating that ventilation was blocked or that the heat exchanger required cleaning.

Larger machines such as automobiles can support diagnostic functions anticipating or avoiding certain malfunctions. Given the lower cost basis for household appliances these maintenance functions are probably too costly, however the more expensive top-of-the-line products may be able to incorporate some.

The other area of fascinating new application is the use of radio-frequency identification (RDIF) on food products. These should become commonplace in supermarkets and larger stores within several years. The refrigerator or freezer equipped with a RDIF reader would know what was inside the appliance. This could be seen either on a display screen incorporated in the door or on a computer screen via Internet. A comparison to a list of standard contents would indicate what was lacking and thus constitute a shopping list.

For food products that are consumed gradually the RDIF reader could register how many times they were removed/replaced. The appliance electronics or home personal computer could make an estimate of the amount of food products remaining, for even a more accurate shopping list. For products labelled with expiration dates, the appliance/computer could inform the household when certain items were about to expire.

Certainly one of the main determinants of the amount of energy required would be the degree that the additional features, such as display screens and computing power, are embodied in the cold appliance or are found on the home personal computer. From a systems point of view the use of a screen and computing power already in the home computer appears to be the best option in terms of energy and environmental impact. It also would allow the consumer to have a central control of all large appliances in addition to the heating/cooling and security system.

Some minimum display and functions will probably be provided for those that do not use a home personal computer. For example, display of internal temperatures and warning messages of abnormal conditions could be provided as part of the cold appliance, also for those who do not have a home computer. Devices such as the RDIF reader and digital communication circuitry (for communication with the computer/Internet are required to be in the refrigerator or the freezer if their functions are to be utilized.

At the extreme we can have combined appliances, refrigerator/television (screen on the door) or refrigerator/personal computer. Some of these products have begun to appear, however their market penetration appears to be very limited. Energy labelling or other policy measures for such combined appliances would be complicated from a system point of view. For the moment they can be ignored because of the limited number produced.

4.5 NEW UTILITY/APPLIANCE INTERFACE

Household electricity demand usually has a strong daily peak between late afternoon and early evening. This peak power requirement causes additional power stations and transmission/ distribution capacity to be built. Even if conventional power stations can absorb part of the peak this implies that normally some stations are working at lower utilization levels and lower efficiency. Better management of peak loads or dynamic demand control (DDC) thus can yield significant energy and capital savings for electric utilities.

For appliances that are used discontinuously, such as washing/drying appliances this involves the shift of their time of application to other periods such late night and the familiar use of delay timers on the appliances and of consumer incentives through night tariffs. Instead continuously used appliances such as refrigerators, freezers and air conditioners under DDC can be made to delay or anticipate their on-cycle (or intensify/diminish it) during the periods of high grid load, with little impact on average temperatures. Grid load is easily sensed from the mains frequency that dips slightly under periods of high gird load. DDC appliances therefore need no user intervention. As in the case of night use of washing machines and dishwashers there is no energy savings for the consumer and special night tariffs have been devised to divide the benefits between the user and the utility. The same principle could be extended to the use of DDC, where the utility and client have a direct relationship.

This DDC method has been tested on domestic refrigerators in laboratory trials and shows that internal temperatures can remain under control while responding to high grid load.[85] No cost information is available as the interfaces are still under development and testing, but presumably the electronics required would be massed produced and utility savings in capacity and energy would offset the cost of the electronics. The power of such an extra chip in the appliance should be negligible, in the order of 0,001 Watt[86]. If effectiveness is confirmed in wider testing, the detection and control chip could begin to be incorporated into refrigerators and freezes within the decade.

4.6 CEDA EU25 PRODUCT AND ENVIRONMENTAL MODEL

1.8 CEDA EU product and environmental model (Version Cold, Task 4)

The outputs of CEDA I/O model of EIPRO are given for year 2003. Unfortunately data and outputs do not exist for more recent years and it outside the scope and means of the present study to update and run this model on more recent data. Therefore we have attempted to take the output of our study and convert it to the conditions of CEDA I/O model.

The first step to use the CEDA model is to extract the total environmental impacts for all economic activity. These are given as scores per impact category in Table 5.1.1 Normalisation values for the EU-25 used in the EIPRO study.[87]

The total EU-25 impacts in year 2003 for the three impact categories (in common) are:

Global warming GWP100: 4,71E+12 kg CO2 eq/yr

Acidification: (incl. fate, average Europe total , A&B)
4,31E+10 kg SO2 eq/yr

Eutrophication: (fate not incl.) 1,05E+10 kg PO4 eq/yr

The other impact categories are not in common with that of the methods used in the present study.

[85] Market Transformation Programme, Briefing Note XS41: Dynamic demand control of domestic appliances, 30 Mar 2007,www.mtprog.com

[86] Personal communication with Simon Leach, Senior Scientist (Domestic Appliances), Intertek RPT, Milton Keynes, MK5 8NL, U.K:

[87] Page 97, Annex 5: Annexes to Chapter 5, Environmental Impact of Products (EIPRO), Annex Report, May 2006, Report EUR 22284 EN.

These totals are multiplied times their fractional shares of impact for use of household refrigerators and freezers (code 540200) from shares table of the same report.[88]

The above vector product is divided by the number of families in EU-25 in year 2003, namely 182,126,800 as indicated in the Table 1. The result is the EU-25 environmental impacts per family, per year, for the use of refrigerators and freezers as shown in the sixth column of the table.

From our study, we utilize the environmental impacts reported in Task 3, dividing them by 15 years to obtain the annual impact and multiplying these single product impacts by their respective ownership levels (98,21% for refrigerators and 47,92% for freezers) to obtain the average family impact as illustrated in the last columns of the Table 4.2. From the present study environmental impacts of combination refrigerators/freezers (appliance cold 7) was used together with that for freezers, the average of upright and horizontal freezers (appliance cold 8 and 9).

This now can be compared with the family impact of the I/O model, indicated in the sixth column with that of the present study shown in the adjacent column.

[88] Page 179, Annex 5: Annexes to Chapter 5, Environmental Impact of Products (EIPRO), Annex Report, May 2006, Report EUR 22284 EN.

Table 4.2: Comparison of Environmental Annual Impact Per Family (EU -25) for the Use of Refrigerators and Freezers

			Comparison for Refrigerators and Freezers: EU25 (2003)	EU25 (2003)	**EU25 (2003)**	**Present Study**	Present Study
	EU25 (2003) Value		Fraction due to:	Total due to	**Aver. Family due to**	**(,9821*Refr. +**	Aver. Refr. (Cold 7)
Units	(from I/O Model)	**Summarized Themes**	Use of Refr + Frez.	Use of Refr + Frez.	**Use of Refr + Frez.**	**0,4792*Frez.)/15**	(over 15 yr. life)
kg antimony eq./yr.	1,33E+10	Abiotic depletion	1,17E-02	1,56E+08	0,854		
kg CO2 eq./yr.	4,71E+12	Global Warming GWP100	1,77E-02	8,34E+10	**457,742**	**311,190**	2493,000
kg CFC-11 eq./yr.	3,69E+07	Ozone layer depletion	9,82E-03	3,62E+05	0,002		
kg 1,4-dichlorobenzene eq./yr.	1,91E+12	Human toxicity htp inf.	1,16E-02	2,22E+10	121,652		
kg 1,4-dichlorobenzene eq./yr.	1,29E+12						
kg 1,4-dichlorobenzene eq./yr.	5,75E+15						
kg 1,4-dichlorobenzene eq./yr.	2,64E+11						
	1,92E+15	Ecotoxicity score(avg.of 3)	1,15E-02	2,20E+13	121056,449		
kg ethylene eq./yr.	3,84E+10	Photochemical oxidation	8,31E-03	3,19E+08	1,752		
kg SO2 eq./yr.	4,31E+10	Acidification	2,95E-02	1,27E+09	**6,981**	**1,897**	14,994
kg PO4---eq./yr.	1,05E+10	Eutrophication	4,11E-03	4,32E+07	**0,237**	**0,040**	0,063

As can be seen the values are considerably different. If we take the ratio of the I/O model values to that of the present study the ratios are: 1,4, 4,0 and 5,0 for global warming, acidification and eutrophication respectively. While the global warming comparison might be considered acceptable, perhaps due to the fact that the EU-25 average refrigerators and freezers are older and less efficient than our average model and due to the fact that with the indirect inputs of the I/O model the requirements should be more inclusive and thus somewhat greater; such large differences in acidification and eutrophication are not reasonable.

Furthermore, the same methodology of comparison was applied to the washing machines and the ratio of the I/O model impact to present study impacts resulted in factors of 5, 15 and 130 respectively.

We could continue to apply such large difference to the various totals and scenarios; however, it is meaningless without understanding the differences at the more fundamental single family or single appliance level, including the inputs to the I/O model. We do not rule out the possibility that we have misread or misunderstood the I/O model results. It is suggested that these results be posted for comments.

5 Task 5: Definition of Base-Case[89]

5.1 SUBTASK 5.1: DEFINITION OF BASE CASE

The feasibility of the first approach for the selection of the base case (13 base cases as developed within the COLD-II study) was evaluated during the first stakeholder meeting against the alternative approach forecasting a reduced number of base cases. The outcome of the discussion was that four base cases are sufficient to describe cold appliances:

1. refrigerator (representing categories 1-6)
2. refrigerator-freezer (representing categories 7 and 10)
3. upright freezers (representing category 8)
4. chest freezers (representing category 9)

The following note accompanied also the decision: **to be pointed out that no manufacturer, stakeholder or expert will say that any policy measure proposed by the European Commission on the basis of the study output is not valid because the LCC/LCA has not been developed for a product category**.

This decision (and the note) was circulated, as part of the meeting minutes, on the cold appliances project website with apparently no stakeholder/expert having any negative comment on objection.

5.1.1 The Analysis of the 2005 Technical Database

The 2005 technical database collected by CECED includes 15 639 models, divided into the 10 categories defined in the energy labelling directive 94/2/EEC (Table 5.1).

The analysis started with the validation of the collected data, mainly in terms of the coherence between the declared Energy Efficiency Class of each model and the relevant annual energy consumption, which implies a coherence of the declared appliance category with the number and type of compartments, their temperature and volume and the presence of other features such as the No-frost system or the built-in possibility. Some additional prescriptions were done to the initial classification in the 10 categories:

- appliances with only a cellar compartment have been (re)classified as Category 2, where instead a more restrictive interpretation of the labelling directive would have classified them as Category 10. However, if the temperature of the cellar compartment is +10°C no difference in the outcome (calculated energy efficiency class) can occur;
- two door appliances having - in addition to one or more 4 star frozen food compartment - a cellar and/or a chill compartment have been classified as Category 10, together with more-than-two-door models. Again, if the design temperature of the compartments remains the same as described in the categories 1-7 of the labelling directive no difference in outcome can occur. This disaggregation of the appliances have been done to evaluate the amount of models with different features compared with the average appliances;

[89] Note: the paragraph numbering of this report starts with the number five to be consistent with the final report paging.

- refrigerators having in addition to a +5°C compartment a 0°C (chiller) compartment have been considered Category 1 (even if they should possibly be classified as Category 10).

Table 5.1: Distribution of the models by category in the original and the corrected 2005 database

Category	Models in the source database		Models in the corrected database	
(number)	(number)	(%)	(number)	(%)
1	2 111	13,5	2 204	14,1
2	106	0,7	97	0,62
3	142	0,91	107	0,68
4	47	0,30	46	0,29
5	79	0,51	78	0,50
6	20	0,13	23	0,15
7	9 572	61,2	9 535	61,0
8	2 478	15,8	2 441	15,6
9	870	5,56	879	5,62
10.7	214	1,37	229	1,46
Total	15 639	100	15 639	100

The data declared for the best and the worst models were particularly examined for errors as far as the appliances being at the border between two energy efficiency classes. In the validation of the energy efficiency classes, the following additional assumption were made:

- cellar temperature has been always considered +10°C (resulting in a $\Omega_c = 0{,}75$), since the exact design temperature is not known
- appliances with an EEI exceeding by 0,1% an energy efficiency class threshold have been considered as belonging to the most performing class[90].

The overall process, lead to the following models found non coherent, at least for one of the declared parameters:

Codes	n	% of non coherent models	% over the database
a	86	5,28	0,55
b	201	12,3	1,29
c	683	41,9	4,37
cat*	84 (120)	5,16	0,54
out	509	31,2	3,25
v	66	4,05	0,42
Total	1 629	100	10,42

*when the category is the only non-coherent parameter, into brackets the number of models with a re-assessed category

where:

- code "a" = calculated EE class better than the declared one
- code "b" = borderline model, EEI exceeding by 0,1% the class thresholds
- code "c" = probable typing mistake occurred, model has been subsequently corrected

[90] for example a model with EEI = 75,1 is considered in class B, while from a strict calculation point of view it should be classified as class C. This because the distinction between a model with EEI = 74,98 and a model with EEI = 75,05 is actually not possible. The difference in EEI can easily be due to a rounding of the compartments volume or of the annual energy consumption.

- code “cat” = declared appliance category to be checked, the model has been reclassified into the (considered) correct category on the basis of the elements listed in the database
- code “out” = calculated energy efficiency class worse than the declared one
- code “v” = problems with volumes declaration (gross/net or compartments volumes), for most of the models the volumes have been subsequently corrected.

In the end, 509 models (3,2% over the 15 639 total models) were found non-coherent with the relevant energy labelling declaration and have been corrected; 294 of them (43%) were “out of production” models, that is models no more produced in 2005 but still in the database because still sold in the European market.

The comparison of the distribution of the models in the energy efficiency classes for the original and the correct database (Table 5.2) shows that the difference between the two databases is negligible. 61% of the models in the validated database belong to Category 7 and 1,5% to Category 10, therefore refrigerator-freezers together are 62,5% of the total models. Upright freezer, with 15,6% is the second most important category, followed by Category 1 (refrigerators without low temperature compartment). Chest freezers (Category 9) follows, accounting only for 5,6% of the models. All the other appliance categories together do not arrive at 2,3% of the total models.

The main characteristics of the cold appliance models are presented in Tables 5.3 and 5.4. Gross and net volume, equivalent volume, energy consumption, energy efficiency index and noise in the former, and refrigerant and foaming agent, climatic class and others in the latter. Finally, the models with 2 compressors are 1 356 (or 13,9%) and those with two thermostats 1 333 (or 13,6%), out of 8 071 models declared with 2 doors (or 82,5%) and 968 models (or 9,9%) have both 2 thermostats and 2 compressors.

Table 5.2: Comparison of the models distribution in energy efficiency classes in the 2005 original and validated database

Energy Efficiency class	All models				Refrigerators				Freezers			
	original db		validated db		original db		validated db		original db		validated db	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
A++	290	1,85	288	1,84	133	1,1	131	1,1	157	4,7	157	4,7
A+	3 164	20,2	3 108	19,9	2 356	19,1	2 269	18,4	808	24,3	839	25,3
A	8 837	56,5	8 635	55,2	7 690	62,4	7 547	61,3	1 147	34,6	1 088	32,8
B	2 977	19,0	3 133	20,0	2 134	17,3	2 308	18,7	843	25,4	825	24,8
C	365	2,33	466	2,98	3	0,02	64	0,5	362	10,9	402	12,1
D	2	0,01	7	0,04					2	0,1	7	0,2
E	0	0,0	2	0,01							2	0,1
F	0	0,0	0	0,0								
G	0	0,0	0	0,0								
Total	15 635	100	15 639	100	12 316	100	12 319	100	3 319	100	3 320	100

Table 5.3: Gross & net volume, equivalent volume, energy consumption, energy efficiency index and noise for the cold appliance models in the CECED 2005 technical database

Categories	Gross volume			Net volume			Energy consumption			Equivalent volume			En. efficiency index			Noise		
	min	max	average	min	max	average	min	max	average	min	max	average	min	max	average	min	max	average
(n)	(litre)			(litre)			(kWh/year)			(litre)			(EEI)			(dB(A))		
1	90	413	236	88	403	231	83,0	241,0	159,7	88,0	477,6	245,5	29,6	78,3	52,9	33	46	38
2	153	414	321	150	390	314	131,0	226,0	164,2	112,5	383,7	282,7	40,4	72,4	53,0	33	40	37
3	70	160	130	67	155	123	102,0	211,0	182,1	68,3	156,8	125,5	38,9	74,9	66,3	35	41	39
4	60	160	103	45	155	91	120,0	208,0	177,4	49,4	158,9	98,1	53,3	79,2	69,6	35	40	38
5	123	323	165	106	290	145	165,0	277,0	217,6	117,9	315,5	158,4	53,2	75,0	68,8	35	44	39
6	120	207	154	118	202	150	207,0	285,0	249,9	137,6	222,7	170,0	54,7	74,9	72,2	34	42	39
7	108	660	294	98	627	277	124,1	786,0	324,1	119,9	1 047,7	377,6	28,0	89,8	54,4	33	48	40
8	50	367	202	45	335	177	135,0	540,2	274,5	96,8	1 037,2	416,6	29,1	105,1	56,3	35	45	40
9	57	601	260	57	572	254	134,0	595,0	300,1	122,6	1 475,8	581,8	27,4	108,2	64,4	37	49	42
10.7	180	523	328	160	501	289	190,0	657,0	336,1	190,6	781,3	443,9	27,3	77,7	50,6	32	45	40
Average			268			251			289,0			372,6			55,2	33	49	40
1-6	60	414	230	45	403	223	83,0	285,0	163,7	49,4	477,6	235,9	29,6	79,2	54,4	33	46	38
7&10.7	108	660	294	98	627	277	124,1	786,0	324,4	119,9	1 047,7	379,2	27,3	89,8	54,3	32	48	40

Table 5.4: Refrigerant and foaming agents, climatic class and other characteristics of the cold appliance models in the CECED 2005 technical database

Categories	Fresh food compart. volume			Frozen food compt. volume			Built-in		No-Frost		Refrigerant			Foaming agent			Climatic Class		
	min	max	average	min	min	average	Yes	No	Yes	No	HFC	HC	Other	HFC	HC	Other	ST	T	Other
(n)	(litre)			(litre)			(n)	(n)	(n)	(n)	(models number)			(models number)			(models number)		
1	88	403	229				792	1412	146	2 058	60	1 914	228	195	1 812	184	1 266	317	621
2	153	242	199				0	97	0	97	2	95	0	0	97	0	38	22	37
3	62	148	115				24	83	0	107	45	57	5	7	95	5	75	6	26
4	37	148	77				11	35	0	46	13	25	8	19	27	0	5	0	41
5	92	260	129				3	75	0	78	53	24	0	2	67	0	26	7	45
6	101	184	133				14	9	0	23	3	20	0	9	14	0	1	1	21
7	79	413	210	11,0	214,0	66,8	1 810	7 725	1 599	7 936	811	7 979	739	643	8 428	449	5 135	1 564	2 836
8				45,0	335,0	176,9	339	2 102	315	2 126	99	2 169	173	233	2 077	113	870	868	703
9				57,0	572,0	253,9	0	879	68	811	75	768	36	217	576	36	444	140	295
10.7	34	362	174	17,0	119,0	68,2	44	188	100	132	10	199	19	0	207	21	106	79	47
Tot./Aver.							3 037	12 606	2 228	13 415	1 171	13 251	1 208	1 325	13 401	808	7 966	3 004	4.673
1-6	37	403	217				844	1.711	146	2.409	176	2.135	241	232	2.112	189	1.411	353	791
7&10.7	34	413	209	11	214	67	1.854	7.913	1.699	8.068	821	8.178	758	643	8.635	470	5.241	1.643	2.883

The annual energy consumption of all the models in the as function of the equivalent volume is presented in Figure 5.1. In Figure 5.2 the models in Categories 1-6 are presented, in Figure 5.3 those in Category 7, in Figure 5.4 those in Category 8 and in Figure 5.5 models in Category 9. The specific energy consumption (in kWh/year equiv_litre) for al the models as function of the equivalent volume is presented in Figure 5.6.

The combination of the energy efficiency classes for the models in the ten Categories the technical database, and the aggregated categories to be used for the definition of the base case, is presented in Table 5.5. The same data are shown in Figure 5.7.

Table 5.5: Distribution of the cold appliance models in the energy efficiency classes

Category	EE Class	**A++**	**A+**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**Total**
Category 1	(n)	33	496	1 346	319	10					2 204
	(%)	1,5	22,5	61,1	14,5	0,45					100
Category 2	(n)		19	59	19						97
	(%)		19,6	60,8	19,6						100
Category 3	(n)		4	30	73						107
	(%)		3,74	28	68,2						100
Category 4	(n)			10	26	10					46
	(%)			21,7	56,5	21,7					100
Category 5	(n)			14	64						78
	(%)			17,9	82,1						100
Category 6	(n)			2	21						23
	(%)			8,7	91,3						100
Category 7	(n)	96	1 660	6 002	1 735	42					9 535
	(%)	1,0	17,4	62,9	18,2	0,44					100
Category 8	(n)	93	548	1 076	605	118		1			2 441
	(%)	3,8	22,4	44,1	24,8	4,8		0,04			100
Category 9	(n)	64	291	12	220	284	7	1			879
	(%)	7,3	33,1	1,4	25,0	32,3	0,80	0,11			100
Category 10	(n)	2	90	84	51	2					229
	(%)	0,87	39,3	36,7	22,3	0,87					100
Category 1-6	(n)	33	519	1 461	522	20					2 555
	(%)	1,3	20,3	57,2	20,4	0,78					100
Category 7&10	(n)	98	1 750	6 086	1 786	44					9 764
	(%)	1,0	17,9	62,3	18,3	0,45					100

5.1.2 The Notary Report of the Industry Voluntary Commitment

The industry voluntary commitment defined by CECED in 2002 for cold appliances foresee that an annual Notary Report is delivered to the Commission and Member States. The Notary Report includes the number of units produced/imported for each category and the corresponding weighted average energy consumption (in kWh/year). The report for the year 2005 is available, therefore both the 2004 and 2005 report outcomes are presented.

In 2005 about 19,1 million cold appliances were produced/imported for the EU25 market by the signatories of the voluntary commitment: 3,3 million units of Categories 1-6, (17,0%) and 11,8 million (61,3%) for Categories 7&10; Upright freezers were 2,5 million units (or 13,3%) while chest freezers were 1,6 million units (or 8,4%) of the total. In 2004 the share was 3,9 million units

Figure 5.1: Energy consumption as function of the equivalent volume for the cold appliance models in the 2005 CECED technical database

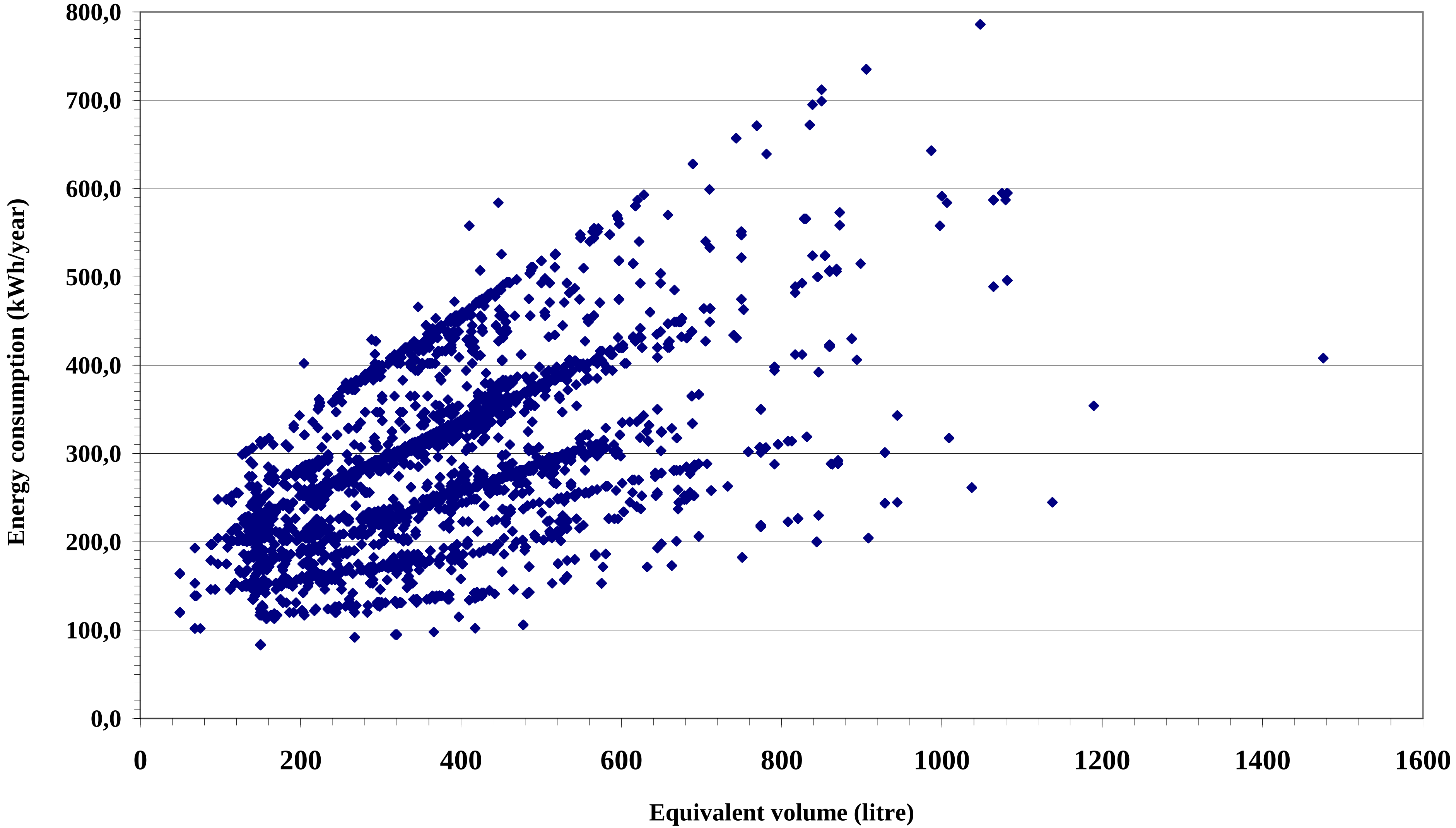


Figure 5.2: Energy consumption as function of the equivalent volume for the Categories 1-6 models in the 2005 CECED technical database

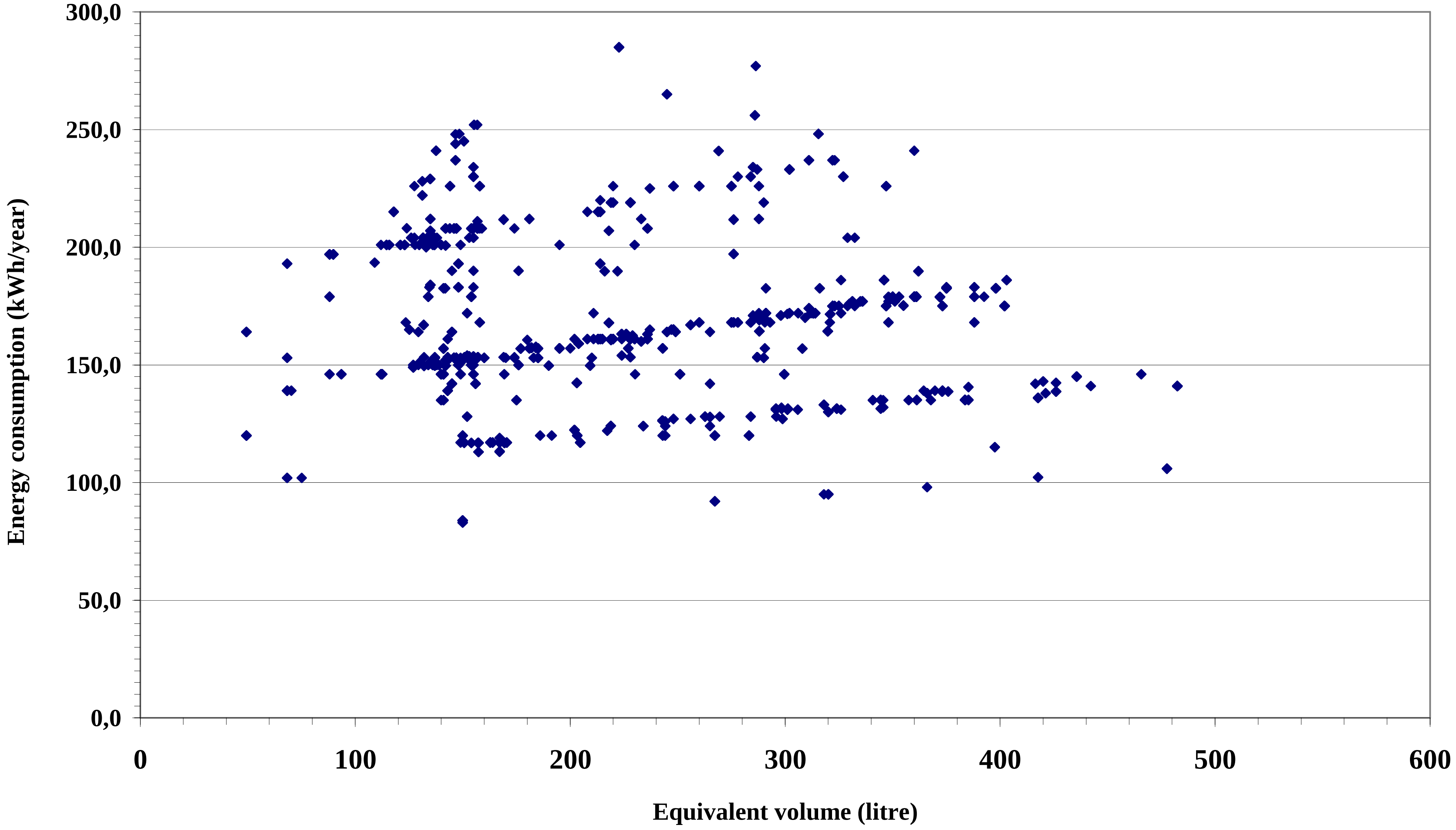


Figure 5.3: Energy consumption as function of the equivalent volume for the Category 7 models in the 2005 CECED technical database

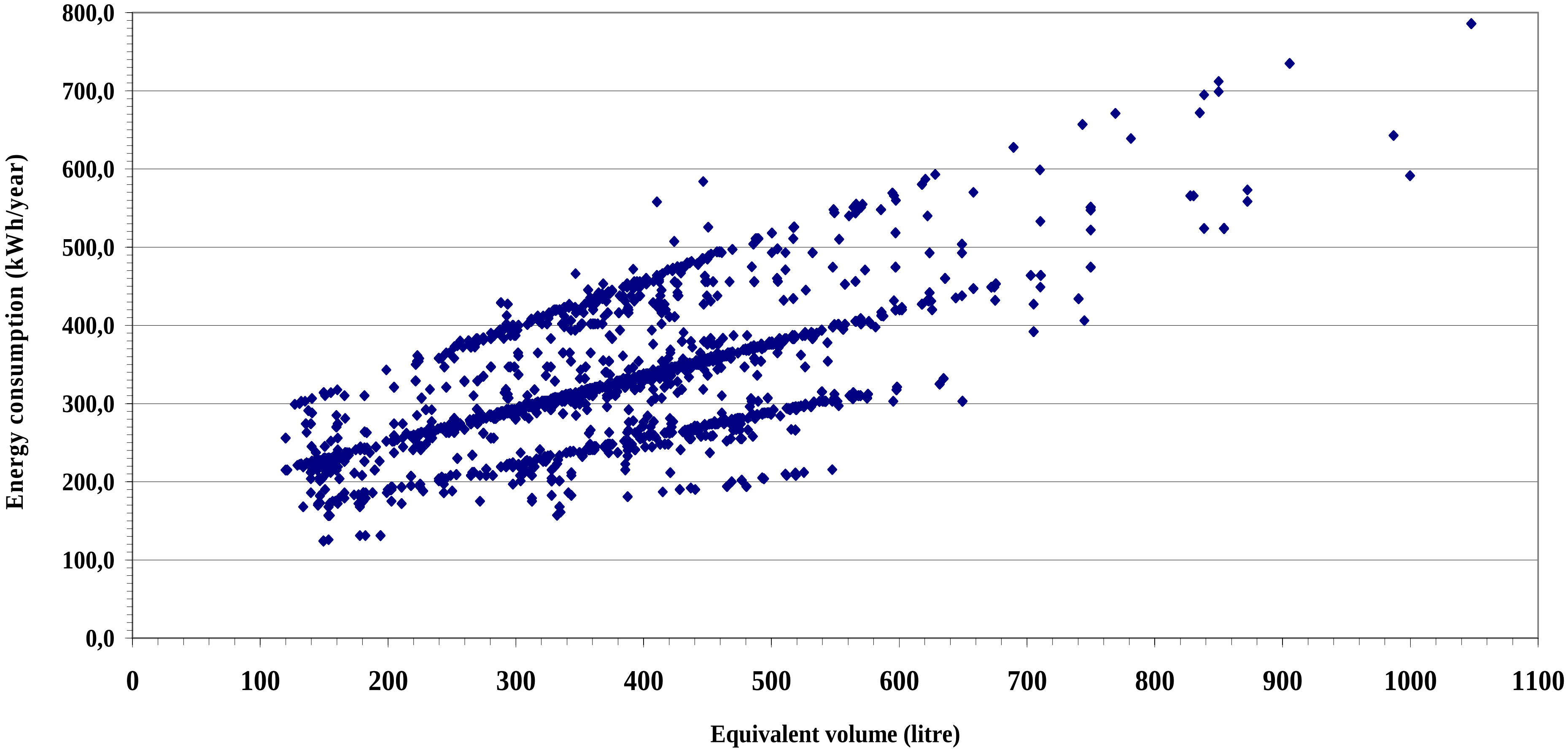


Figure 5.4: Energy consumption as function of the equivalent volume for the Category 8 models in the 2005 CECED technical database

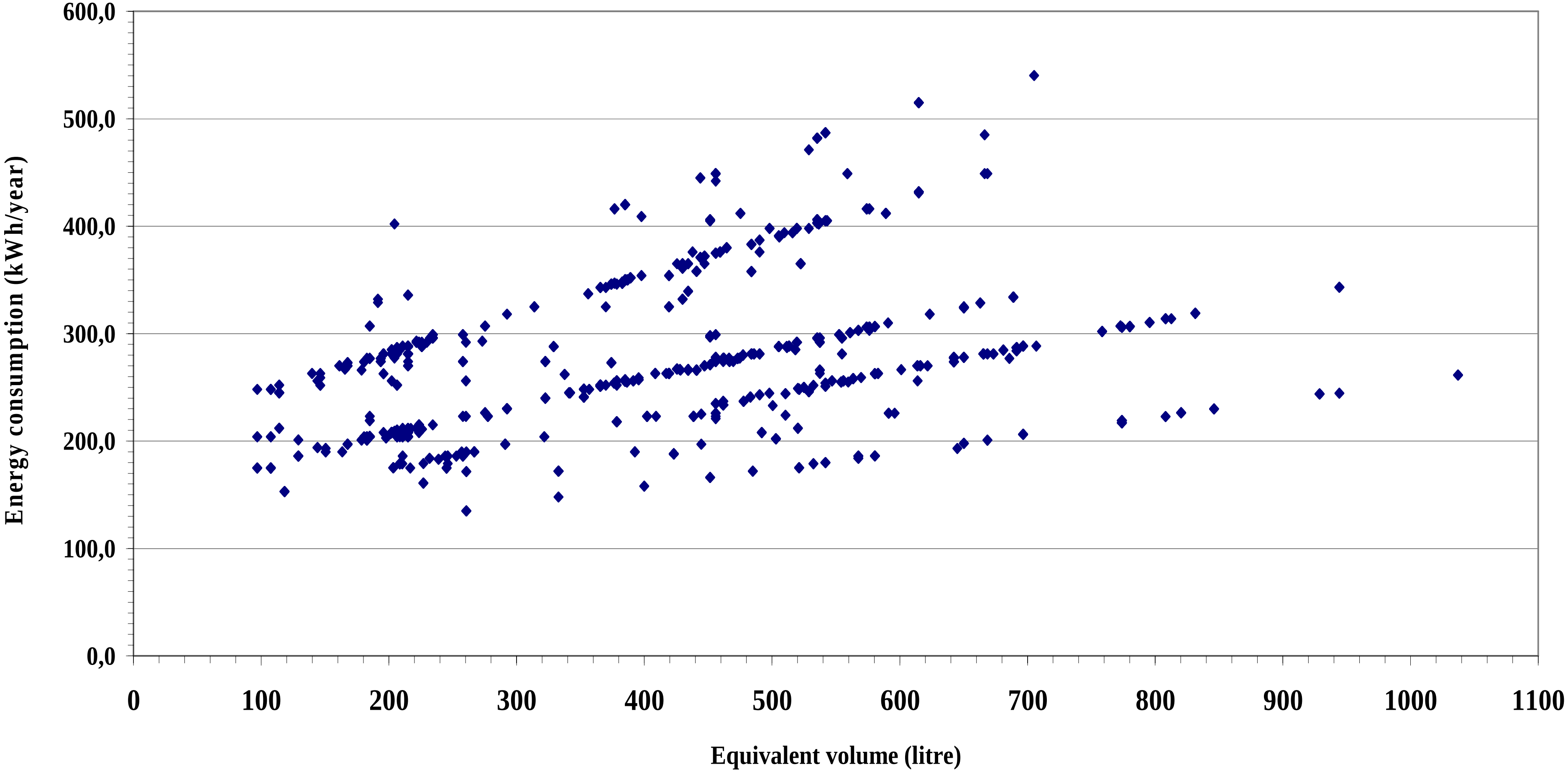


Figure 5.5: Energy consumption as function of the equivalent volume for the Category 9 models in the 2005 CECED technical database

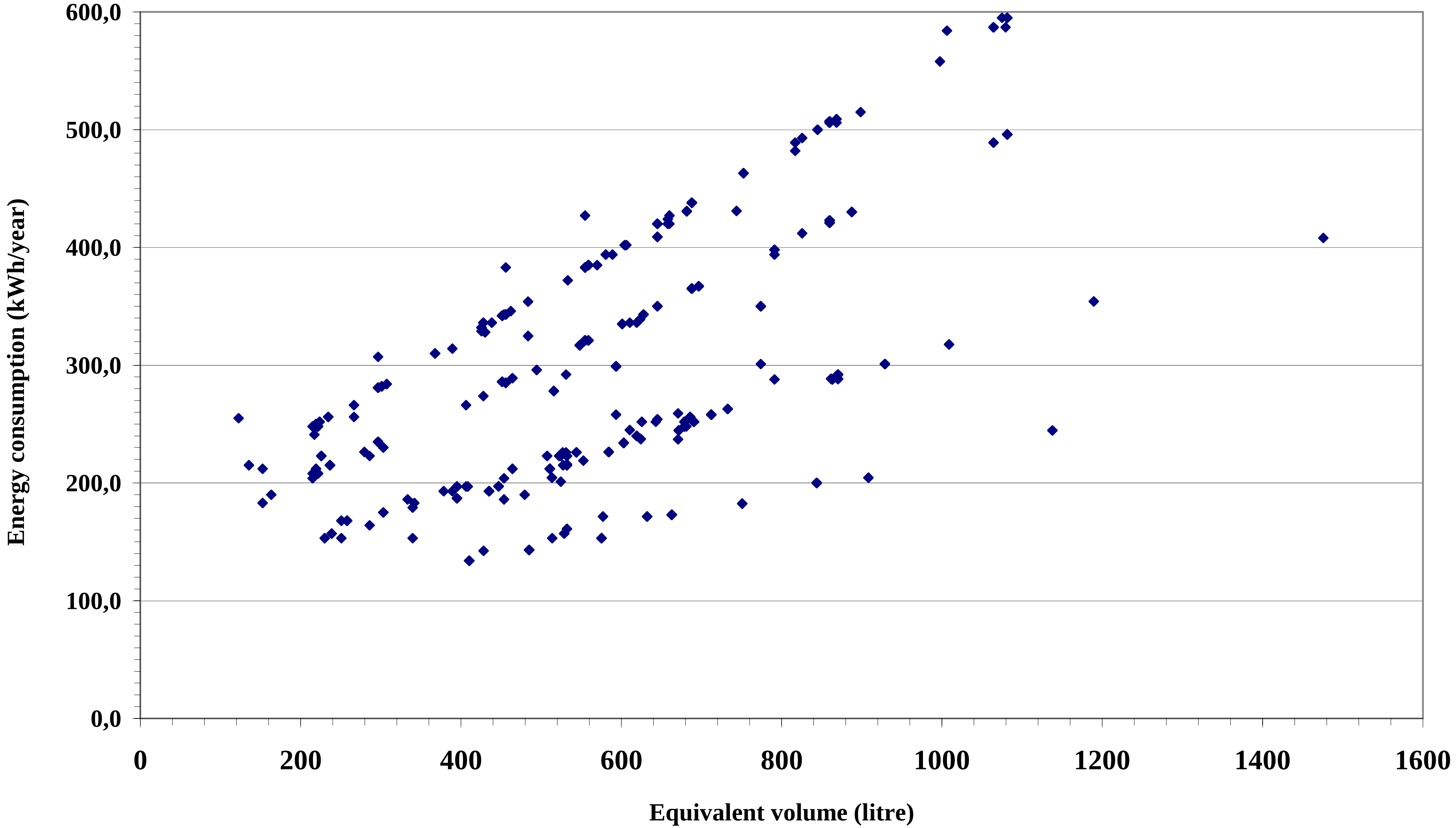


Figure 5.6: Specific energy consumption as function of the equivalent volume for the models in the 2005 CECED technical database

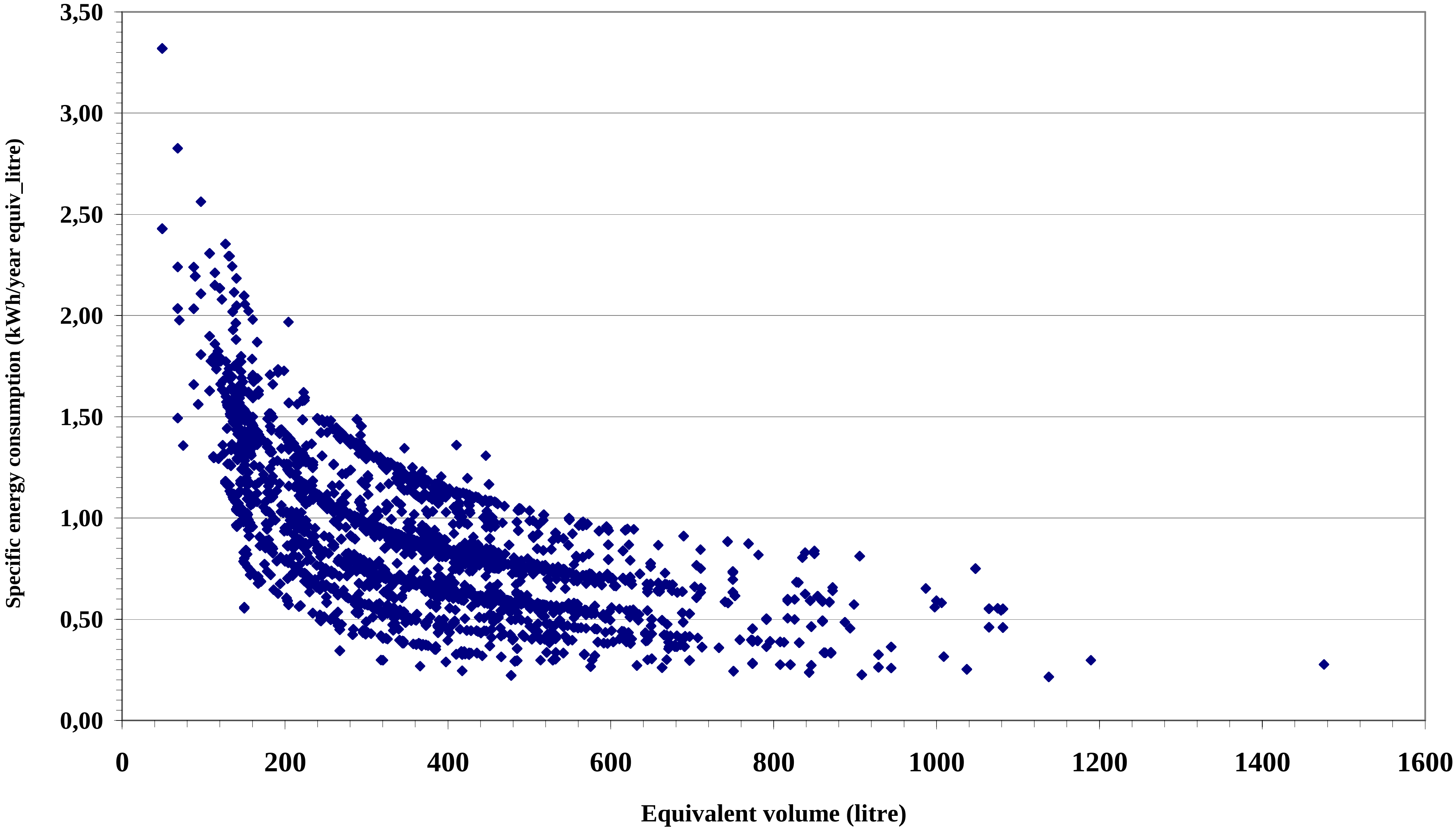


Figure 5.7: Energy efficiency of the cold appliance categories in the 2005 CECED technical database

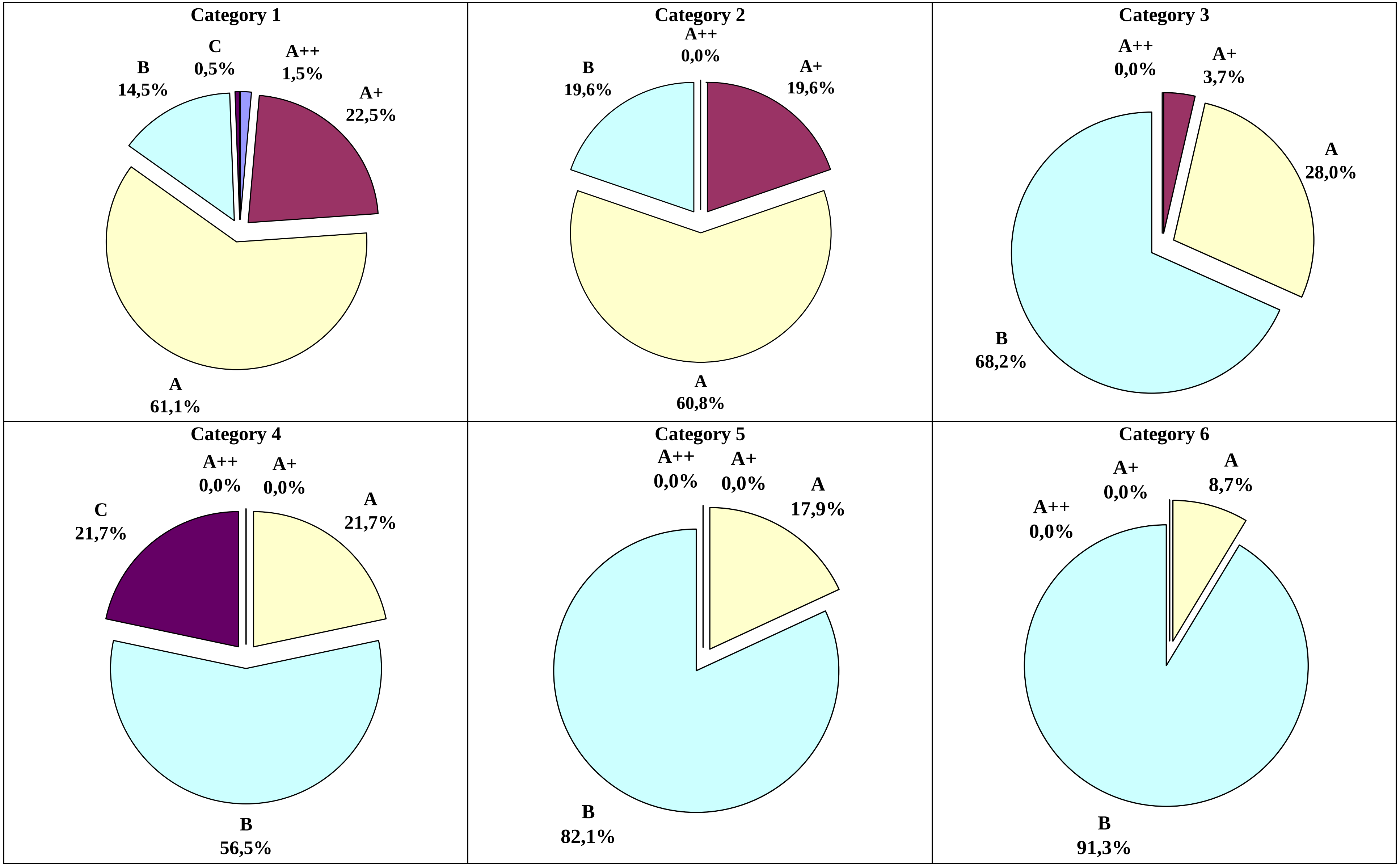
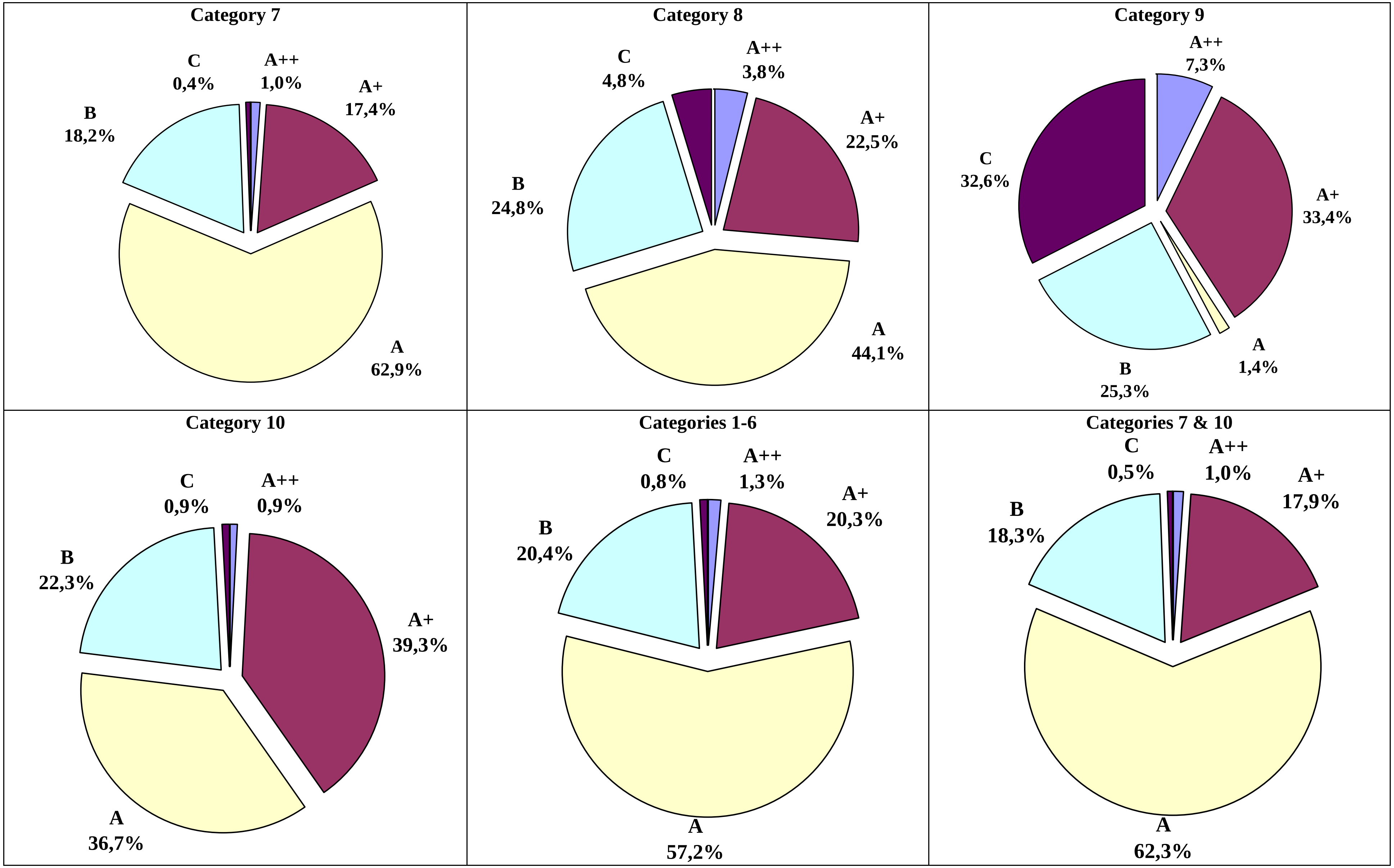


Figure 5.8: Energy efficiency of the cold appliance categories in the 2005 CECED technical database (continued)



in Categories 1-6, (19,4%), 11,8 million (58,3%) in Categories 7&10, 2,7 million units in Category 8 (or 13,4%) and 1,8 million units (or 8,8%) in Category 9, for a total of about 20,3 million units.

In general there is a good correspondence between the number of models in the technical database in 2005 and the production/import for 2005 (Table 5.6) and the distribution of the models in the energy efficiency classes (Table 5.7).

Table 5.6: Comparison between the outcome of the Notary Reports 2004-2005 and the technical database 2005 for cold appliances

Category	Technical database 2005			Notary report 2004			Notary report 2005		
	models		EEI	models		EEI*	models		EEI*
(number)	(number)	(%)		(10^3 units)	(%)		(10^3 units)	(%)	
1	2 204	14,1	52,9	2 737	13,5	56,7	2 549	13,3	54,8
2	97	0,62	53,0	69	0,34	52,1	130	0,68	53,1
3	107	0,68	66,3	519	2,56	73,2	336	1,75	69,1
4	46	0,29	69,6	149	0,73	75,0	46	0,24	65,0
5	78	0,50	68,8	235	1,16	70,6	186	0,97	69,8
6	23	0,15	72,2	229	1,13	55,2	16	0,08	73,1
7	9 535	61,0	54,4	11 691	57,6	58,4	11 600	60,5	56,1
8	2 441	15,6	56,3	2 726	13,4	60,3	2 542	13,3	56,4
9	879	5,62	64,4	1 792	8,83	73,2	1 608	8,39	66,6
10	229	1,46	51,0	141	0,70	60,6	162	0,84	49,6
Total	15 639	100	55,23	20 288	100	60,35	19 175	100	57,19

*estimated from Notary Report data

Table 5.7: Comparison between the outcome of the Notary Report 2004 and the technical database 2005 for the energy efficiency of cold appliances

Category	Technical database 2005			Notary report 2004			Notary report 2005		
	models		EEI	models		EEI	models		EEI
(number)	(number)	(%)		(10^3 units)	(%)		(10^3 units)	(%)	
A++	288	1,84	29,4	81	0,40	29,42	210	1,10	29,44
A+	3 108	19,9	40,9	1 852	9,13	40,47	2 786	14,5	40,83
A	8 635	55,2	54,0	10 591	52,2	53,25	10 886	56,8	53,90
B	3 133	20,0	70,5	6 225	30,7	71,35	4 622	24,1	71,63
C	466	2,98	86,6	1 225	6,04	87,84	666	3,47	87,63
D	7	0,04	94,4	274	1,35	98,33	1	0,01	97,83
E	2	0,01	106,7	42	0,21	104,77	4	0,02	104,10
F	0	0,0	--	0,531	0,003	120,9	0	0	0
G	0	0,0	--	--	--	--	0	0	0
Total	15 639	100	55,23	20 291	100	60,35	19 175	100	57,19

Only the average EEI from the models in the technical database (shown in the fourth column of Table 5.7) and the average production/import weighted EEI from the notary report (shown in the last column of the same Table) differ of about 5 points.

5.1.3 The Sales Data for 2004

Sales data were collected by GfK, a market research firm specialised in household appliances, for 2002 and 2004[91]. Cold appliance sales for 13 Western Europe (AT, BE, DE, DK, ES, FI, FR, GB, GR, IT, NL, PT, SE) and 8 Eastern Europe (CZ, EE, HU, LT, LV, PL, SI, SK) countries were collected by energy efficiency class and other parameters. The results are presented in Table 5.8, and compared with the analysis of the technical database for the 2005 and the Notary Report for 2004. In the 21 covered countries 14,3 million units were sold, 56,0% of which in class A and 30,0% in class B.

Compared with the analysis of the CECED 2004 technical database a 3,3% difference is found for the class B appliances, a 6% for the class A and a 7,2% for the class A+. The difference with the 2004 Notary Report is 6 million units, but there is a good agreement with the break-down by energy efficiency class.

Table 5.8: Comparison between the GfK sales data for 2004 and the technical database for cold appliances for 2004

Energy efficiency class	Western Europe	Eastern Europe	EU total		Technical database 2004	Notary Report 2004
	(n)	(n)	(n)	(%)	(%)	(%)
A++	20 811	25	20 836	0,15	1,00	0,40
A+	724 853	56 297	781 150	5,47	12,8	9,13
A	6 865 883	1 138 703	8 004 586	56,0	50,9	52,2
B	3 730 621	559 360	4 289 981	30,0	26,6	30,7
C	798 017	81 535	879 552	6,16	7,02	6,04
D	40 800	1 002	41 802	0,29	1,55	1,35
E	5 330	93	5 423	0,04	0,18	0,21
F	1 902	1	1 903	0,01	0	0,003
G	5 973	1	5 974	0,04	0	--
Unknown	236 929	20 192	257 121	1,80	--	--
Total	12 431 120	1 857 210	14 288 330	100	100	100

5.1.4 The Standard Base Case Characteristics

5.1.4.1 First choice: the average model in the technical database

Taking into consideration the analysis developed in the previous paragraphs, the proposed characteristics of the four standard base cases are:

- Refrigerator (average of categories 1-6):
  - free-standing, without No-Frost, one door
  - gross volume: 230 litre
  - net volume: 223 litre
  - energy consumption: 163,7 kWh/year (energy efficiency class A, EEI ≅ 54,4)
  - max climatic class: ST
  - refrigerating agent: HC

[91] data for 2005 were too costly for the study budget.

- foaming agent: HC
- noise: 38 dB(A)

- Refrigerator-freezer (average of categories 7 & 10):
  - free-standing, without No-Frost, two doors, top mounted freezer, one thermostat/compressor
  - gross volume: 294 litre
  - net volume: 277 litre
  - fresh food compartment volume 209 litre
  - frozen food compartment volume: 67 litre (4 stars)
  - energy consumption: 324,4 kWh/year (energy efficiency class A, EEI ≅ 54,3)
  - max climatic class: ST
  - refrigerating agent: HC
  - foaming agent: HC
  - noise: 40 dB(A)

- Upright freezer (average of category 8):
  - free-standing, without No-Frost
  - gross volume: 202 litre
  - net volume: 178 litre
  - frozen food compartment volume: 178 litre (4 stars)
  - energy consumption: 274,5 kWh/year (energy efficiency class A/B, EEI ≅ 56,3)
  - max climatic class: any class
  - refrigerating agent: HC
  - foaming agent: HC
  - noise: 40 dB(A)

- Chest freezer (average of category 9):
  - free-standing, without No-Frost
  - gross volume: 260 litre
  - net volume: 254 litre
  - frozen food compartment volume: 254 litre (4 stars)
  - energy consumption: 300,6 kWh/year (energy efficiency class B, EEI ≅ 64,4)
  - max climatic class: ST or SN/N
  - refrigerating agent: HC
  - foaming agent: HC/HFC
  - noise: 42 dB(A)

In Tables 5.9-5.12 the characteristics of the four base cases are compared with different average appliances and top of the range models, found in the CECED technical database and in specialised journals. In the same Table, the characteristics of the standard base cases and the corresponding real models selected in the COLD-II study are shown. It is clear, from comparison of the ideal base-case model characteristics with the real base-case model characteristics, that it was not always possible to find models on the market that had features consistent with the ideal ones.

5.1.4.2 Possible alternatives: other frequent model(s) groups in the technical database

Through the analysis developed in the following *paragraph 5.2.1* a number of possible alternative base cases have been identified and are shown in Figures 5.8-5.12 for the four appliance categories. For refrigerators and upright freezers two other frequent models groups were identified, one larger and one smaller than the category average. For refrigerator-freezers and chest freezers only one models group was identified, larger than the category average.

Table 5.9: Results of the improvements for the average refrigerator (categories 1-6) and comparison with the standard base case alternatives in 2005

Model	Cat. (n)	Energy consump. (kWh/year)	EEI/ EE Class	Gross volume (litre)	Net volume (litre)	Fresh food c. (litre)	Frozen food c. (litre)	Climatic class	Refriger. agent (type)	Foaming agent (type)	Noise dB(A)	Weight (kg)
COLD-II study base cases	1-6											
average model	1	249,4	71,4	--	151,6			--	--	--	--	--
real model	1	223	80,2/C	--	142	142		N	--	--	--	--
average model	2	237,9	65,7	--	n.a.			--	--	--	--	--
real model	2	241	74,2/B	--	377	241	136 cellar	N	--	--	--	--
average model	3	257,7	85	--	187,3	169,1	18,2	--	--	--	--	--
real model	3	226	80,1/C	--	158	151	7	SN	--	--	--	--
average model	4	243,5	86	--	123,1	112,2	10,9	--	--	--	--	--
real model	4	201	74,9/B	--	112	97	15	N/ST	--	--	--	--
average model	5	280,5	85,6	--	141	126,9	14,1	--	--	--	--	--
real model	5	219	70/B	--	136	119	17	N	--	--	--	--
average model	6	299,8	81,6	--	143,4	125,7	17,7	--	--	--	--	--
real model	6	251	74,5/B	--	138	123	15	N	--	--	--	--
Production wgt. average, 2004	1-6	n.a.	63,8	n.a.	n.a.			n.a.	n.a.	n.a.	n.a.	n.a.
Technical db average, 2005	1-6	163,7	54,4	230	223			ST	HC	HC	38	n.a.
Standard base case, 2005												
Alternative 1 (average model)	**1**	**163,7**	**54,4**	**230**	**223**			**ST**	**HC**	**HC**	**38**	**n.a.**
Alternative 2 (smaller refrigerator)	1	150	53,5	156	153			ST	HC	HC	37	n.a.
Alternative 3 (larger refrigerator)	1	170	53	300	290			N/SN/ST	HC	HC	40	n.a.
Top of the range, db 2005:												
energy consumption	1	83	**29,6**/A++	153	150			SN	Other	Other	36	n.a.
EEI	1	**83**	29,6/A++	153	150			SN	Other	Other	36	n.a.
noise	1	120	39,7/A+	187	185			ST	HC	HC	**33**	n.a.

*low temperature compartment volume

Table 5.10: Results of the improvements for the average refrigerator-freezer (category 7&10.7) and comparison with the standard base case alternatives in 2005

Model	Cat. (n)	Energy consump. (kWh/year)	EEI/ EE class	Gross volume (litre)	Net volume (litre)	Climatic class	Fresh food compart. volume (litre)	Frozen food comp. volume (litre)	Refriger. agent (type)	Foaming agent (type)	Noise dB(A)	Weight (kg)
COLD-II study base cases	7											
average model (1-door)	7	403,4	~75	--	165,4	--	145,3	20,1	--	--	--	--
real model (1-door)	7	292	60,5/B	--	212	ST	195	17	--	--	--	--
aver. model (2-door manual defrost)	7	530	~75	--	284	--	214	70	--	--	--	--
real model (2-door, BM)	7	555	89,3/C	--	295	N	195	100	--	--	--	--
real model (2-door, TM)	7	511	80,3/C	--	351	N	283	68	--	--	--	--
average model (2-door NoFrost)	7	640,5	>75	--	347,2	--	266	81,2	--	--	--	--
real model (2-door, TM, NF)	7	617	89,5/C	--	379	N	304	75	--	--	--	--
real model(2-door, SbS, NF)	7	710	69,6/B	--	567	ST/T	389	177	--	--	--	--
Production wgt. average, 2004	7	n.a.	58,4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Technical db average, 2005	7&10	324,4	54,3	294	277	ST	209	67	HC	HC	40	n.a.
Standard base case, 2005												
Alternative 1 (average model)	**7**	**324,4**	**54,3**	**294**	**277**	**ST**	**209**	**67**	**HC**	**HC**	**40**	**n.a.**
Alternative 2 (larger model)	7	337,5	54,0	327	311	any	225	87	any	HC	40,5	n.a.
Top of the range, db 2005:												n.a.
energy consumption	7	**124,1**	29,6/ A++	138	131	SN	115	16	Other	Other	38	n.a.
EEI	10.7	190,0	**27,3**/ A++	303	284	T	200/ 15 chill	69	HC	HC	37	n.a.
noise	10.7	405,2	74,3 /B	278	255	N	175/ 39 chill	41	HC	HC	**32**	n.a.

Table 5.11: Results of the improvements for the average upright freezer (category 8) and comparison with the standard base case alternatives in 2005

Model	Cat. (n)	Energy consump. (kWh/year)	EEI/ EE Class	Gross volume (litre)	Net volume (litre)	Climatic class max	Frozen food comp. volume (litre)	Refriger. agent (type)	Foaming agent (type)	Noise dB(A)	Weight (kg)
COLD-II study base case:	8										
Average model	8	371,5	81,7	--	117,4	--	117,4	--	--	--	--
Real model	8	361	95,2/D	--	92	N	92	--	--	--	--
Production wgt. average, 2004	8	n.a.	60,3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Technical db average, 2005	8	274,5	56,3	202	177	any	177	HC	HC	40	n.a.
Standard base case, 2005											
Alternative 1 (average model)	**8**	**274,5**	**56,3**	**202**	**178**	**any**	**178**	**HC**	**HC**	**40**	**n.a.**
Alternative 2 (smaller freezer)	8	208	53,7	110	100	any	100	HC/Others	HC/Others	40	n.a.
Alternative 3 (larger freezer)	8	269	54,0	230	206	any	206	HFC/HC	HC/Others	40	n.a.
Top of the range, db 2005:											
energy consumption	8	**135,0**	29,6/A++	104	101	T	101	Other	Other	42	n.a.
EEI	8	193,0	**29,1**/A++	288	250	T	250	HC	HFC	39	n.a.
noise	8	197,0	41,7/A+	110	94	T	94	HC	HC	**35**	n.a.

Table 5.12: Results of the improvements for the average chest freezer (category 9) and comparison with the standard base case alternatives in 2005

Model	Cat. (n)	Energy consump. (kWh/year)	EEI/ EE Class	Gross volume (litre)	Net volume (litre)	Climatic class max	Frozen food comp. volume (litre)	Refriger. agent (type)	Foaming agent (type)	Noise dB(A)	Weight (kg)
COLD-II study base case:	9										
Average model	9	370	100,2	--	169,6	--	169,6	--	--	--	--
Real model	9	270	76,6/C	--	179	N	179	--	--	--	--
Production wgt. average, 2004	9	n.a.	73,2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Technical db average, 2005	9	300,1	64,4	260	254	ST/SN-N	254	HC	HC	42	n.a.
Standard base case, 2005											
Alternative 1 (average model)	**9**	**300,6**	**64,4**	**260**	**254**	**ST/SN-N**	**254**	**HC**	**HC**	**42**	**n.a.**
Alternative 2 (larger freezer)	9	320	75	262	257	N/ST/T	257	HC	HC/HFC	42,5	n.a.
Top of the range, db 2005:											
energy consumption	9	**134,0**	27,9/A++	163	159	T	159	HC	HC	43	n.a.
EEI	9	153,0	**27,4**/A++	229	223	T	223	HC	HC	39	n.a.
noise	9	197,1	39,7/A+	198	189	ST	189	HC	HC	**37**	n.a.

Figure 5.9: Energy consumption as function of the volume for the Categories 1-6 models in the 2005 CECED technical database and possible alternative for the base case selection

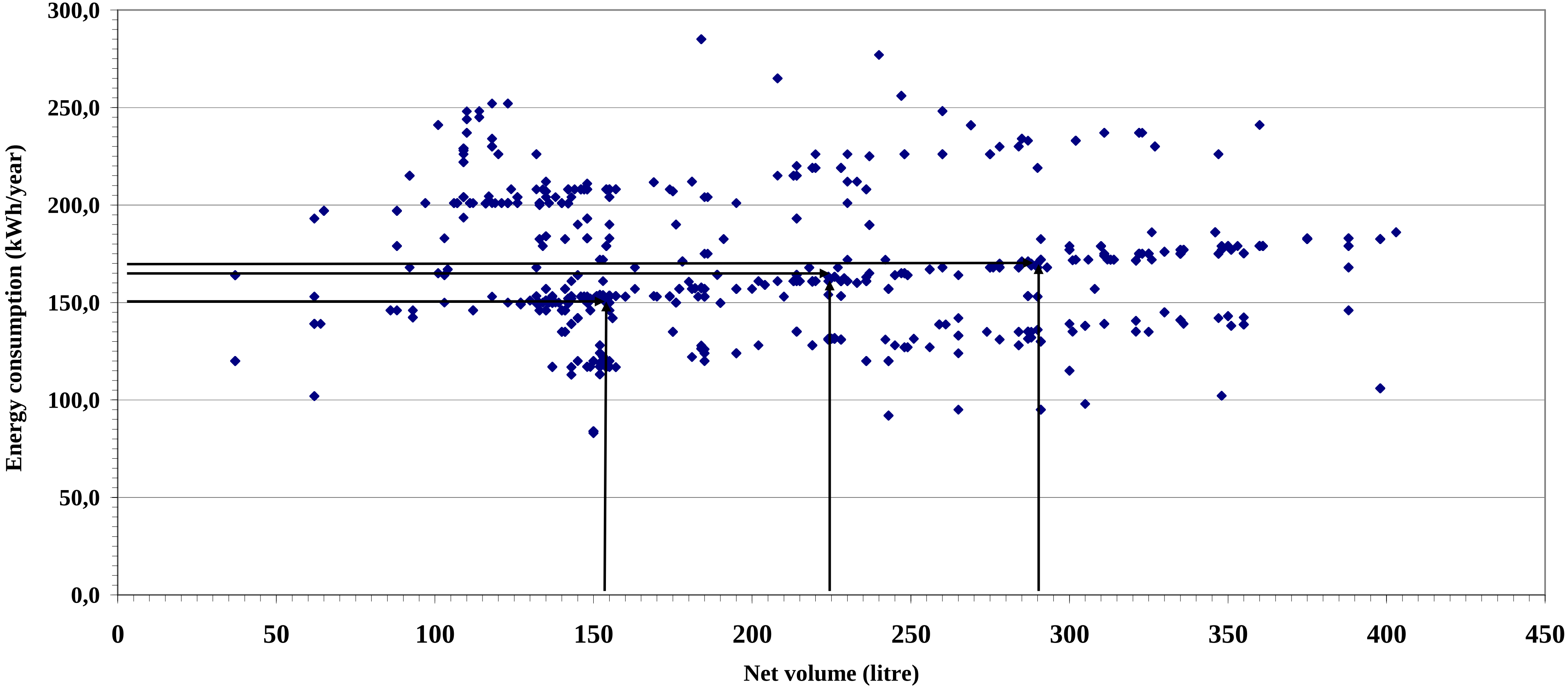


Figure 5.10:.Energy consumption as function of the volume for the Category 7 models in the 2005 CECED technical database

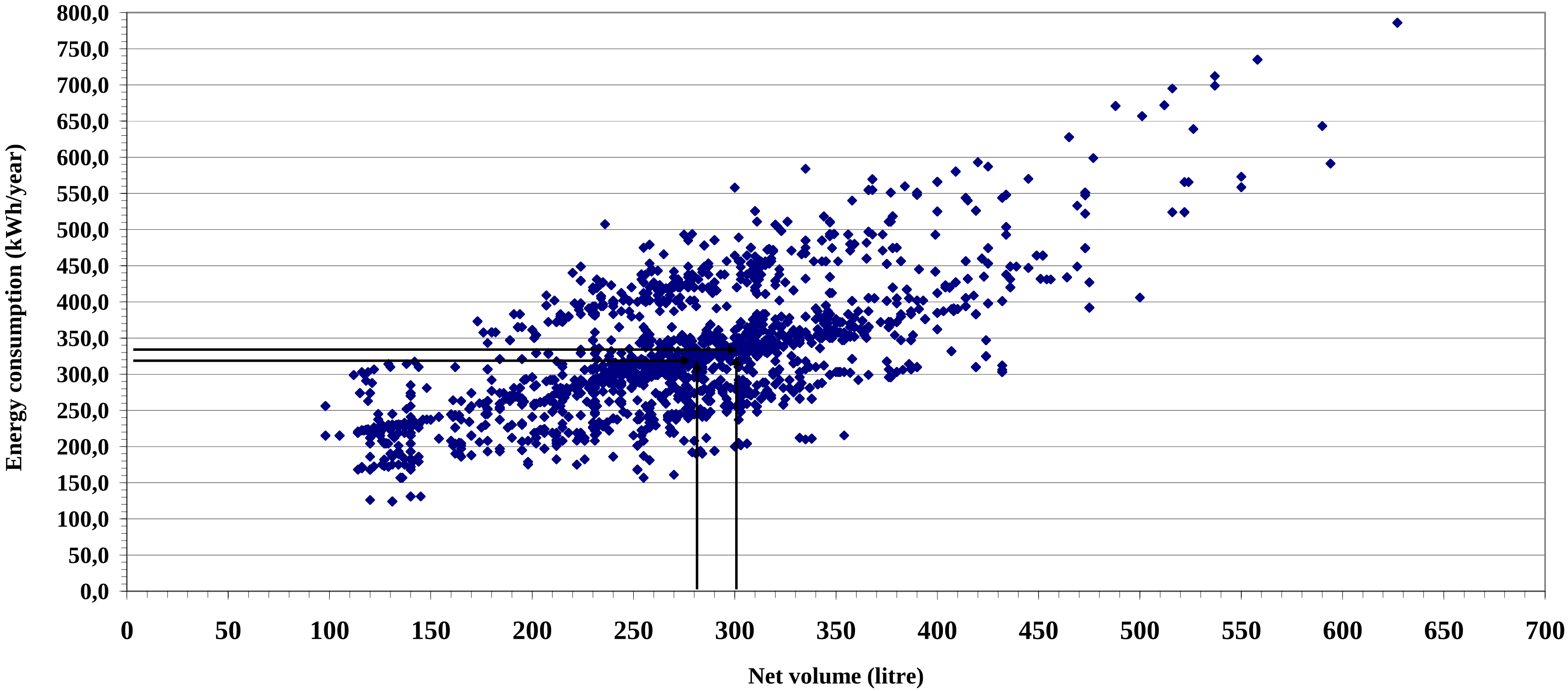


Figure 5.11: Energy consumption as function of the volume for the Category 8 models in the 2005 CECED technical database

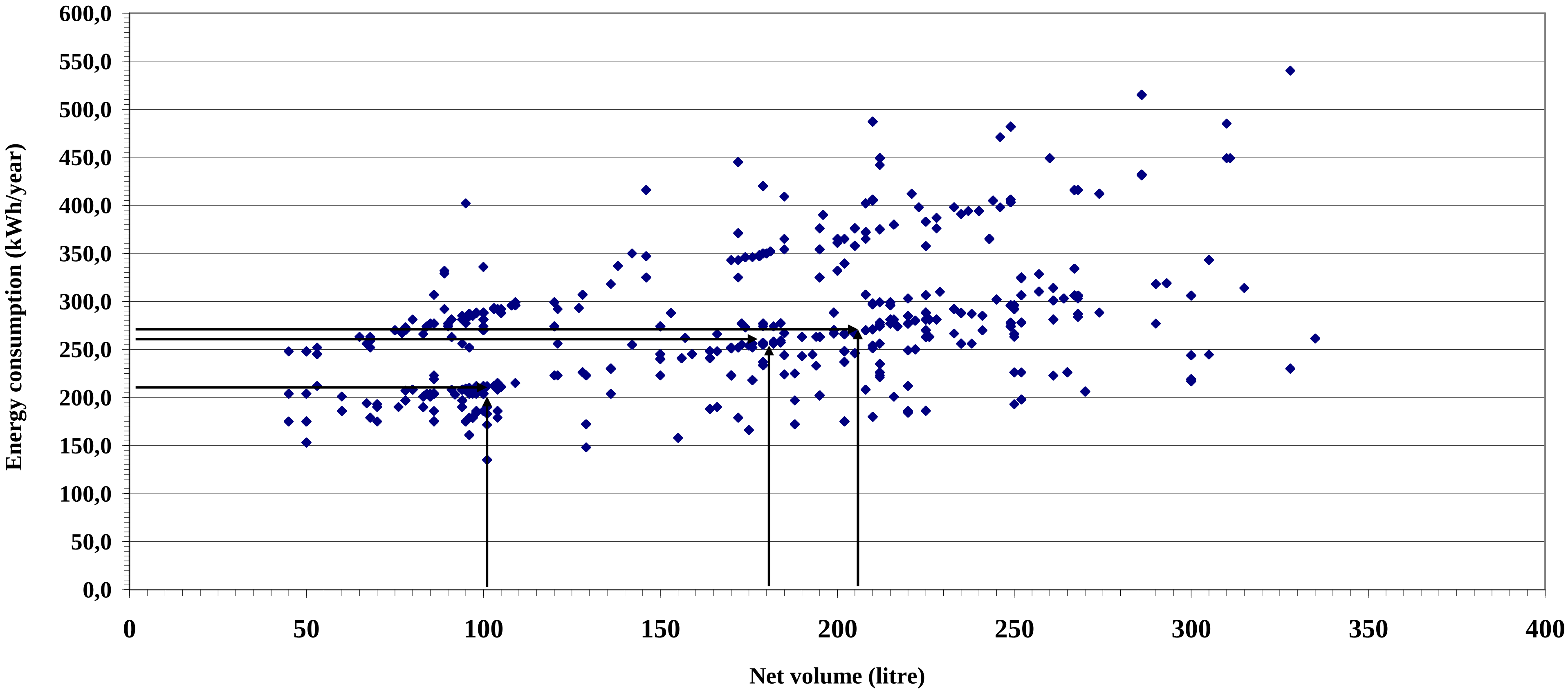
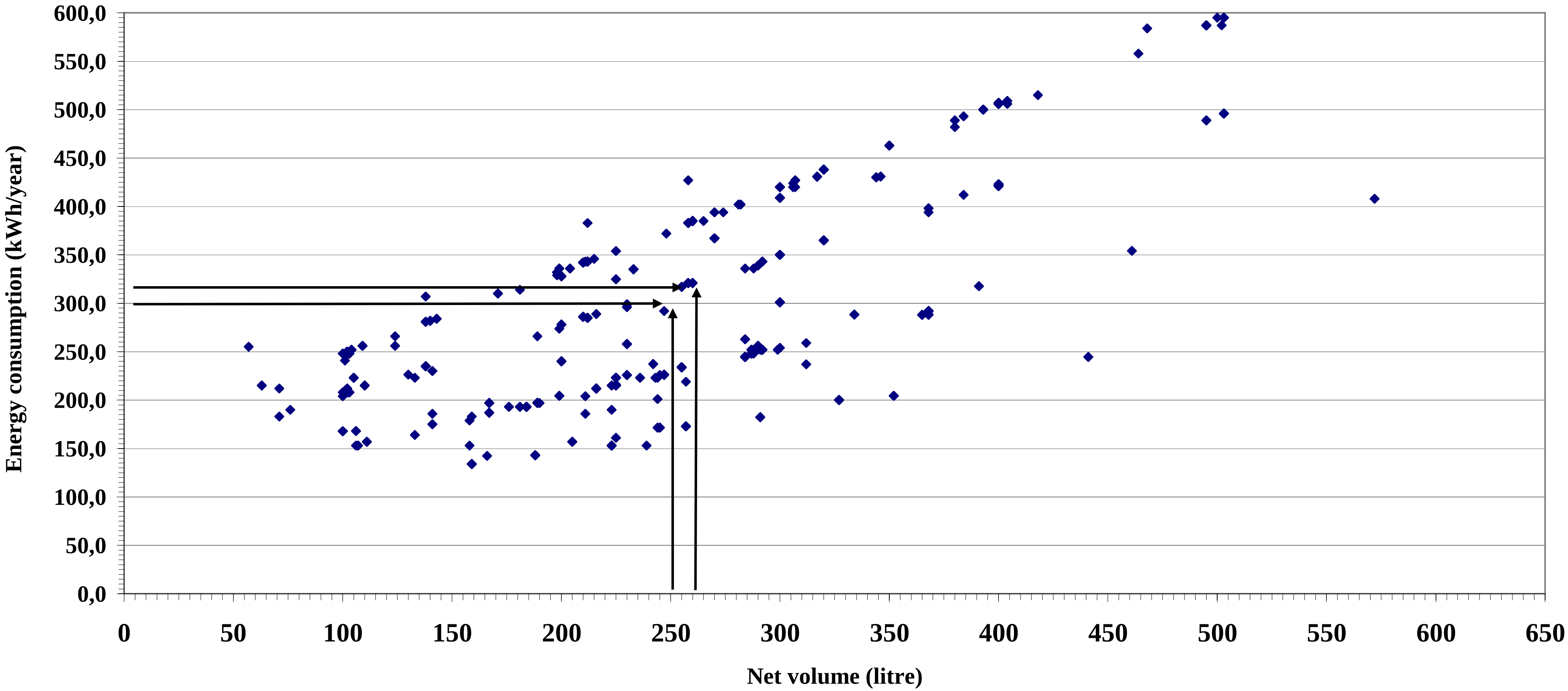


Figure 5.12: Energy consumption as function of the volume for the Category 9 models in the 2005 CECED technical database



In general the number of real models in the alternative groups of similar models is lower than or close to the number of models found for the category average. Therefore there are no real advantages in the use an alternative group of models instead of the average model in the database as standard base case.

5.1.5 The Real Life Base Case Characteristics

In general, for the definition of the "Real Life Base Case" (RLBC) the characteristics of the average sold appliance are considered. However, during the development of Task 3, it was evaluated that **this differentiation is not useful for cold appliances.** All the collected information on the consumer behaviour allowed to estimate the difference between the energy consumption under real life and standard conditions. Due to the lower ambient temperature in real life, compared to the 25°C used in the European standard, the energy consumption of the cold appliances is considerably lowered. Part of this saving is balanced by the cooling of new loaded food and the air which is exchanged when opening the door. So all in all the measured energy consumption under standardised consumption is somehow taking care of the real life behaviour, including the possible additional energy consumption for refrigerator-freezers operated at very low ambient temperatures.

5.2 SUBTASK 5.2: PRODUCT-SPECIFIC INPUTS

Product-specific inputs are necessary for the development of the LCA and are collected for the following life phases:

- Production (raw materials, components and assembling)
- Distribution of products (average distances and types of transport modes)
- Use (average life, specific consumption, maintenance and repairs)
- Packaging (type and weight)
- End of Life (disposal, thermal valorisation, incineration, dismantling…)

These data will be collected and organised according to the "EuP Eco Report" requirements and to the LCA ISO 14040 norms. Similarly, the methodology used for the LCA assessment will be, at first glance, based on the EuP-Ecoreport settings, but it will be, as close as possible, also compared and aligned with the LCA standard methodology by using others LCA software and data (like, i.e. the Simapro tool and databases).

Primary input data come from direct communication with producers and/or, if not available, collected on sector specific or commercial data base (secondary data) for both the standard and (if identified) the real base cases. Product-specific inputs are gathered through a specific "BOM and Inventory Data Template" prepared by the study Team to simplify and standardise the elementary information collection.

Manufacturers are requested to collect the information listed in the BOM and Inventory Data Template for a real appliance they produce, whose characteristics are as close as possible to those of the identified standard base cases.

5.2.1 The Selection of Real Models for Data Collection

To facilitate manufacturers data collection task a specific research has been developed in the CECED 2005 technical database to evaluate (i) how many real models do exist close to the standard base cases; (ii) how close the characteristics of these models comply with those of the base cases; (iii) other frequent model(s) in the database and their possible selection as alternative base case(s)

5.2.1.1 Availability of average models in the technical database

The analysis lead to the identification of four sets of real models, close to the average model proposed as standard base case, with the following characteristics:

- Refrigerator (average of categories 1-6),
  - free-standing, without No-Frost, Category 1
  - gross volume: 221-253 litre
  - net volume: 219-236 litre
  - dimensions:
    - height: 117-129 cm
    - length: 54,0-59,3 cm
  - energy consumption: 160-163,2 kWh/year (EEI ≅ 53,5-54,9)
  - max climatic class: ST
  - refrigerating agent: HC/Others
  - foaming agent: HC/Others
  - noise: 34-41 dB(A)
  - 65 models were found in the described range.

- Refrigerator-freezer (average of categories 7 & 10):
  - free-standing, without No-Frost, two doors, one thermostat/compressor, Category 7
  - gross volume: 267-293 litre
  - net volume: 275-278 litre
  - dimensions:
    - height: 143-186 cm
    - length: 54-60 cm
  - fresh food compartment volume 199-219 litre
  - frozen food compartment volume: 61-78 litre (4 stars)
  - energy consumption: 307-329 kWh/year (EEI ≅ 53,5- 55,1)
  - max climatic agent: ST
  - refrigerating fluid: HC
  - foaming agent: HC
  - noise: 38-44 dB(A)
  - 206 models were found in the described range.

- Upright freezer (average of category 8):
  - free-standing, without No-Frost
  - gross volume: 190-210 litre
  - net volume: 164-190 litre
  - dimensions:
    - height: 123-156 cm
    - length: 59,3-66 cm
  - frozen food compartment volume: 164-190 litre (4 stars)
  - energy consumption: 248-273 kWh/year (EEI ≅ 54,2-59)
  - max climatic class: any class
  - refrigerating agent: HC/Others
  - foaming agent: HC/HFC
  - noise: 36-43 dB(A)
  - 92 models were found in the described range.

- Chest freezer (average of category 9):
  - free-standing, without No-Frost
  - gross volume: 257-265 litre
  - net volume: 247-260 litre
  - dimensions:

  - height: 85-89 cm
  - length: 93,5-119 cm
- frozen food compartment volume: 247-260 litre (4 stars)
- energy consumption: 292-321 kWh/year (energy efficiency class B, EEI ≅ 70-75)
- max climatic class: N/ST/T
- refrigerating agent: HC
- foaming agent: HC/HFC
- noise: 38-45 dB(A)
- 34 models were found in the described range.

The number of real models presenting characteristics similar to the relevant standard base case is not extremely large for some appliance categories, but hopefully sufficient to allow most of the producers to provide the relevant BOM and inventory data.

In fact, if a too low number of real models is found, the implicit risk is that some manufacturers will not be able provide the BOM and inventory data because, although producing cold appliances, none of their own models is sufficiently close to the standard base cases characteristics. On the other side, if the collected BOM and inventory data refer to models with too different characteristics, then the averaged data input in the LCA will not be representative of the single models. In both cases the development of a representative LCA will be critical.

5.2.1.2 Other frequent model(s) in the technical database

A second attempt was run to evaluate the possibility to find, in the technical database, a large number of real cold appliance models with similar characteristics, and then to evaluate if the average characteristics of this group(s) of models can be proposed as an alternative base case(s).

For **refrigerators** two alternative groups of similar models could be identified:

- **Alternative 2** - Refrigerator (average of categories 1-6):
  - free standing, without No-Frost
  - gross volume: 154-158 litre
  - net volume: 151-155 litre
  - dimensions:
    - height: 82-87,8 cm
    - length: 54,1-59,5 cm
  - energy consumption: 146-154 kWh/year (energy efficiency class A, EEI ≅ 52-55)
  - max climatic class: ST
  - refrigerating agent: HC/Others
  - foaming agent: HC/Others
  - noise: 35-39 dB(A)
  - 53 models were found in the described range.

- **Alternative 3** - Refrigerator (average of categories 1-6):
  - free standing, without No-Frost
  - gross volume: 285-320 litre
  - net volume: 284-293 litre
  - dimensions:
    - height: 143-160 cm
    - length: 59,5-60,0 cm
  - energy consumption: 168-172 kWh/year (energy efficiency class A, EEI ≅ 51,5-55)
  - max climatic class: N/SN/ST
  - refrigerating agent: HC
  - foaming agent: HC
  - noise: 38-42 dB(A)
  - 52 models were found in the described range.

In Table 5.13 the average characteristics of the two alternative groups of models are shown and compared with the initially proposed average model characteristics.

For **refrigerator-freezers** one alternative group of similar models could be identified:

- **Alternative 2 -** Refrigerator-freezer (average of categories 7&10):
  - free standing, without No-Frost, two doors, one thermostat/compressor
  - gross volume: 308-346 litre
  - net volume: 303-319 litre
  - dimensions:
    - height: 175-191 cm
    - length: 59,3-60 cm
  - fresh food compartment volume 220-229 litre
  - frozen food compartment volume: 82-92 litre (4 stars)
  - energy consumption: 329-346 kWh/year (EEI ≅ 53,3- 55,1)
  - max climatic class: N/SN/ST
  - refrigerating agent: HC/HFC/Others
  - foaming agent: HC
  - noise: 38-43 dB(A)
  - 166 models were found in the described range.

In Table 5.14 the average characteristics of this group are shown and compared with the initially proposed average model characteristics.

For **upright freezers** two alternative groups of similar models could be identified:

- **Alternative 2** - Upright freezer (average of category 8):
  - free standing, without No-Frost
  - gross volume: 217-243 litre
  - net volume: 202-210 litre
  - dimensions:
    - height: 145-160 cm
    - length: 59,3-66 cm
  - frozen food compartment volume: 202-210 litre (4 stars)
  - energy consumption: 266-271 kWh/year (EEI ≅ 53,8-54,3)
  - max climatic class: any class
  - refrigerating agent: HFC/HC
  - foaming agent: HC/Others
  - noise: 37-42 dB(A)
  - 99 models were found in the described range.

- **Alternative 3** - Upright freezer (average of category 8):
  - free standing, without No-Frost
  - gross volume: 101-120 litre
  - net volume: 95-104 litre
  - dimensions:
    - height: 82-85 cm
    - length: 55-60 cm
  - frozen food compartment volume: 95-104 litre (4 stars)
  - energy consumption: 204-212 kWh/year (EEI ≅ 52,6-54,9)
  - max climatic class: any class
  - refrigerating agent: HC/Others
  - foaming agent: HC/Others
  - noise: 38-42 dB(A)
  - 97 models were found in the described range.

In Table 5.15 the average characteristics of the two alternative groups of models are shown and compared with the initially proposed average model characteristics.

For **chest freezers** one alternative group of similar models could be identified:

- **Alternative 2** - Upright freezer (average of category 8):
  - free standing, without No-Frost
  - gross volume: 261-265 litre
  - net volume: 255-260 litre
  - dimensions:
    - height: 87.89 cm
    - length: 94-119 cm
  - frozen food compartment volume: 255-260 litre (4 stars)
  - energy consumption: 317-321 kWh/year (EEI ≅ 75)
  - max climatic class: N/ST/T
  - refrigerating agent: HC
  - foaming agent: HC/HFC
  - noise: 40-45 dB(A)
  - 33 models were found in the described range.

The only parameter significantly modified compared with Alternative 1 is the energy efficiency index. In Table 5.16 the average characteristics of this group are shown and compared with the initially proposed average model characteristics.

In general the number of real models in the alternative groups of similar models is lower or close to the average of the category in the database. Therefore there are no clear advantages in the use of an alternative group of models instead of the average models in the database as standard base cases.

5.2.2 Base-cases

According to the findings of paragraph 5.1, here below are summarized the characteristics of the four models chosen as base-cases.

1. Refrigerator (average of categories 1-6):
   - free-standing, without No-Frost, one door
   - gross volume: 230 litre
   - net volume: 223 litre
   - energy consumption: 163,7 kWh/year (energy efficiency class A, EEI ≅ 54,4)
   - max climatic class: ST
   - refrigerating agent: HC
   - foaming agent: HC
   - noise: 38 dB(A)

2. Refrigerator-freezer (average of categories 7 & 10):
   - free-standing, without No-Frost, two doors, top mounted freezer, one thermostat/compressor
   - gross volume: 294 litres
   - net volume: 277 litres
   - fresh food compartment volume 209 litres
   - frozen food compartment volume: 67 litres (4 stars)
   - energy consumption: 324,4 kWh/year (energy efficiency class A, EEI ≅ 54,3)
   - max climatic class: ST
   - refrigerating agent: HC
   - foaming agent: HC
   - noise: 40 dB(A)

Table 5.13: Average characteristics of the alternative groups of similar models in the CECED 2005 technical database for refrigerators (Categories 1-6)

Model	Cat. (n)	Energy consump. (kWh/year)	Specific en.cons. (kWh/y l)	EEI/ EE Class	Gross volume (litre)	Net volume (litre)	Climatic class	Refriger. agent (type)	Foaming agent (type)	Noise dB(A)	Real models (n)
Technical db average, 2005	1-6	163,7	0,734	54,4	230	223	ST	HC	HC	38	--
Model groups:											
Alternative 1 (average model)	1	163,7	0,734	54,4	230	223	ST	HC	HC	38	65
Alternative 2 (smaller refrigerator)	1	150	0,980	53,5	156	153	ST	HC	HC	37	53
Alternative 3 (larger refrigerator)	1	170	0,586	53	300	290	N/SN/ST	HC	HC	40	52

Table 5.14: Average characteristics of the alternative groups of similar models in the CECED 2005 technical database for refrigerator-freezers (Categories 7&10.7)

Model	Cat. (n)	Energy consump. (kWh/year)	EEI/ EE class	Gross volume (litre)	Net volume (litre)	Climatic class	Fresh food compart. volume (litre)	Frozen food comp. volume (litre)	Refriger. agent (type)	Foaming agent (type)	Noise dB(A)	Real models (n)
Technical db average, 2005	7&10	324,4	54,3	294	277	ST	209	67	HC	HC	40	n.a.
Model groups:												
Alternative 1 (average model)	7	324,4	54,3	294	277	ST	209	67	HC	HC	40	206
Alternative 2 (larger model)	7	337,5	54,0	327	311	any	225	87	any	HC	40,5	166

Table 5.15: Average characteristics of the alternative groups of similar models in the CECED 2005 technical database for upright freezers (Category 8)

Model	Cat. (n)	Energy consump. (kWh/year)	EEI/ EE class	Gross volume (litre)	Net volume (litre)	Climatic class max	Frozen food comp. volume (litre)	Refriger. agent (type)	Foaming agent (type)	Noise dB(A)	Real models (n)
Technical db average, 2005	8	274,5	56,3	202	177	any	177	HC	HC	40	n.a.
Model groups:											
Alternative 1 (average model)	8	274,5	56,3	202	177	any	177	HC	HC	40	92
Alternative 2 (smaller freezer)	8	208	53,7	110	100	any	100	HC/Others	HC/Others	40	97
Alternative 3 (larger freezer)	8	269	54,0	230	206	any	206	HFC/HC	HC/Others	40	99

Table 5.16: Average characteristics of the alternative groups of similar models in the CECED 2005 technical database for chest freezers (Category 9)

Model	Cat. (n)	Energy consump. (kWh/year)	EEI/ EE class	Gross volume (litre)	Net volume (litre)	Climatic class max	Frozen food comp. volume (litre)	Refriger. agent (type)	Foaming agent (type)	Noise dB(A)	Real models (n)
Technical db average, 2005	9	300,1	64,4	260	254	ST/SN-N	254	HC	HC	42	n.a.
Model groups:											
Alternative 1(average model)	9	300,1	64,4	260	254	ST/SN-N	254	HC	HC	42	34
Alternative 2 (less efficient freezer)	9	320	75	262	257	N/ST/T	257	HC	HC/HFC	42,5	33

3. Upright freezer (average of category 8):
   - free-standing, without No-Frost
   - gross volume: 202 litres
   - net volume: 178 litres
   - frozen food compartment volume: 178 litres (4 stars)
   - energy consumption: 274,5 kWh/year (energy efficiency class A/B, EEI ≅ 56,3)
   - max climatic class: any class
   - refrigerating agent: HC
   - foaming agent: HC
   - noise: 40 dB(A)

4. Chest freezer (average of category 9):
   - free-standing, without No-Frost
   - gross volume: 260 litres
   - net volume: 254 litres
   - frozen food compartment volume: 254 litres (4 stars)
   - energy consumption: 300,6 kWh/year (energy efficiency class B, EEI ≅ 64,4)
   - max climatic class: ST or SN/N
   - refrigerating agent: HC
   - foaming agent: HC/HFC
   - noise: 42 dB(A)

5.2.3 Data from manufacturers

For each of the above outlined models, the manufacturers have been required to fill specific inventory tables as described below.

The following table shows the data provided from manufacturers for each of the four categories.

Appliances	Code	Data from manufacturers
Refrigerator (average of categories 1-6)	COLD 1	5
Refrigerator-freezer (average of categories 7 & 10)	COLD 7	5
Upright freezer (average of category 8)	COLD 8	5
Chest freezer (average of category 9)	COLD 9	4

The majority of the data sheets provided by the manufacturers were in line with the requirements of the consultant and quite complete. The following are the main remarks regarding the data provided initially:

- Only some producers have provided data on specific devices or operative situations (as: stand-by mode, off-mode, information on maintenance, end of life data)
- **Production**:
  - *Material*: data are sufficiently complete; some manufacturers produced data on "assembled components" (mainly compressors), without indication on the material composition.
  - *Scrap*: general data (% and EoL) do not represent all materials used;

    - *Processing*: information is provided, sometimes it is exhaustive, often it is generic and incomplete;
    - *Transport*: data (average kms and transport mode) are often complete, but sometimes, the data are not available;
- **Assembly**: data are generally complete; sometimes units of measure are not that required in inventory data sheets;
- **Use phase**: data are occasionally incomplete and units of measure are not that required in inventory data sheets;
- **End of Life**: some producers provided congruent indications, some data are difficult to understand and to use.

In order to have clarification and additional information regarding the received data, the following comments and questions were sent to the producers:

- Production: generally only total weight for compressor and some "objects" were available; also composition could be useful if available. If no data was available, data from other producers (at least one has furnished compressor weight and material composition) have been used.
- Processing: sometimes only generic data is available; if possible specify details. As an alternative data from other producers has been used. When no % was indicated we have supposed 100% of that process. Sometimes there is no data for compressor and ferrous materials.
- Scrap and EoL: When no data is available or only partial data for materials is presented, data from other producers have been be used.
- End of life: When no indications or only generic indications are present, the EU average for each material or data form other producers have been used. Clarification regarding specific recovery systems were requested.

Up to now **answers from three producers** have been received, as summarised:

Production: Data on compressor composition have been received from two producers. In any case, there is general agreement on the data to use from others producers.

Processing: A brief description of the processing used in its own factories has been received from a producer. Also in this case, general agreement has been reached on the data to be used from other producers.

Scrap and EoL: No more data is available. Agreement was reached to use data from other producers (when available).

End of life: Clarification and indications regarding specific systems have been received. There is general agreement on the use of EU average figures and data on specific recovery systems.

Taking into account these indications, in order to define the "average models", the following assumptions and simplifications have been made:

- **Production**:
    - Integration of "similar" or "analogous" materials;
    - Detailed data for assembled components is divided in the inventory table as part of "main categories", as ferrous metals, non ferrous metals, plastics, etc;
    - For *assembled components*, without indication of material composition, data have been used only to define the total weight, but they were not taken into consideration for average material composition;

- As *general approach* of “linear average” was used for available data; if data was given from one producer only, this case was used without elaboration;
- For *scrap, EoL of scrap and processing* data from producers that gave the most complete and detailed data have been used;
- For the average distance calculation, average values of Km for each model were considered (by the weighted average of km of transport for each material); a new weighted average has been made with obtained data, according to the total weight of each model.

- **Assembling**:
  - Unit of measure conversion was applied, when necessary;
  - Obtained data have been used in the “linear average approach”;
- **Use phase**:
  - Unit of measure conversion was applied, when necessary;
  - Obtained data have been used in the “linear average approach”;
- **End of Life**:
  - Available data were often not comparable and construction was not easy. In this case most complete and congruent data were used, as representative of the average model.

Here following averages models are presented. It has to be noted that:

- Production, assembly, use, and end of life phases are shown separately for every average model;
- For the production phase:
  - scrap percentage and end of life have been assumed to be always the same, independent of the model; figures have been selected from an overview of all cold models;
  - also for main processing, it was assumed to be always the same, independent of the model; figures have been selected from an overview of all cold models;
  - for transport, we have calculated average km for every model and then a second average km for every average model; in this way fours figures, one for every cold model, have been obtained
  - For compressors, two manufacturers produced data on material composition; according to this the following average composition for compressor was used:

Compressor	(%)
Fe / cast iron	0,840
Cu	0,105
Al	0,020
Plastics	0,011
Lubricating oil	0,025

- For end of life, according to the received data, average values for different processes (recycling, energy recovery, dismantling, land filling) were used, often, for all the materials.

5.3 BASE-CASE ENVIRONMENTAL IMPACT ASSESSMENT

In this subtask product specific inputs, developed in sub-task 5.3 for cold appliances, are used to define environmental profile and impact analysis .

The system used is the EuP EcoReport, version 5 (see http://www.eupproject.org/) ; by this system it is possible to indicate the environmental impact analysis, specifying for:

- Raw Materials, Manufacturing, transport;
- Distribution;
- Use;
- End-of-Life Phase.

EuP Ecoreport outputs are expressed as:

- Material consumption;
- Other resources and Waste as:
    - Total energy (including electricity);
    - Water (process and cooling);
    - Waste (hazardous and non-hazardous)
- Emission (air) as :
    - GWP;
    - ODP;
    - Acidification;
    - VOC;
    - POP;
    - Heavy metals;
    - PAHs;
    - Particulate matter (PM, dust).
- Emission (water) as :
    - Heavy metals;
    - Eutrophication;
    - POP.

5.3.1 Considerations and assumptions to use inventory data in EuP Ecoreport

In order to use inventory data from subtask 5.2 in EuP Ecoreport methodology, some considerations and assumptions are required.

The main elements to be considered are:

- Production phase:
    - Data on Scrap, processing ("manufacturing" in EuP Ecoreport) and transport cannot be used; fixed values are already considered in value reported in EuP. Only for "sheet metal scrap" it is possible to adjust %.
- Distribution phase:
    - Only "volume of packaged final product" can be used; values for transport (distance and medium) and materials used for packaging are already considered in EuP.
- End of life phase :
    - Only landfill % and plastics re-use and recycling % can be used in EuP; other parameters are already considered as fixed values.

For production phase we have also to take into account that not all the materials reported in Subtask 5.2 are in the EuP Ecoreport data base.

Accordingly, the following assumptions have been made:

A For some materials a direct correspondence with items in EuP data base is possible.

B For some materials only by specific assumptions and simplifications it is possible to have a correspondence with items in EuP data base. The following correspondences have been used:

- Ferrous metals as Cast Iron;
- Mixed steel + plastic as Stainless 18/8;
- Steel other as Stainless 18/8;
- Steel strip as St sheet galv.;
- Solder & braze as solder SnAg4Cu0.5;
- Elastomer as LDPE;
- PET as HDPE;
- POM as HDPE;
- PPO as PP;
- TPE as LDPE;
- Butyl rubber as LDPE;
- Paint as coating powder;
- Rubber as LDPE;
- Thermostat as Controller board;
- Wood as cardboard;
- Refrigerant:

Refrigerant in inventory data from producers is expressed as

- Refrigerant and
- Refrigerant HC

In EuP Ecoreport Refrigerant is only considered in “Disposal & recycling” as “Substances released during product life and land filling”, but not in Production phase.

According to the data in EuP data base and with the possibility to select only a kind of refrigerant we have chosen to use R290 a (full HC refrigerant : Propane); we think that this is not totally true and it is possible that also different kind of refrigerating medium are used (as R 134a) but at the moment this seems the best solution.

C For some materials no correspondence is possible ; in this case materials’ weight is split on the weight of the other materials, according to their percentage . Materials without correspondence are :

- Ag;
- Foamed Cabinet;
- Plastics, others;
- Plastics;
- Adhesive tape;
- Desiccant;
- Glue;
- Others;
- Lubricating oil;
- Accumulator;
- Magnet;
- Handle;
- PCB;

- EPE
- Thermo paste

According to assumptions reported in point B and C the EuP environmental profiles for Cold 1, Cold 7, Cold 8 and Cold 9 are as follows.

5.3.2 LCA of cold models using EuP Ecoreport

In Appendix B "EUP Ecoreport data" the detail of the input and output figures obtained by EuP Ecoreport software are shown.

For each model it is reported:

- input tables (production phase, assembling, use, end of life);
- output tables (Materials, Other Resources & Waste, Emissions (Air), Emissions (Water))

As outlined above, for some materials it has not been possible to have correspondence between inventory data from producers and EuP Ecoreport data base: the amount of these materials have been added to the weight of the other materials, according to their percentage. In order to show inventory data as in inventory data sheets from producers for average models (§5.2), we reported in bracket (near the name of each material) "original" average weight. Final weight used in EuP Ecoreport is in the central column of input sheet.

5.3.3 Preliminary conclusions and remarks

It is worth noting that some materials have no correspondence in the categories included in the EuP Ecoreport data base. This occurred for the following weight percentage:

- 1,1 % for Cold 1;
- 0,9 % for Cold 7;
- 1,5 % for Cold 8;
- 4,3 % for Cold 9.

Assumptions were made for other materials to find a correspondence with existing categories:

- 9,4 % for Cold 1;
- 10,8 % for Cold 7;
- 14,8 % for Cold 8;
- 31,5 % for Cold 9.

This means that between 10,5% and 34,8% of the materials do not have a direct correspondence in the EuP Ecoreport data base; this fact has to be taken into consideration for the analysis of the appliances environmental impacts in the EuP Ecoreport output.

Moreover, it is also important to remember that in the EuP database:

- The environmental impact for transport is included in materials environmental impacts; this means that the production phase outputs account also the impact and consumption due to transport.
- In the distribution phase the impact due to the Packaging includes the transport to retailer;

In the second part of the study we will investigate to which extent these simplifications affect the final LCA results, for the moment, based on the assumptions we made on the materials substitution and the EuP database results we find that:

- the production and use phases are responsible for the majority of environmental impact;

- for the use phase, energy consumption and water use are the most relevant elements (for both process and cooling) , while for the production phase the wastes are more relevant;
- regarding emissions in air, the use phase is most relevant for Greenhouse gases, and acidification while for the production phase yields higher impact of POP, heavy metals and PAHs; and the distribution phase is relevant for particulate matter (three times the total of Production and Use phases) and VOCs;

In the following paragraphs the graphic outputs and tables from the EuP method are finally shown.

5.3.3.1 Impact and consumption for COLD 1

Going into details, Figures 5.13 to 5.17, show the energy and water consumption as well the air, water and wastes impacts of the COLD 1 models.

The figures clearly show that the higher energy and water consumption levels are found in the use phase (Figure 5.13) while the production phase is responsible for the higher quota of the waste production (Figure 5.14). The emissions to air (Figure 5.15) are shared between the production and use phases but in a different way: GWP and acid rain are higher in the use phase while POP, Heavy metals and PAH are mainly emitted from the production one. Particulate matter emissions and VOCs are finally mainly produced during the distribution phase (these are the typical PM10 emitted by Diesel motors). The emissions to water (Figure 5.16) are mainly provided by the production phase especially for what concerns the heavy metals. Finally Figure 5.17 provides the overall synthesis of all the environmental impact of this class of appliances.

Figure 5.13: COLD1 – Energy and water consumptions

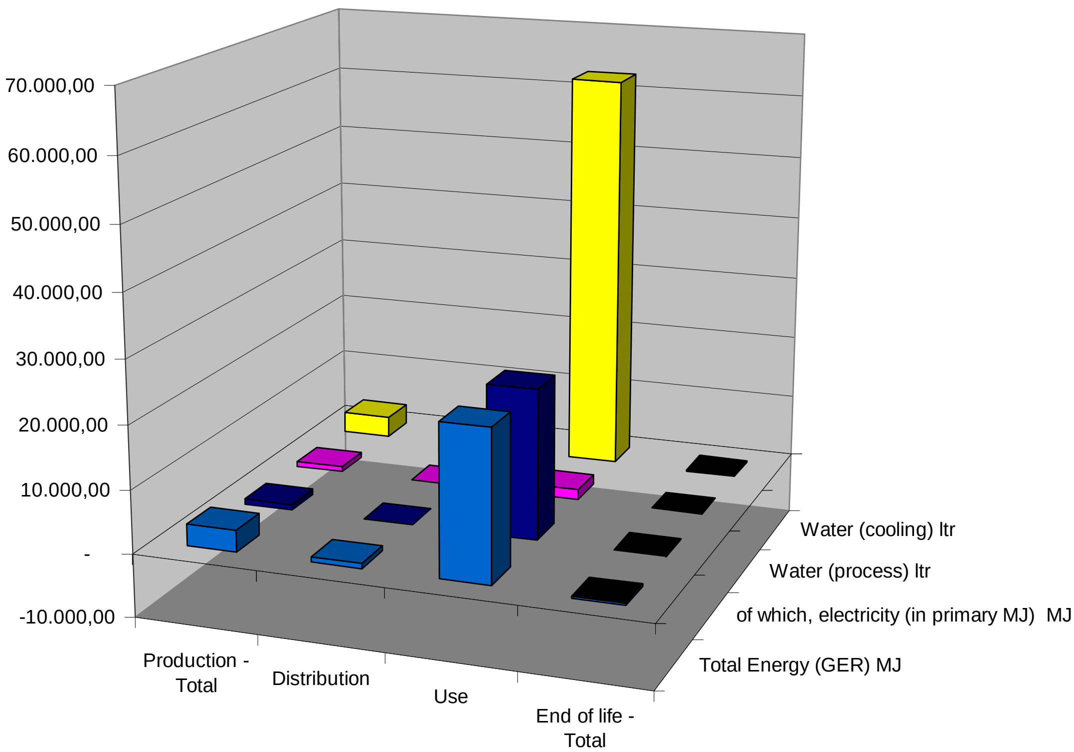


Figure 5.14: COLD1 – Waste production

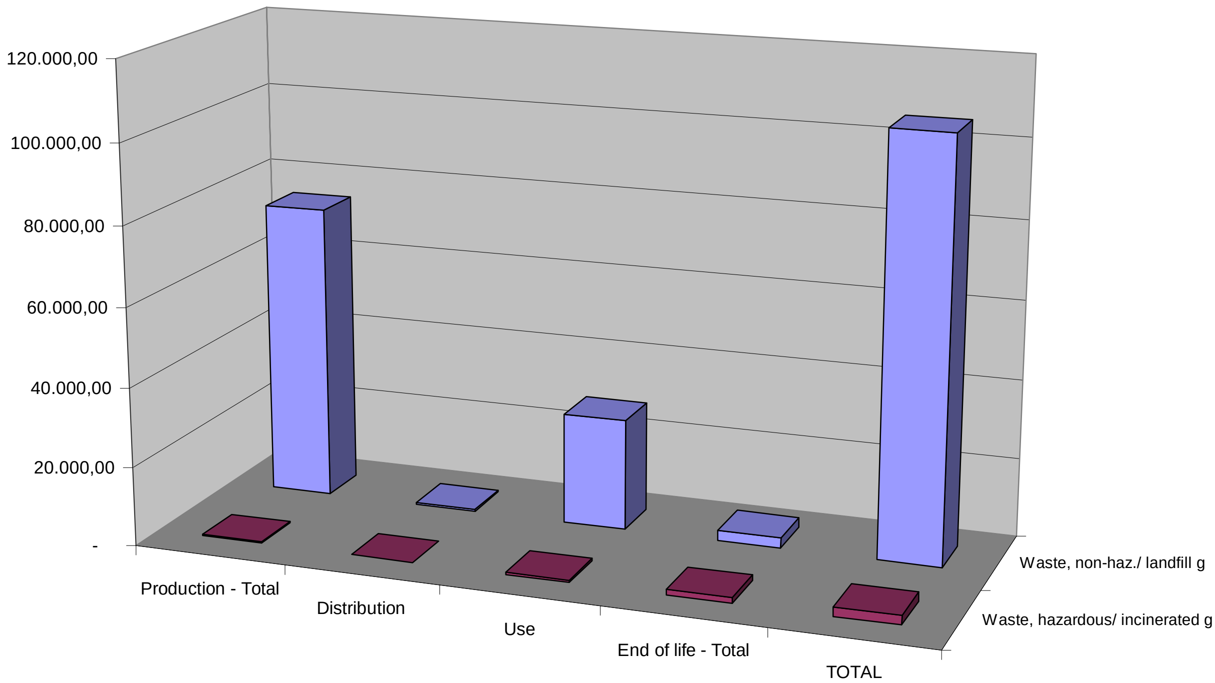


Figure 5.15: COLD1 – Emissions (air)

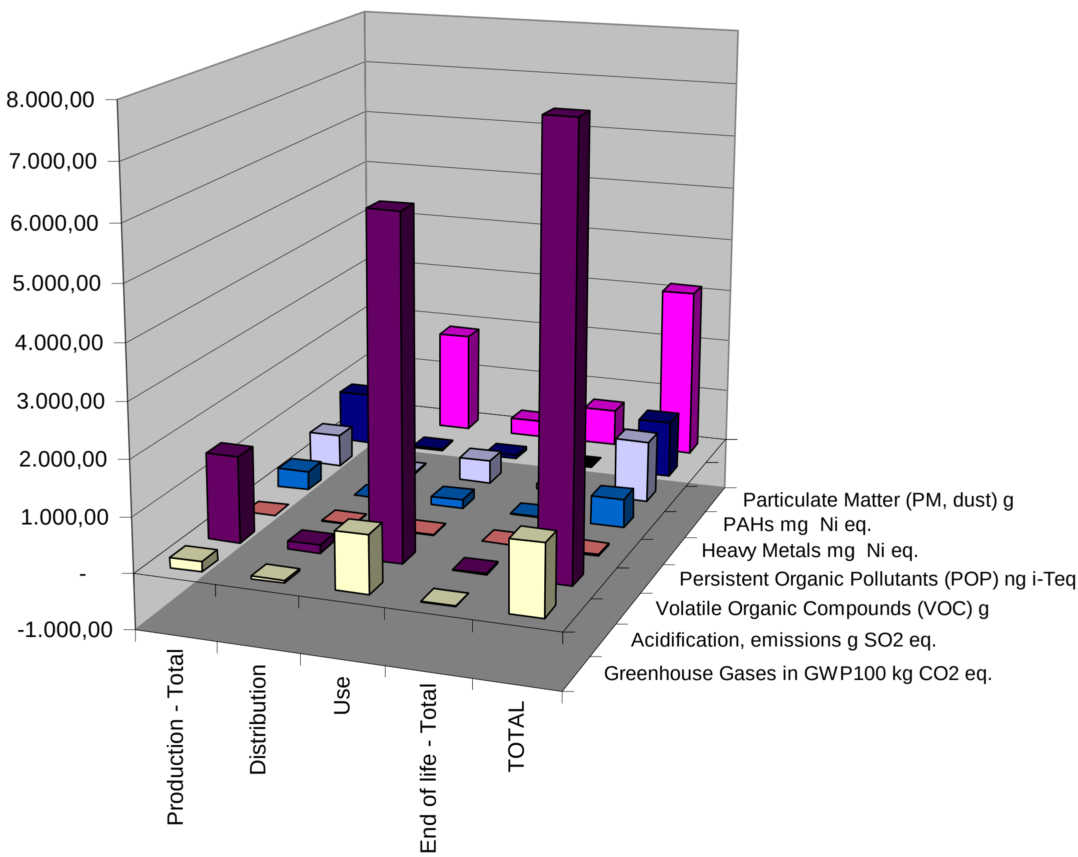


Figure 5.16: COLD1 – Emissions (water)

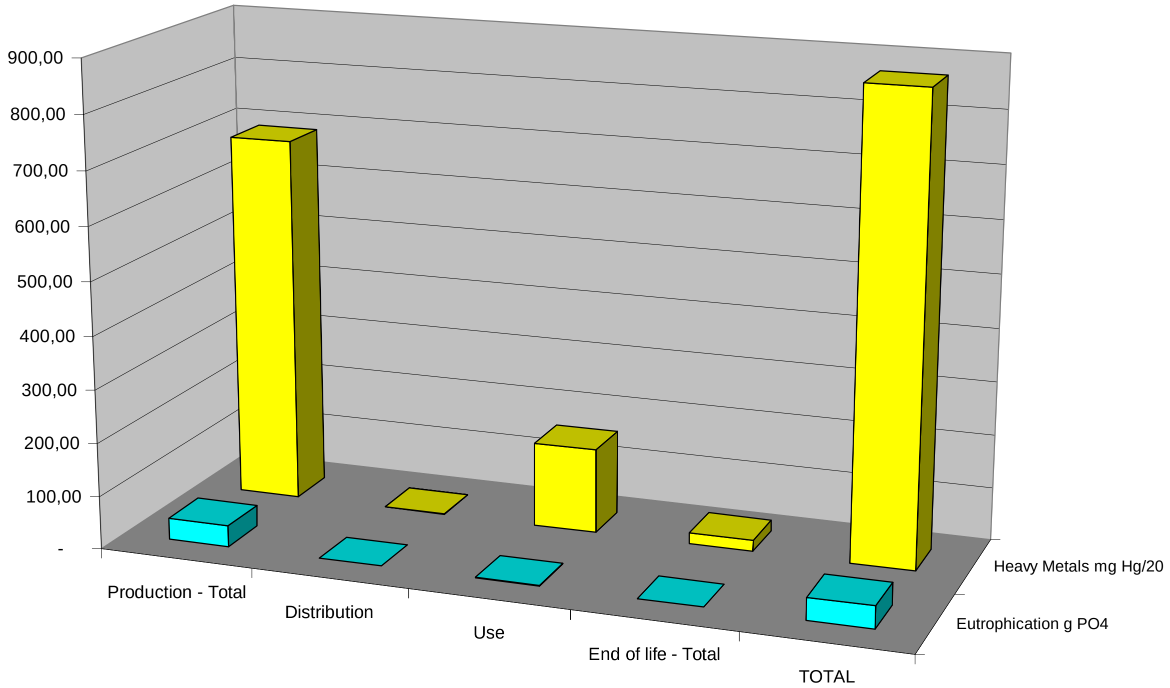
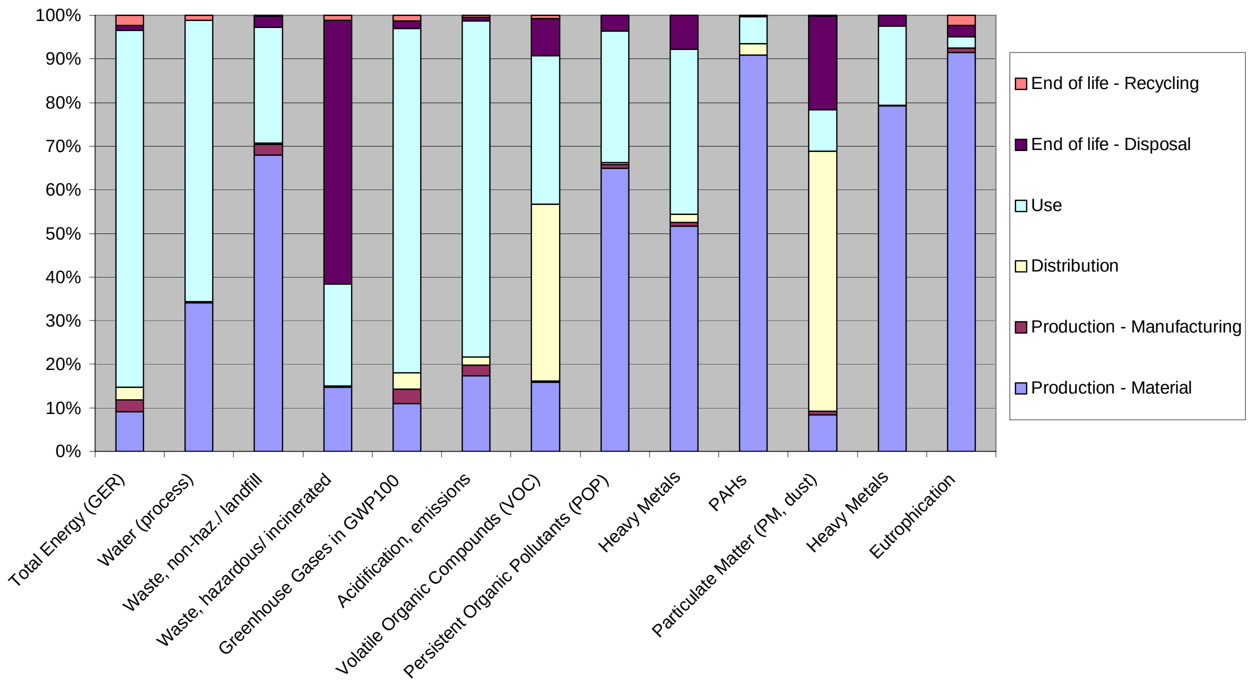


Figure 5.17: COLD1 – % of impacts on LCA



5.3.3.2 Impact and consumptions for COLD 7

For this appliance the environmental impact analysis, shown in Figures 5.18-5.21, is practically the same of the COLD 1 case. The only difference concerns the VOCs emissions in air (Figure 5.20); for this class of models, the use phase has impact values higher than the distribution phase (but the values are not very different). Also in this case the overall impacts are summarised in Figure 5.21 (LCA % of COLD 7).

Figure 5.18: COLD7 – Energy and water consumptions

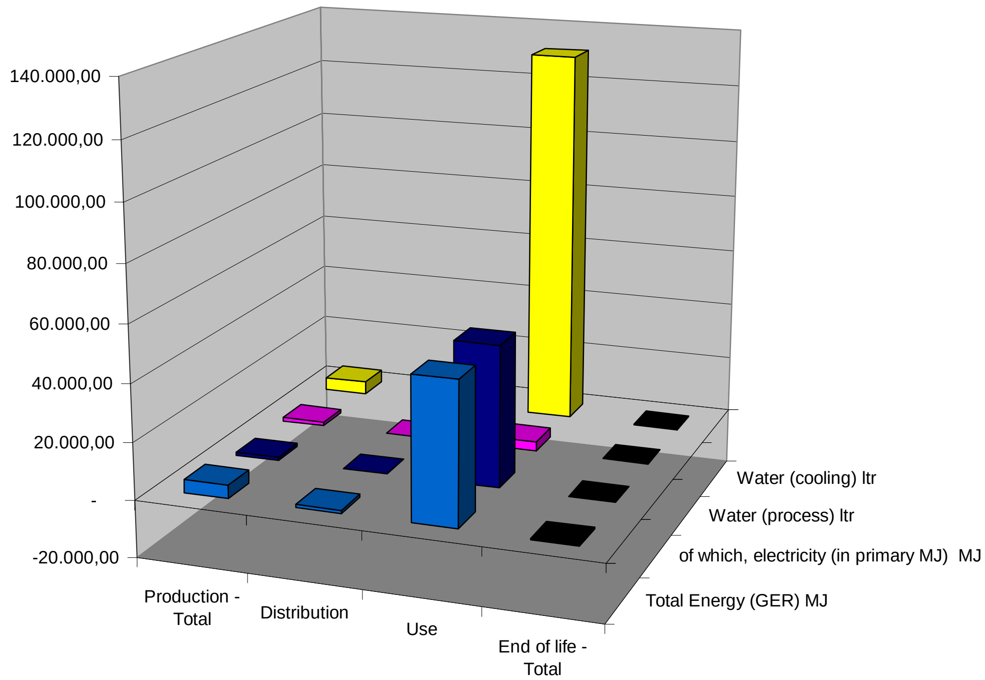


Figure 5.19: COLD7 – Waste production

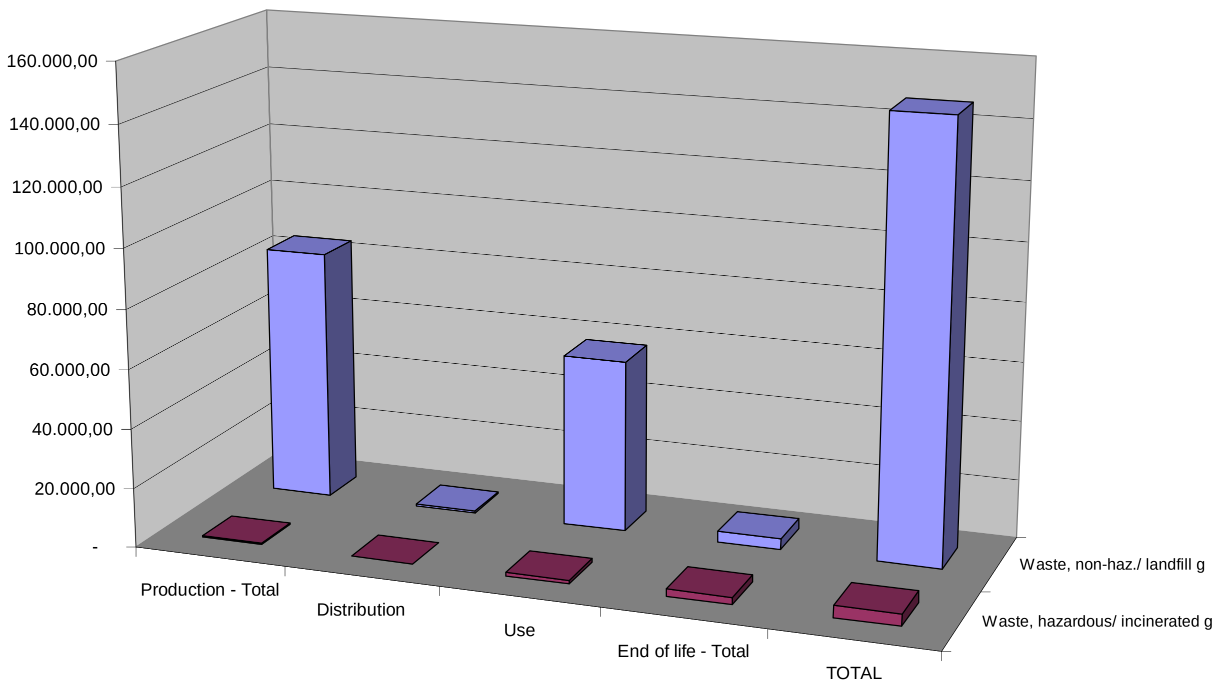


Figure 5.20: COLD7 – Emissions (air)

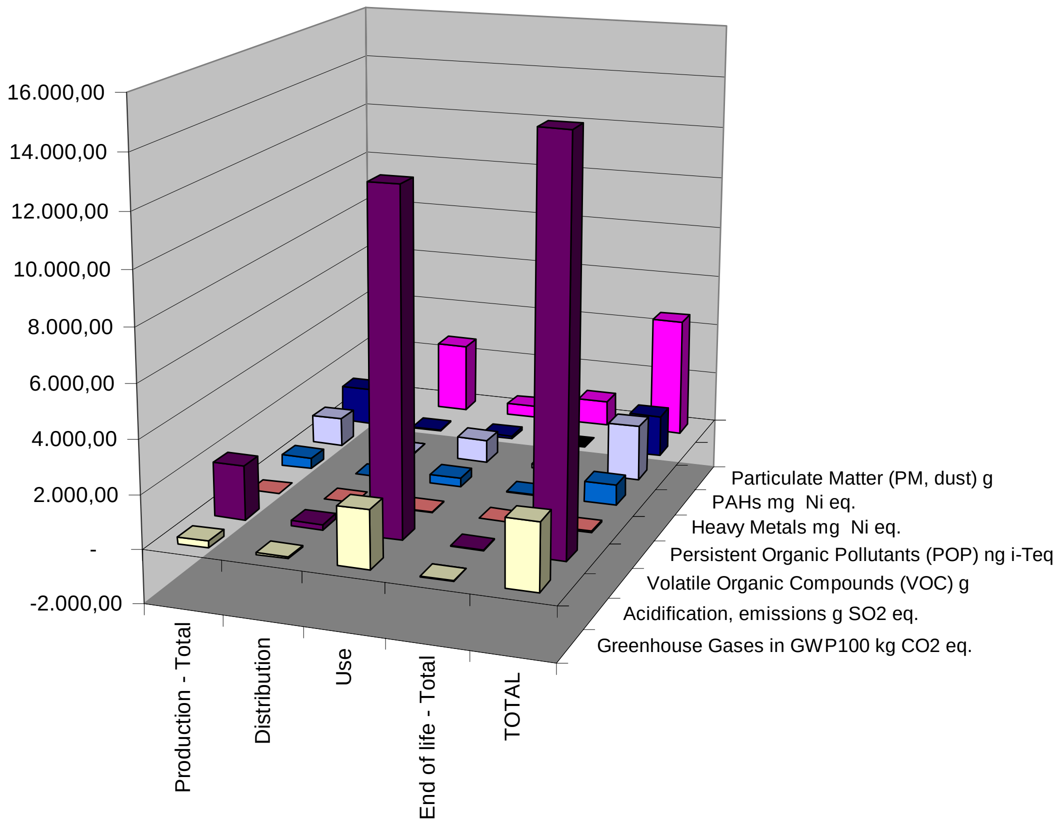


Figure 5.21: COLD7 – Emissions (water)

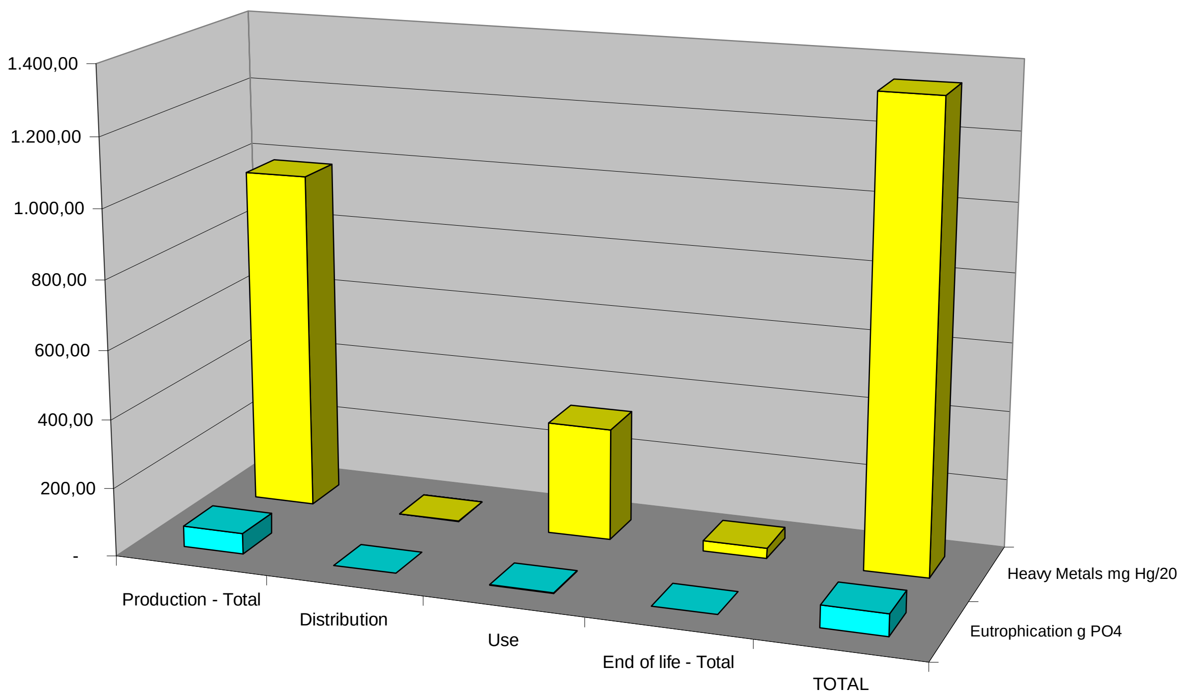
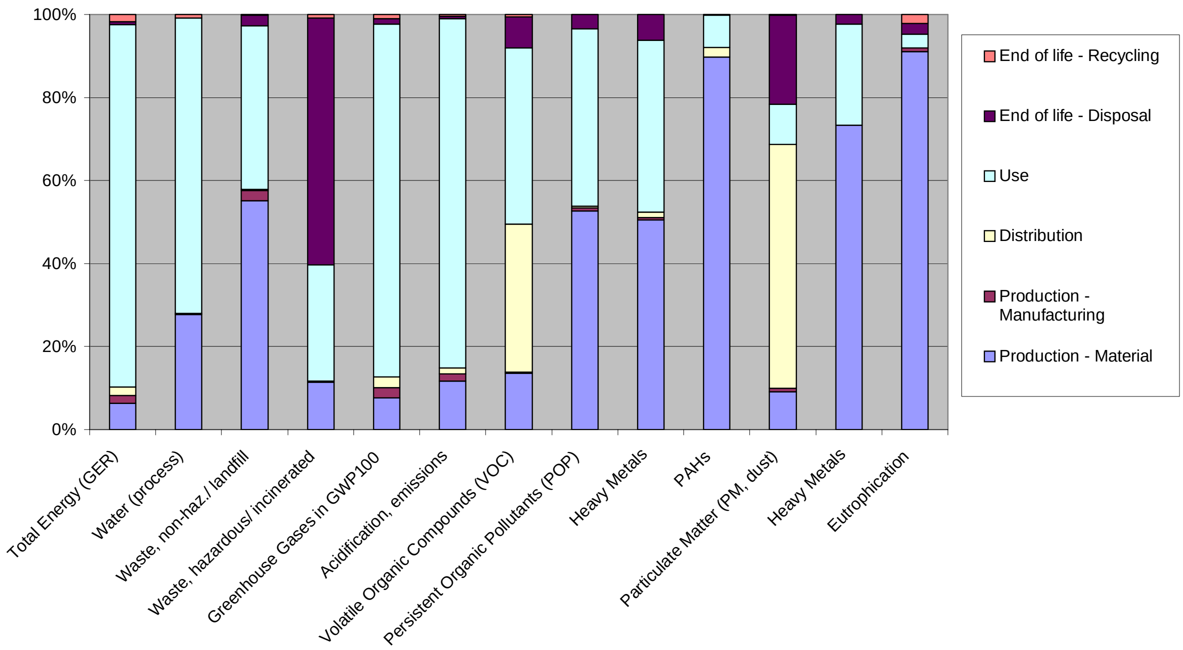


Figure 5.22: COLD7 – % of impacts on LCA



5.3.3.3 Impact and consumptions for COLD 8

Also for the upright freezers, the impact results, shown in Figures 5.23-5.26, are similar to that of the refrigerators models. Here again the figures clearly show that the higher energy and water consumption level are occurring in the use phase (Figure 5.23) while the production phase is responsible for the higher quota of the waste production (Figure5.24).

Figure 5.23: COLD8 – Energy and water consumptions

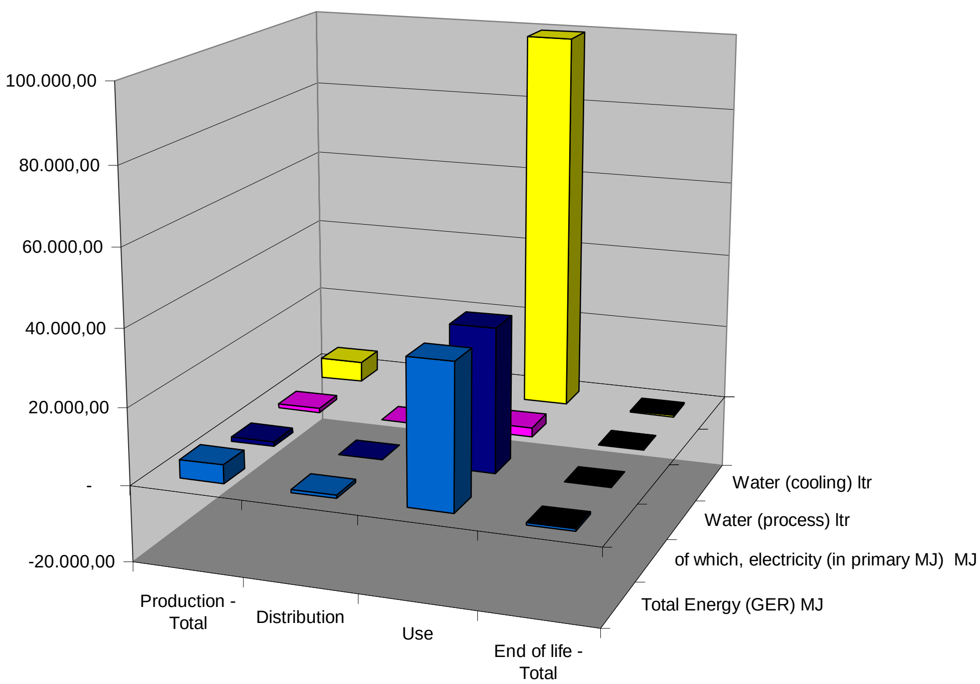
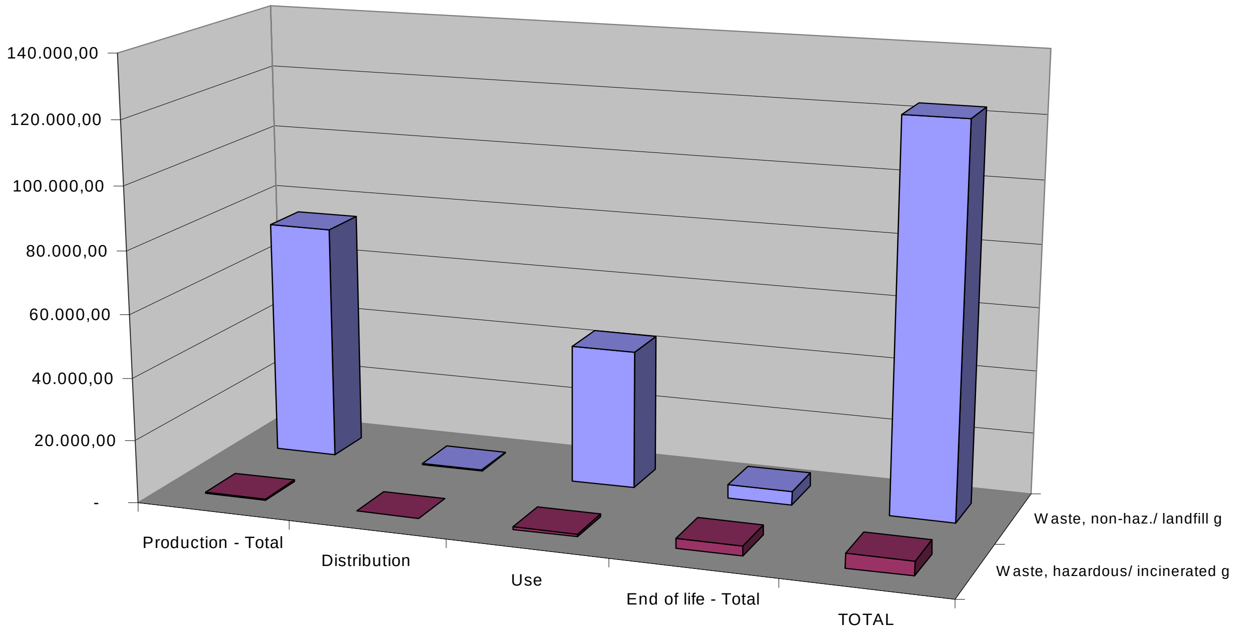


Figure 5.24: COLD8 – Waste production



For emissions to air (Figure 5.25) GWP, acid rain and VOC are more relevant in the use phase while POP, Heavy metals and PAH are mainly emitted from the production phase, and the distribution phase produces the higher quota of PM dust emissions. Finally also in this case the emissions to water (Figure 5.26) are mainly provided by the production phase especially for what concerns the heavy metals. The overall situation is summarised in Figure 5.27 (LCA% of COLD 8).

Figure 5.25: COLD8 – Emissions (air)

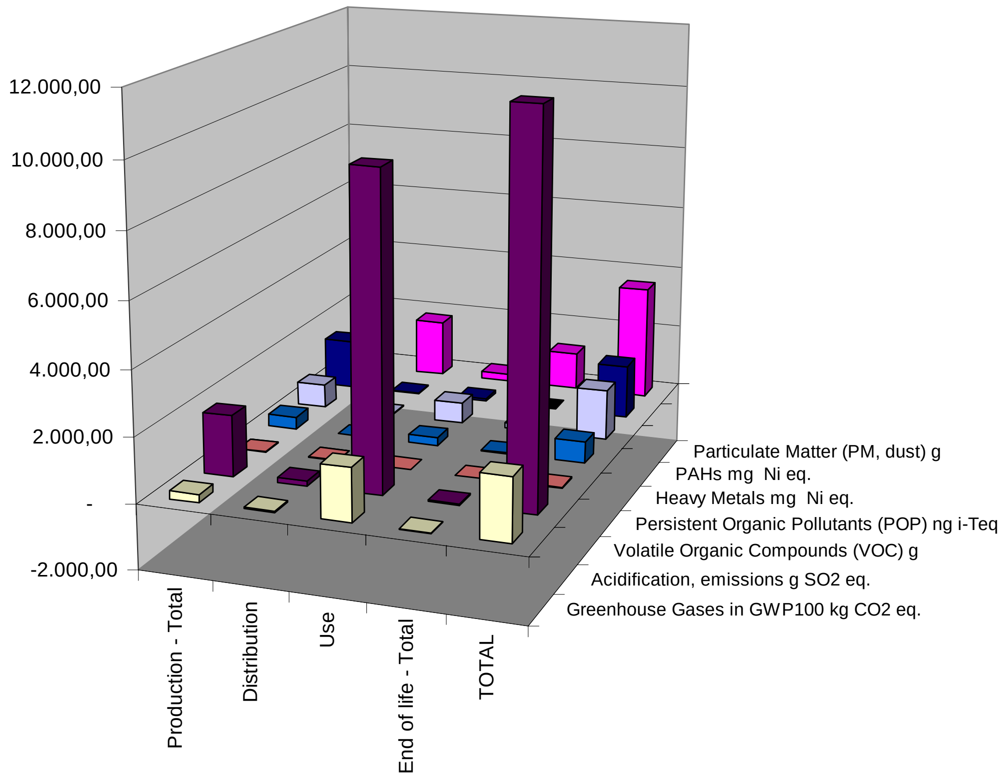


Figure 5.26: COLD8 – Emissions (water)

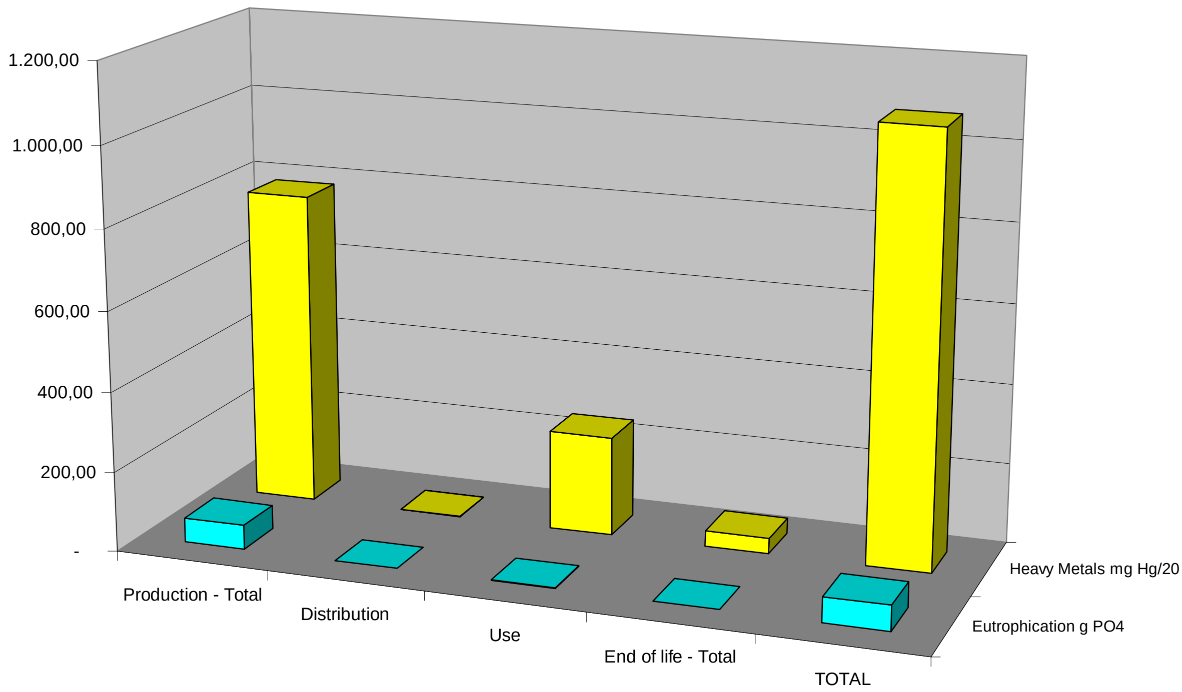
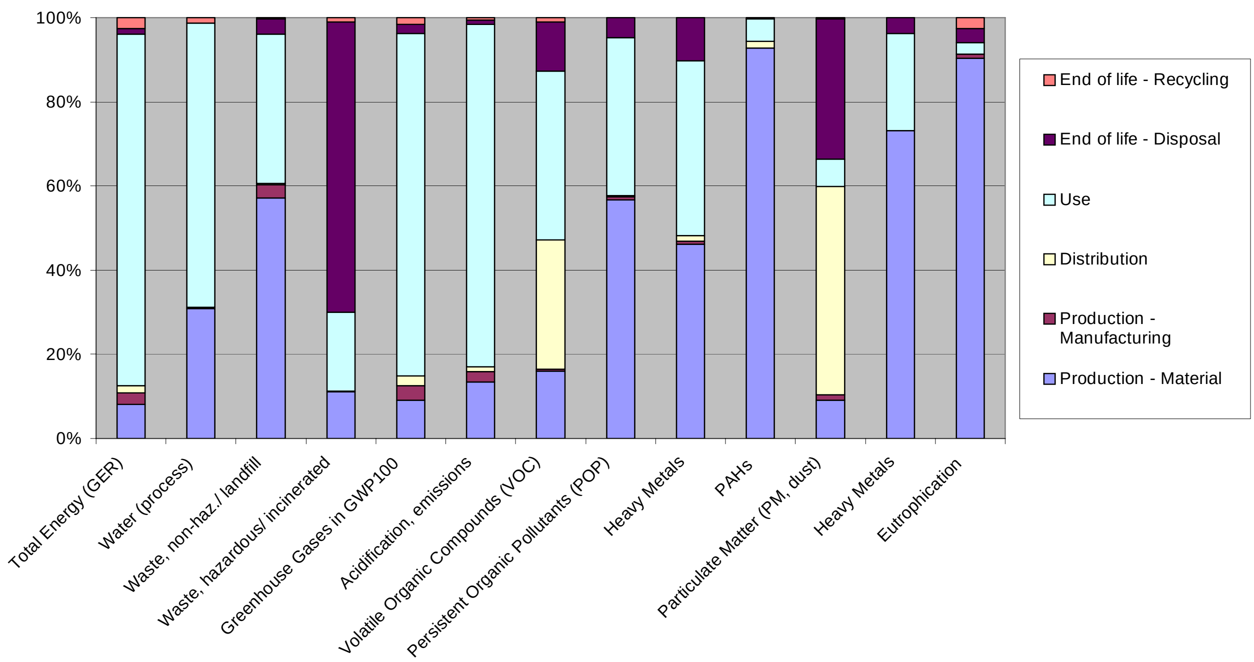


Figure 5.27: COLD8 – % of impacts on LCA



5.3.3.4 Impact and consumptions for COLD 9

Figures 5.28 – 5.32 show the output result for the chest freezers. In practical there are no differences with the results concerning the upright freezers and it is possible to affirm that, form the environmental point of view, the freezers' profile is practically the same.

Figure 5.28: COLD9 – Energy and water consumptions

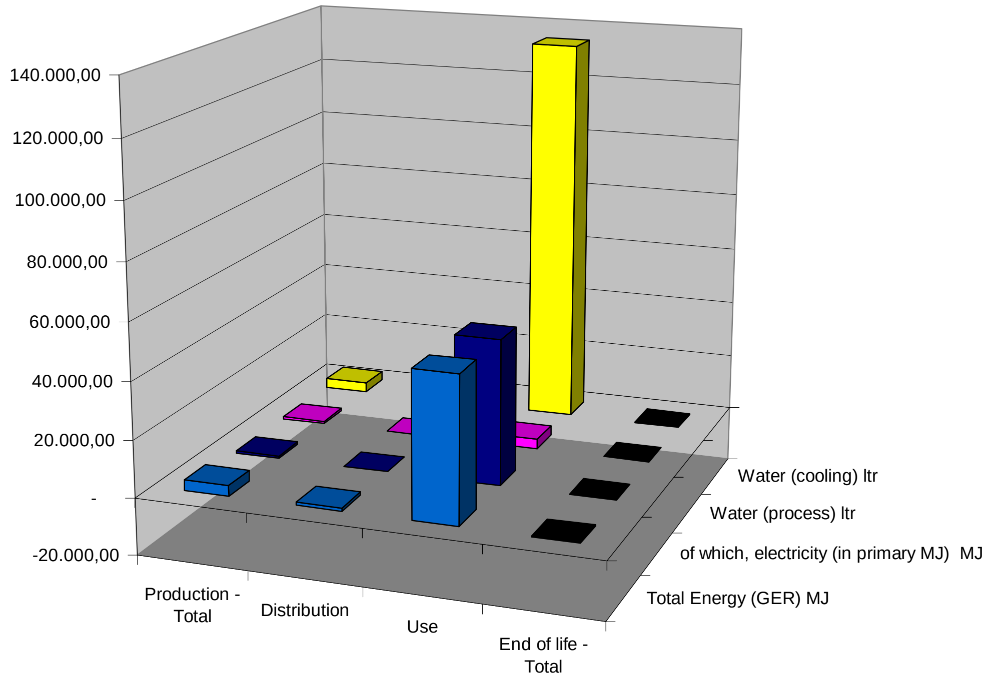


Figure 5.29: COLD9 – Waste production

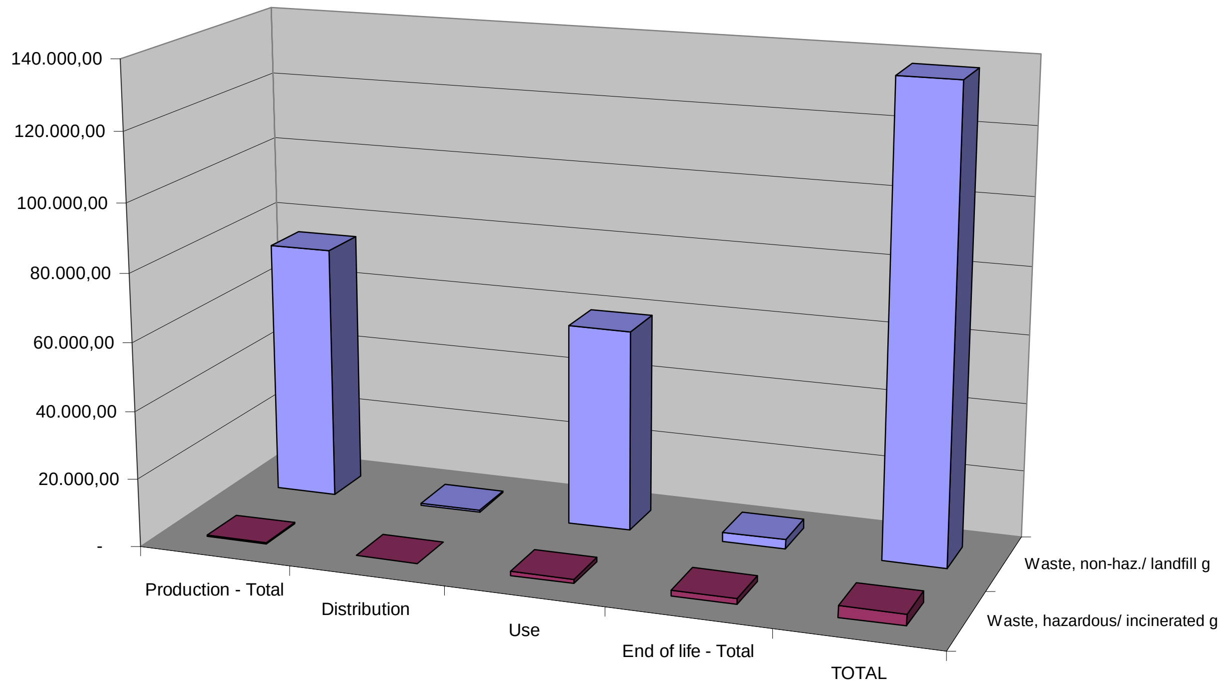


Figure 5.30: COLD9 – Emissions (air)

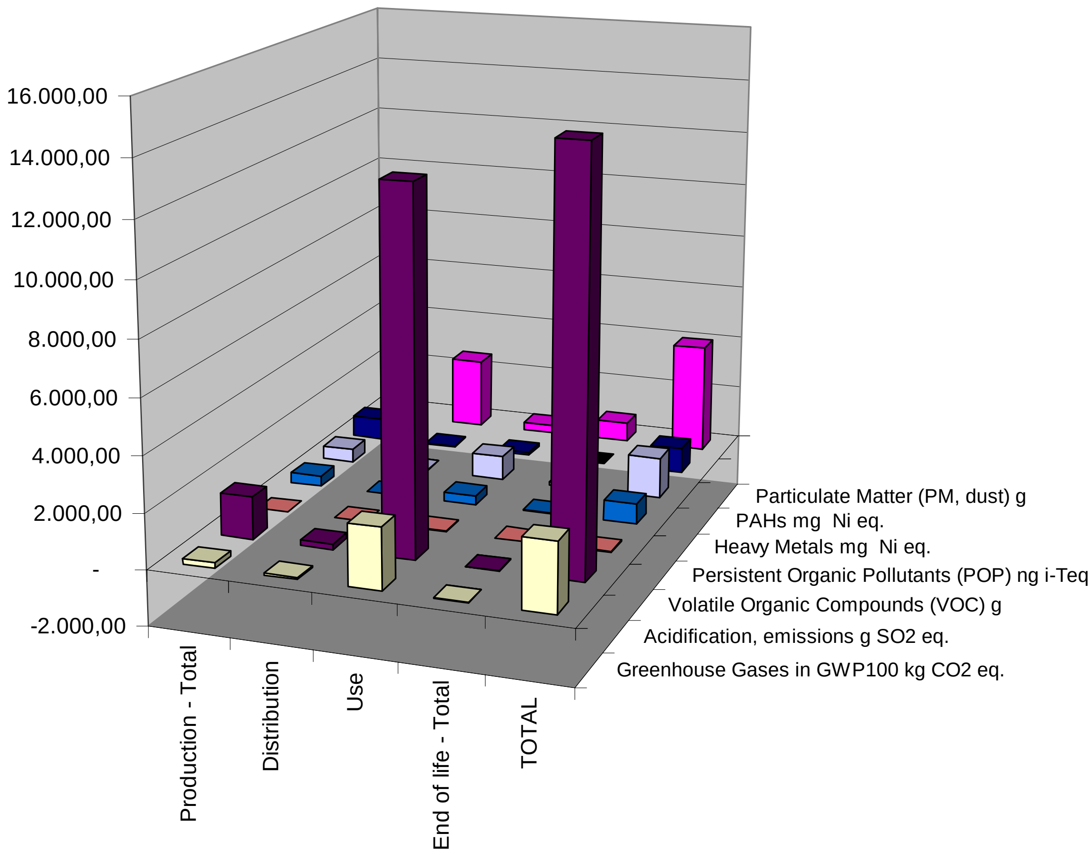


Figure 5.31: COLD9 – Emissions (water)

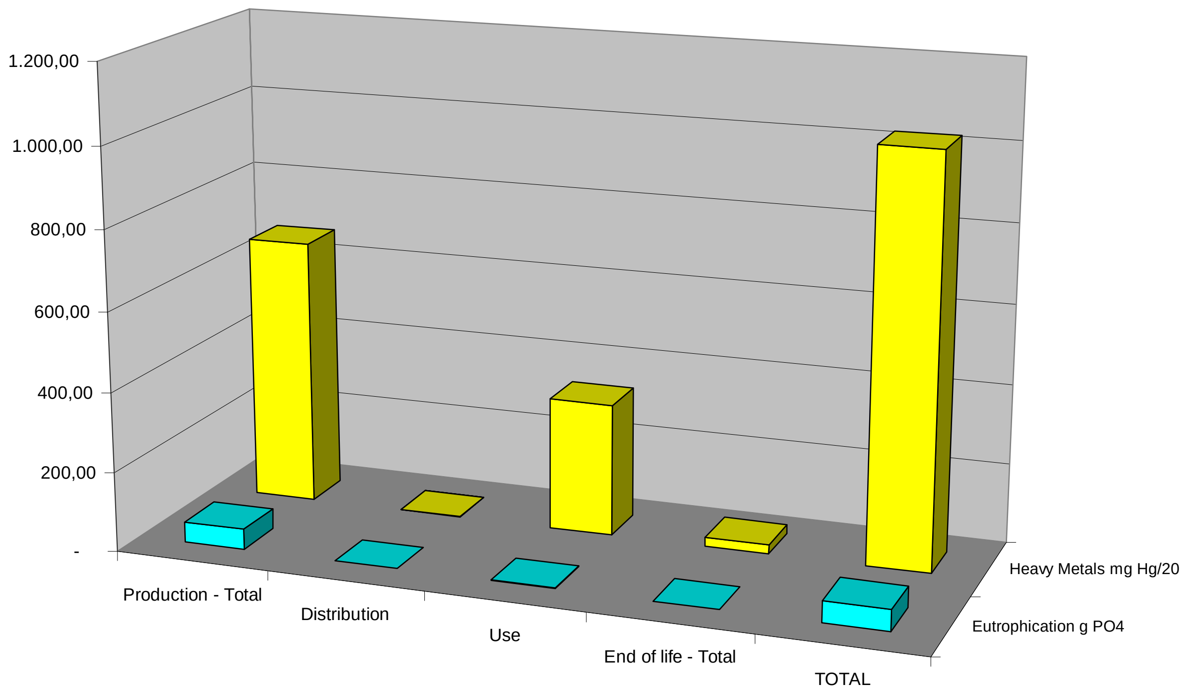
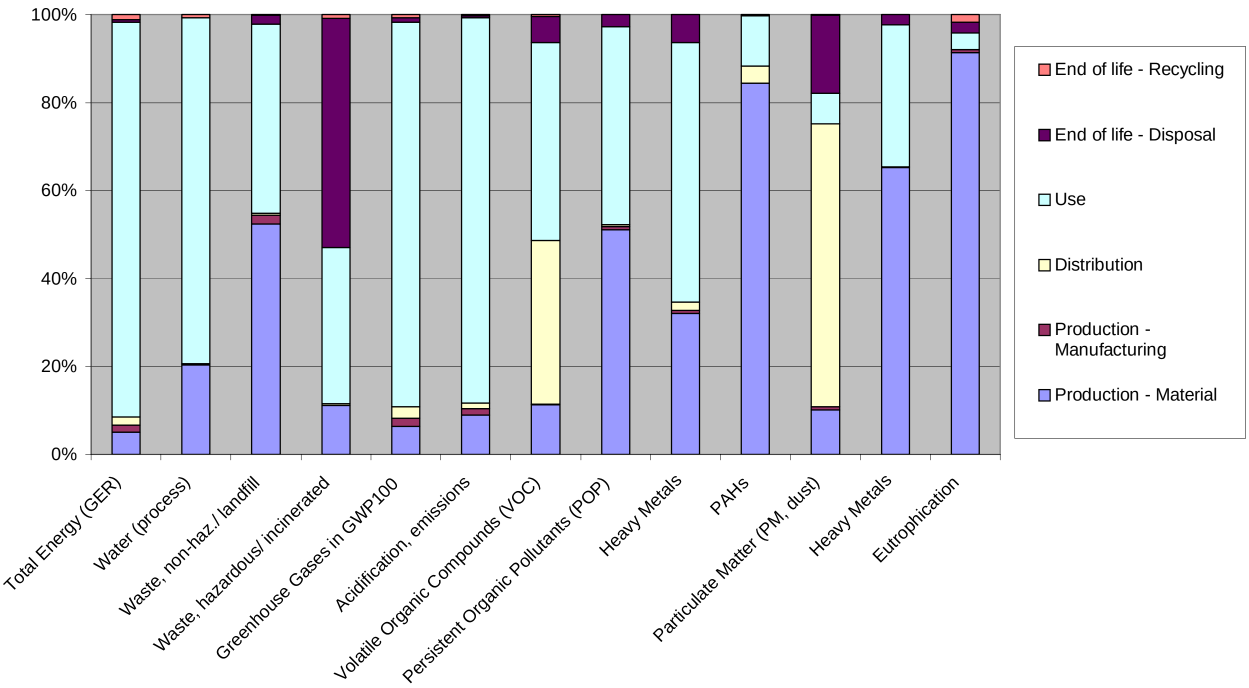


Figure 5.32: COLD9 – % of impacts on LCA



5.3.4 The results from the SimaPro analysis and comparison with the EUP Ecoreport outputs

As explained before EuP Ecoreport has some limits regarding the material data base (lack of data), transportatin (included as a fixed amount in material characteristics) and end of life (only partially considered).

In order to assess compliance of EuP results with real environmental impact, a comparison with data from a well know LCA software has been performed.

The software is the SimaPro and in appendix C its characteristics are described; the comparison was made for one Cold appliance: Cold 7 – Refrigerator - Freezer

In Appendix C all SimaPro outputs have been reported as characterisation chart: assembling, use and end of life.

5.3.4.1 Steps of the comparison

Correspondence of materials used in Cold 7 manufacture with SimaPro Database

As reported before, in the SimaPro software there are available many databases and it is also possible for the user to create specific record. In this way it is possible, and it was possible for us, to reduce consistently the number of data present in the inventory data sheet without any deterioration of the correspondence in the SimaPro implementation.

In the same way also the number of materials for which assumptions were made to find a correspondence with existing categories was reduced.

In Appendix C are shown the input tables in the SimaPro method for the COLd7 base case models. Comparing these tables with the original data of the base case models (see Appendix A) it is possible to underline that using SimaPro it was possible to find a proper correspondence quickly for almost all materials or processes. It was not possible to find a proper correspondence for the following materials:

- o Ag, TPE and cleaning agent.

In these tables also reported, where necessary, are notes explaining the correspondence of the material or processes selected by the SimaPro database and the original data of the base case model.

Main assumptions in SimaPro application

In order to implement the SimaPro software, the following assumptions were made regarding the inventory data of the chosen base case model (COLD 7):

- For Assembling
    - o Scraps: valuating data provided from producers, it was possible to consider the scrap percentage equal to 5% for metals and to 1% for other materials (mainly plastics); In this way, the simulation of assembly has been made on the gross weight of materials composing the machine;
    - o Processing: once more, valuating data from producers it was possible to consider a sort of average indication for the type of processing needed for each material during the assembly phase (simplified approach); in this way it was possible to find a list of typical processes for different class of materials (steels, iron, plastics, PVCs, expanded plastics);
    - o Processing: in order to avoid an iper-evaluation of impacts deriving from processing of materials and on the basis of information provided from producers, as general rule metals have been assumed to be processed as 50% of total weight and plastics as 70%.
    - o Transport: according to received data, it has been calculated for each model an average km for transport of materials for the assembly phase. Because the need in the SimaPro to set both the average km (in terms of t km) and the transport medium, on the basis on general considerations on data provided from producers, average km has been sub-divided as following:
        - 70% truck
        - 30% ship
- For Use: in this case it was possible to use all data provided from producers. In addition, in order to take into account of spare parts as provided from producers (about 300g per life cycle, corresponding to 0,45% of the total weight of the COLD 7 average model), they has been accounted for as a production of 0,45% of a COLD7 model. For transport in use phase the use of a van less than 3,5 tons was considered.
- End of life: according to the data received from producers, the % of treatments for the appliances at the end of life have been calculated and reported in SimaPro data input (Appendix C). It has to be underlined how in EuP-Ecoreport, end of life was an “internal preassembled calculation methodology” as % and final destinations of some materials; it could be considered as a “partially close system”, while in SimaPro it was possible to use data from producers. For this reason it was decided to show outputs from SimaPro and EuP-Ecoreport “with and without End of life” outputs and to make comparison on outputs “without end of life phase” to reduce differences.

Adapting Ecoindicator 95 environmental impact assessment method to EuP-Ecoreport output indicators

Environmental indicators (environmental assessment methods) available in SimaPro SW refer to various databases and are different from those used in EuP-Ecoreport ones.

In order to make "comparable" these Environmental indicators a "modified ecoindicator95 method" has been set up and applied to SimaPro outputs.

In Table 5.17 Environmental indicators and related units used as outputs in EuP-Ecoreport have been reported, while in Table 5.18 same data, referred to SimaPro outputs have been reported (as in Ecoindicator 95 method).

Table 5.17: Output indicators in EuP-Ecoreport method

Other Resources & Waste	
Total Energy (GER)	PJ
of which, electricity (in primary PJ)	PJ
Water (process)	mln. m3
Water (cooling)	mln. m3
Waste, non-haz./ landfill	kt
Waste, hazardous/ incinerated	kt
Emissions (Air)	
Greenhouse Gases in GWP100	mt CO2 eq.
Ozone Depletion, emissions	t R-11 eq.
Acidification, emissions	kt SO2 eq.
Volatile Organic Compounds (VOC)	kt
Persistent Organic Pollutants (POP)	g i-Teq
Heavy Metals	ton Ni eq.
PAHs	ton Ni eq.
Particulate Matter (PM, dust)	kt
Emissions (Water)	
Heavy Metals	ton Hg/20
Eutrophication	kt PO4
Persistent Organic Pollutants (POP)	g i-Teq

Table 5.18: Output indicators in Ecoindicator95 method

Environmental impact	unit
greenhouse	kg CO2
ozone layer	kg CFC11
acidification	kg SO2
eutrophication	kg PO4
heavy metals	kg Pb
carcinogens	kg B(a)P
winter smog	kg SPM
summer smog	kg C2H4
pesticides	kg act.subst.
energy resources	MJ LHV
solid waste	kg

In appendix C the methodology used to compare SimaPro and EuP-Ecoreport outputs has been reported and explained.

In any case, it was not possible to adapt exactly the "Ecoindicator 95 method" to the EuP-Ecoreport mrethod because of lack a complete list of components in many indicators and related weight in EuP methodology.

In the following Table 5.19 the "compliance" between EuP-Ecoreport indicators and "modified SimaPro indicators" has been reported.

Table 5.19: Complaince between SimaPro (Eco-indicator 95 rev EuP) and EuP-Ecoreport list of output

Eup / Simapro	8 - Total Energy (GER)	12 (+13) - waste	14 - Greenhouse Gases in GWP100	15 - Ozone Depletion, emissions	16 - Acidification, emissions	17 - Volatile Organic Compounds (VOC)	18 - Persistent Organic Pollutants (POP)	19 - Heavy Metals	19,1 - PAHs	20 - Particulate Matter (PM, dust)	21 - Heavy Metals	22 - Eutrophication	23 - Persistent Organic Pollutants (POP)
8 - energy resources	**ok**												
12 (+13) - solid waste		**p**											
14 - Greenhouse			**ok**										
15 - ozone layer				**ok**									
16 - Acidification					**ok**								
17 - summer smog – VOCs						**p**							
18 - POP (air)							**p**						
19 - Heavy metals (air)								**p**					
19,1 - PAHs (air)									**no**				
20 - winter smog - P.M.										**p**			
21 - Heavy metals (water)											**p**		
22 - Eutrophication												**p**	
23 - POP (water)													**p**
- heavy metals													
- Carcinogens													
- Pesticides													

In the Table 5.19 we have:

- For SimaPro indicator:

- **blue color** means that the indicator has been modified (in terms of weight factor of some single components) to be in compliance with EuP;
    - **orange color** means a new indicator for SimaPro software, "elaborated" so as replicate the EuP one.
- For compliance index:
    - "Ok" means a good compliance between SimaPro and EuP indicators;
    - "P" means partial compliance between SimaPro and EuP indicators due to relevant differences of numbers of components taken into account and, sometimes, to the kind of components itself.
    - "No" means practically low compliance between SimaPro and EuP indicators. This is true only for PAHs, in fact in EuP methodology a "weight coefficient" equal to 20 for all PAHs has been used, without a list of kind of PAH considered.

5.3.4.2 SimaPro vs. EuP-Ecoreport output

In the following Table 5.20 LCA outputs from SimaPro with Ecoindicator 95 – revised according to EuP Method have been reported for COLD 7- refrigerator-freezers, while in the following Table 5.22 the LCA output from EuP-Ecoreport has been reported.

Table 5.20: COLD 7 – LCA output (Ecoindicator95-rev. EuP method) adapted to that of EuP-Ecoreport

Row in EuP-Ecoreport	Impact category	Unit	COLD7 assembling	Use	cold 7 EoL	Total
8	energy resources	MJ LHV	1,15E+04	7,19E+04	-1,11E+03	8,23E+04
12 (+13)	solid waste	kg	3,31E+02	2,34E+02	-4,51E+01	5,20E+02
14	greenhouse	kg CO2	6,00E+02	3,09E+03	-5,94E+01	3,63E+03
15	ozone layer	kg CFC11	6,36E-04	2,11E-03	-2,77E-05	2,72E-03
16	acidification	kg SO2	6,29E+00	2,33E+01	-2,63E-01	2,94E+01
17	summer smog - VOCs	kg C2H4	3,73E-01	8,02E-01	-6,77E-02	1,11E+00
18	POP (air)	kg TE eq	1,52E-09	1,28E-09	4,60E-11	2,85E-09
19	Heavy metals (air)	kg Ni eq	6,82E-04	5,65E-03	-1,83E-05	6,32E-03
19,1	PAHs (air)	kg PAH/20 eq	2,13E-06	2,77E-06	-7,91E-07	4,11E-06
20	winter smog - P.M.	kg SPM	4,89E+00	1,94E+01	-1,56E-01	2,41E+01
21	Heavy metals (water)	kg Hg/20 eq	4,82E-03	3,07E-02	-8,49E-04	3,46E-02
22	eutrophication	kg PO4	2,88E-01	8,22E-01	-2,33E-02	1,09E+00
23	POP (water)	kg TE eq	0,00E+00	0,00E+00	0,00E+00	0,00E+00
	heavy metals	kg Pb	5,03E-03	2,44E-02	-3,59E-04	2,91E-02
	carcinogens	kg B(a)P	3,05E-05	8,15E-05	-4,24E-05	6,96E-05
	pesticides	kg act.subst	0,00E+00	0,00E+00	0,00E+00	0,00E+00

According to Simapro outputs, the use phase and production phase have to be considered as more relevant than others regarding environmental impacts; this has been considered true also for EuP Ecoreport outputs. The main difference was in the comparison of environmental impact relevance between use and production phase.

Table 5.21: Relevance of Production and Use phases for COLD 7

Row in EuP-Ecoreport	Impact category	COLD7 assembling	Use	Total - EoL
8	energy resources	14%	86%	100%
12 (+13)	solid waste	59%	41%	100%
14	greenhouse	16%	84%	100%
15	ozone layer	23%	77%	100%
16	acidification	21%	79%	100%
17	summer smog - VOCs	32%	68%	100%
18	POP (air)	54%	46%	100%
19	Heavy metals (air)	11%	89%	100%
19,1	PAHs (air)	43%	57%	100%
20	winter smog - P.M.	20%	80%	100%
21	Heavy metals (water)	14%	86%	100%
22	eutrophication	26%	74%	100%
23	POP (water)			
	heavy metals	17%	83%	100%
	carcinogens	27%	73%	100%
	pesticides			

As reported in Table 5.21, for Simapro use phase has to be considered the most relevant regarding environmental impact.
Analyzing SimaPro outputs it is clear how energy consumption, greenhouse gas, acidification and VOC are more relevant in use phase while POP (air) and solid waste are mainly emitted from production phase.
This is in compliance with EuP Ecoreport outputs; for all other indicators use phase has to be considered the most relevant.

Table 5.22: COLD 7 – LCA output from EuP-Ecoreport

			Production	Distribution	Use	End of Life	Total
8	Total Energy (GER)	MJ	4669	1115	49414	-459	54738
9	of which, electricity (in primary MJ)	MJ	1209	2	49333	-61	50484
10	Water (process)	ltr	1298	0	3301	-40	4559
11	Water (cooling)	ltr	4685	0	131570	-337	135918
12	Waste, non-haz./ landfill	g	84942	564	58035	3599	147140
13	Waste, hazardous/ incinerated	g	463	11	1141	2378	3994
14	Greenhouse Gases in GWP100	kg CO2 eq.	257	67	2158	10	2493
15	Ozone Depletion, emissions	mg R-11 eq.					
16	Acidification, emissions	g SO2 eq.	2034	206	12724	31	14994
17	Volatile Organic Compounds (VOC)	g	6	16	19	3	45
18	Persistent Organic Pollutants (POP)	ng i-Teq	408	3	327	26	765
19	Heavy Metals	mg Ni eq.	1069	29	867	129	2093
	PAHs	mg Ni eq.	1414	37	121	-3	1569
20	Particulate Matter (PM, dust)	g	456	2679	443	976	4554
21	Heavy Metals	mg Hg/20	988	1	328	31	1348
22	Eutrophication	g PO4	61	0	2	0	63
23	Persistent Organic Pollutants (POP)	ng i-Teq					

Going into details comparing Simapro and EuP outputs in Table 5.23 LCA output from EuP-Ecoreport has been reported.

Table 5.23: COLD 7 – comparison for LCA output with EuP-Ecoreport vs. SimaPro.

Row in EuP-Ecoreport	Impact category	Unit	COLD7 assembling	Use	Total - EoL
8	energy resources	MJ LHV	146,58%	45,50%	54,23%
12 (+13)	solid waste	kg	287,82%	295,51%	290,97%
14	greenhouse	kg CO2	133,54%	43,01%	52,58%
15	ozone layer	kg CFC11			
16	acidification	kg SO2	209,28%	83,47%	100,82%
17	summer smog - VOCs	kg C2H4	6108,48%	4122,48%	4418,38%
18	POP (air)	kg TE eq	273,70%	291,63%	281,15%
19	Heavy metals (air)	kg Ni eq	-36,24%	552,24%	227,46%
19,1	PAHs (air)	kg PAH/20 eq	-99,85%	-97,71%	-99,68%
20	winter smog - P.M.	kg SPM	972,66%	4278,17%	2601,52%
21	Heavy metals (water)	kg Hg/20 eq	387,63%	9252,67%	2597,15%
22	eutrophication	kg PO4	371,84%	40994,78%	1661,46%
23	POP (water)	kg TE eq			

Main considerations and remarks on Simapro vs. EuP outputs

- Regarding the main "classic" indicators, as Energy resources, green house gas and acidification, total values reported can be considered in compliance with EuP ones; Simapro outputs were higher mainly because of better data accuracy, mainly on materials used and assembly and the energy sources environmental impact definition. It has to be underlined that these indicators are to be considered in compliance with EuP outputs. For these indicators it was confirmed that use phase is more relevant than production phase and with the same ratio.
- For VOC's and Heavy Metals (water) the difference could be mainly due to the higher number of compounds considered in Simapro database as contributors to the environmental indicator, compared with a lower number in EuP.
- PAHs value in EuP was higher than in Simapro output; this could be due to the different calculation methodology used in EuP (MEEuP report) and Simapro (Ecoindicator 95 modified).
- For all the other indicators general higher values in SimaPro output have been reported; this was due to the greater number of data considered in SimaPro and also due to the not incomplete compliance between Simapro and EuP indicators.

It is interesting to underline as in SimaPro use phase is responsible for about 72% of environmental impact, while for EuP this value is about 50%.

5.4 Base-Case Life Cycle Costs

The Life Cycle Costs (LCC) for the various base cases are estimated given the economic assumptions, including the consumer prices for various models. The LLC of the base case is the starting point for the optimisation of the technology options in Task 6 and will be re-presented in that context.

5.4.1 Key economic assumptions

The key common economic and financial assumptions, discussed in Task 2.4, are summarized here:

- Product life 15 years (with a sensitivity analysis for 10, 12 and 17 years)
- Discount rate 5%/year (PWF =10,38; 11,27 for 10, 12, 15 and 17 years)
- Electricity price 0,17 €/kWh
- Maintenance & repairs 5,5 €/year = 82,5 € in 15y
- Disposal & recycling 61 €/life
- Refrigerators price (Cat.1): 345,1 €
- refrigerator-freezers price: 485,0 €
- upright & chest freezers price: 328,0 €

The standard base-case annual energy consumption (from Task 5.2) and efficiency are:

Standard base case (description)	**EEI** (EEI)	**Energy consumption** (kWh/year)
refrigerator, Cat.1-6	54,4	163,7
refrigerator-freezer, Cat.7&10	54,3	324,4
upright freezer, Cat. 8	56,3	274,5
chest freezer, Cat. 9	64,4	300,6

Using these parameters the LCC is calculated in the following paragraph for the basic parameter combination. A sensitivity analysis is here presented only for the appliance lifetime, which has an immediate impact on the operating costs, while the sensitivity for the other parameters will be presented in Task 6.

5.4.2 The analysis results

The Life Cycle Cost for the consumer is the sum of the purchase price plus the discounted annual costs and the discounted end of life cost of recycling and disposal as shown in Table 5.24

The life cycle costs are more than double the purchase price in most cases, indicating the importance of the annual operating costs in particular the electricity, which will be subject to reduction in Task 6.

Table 5.24: Life Cycle Costs of Base Cases of Refrigerators and Freezers

Standard Base Case (description)	Consumer price (€)	Energy consumption (kWh/year)	Annual energy costs (€/year)	Annual maintenance costs (€/year)	Recycling & disposal costs (at end of life) (€)	LCC at 10 years (€)	LCC at 12 years (€)	LCC at 15 years (€)	LCC at 17 years (€)
Refrigerators	345	163,7	27,83	5,50	61,00	640	674	720	747
Refrigerator-freezers	485	324,4	55,15	5,50	61,00	991	1 057	1 144	1 195
Upright freezers	328	274,5	46,67	5,50	61,00	768	824	899	943
Chest freezers	328	300,6	51,10	5,50	61,00	803	864	945	993

5.5 EU TOTALS

For the cold appliances the lifetime energy consumption, life cycle cost, and life cycle environmental impacts are aggregated for the total units sold in 2005 in EU-25.

This is calculated for the base case and BAT models, using the characteristics of the models described in the Tasks 5 and 6, together with the stock and market data from Task 2. In addition to the total environmental impacts, the partial impacts are shown, including disposal assuming post-RoHS and post-WEEE conditions.

The 2005 total for the base case represents today's situation of the average models sold. A total for year 2005 was also calculated for the BAT model and these values are subtracted from those of the base case, this difference representing the potential maximum of technological savings from the substitution of all the base case models by the BAT model. This is a theoretical maximum savings potential as certainly BAT penetration will not reach 100%, however the number of models sold will increase slowly from the level in year 2005.

The lifetime energy consumption and life cycle costs are shown for the single models and for the total of year 2005 in Table 5.25.

Table 5.25: Average Freezer and Refrigerators: Lifetime Energy Consumption and Life Cycle Costs for Single Models and for Total Models Sold in Year 2005 in EU-25

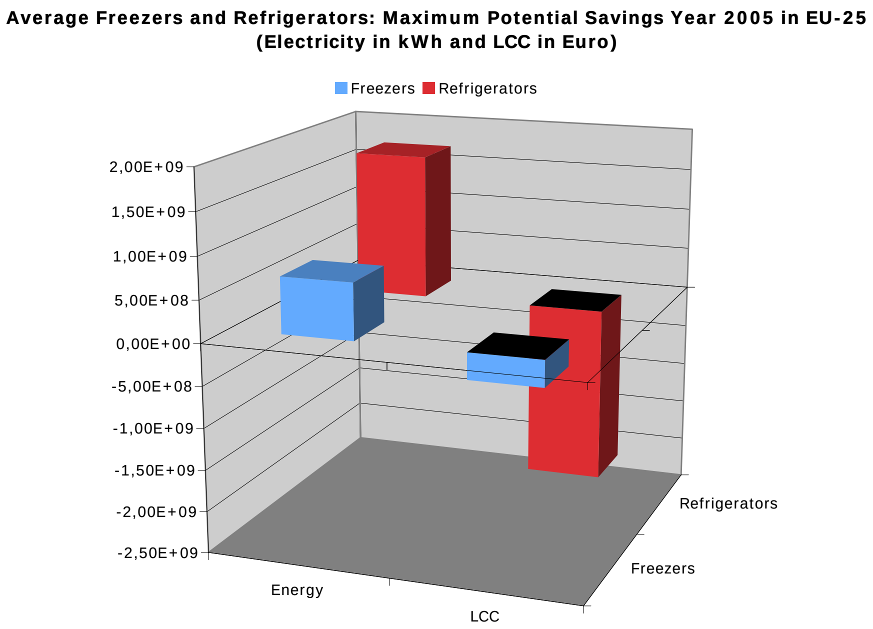
AVERAGE FREEZERS (AVERAGE OF CAT. 8 & 9)						
	Single Model (Avg of Cat 8 & 9)			Year 2005 (EU-25 Sales = 4.600.000 units)		
Characteristics	Base	BAT	Potential Savings	100% Base	100% BAT	Potential Savings
Lifetime Energy Consumption (kWh)	287,55	140,2	147,35	1,32E+09	6,45E+08	6,78E+08
Life Cycle Costs (Euro)	922	991	-69	4,24E+09	4,56E+09	-3,17E+08

AVERAGE REFRIGERATORS (30% Cat. 1-6; 70% Cat.7 & 10)						
	Single Model (30% /70%):			Year 2005 (EU-25 Sales = 14.200.000 units)		
Characteristics	Base	BAT	Potential Savings	100% Base	100% BAT	Potential Savings
Lifetime Energy Consumption (kWh)	276,19	154,29	121,9	3,92E+09	2,19E+09	1,73E+09
Life Cycle Costs (Euro)	1016,8	1164	-147,2	1,44E+10	1,65E+10	-2,09E+09

As indicated, the arithmetic average of the characteristics of Categories 8 and 9 is used to represent overall freezers; instead for refrigerators, a 30% weight is used for Categories 1 through 6, and a 70% weight for Categories 7 and 10. The potential energy savings per unit is slightly higher in the case of freezers, however this impact is diminished by the fact that number of refrigerators sold is more than three times that of freezers.

The maximum savings potentials for the aggregate amount in year 2005 are illustrated in Figure 5.33.

Figure 5.33: Maximum Potential Lifetime Savings for Models Sold in Year 2005 EU-25



As shown the refrigerators would produce almost triple the energy savings of freezers, however at a greater cost to the user. A detailed analysis of life cycle costs is given in Task 6, including that of the intermediate LLCC model.

Appendix A Life Cycle Inventory data

Table A.1: Cold1 average model Life Cycle Inventory

PRODUCTION

Materials type	**Material**	**COLD1 AVERAGE MODEL (g)**
Ferrous metals	Ferrous metals	8.089
	Iron	762
	Mixed steel+plastic	56
	Stainless Steel	62
	Steel other	2.064
	Steel strip	9.444
	Steel tube & wire	282
	Steel	384
Ferrous metals TOT		21.143
Non ferrous metals	Ag	4
	Al	863
	AL sheet	71
	AL tube	86
	Cu	1.825
	Cu tube	28
	solder & braze	2
Non ferrous metals TOT		2.879
Packaging	Cardboard	1.444
	EPS	1.034
	PE - foil	248
	PP	31
	Wood	10
Packaging TOT		2.767
Plastics	ABS	766
	Elastomers	24
	EPS - Insulation	3
	Foamed Cabinet	-
	PA	57
	PE	53
	PET	2
	Plastics, others	174
	POM	26
	PP	922
	PPO	17
	PS	5.769
	PU Foam - Insulation	3.798
	PUR	2.128
	PVC (excl. wire insul.)	348
	TPE	2
	Plastics	60
Plastics TOT		14.148
Various	Adhesive tape	9
	Dessicant	2
	Electronic, boards, switches, lamp etc	83
	Glass	5.110
	Glue	80
	Magnet	46

Materials type	Material	COLD1 AVERAGE MODEL (g)
	Others	3
	Paint	64
	Paper (booklets etc)	195
	Refrigerant	28
	Refrigerant HC	5
	Rubber	49
	Running capacitor	2
	Thermostat	147
	Wiring	242
	Lubricating oil	140
Various TOT		6.204
TOTAL		47.141

SCRAP

Materials	Scrap (%)	Scrap End of Life
Ferrous metals	3	Recycled 90%
Non ferrous metals	1	Recycled 90%
Plastics	1,5	Recycled 90%
Various	0,5	Recycled 90%
Packaging	1,5	Recycled 90%

PROCESSING

Materials	Processing
Ferrous metals	Forming
Non ferrous metals	Forming/Wiring
Plastics	Extrusion/Injection moulding
Various	Assembling
Packaging	Cutting/Assembling

TRANSPORT

Average km COLD1 = 1.235,83 km

70 % TRUCK

30% SHIP

ASSEMBLING

	COLD1 AVERAGE MODEL

Electricity	31,495	kWh
Heat	11,59	kWh
Water	0,048	m3
Other materials		
lubricant	27	g
cleaning agent	8	g
nitrogen	43	g
Argon	5	g
Oxigen	27	g
Helium	1,7	g
Volume of packaged final product	0,549	m3

USE

	COLD1 AVERAGE MODEL
Product Life (years)	14,00
Electricity	
On-mode: Consumption per YEAR	160,54
On-mode: n. of hours, cycles, settings, etc. / year	
Standby-mode: Consumption per hour	
Standby-mode: n. of hours / year	
Off-mode: Consumption per hour	
Off-mode: n. of hours / year	
TOTAL over Product Life	
Heat	
Avg. Heat Power Output	
No. of hours / year	
Type and efficiency	
TOTAL over Product Life	
Consumables (excl. spare parts)	
Water	
Auxiliary material 1	
Auxiliary material 2	
Auxiliary material 3	
Auxiliary material 4	
Auxiliary material 5	
Auxiliary material 6	
Auxiliary material 7	
Auxiliary material 8	
Auxiliary material 9	
Auxiliary material 10	
Auxiliary material 11	
Maintenance, Repairs, Service	
n. of km over Product-Life	18,93
Spare parts	
Spare parts (functional components)	0,04
Spare parts (aesthetic components- non functional)	0,30
Spare parts (object 50 thermostat)	0,03
Spare parts (object 7 compressor)	0,02

END OF LIFE

	Cold1 AVERAGE MODEL (%)
recycling	84,50
energy recovery	10,00
landfilling	5,50

Table A.2: Cold7 average model Life Cycle Inventory

PRODUCTION

Materials type	Material	COLD7 AVERAGE MODEL (g)
Ferrous metals	Ferrous metals	15.262
	Iron	711
	Mixed steel+plastic	7
	Stainless Steel	860
	Steel	3.328
	Steel other	1.373
	Steel strip	9.198
Ferrous metals TOT		**30.738**
Non ferrous metals	Ag	4
	Al	1.343
	Cu	1.893
	Zn	169
Non ferrous metals TOT		**3.408**
Packaging	Cardboard	2.673
	EPS	1.239
	PE foil	257
	PP	35
	Wood	10
Packaging TOT		**4.214**
Plastics	ABS	840
	Elastomers	4
	EPS	38
	PA	20
	PC	5
	PE	37
	PE foil	45
	PET	3
	Plastics, others	140
	POM	5
	PP	1.549
	PS	8.900
	PU foam - insulation	6.223
	PUR	1.712
	PVC (excl. wire insul.)	352
	TPE	3
	Plastics	81
Plastics TOT		**19.958**
Various	Adhesive tape	14
	color/paint	9
	Glass	6.219
	Glue	127

Materials type	Material	COLD7 AVERAGE MODEL (g)
	Paper	272
	Refrigerant	49
	Rubber	202
	Thermostat	146
	Wiring	273
	Electronic, boards, switches, lamp etc	155
	Lubricating oil	190
Various TOT		**7.654**
TOTAL		**65.972**

SCRAP

Materials	Scrap (%)	Scrap End of Life
Ferrous metals	3	Recycled 90%
Non ferrous metals	1	Recycled 90%
Plastics	1,5	Recycled 90%
Various	0,5	Recycled 90%
Packaging	1,5	Recycled 90%

PROCESSING

Materials	Processing
Ferrous metals	Forming
Non ferrous metals	Forming/Wiring
Plastics	Extrusion/Injection moulding
Various	Assembling
Packaging	Cutting/Assembling

TRANSPORT

Average km COLD7 = 1.467 km

70 % TRUCK

30% SHIP

ASSEMBLING

	COLD7 AVERAGE MODEL
Energy (kWh)	
Electricity	25,34
Heat	15,69
Mechanical	
Water (m3)	0,228
Other materials (g)	
lubricant	27,000
cleaning agent	8,000
nitrogen	84,000
Argon	5,000
Oxigen	27,000
Volume of packaged final product (m3)	0,784

USE PHASE

	COLD7 AVERAGE MODEL	
Product Life	**15**	years
Electricity		
On-mode: Consumption per year	**313,15**	kWh
On-mode: n. of hours, cycles, settings, etc. / year		
Standby-mode: Consumption per hour		
Standby-mode: n. of hours / year		
Off-mode: Consumption per hour		
Off-mode: n. of hours / year		
TOTAL over Product Life		
Heat		
Avg. Heat Power Output		
No. of hours / year		
Type and efficiency		
TOTAL over Product Life		
Consumables (excl. spare parts)		
Water		
Auxiliary material 1		
Auxiliary material 2		
Auxiliary material 3		
Auxiliary material 4		
Auxiliary material 5		
Auxiliary material 6		
Auxiliary material 7		
Auxiliary material 8		
Auxiliary material 9		
Auxiliary material 10		
Auxiliary material 11		
Maintenance, Repairs, Service		
n. of km over Product-Life	14,30	km/product life
Spare parts		
or Spare parts (object functional)	0,14	n/product life
Spare parts (object aesthetic)	0,40	n/product life
bottom glass shelf with profiles		
glass shelves with profiles	151,00	(g/product life ?)
thermostat	134,00	(g/product life ?)

END OF LIFE

	COLD7 AVERAGE MODEL
Dismantling	2,50
recycling	80,00
energy recovery	12,00
landfilling	5,50

Table A.3: Cold 8 average model Life Cycle Inventory

PRODUCTION

Materials type	Material	COLD8 AVERAGE MODEL
Ferrous metals	Ferrous metals	9.928
	Iron	437
	Mixed steel+plastic	603
	Stainless Steel	43
	Steel	2.880
	Steel strip	9.729
	Steel tube & wire	1.347
Ferrous metals TOT		24.966
Non ferrous metals	Ag	4
	Al	694
	AL tube	16
	Cu	1.570
	Cu tube	46
	solder & braze	2
Non ferrous metals TOT		2.332
objects	Accumulator	272
	Handle	65
objects TOT		337
packaging	Cardboard	1.935
	EPS	1.046
	Others (packaging)	24
	PE - foil	328
	PP	22
	Wood	10
packaging TOT		3.365
Plastics	ABS	999
	Elastomers	8
	EPS - Insulation	2
	PA	55
	PE	580
	Plastics, others	116
	POM	21
	PP	1.865
	PPO	7
	PS	10.322
	PU Foam - Insulation	6.524
	PUR	1.986

Materials type	Material	COLD8 AVERAGE MODEL
	PVC (excl. wire insul.)	529
	SAN	1.232
	TPE	6
	Plastics	73
Plastics TOT		24.326
Various	Adhesive tape	0
	Butyl rubber	19
	Capacitor	11
	Dessicant	2
	Electronic, boards, switches, lamp etc	240
	Glue	5
	Magnet	46
	Others	1
	Paint	142
	Paper (booklets etc)	182
	PCB	9
	Refrigerant	53
	Refrigerant HC	12
	Rubber	27
	Thermostat	88
	Wiring	268
	Lubricating oil	170
Various TOT		1.274
TOTAL		56.601

SCRAP

Materials	**Scrap (%)**	**Scrap End of Life**
Ferrous metals	3	Recycled 90%
Non ferrous metals	1	Recycled 90%
Plastics	1,5	Recycled 90%
Various	0,5	Recycled 90%
Packaging	1,5	Recycled 90%

PROCESSING

Materials	**Processing**
Ferrous metals	Forming
Non ferrous metals	Forming/Wiring
Plastics	Extrusion/Injection moulding

Various	Assembling
Packaging	Cutting/Assembling

TRANSPORT

Average km COLD8 = 563,51 km

70 % TRUCK

30% SHIP

ASSEMBLING

	COLD8 AVERAGE MODEL
Energy (kWh)	
Electricity	26,51
Electricity (assembling+lighting)	
Electricity (heating buildings)	
Heat	16,8
Heat (assembling)	
Heat (heating buildings)	
Mechanical	
Water (m3)	0,180
Other materials (g)	
Lubricant	27
Cleaning agent	8
Nitrogen	43
Argon	5
Oxigen	27
Helium	1,7
Volume of packaged final product (m3)	0,5216

USE

		COLD8 AVERAGE MODEL
Product Life	years	**14,00**
Electricity	-	
On-mode: Consumption per hour, cycle, setting, etc.	kWh	**254,43**
On-mode: n. of hours, cycles, settings, etc. / year	hrs.	
Standby-mode: Consumption per hour	kWh	
Standby-mode: n. of hours / year	-	
Off-mode: Consumption per hour	kWh	
Off-mode: n. of hours / year	-	
TOTAL over Product Life	-	
Heat	-	

		COLD8 AVERAGE MODEL
Avg. Heat Power Output	kW	
No. of hours / year	hrs.	
Type and efficiency	1	
TOTAL over Product Life	-	
Consumables (excl. spare parts)	-	
Water	m3/year	
Auxiliary material 1	kg/ year	
Auxiliary material 2	kg/ year	
Auxiliary material 3	kg/ year	
Auxiliary material 4	kg/ year	
Auxiliary material 5	kg/ year	
Auxiliary material 6	kg/ year	
Auxiliary material 7	kg/ year	
Auxiliary material 8	-	
Auxiliary material 9	-	
Auxiliary material 10	-	
Auxiliary material 11	-	
Maintenance, Repairs, Service	-	
n. of km over Product-Life	km/product life	**2,75**
Spare parts	g/product life	**27,00**
or Spare parts (functionals)	n/product life	**0,10**
Spare parts (aesthetics)	n/product life	**0,15**

END OF LIFE

	COLD8 AVERAGE MODEL
Dismantling	9
recycling	71
energy recovery	13
landfilling	6

Table A.4: Cold 9 average model Life Cycle Inventory

PRODUCTION

Materials type	Material	COLD9 AVERAGE MODEL
Ferrous metals	Iron	6.538
	Mixed steel+plastic	163
	Steel other	1.780
	Steel strip	9.055
	Ferrous metals	8.554
Ferrous metals TOT		26.089
Non ferrous metals	Al	3.216
	Cu	1.189
Non ferrous metals TOT		4.406
packaging	Cardboard	1.472
	EPE (protections)	33
	EPS	1.729

Materials type	Material	**COLD9 AVERAGE MODEL**
	Others (packaging)	14
	PE - foil	542
	PP	17
	PVC	3
packaging TOT		3.810
Plastics	ABS	197
	PA	41
	PE	51
	Plastics, others	94
	PP	846
	PS	2.212
	PU Foam - Insulation	5.821
	PUR	2.188
	PVC	2.027
	PVC (excl. wire insul.)	327
	Plastics	107
Plastics TOT		13.910
Various	Electronic, boards, switches, lamp etc	25
	Others	843
	Paper (booklets etc)	115
	Refrigerant	83
	Rubber	9
	Thermopaste (paste)	707
	Thermostat	129
	Wiring	295
	Lubricating oil	249
Various TOT		2.455
TOTAL		50.669

SCRAP

Materials	**Scrap (%)**	**Scrap End of Life**
Ferrous metals	3	Recycled 90%
Non ferrous metals	1	Recycled 90%
Plastics	1,5	Recycled 90%
Various	0,5	Recycled 90%
Packaging	1,5	Recycled 90%

PROCESSING

Materials	**Processing**
Ferrous metals	Forming
Non ferrous metals	Forming/Wiring
Plastics	Extrusion/Injection moulding
Various	Assembling
Packaging	Cutting/Assembling

TRANSPORT

Average km COLD9 = 2.444 km

70 % TRUCK

30% SHIP

ASSEMBLING

	COLD9 AVERAGE MODEL
Energy (kWh)	
Electricity	17,65
Heat	6,64
Mechanical	
Water (m3)	0,08
Other materials (g)	
material 11	
material 12	
material 13	
Volume of packaged final product (m3)	0,76

USE PHASE

		COLD9 AVERAGE MODEL
Product Life	years	
Electricity	-	
On-mode: Consumption per year	kWh	321,1
On-mode: n. of hours, cycles, settings, etc. / year	-	
Standby-mode: Consumption per hour	kWh	
Standby-mode: n. of hours / year	-	
Off-mode: Consumption per hour	kWh	
Off-mode: n. of hours / year	-	

		COLD9 AVERAGE MODEL
TOTAL over Product Life	-	
Heat	-	
Avg. Heat Power Output	kW	
No. of hours / year	hrs.	
Type and efficiency	1	
TOTAL over Product Life	-	
Consumables (excl. spare parts)	-	
Water	m3/year	
Auxiliary material 1	kg/ year	
Auxiliary material 2	kg/ year	
Auxiliary material 3	kg/ year	
Auxiliary material 4	kg/ year	
Auxiliary material 5	kg/ year	
Auxiliary material 6	kg/ year	
Auxiliary material 7	kg/ year	
Auxiliary material 8	-	
Auxiliary material 9	-	
Auxiliary material 10	-	
Auxiliary material 11	-	
Maintenance, Repairs, Service	-	
n. of km over Product-Life	km/product life	
Spare parts	g/product life	
or Spare parts (functional)	n/product life	0,15
Spare parts (aesthetic)	n/product life	0,2

END OF LIFE

	COLD9 AVERAGE MODEL (%)
Dismantling	-
Recycling	**83**
ferrous metals	49
non ferrous metals	8
plastics	14
glass	-
packaging	12
Energy recovery	**12**
plastics	-
wood	-
paper	-
PUR	12
Land filling	**5**

Appendix B: EuP-Ecoreport data

Table A.5: COLD 1 – Refrigerator – INPUT in EuP-Ecoreport

Version 5 VHK for European Commission 28 Nov. 2005 Document subject to a legal notice (see below)

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: INPUTS
Assessment of Environmental Impact

Nr	Product name	Date	Author
1	COLD 1	08/05/2007	CUTAIA-SCIALDONI

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Ferrous metals (8089 g)	8184,6	3-Ferro	23-Cast iron
2	Iron (762 g)	771,0	3-Ferro	23-Cast iron
3	Mixed steel+plastic (56 g)	56,7	3-Ferro	25-Stainless 18/8 coil
4	Stainless Steel (62 g)	62,7	3-Ferro	25-Stainless 18/8 coil
5	Steel other (2064 g)	2088,4	3-Ferro	25-Stainless 18/8 coil
6	Steel strip (9444 g)	9555,6	3-Ferro	21-St sheet galv.
7	Steel tube & wire (282 g)	285,3	3-Ferro	22-St tube/profile
8	Steel (384 g)	388,5	3-Ferro	25-Stainless 18/8 coil
9	Ag (4 g)			
10	Al (863 g)	873,2	4-Non-ferro	26-Al sheet/extrusion
11	AL sheet (71 g)	71,8	4-Non-ferro	26-Al sheet/extrusion
12	AL tube (86 g)	87,0	4-Non-ferro	26-Al sheet/extrusion
13	Cu (1825 g)	1846,6	4-Non-ferro	29-Cu wire
14	Cu tube (28 g)	28,3	4-Non-ferro	30-Cu tube/sheet
15	solder & braze (2 g)	2,0	6-Electronics	52-Solder SnAg4Cu0.5
16	ABS (766 g)	775,1	1-BlkPlastics	10-ABS
17	Elastomers (24 g)	24,3	1-BlkPlastics	1-LDPE
18	EPS - Insulation (3 g)	3,0	1-BlkPlastics	6-EPS
19	Foamed Cabinet (0 g)			
20	PA (57 g)	57,7	2-TecPlastics	11-PA 6
21	PE (53 g)	53,6	1-BlkPlastics	2-HDPE
22	PET (2 g)	2,0	1-BlkPlastics	2-HDPE
23	Plastics, others (174 g)			
24	POM (26 g)	26,3	1-BlkPlastics	2-HDPE
25	PP (922 g)	932,9	1-BlkPlastics	4-PP
26	PPO (17 g)	17,2	1-BlkPlastics	4-PP
27	PS (5769 g)	5837,2	1-BlkPlastics	5-PS
28	PU Foam - Insulation (3798 g)	3842,9	2-TecPlastics	16-Flex PUR
29	PUR (2128 g)	2153,2	2-TecPlastics	15-Rigid PUR
30	PVC (excl. wire insul.) (348 g)	352,1	1-BlkPlastics	8-PVC
31	TPE (2 g)	2,0	1-BlkPlastics	1-LDPE
32	Plastics (60 g)			
33	Adhesive tape (9 g)			

34	Dessicant (2 g)			
35	Electronic, boards, switches, lamp etc (83 g)	83,9810382	6-Electronics	**98-controller board**
36	Glass (5110 g)	5.170	7-Misc.	**54-Glass for lamps**
37	Glue (80 g)			
38	Magnet (46 g)			
39	Others (3 g)			
40	Paint (64 g)	64,7564632	5-Coating	**39-powder coating**
41	Paper (booklets etc) (195 g)	197,304849	7-Misc.	**57-Office paper**
42	Refrigerant (see in Disposal)			
43	Refrigerant HC (see in Disposal)			
44	Rubber (49 g)	49,5791671	1-BlkPlastics	**1-LDPE**
45	Running capacitor (2 g)	2,02363948	6-Electronics	**98-controller board**
46	Thermostat (147 g)	148,737501	6-Electronics	**98-controller board**
47	Wiring (242 g)	244,860376	4-Non-ferro	**29-Cu wire**
48	Lubricating oil (140 g)			
	TOTAL	**44343**		

Pos nr	MANUFACTURING Description	Weight in g	Percentage Adjust	Category index (fixed)
201	**OEM Plastics Manufacturing** (fixed)	14129		20
202	**Foundries Fe/Cu/Zn** (fixed)	8956		34
203	**Foundries Al/Mg** (fixed)	0		35
204	**Sheetmetal Manufacturing** (fixed)	13212		36
205	**PWB Manufacturing** (fixed)	2		53
206	**Other materials** (Manufacturing already included)	8044		
207	**Sheetmetal Scrap** **(Please adjust percentage only)**	396	**3%**	37

Pos nr	DISTRIBUTION (incl. Final Assembly) Description		Answer	Category index (fixed)	
208	**Is it an ICT or Consumer Electronics product <15 kg ?**		NO	59	0
209	**Is it an installed appliance (e.g. boiler)?**		NO	60	1
				62	1
210	**Volume of packaged final product in m^3**	in m3	0,549	63	0

Pos nr	USE PHASE Description		unit	Subtotals
211	**Product Life in years**	**14**	years	
	Electricity			
212	**On-mode: Consumption per hour, cycle, setting, etc.**	160,54	kWh	160,54
213	**On-mode: No. Of hours, cycles, settings, etc. / year**	1	#	
214	**Standby-mode: Consumption per hour**	0	kWh	0
215	**Standby-mode: No. Of hours / year**	0	#	
216	**Off-mode: Consumption per hour**	0	kWh	0
217	**Off-mode: No. Of hours / year**	0	#	
	TOTAL over Product Life	**2,25**	**MWh (=000 kWh)**	65
	Heat			

218	**Avg. Heat Power Output**	0	kW	
219	**No. Of hours / year**	0	hrs.	
220	**Type and efficiency (Click & select)**			**85-not applicable**
	TOTAL over Product Life	**0,00**	**GJ**	
	Consumables (excl, spare parts)			**material**
221	**Water**	0	m^3/year	**83-Water per m3**
222	**Auxilliary material 1 (Click & select)**	0	kg/ year	**85-None**
223	**Auxilliary material 2 (Click & select)**	0	kg/ year	**85-None**
224	**Auxilliary material 3 (Click & select)**	0	kg/ year	**85-None**
	Maintenance, Repairs, Service			
225	**No. of km over Product-Life**	18,93	km / Product Life	**86**
226	**Spare parts** (fixed, 1% of product materials & manuf.)	443	g	

Pos nr	DISPOSAL & RECYCLING Description		unit	Subtotals
	Substances released during Product Life and Landfill			
227	**Refrigerant in the product (Click & select)**	33	g	**9-R290**
228	**Percentage of fugitive & dumped refrigerant**	0%		
229	**Mercury (Hg) in the product**	0	g Hg	
230	**Percentage of fugitive & dumped mercury**	0%		
	Disposal: Environmental Costs perkg final product			
231	**Landfill (fraction products not recovered) in g en %**	2217	5%	**88-fixed**
232	**Incineration (plastics & PWB not re-used/recycled)**	1414	g	**91-fixed**
233	**Plastics: Re-use & Recycling ("cost"-side)**	11939	g	**92-fixed**
	Re-use, Recycling Benefit	**in g**	**% of plastics fraction**	
234	**Plastics: Re-use, Closed Loop Recycling (please edit%)**	0	0%	4
235	**Plastics: Materials Recycling (please edit% only)**	11939	85%	4
236	**Plastics: Thermal Recycling (please edit% only)**	1413	10%	72
237	**Electronics: PWB Easy to Disassemble ? (Click&select)**	1	**YES**	98
238	**Metals & TV Glass & Misc.** (95% Recycling)	28701		fixed

Table A.6: COLD 1 – Refrigerator – OUTPUT from EuP-Ecoreport

Nr	Life cycle Impact per product:	Date	Author
1	COLD 1	39210	CUTAIA-SCIALDONI

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**8075**			808	7268	**8075**	**0**
2	TecPlastics	g			**6054**			605	5448	**6054**	**0**
3	Ferro	g			**21393**			1070	20323	**21393**	**0**
4	Non-ferro	g			**3152**			158	2994	**3152**	**0**
5	Coating	g			**65**			3	62	**65**	**0**
6	Electronics	g			**237**			236	1	**237**	**0**
7	Misc.	g			**5368**			268	5099	**5368**	**0**
	Total weight	g			**44343**			3148	41195	**44343**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	2637	802	**3439**	**797**	**23679**	324	659	**-335**	**27580**
9	of which, electricity (in primary MJ)	MJ	407	482	**889**	**2**	**23608**	0	43	**-43**	**24456**
10	Water (process)	ltr	835	7	**843**	**0**	**1582**	0	29	**-29**	**2396**
11	Water (cooling)	ltr	3138	226	**3364**	**0**	**62965**	0	239	**-239**	**66090**
12	Waste, non-haz./ landfill	g	72030	2568	**74598**	**411**	**28108**	2757	168	**2588**	**105705**
13	Waste, hazardous/ incinerated	g	343	0	**343**	**8**	**547**	1415	27	**1388**	**2286**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	143	45	**187**	**48**	**1035**	24	17	**7**	**1278**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	1371	192	**1563**	**148**	**6096**	60	40	**21**	**7827**
17	Volatile Organic Compounds (VOC)	g	4	0	**5**	**11**	**10**	2	0	**2**	**28**
18	Persistent Organic Pollutants (POP)	ng i-Teq	341	4	**345**	**2**	**158**	19	0	**19**	**524**
19	Heavy Metals	mg Ni eq.	576	10	**586**	**21**	**421**	87	0	**87**	**1114**
	PAHs	mg Ni eq.	955	0	**955**	**27**	**66**	0	2	**-2**	**1045**
20	Particulate Matter (PM, dust)	g	263	30	**293**	**1877**	**300**	679	5	**674**	**3144**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	690	0	**690**	**1**	**159**	21	0	**21**	**871**
22	Eutrophication	g PO4	40	0	**40**	**0**	**1**	1	1	**0**	**42**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Table A.7: COLD 7 – Refrigerator-freezer – INPUT in EuP-Ecoreport

Version 5 VHK for European Commission 28 Nov. 2005 Document subject to a legal notice (see below)

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: INPUTS
Assessment of Environmental Impact

Nr	Product name	Date	Author
1	COLD 7	08/05/2007	CUTAIA-SCIALDONI

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Ferrous metals (15261,85 g)	15400,6	3-Ferro	23-Cast iron
2	Iron (710,8 g)	717,3	3-Ferro	23-Cast iron
3	Mixed steel+plastic (7 g)	7,1	3-Ferro	25-Stainless 18/8 coil
4	Stainless Steel (859,6 g)	867,4	3-Ferro	25-Stainless 18/8 coil
5	Steel (3327,92 g)	3358,2	3-Ferro	25-Stainless 18/8 coil
6	Steel other (1372,6 g)	1385,1	3-Ferro	25-Stainless 18/8 coil
7	Steel strip (9198 g)	9281,6	3-Ferro	21-St sheet galv.
8	Ag (4 g)			
9	Al (1342,85 g)	1355,1	4-Non-ferro	26-Al sheet/extrusion
10	Cu (1892,64 g)	1909,8	4-Non-ferro	29-Cu wire
11	Zn (168,8 g)	170,3	4-Non-ferro	31-CuZn38 cast
12	ABS (840,34 g)	848,0	1-BlkPlastics	10-ABS
13	Elastomers (4 g)	4,0	1-BlkPlastics	1-LDPE
14	EPS (38,2 g)	38,5	1-BlkPlastics	6-EPS
15	PA (19,68 g)	19,9	2-TecPlastics	11-PA 6
16	PC (5,2 g)	5,2	2-TecPlastics	12-PC
17	PE (36,51 g)	36,8	1-BlkPlastics	2-HDPE
18	PE foil (45,42 g)	45,8	1-BlkPlastics	2-HDPE
19	PET (2,53 g)	2,6	1-BlkPlastics	2-HDPE
20	Plastics, others (140,06 g)			
21	POM (4,63 g)	4,7	1-BlkPlastics	2-HDPE
22	PP (1549,35 g)	1563,4	1-BlkPlastics	4-PP
23	PS (8900,26 g)	8981,2	1-BlkPlastics	5-PS
24	PU foam - insulation (6223,47 g)	6280,0	2-TecPlastics	16-Flex PUR
25	PUR (1712,34 g)	1727,9	2-TecPlastics	15-Rigid PUR
26	PVC (excl. wire insul.) (352,14 g)	355,3	1-BlkPlastics	8-PVC
27	TPE (2,53 g)	2,6	1-BlkPlastics	1-LDPE
28	Plastics (81,29 g)			
29	Adhesive tape (14,24 g)			
30	color/paint (8,86 g)	8,9	5-Coating	39-powder coating
31	Glass (6219,32 g)	6275,84371	7-Misc.	54-Glass for lamps
32	Glue (126,56 g)			
33	Paper (271,56 g)	274,033103	7-Misc.	57-Office paper
34	Refrigerant (see in Disposal)			
35	Rubber (202,04 g)	203,879204	1-BlkPlastics	1-LDPE

36	Thermostat (145,7 g)	147,020258	6-Electronics	**98-controller board**
37	Wiring (272,6 g)	275,077712	4-Non-ferro	**29-Cu wire**
38	Electronic, boards, switches, lamp etc (155,09 g)	156,504485	6-Electronics	**98-controller board**
39	Lubricating oil (189,69 g)			
	TOTAL	**61710**		

Pos nr	MANUFACTURING Description	Weight in g	Percentage Adjust	Category index (fixed)
201	**OEM Plastics Manufacturing** (fixed)	20120		20
202	**Foundries Fe/Cu/Zn** (fixed)	16288		34
203	**Foundries Al/Mg** (fixed)	0		35
204	**Sheetmetal Manufacturing** (fixed)	16254		36
205	**PWB Manufacturing** (fixed)	0		53
206	**Other materials** (Manufacturing already included)	9047		
207	**Sheetmetal Scrap** (Please adjust percentage only)	488	**3%**	37

Pos nr	DISTRIBUTION (incl. Final Assembly) Description		Answer	Category index (fixed)	
208	**Is it an ICT or Consumer Electronics product <15 kg ?**		NO	59	0
209	**Is it an installed appliance (e.g. boiler)?**		NO	60	1
				62	1
210	**Volume of packaged final product in m^3**	in m3	0,7835	63	0
				64	1

Pos nr	USE PHASE Description		unit	Subtotals
211	**Product Life in years**	**15**	years	
	Electricity			
212	On-mode: **Consumption per hour, cycle, setting, etc.**	313,151	kWh	313,151
213	On-mode: **No. Of hours, cycles, settings, etc. / year**	1	#	
214	Standby-mode: **Consumption per hour**	0	kWh	0
215	Standby-mode: **No. Of hours / year**	0	#	
216	Off-mode: **Consumption per hour**	0	kWh	0
217	Off-mode: **No. Of hours / year**	0	#	
	TOTAL over Product Life	**4,70**	**MWh (=000 kWh)**	65
	Heat			
218	**Avg. Heat Power Output**	0	kW	
219	**No. Of hours / year**	0	hrs.	
220	**Type and efficiency** (Click & select)			**85-not applicable**
	TOTAL over Product Life	**0,00**	**GJ**	
	Consumables (excl. spare parts)			material
221	**Water**	0	m^3/year	**83-Water per m3**
222	**Auxilliary material 1** (Click & select)	0	kg/ year	**85-None**
223	**Auxilliary material 2** (Click & select)	0	kg/ year	**85-None**
224	**Auxilliary material 3** (Click & select)	0	kg/ year	**85-None**

Pos nr	Description		unit	Subtotals
	Maintenance, Repairs, Service			
225	No. of km over Product-Life	18,93	km / Product Life	86
226	Spare parts (fixed, 1% of product materials & manuf.)	617	g	
Pos nr	**DISPOSAL & RECYCLING** Description		**unit**	**Subtotals**
	Substances released during Product Life and Landfill			
227	Refrigerant in the product (Click & select)	48,71	g	4-R134a
228	Percentage of fugitive & dumped refrigerant	0%		
229	Mercury (Hg) in the product	0	g Hg	
230	Percentage of fugitive & dumped mercury	0%		
	Disposal: Environmental Costs perkg final product			
231	Landfill (fraction products not recovered) in g en %	3085	5%	88-fixed
232	Incineration (plastics & PWB not re-used/recycled)	2414	g	91-fixed
233	Plastics: Re-use & Recycling ("cost"-side)	16599	g	92-fixed
	Re-use, Recycling Benefit	in g	% of plastics fraction	
234	Plastics: Re-use, Closed Loop Recycling (please edit%)	503	3%	4
235	Plastics: Materials Recycling (please edit% only)	16096	80%	4
236	Plastics: Thermal Recycling (please edit% only)	2414	12%	72
237	Electronics: PWB Easy to Disassemble ? (Click&select)	0	YES	98
238	Metals & TV Glass & Misc. (95% Recycling)	39510		fixed

Table A.8: COLD 7 – OUTPUT from EuP-Ecoreport

Nr	Life cycle Impact per product:	Date	Author
1	COLD 7	39210	CUTAIA-SCIALDONI

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**12087**			1450	10636	**12087**	**0**
2	TecPlastics	g			**8033**			964	7069	**8033**	**0**
3	Ferro	g			**31017**			1551	29466	**31017**	**0**
4	Non-ferro	g			**3710**			186	3525	**3710**	**0**
5	Coating	g			**9**			0	8	**9**	**0**
6	Electronics	g			**304**			304	0	**304**	**0**
7	Misc.	g			**6550**			327	6222	**6550**	**0**
	Total weight	g			**61710**			4782	56927	**61710**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	3560	1109	**4669**	**1115**	**49414**	481	940	**-459**	**54738**
9	of which, electricity (in primary MJ)	MJ	543	667	**1209**	**2**	**49333**	0	61	**-61**	**50484**
10	Water (process)	ltr	1288	10	**1298**	**0**	**3301**	0	40	**-40**	**4559**
11	Water (cooling)	ltr	4372	313	**4685**	**0**	**131570**	0	337	**-337**	**135918**
12	Waste, non-haz./ landfill	g	81396	3546	**84942**	**564**	**58035**	3836	237	**3599**	**147140**
13	Waste, hazardous/ incinerated	g	463	0	**463**	**11**	**1141**	2415	37	**2378**	**3994**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	195	62	**257**	**67**	**2158**	35	25	**10**	**2493**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	1768	266	**2034**	**206**	**12724**	88	58	**31**	**14994**
17	Volatile Organic Compounds (VOC)	g	6	0	**6**	**16**	**19**	3	0	**3**	**45**
18	Persistent Organic Pollutants (POP)	ng i-Teq	403	5	**408**	**3**	**327**	26	0	**26**	**765**
19	Heavy Metals	mg Ni eq.	1056	12	**1069**	**29**	**867**	129	0	**129**	**2093**
	PAHs	mg Ni eq.	1414	0	**1414**	**37**	**121**	0	3	**-3**	**1569**
20	Particulate Matter (PM, dust)	g	415	41	**456**	**2679**	**443**	982	6	**976**	**4554**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	988	0	**988**	**1**	**328**	31	0	**31**	**1348**
22	Eutrophication	g PO4	60	1	**61**	**0**	**2**	2	1	**0**	**63**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Table A.9: COLD 8 – Upright freezer – INPUT in EuP-Ecoreport

Version 5 VHK for European Commission 28 Nov. 2005

Document subject to a legal notice (see below)

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: INPUTS
Assessment of Environmental Impact

Nr	Product name	Date	Author
1	COLD 8	08/05/2007	CUTAIA-SCIALDONI

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Ferrous metals (9927,79 g)	10084,51517	3-Ferro	23-Cast iron
2	Iron (437,2 g)	444,1017735	3-Ferro	23-Cast iron
3	Mixed steel+plastic (603 g)	612,5191432	3-Ferro	25-Stainless 18/8 coil
4	Stainless Steel (42,8 g)	43,47565395	3-Ferro	25-Stainless 18/8 coil
5	Steel (2879,6 g)	2925,05825	3-Ferro	25-Stainless 18/8 coil
6	Steel strip (9728,6 g)	9882,178668	3-Ferro	21-St sheet galv.
7	Steel tube & wire (1347 g)	1368,264156	3-Ferro	22-St tube/profile
8	Ag (4 g)			
9	Al (694,28 g)	705,2360542	4-Non-ferro	26-Al sheet/extrusion
10	AL tube (16 g)	16,25258091	4-Non-ferro	26-Al sheet/extrusion
11	Cu (1570 g)	1594,783486	4-Non-ferro	29-Cu wire
12	Cu tube (45,6 g)	46,31985561	4-Non-ferro	30-Cu tube/sheet
13	solder & braze (2,2 g)	2,234729876	4-Non-ferro	31-CuZn38 cast
14	Accumulator (272 g)			
15	Handle (65 g)			
16	ABS (999,4 g)	1015,176835	1-BlkPlastics	10-ABS
17	Elastomers (8 g)	8,126290457	1-BlkPlastics	1-LDPE
18	EPS - Insulation (2,4 g)	2,437887137	1-BlkPlastics	6-EPS
19	PA (55,2 g)	56,07140415	2-TecPlastics	11-PA 6
20	PE (580 g)	589,1560581	1-BlkPlastics	2-HDPE
21	Plastics, others (116,2 g)			
22	POM (20,6 g)	20,92519793	1-BlkPlastics	2-HDPE
23	PP (1865,2 g)	1894,64462	1-BlkPlastics	4-PP
24	PPO (7,2 g)	7,313661411	1-BlkPlastics	4-PP
25	PS (10322,4 g)	10485,35258	1-BlkPlastics	5-PS
26	PU Foam - Insulation (6523,8 g)	6626,786711	2-TecPlastics	16-Flex PUR
27	PUR (1985,8 g)	2017,148449	2-TecPlastics	15-Rigid PUR
28	PVC (excl. wire insul.) (529 g)	537,4	1-BlkPlastics	8-PVC
29	SAN (1232,2 g)	1251,7	1-BlkPlastics	9-SAN
30	TPE (6,2 g)	6,3	1-BlkPlastics	1-LDPE
31	Plastics (72,7 g)			
32	Adhesive tape (0,4 g)			
33	Butyl rubber (19 g)	19,3	1-BlkPlastics	1-LDPE
34	Capacitor (10,6 g)	10,7673349	6-Electronics	44-big caps & coils
35	Dessicant (2 g)			

36	Electronic, boards, switches, lamp etc (240,2 g)	243,991871	6-Electronics	**98-controller board**
37	Glue (5 g)			
38	Magnet (45,6 g)			
39	Others (0,6 g)			
40	Paint (141,6 g)	143,835341	5-Coating	**39-powder coating**
41				
42	Paper (booklets etc) (182,4 g)	185,279422	7-Misc.	**57-Office paper**
43	PCB (8,8 g)			
44	Refrigerant (see in Disposal) (53 g)			
45	Refrigerant HC (see in Disposal) (12,4 g)			
46	Rubber (26,6 g)	27,0199158	1-BlkPlastics	**1-LDPE**
47	Thermostat (88,4 g)	89,7955096	6-Electronics	**98-controller board**
48	Wiring (268 g)	272,23073	4-Non-ferro	**29-Cu wire**
49	Lubricating oil (169,63 g)			
	TOTAL	**53236**		

Pos nr	MANUFACTURING Description	Weight in g	Percentage Adjust	Category index (fixed)	
201	**OEM Plastics Manufacturing** (fixed)	24565		20	
202	**Foundries Fe/Cu/Zn** (fixed)	10531		34	
203	**Foundries Al/Mg** (fixed)	0		35	
204	**Sheetmetal Manufacturing** (fixed)	14231		36	
205	**PWB Manufacturing** (fixed)	11		53	
206	**Other materials** (Manufacturing already included)	3898			
207	**Sheetmetal Scrap** (Please adjust percentage only)	427	**3%**	37	
Pos nr	**DISTRIBUTION (incl. Final Assembly) Description**		**Answer**	**Category index (fixed)**	
208	**Is it an ICT or Consumer Electronics product <15 kg ?**		NO	59	0
209	**Is it an installed appliance (e.g. boiler)?**		NO	60	1
				62	1
210	**Volume of packaged final product in m^3**	in m3	0,5216	63	0
				64	1
Pos nr	**USE PHASE Description**		**unit**	**Subtotals**	
211	**Product Life in years**	**14**	years		
	Electricity				
212	On-mode: **Consumption per hour, cycle, setting, etc.**	254,4284	kWh	254,4284	
213	On-mode: **No. Of hours, cycles, settings, etc. / year**	1	#		
214	Standby-mode: **Consumption per hour**	0	kWh	0	
215	Standby-mode: **No. Of hours / year**	0	#		
216	Off-mode: **Consumption per hour**	0	kWh	0	
217	Off-mode: **No. Of hours / year**	0	#		
	TOTAL over Product Life	**3,56**	**MWh (=000 kWh)**	65	

Pos nr	Description		unit	Subtotals
	Heat			
218	Avg. Heat Power Output	0	kW	
219	No. Of hours / year	0	hrs.	
220	Type and efficiency (Click & select)			85-not applicable
	TOTAL over Product Life	0,00	GJ	
	Consumables (excl. spare parts)			material
221	Water	0	m^3/year	83-Water per m3
222	Auxilliary material 1 (Click & select)	0	kg/ year	85-None
223	Auxilliary material 2 (Click & select)	0	kg/ year	85-None
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None
	Maintenance, Repairs, Service			
225	No. of km over Product-Life	2,75	km / Product Life	86
226	Spare parts (fixed, 1% of product materials & manuf.)	532	g	

Pos nr	DISPOSAL & RECYCLING Description		unit	Subtotals
	Substances released during Product Life and Landfill			
227	Refrigerant in the product (Click & select)	65,4	g	4-R134a
228	Percentage of fugitive & dumped refrigerant	0%		
229	Mercury (Hg) in the product	0	g Hg	
230	Percentage of fugitive & dumped mercury	0%		
	Disposal: Environmental Costs perkg final product			
231	Landfill (fraction products not recovered) in g en %	3726	7%	88-fixed
232	Incineration (plastics & PWB not re-used/recycled)	3199	g	91-fixed
233	Plastics: Re-use & Recycling ("cost"-side)	19652	g	92-fixed
	Re-use, Recycling Benefit	in g	% of plastics fraction	
234	Plastics: Re-use, Closed Loop Recycling (please edit%)	2211	9%	4
235	Plastics: Materials Recycling (please edit% only)	17441	71%	4
236	Plastics: Thermal Recycling (please edit% only)	3193	13%	72
237	Electronics: PWB Easy to Disassemble ? (Click&select)	5	YES	98
238	Metals & TV Glass & Misc. (95% Recycling)	27227		fixed

Table A.10: COLD 8 – OUTPUT from EuP-Ecoreport

Nr	Life cycle Impact per product:	Date	Author
1	COLD 8	39210	CUTAIA-SCIALDONI

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**15865**			2062	13802	**15865**	**0**
2	TecPlastics	g			**8700**			1131	7569	**8700**	**0**
3	Ferro	g			**25360**			1775	23585	**25360**	**0**
4	Non-ferro	g			**2637**			185	2452	**2637**	**0**
5	Coating	g			**144**			10	134	**144**	**0**
6	Electronics	g			**345**			339	5	**345**	**0**
7	Misc.	g			**185**			13	172	**185**	**0**
	Total weight	g			**53236**			5515	47720	**53236**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	3617	1248	**4865**	**759**	**37456**	598	1137	**-539**	**42542**
9	of which, electricity (in primary MJ)	MJ	505	750	**1255**	**1**	**37414**	0	76	**-76**	**38594**
10	Water (process)	ltr	1148	11	**1160**	**0**	**2505**	0	50	**-50**	**3614**
11	Water (cooling)	ltr	5113	353	**5466**	**0**	**99791**	0	415	**-415**	**104841**
12	Waste, non-haz./ landfill	g	71214	3969	**75184**	**393**	**44116**	4632	294	**4338**	**124031**
13	Waste, hazardous/ incinerated	g	514	0	**514**	**8**	**867**	3200	47	**3153**	**4542**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	184	69	**253**	**46**	**1635**	44	31	**12**	**1947**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	1584	299	**1883**	**141**	**9650**	109	72	**36**	**11711**
17	Volatile Organic Compounds (VOC)	g	6	0	**6**	**11**	**14**	4	0	**4**	**35**
18	Persistent Organic Pollutants (POP)	ng i-Teq	377	5	**382**	**2**	**249**	32	0	**32**	**665**
19	Heavy Metals	mg Ni eq.	722	11	**733**	**20**	**650**	161	0	**161**	**1564**
	PAHs	mg Ni eq.	1548	0	**1549**	**26**	**91**	0	4	**-4**	**1661**
20	Particulate Matter (PM, dust)	g	326	46	**372**	**1784**	**234**	1198	8	**1190**	**3580**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	786	0	**786**	**1**	**249**	39	0	**39**	**1075**
22	Eutrophication	g PO4	60	1	**61**	**0**	**2**	2	2	**1**	**63**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Table A.11: COLD 9 – Chest freezer – INPUT in EuP-Ecoreport

Version 5 VHK for European Commission 28 Nov. 2005 — Document subject to a legal notice (see below)

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: INPUTS
Assessment of Environmental Impact

Nr	Product name	Date	Author
1	**COLD 9**	**08/05/2007**	**CUTAIA-SCIALDONI**

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Iron (6537,67 g)	6829,7	3-Ferro	23-Cast iron
2	Mixed steel+plastic (162,67 g)	169,9	3-Ferro	25-Stainless 18/8 coil
3	Steel other (1779,67 g)	1859,2	3-Ferro	25-Stainless 18/8 coil
4	Steel strip (9054,67 g)	9459,1	3-Ferro	21-St sheet galv.
5	Ferrous metals (8554 g)	8936,1	3-Ferro	23-Cast iron
6	Al (3216,33 g)	3360,0	4-Non-ferro	26-Al sheet/extrusion
7	Cu (1189,25 g)	1242,4	4-Non-ferro	29-Cu wire
8	ABS (197,33 g)	206,1	1-BlkPlastics	10-ABS
9	PA (41 g)	42,8	2-TecPlastics	11-PA 6
10	PE (51 g)	53,3	1-BlkPlastics	2-HDPE
11	Plastics, others (94 g)			
12	PP (845,6 g)	883,4	1-BlkPlastics	4-PP
13	PS (2211,67 g)	2310,5	1-BlkPlastics	5-PS
14	PU Foam - Insulation (5821 g)	6081,0	2-TecPlastics	16-Flex PUR
15	PUR (2188 g)	2285,7	2-TecPlastics	15-Rigid PUR
16	PVC (2026,67 g)	2117,2	1-BlkPlastics	8-PVC
17	PVC (excl. wire insul.) (327 g)	341,6	1-BlkPlastics	8-PVC
18	Plastics (106,93 g)			
19	Electronic, boards, switches, lamp etc (25,47 g)	26,6	6-Electronics	98-controller board
20	Others (842,67 g)			
21	Paper (booklets etc) (114,67 g)	119,8	7-Misc.	57-Office paper
22	Refrigerant (see in Disposal)			
23	Rubber (9,33 g)	9,8	1-BlkPlastics	1-LDPE
24	Thermopaste (paste) (707 g)			
25	Thermostat (128,67 g)	134,4	6-Electronics	98-controller board
26	Wiring (295 g)	308,2	4-Non-ferro	29-Cu wire
27	Lubricating oil (249,49 g)			
	TOTAL	**46777**		

Pos nr	MANUFACTURING Description	Weight in g	Percentage Adjust	Category index (fixed)
201	**OEM Plastics Manufacturing** (fixed)	14331		20
202	**Foundries Fe/Cu/Zn** (fixed)	15766		34
203	**Foundries Al/Mg** (fixed)	0		35
204	**Sheetmetal Manufacturing** (fixed)	14848		36

Pos nr	Description			
205	**PWB Manufacturing** (fixed)	0		53
206	**Other materials** (Manufacturing already included)	1831		
207	**Sheetmetal Scrap** (Please adjust percentage only)	445	**3%**	37

Pos nr	DISTRIBUTION (incl. Final Assembly) Description		Answer	Category index (fixed)	
208	Is it an ICT or Consumer Electronics product <15 kg ?		NO	59	0
209	Is it an installed appliance (e.g. boiler)?		NO	60	1
				62	1
210	Volume of packaged final product in m^3	in m3	0,756333333	63	0
				64	1

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	**15**	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	321,1	kWh	321,1
213	On-mode: No. Of hours, cycles, settings, etc. / year	1	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	**4,82**	**MWh (=000 kWh)**	65
	Heat			
218	Avg. Heat Power Output	0	kW	
219	No. Of hours / year	0	hrs.	
220	Type and efficiency (Click & select)			85-not applicable
	TOTAL over Product Life	**0,00**	**GJ**	
	Consumables (excl. spare parts)			material
221	Water	0	m^3/year	83-Water per m3
222	Auxilliary material 1 (Click & select)	0	kg/ year	85-None
223	Auxilliary material 2 (Click & select)	0	kg/ year	85-None
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None
	Maintenance, Repairs, Service			
225	No. of km over Product-Life		km / Product Life	86
226	Spare parts (fixed, 1% of product materials & manuf.)	468	g	

Pos nr	DISPOSAL & RECYCLING Description		unit	Subtotals
	Substances released during Product Life and Landfill			
227	Refrigerant in the product (Click & select)	82,7	g	4-R134a
228	Percentage of fugitive & dumped refrigerant	0%		
229	Mercury (Hg) in the product	0	g Hg	
230	Percentage of fugitive & dumped mercury	0%		

	Disposal: Environmental Costs perkg final product			
231	Landfill (fraction products not recovered) in g en %	2339	5%	88-fixed
232	Incineration (plastics & PWB not re-used/recycled)	1720	g	91-fixed
233	Plastics: Re-use & Recycling ("cost"-side)	11895	g	92-fixed
	Re-use, Recycling Benefit	in g	% of plastics fraction	
234	Plastics: Re-use, Closed Loop Recycling (please edit%)	0	0%	4
235	Plastics: Materials Recycling (please edit% only)	11895	83%	4
236	Plastics: Thermal Recycling (please edit% only)	1720	12%	72
237	Electronics: PWB Easy to Disassemble ? (Click&select)	0	YES	98
238	Metals & TV Glass & Misc. (95% Recycling)	30823		fixed

Table A.12: COLD 9 – Refrigerator – OUTPUT from EuP-Ecoreport

Nr	Life cycle Impact per product:	Date	Author
1	COLD 9	39210	CUTAIA-SCIALDONI

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	g			**5922**			711	5211	**5922**	**0**
2	TecPlastics	g			**8410**			1009	7400	**8410**	**0**
3	Ferro	g			**27254**			1363	25891	**27254**	**0**
4	Non-ferro	g			**4911**			246	4665	**4911**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**161**			161	0	**161**	**0**
7	Misc.	g			**120**			6	114	**120**	**0**
	Total weight	g			**46777**			3495	43282	**46777**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	2871	850	**3721**	**1078**	**50610**	353	661	**-308**	**55101**
9	of which, electricity (in primary MJ)	MJ	336	511	**847**	**2**	**50582**	0	43	**-43**	**51388**
10	Water (process)	ltr	876	8	**883**	**0**	**3380**	0	29	**-29**	**4235**
11	Water (cooling)	ltr	3234	240	**3474**	**0**	**134897**	0	238	**-238**	**138133**
12	Waste, non-haz./ landfill	g	72347	2727	**75074**	**546**	**59388**	2906	167	**2738**	**137746**
13	Waste, hazardous/ incinerated	g	368	0	**368**	**11**	**1169**	1721	26	**1694**	**3242**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	160	47	**207**	**65**	**2209**	26	17	**9**	**2491**
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	1339	204	**1542**	**199**	**13038**	64	40	**25**	**14804**
17	Volatile Organic Compounds (VOC)	g	5	0	**5**	**16**	**19**	2	0	**2**	**42**
18	Persistent Organic Pollutants (POP)	ng i-Teq	380	5	**385**	**3**	**335**	20	0	**20**	**743**
19	Heavy Metals	mg Ni eq.	475	11	**486**	**28**	**873**	95	0	**95**	**1482**
	PAHs	mg Ni eq.	792	0	**792**	**36**	**108**	0	2	**-2**	**934**
20	Particulate Matter (PM, dust)	g	406	31	**438**	**2586**	**283**	714	5	**710**	**4016**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	669	0	**669**	**1**	**333**	23	0	**23**	**1026**
22	Eutrophication	g PO4	51	0	**51**	**0**	**2**	1	1	**0**	**53**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Appendix C: SimaPro data

A.1 THE SIMAPRO V.7.1 SOFTWARE

Even if it is not in the scope of this study to perform a LCA in full accordance with ISO 14040, the methodology was applied as close as possible. To this end a specialized LCA software tool was used, the SimaPro 7.1, the last version of the software edit by Prè, NL (http://www.pre.nl/simapro/default.htm).

This software allows one to perform an ecological balance of a product along all its life, taking into account for each material used, raw material extraction, energy and water consumption (with distinction between renewable and non renewable resources) , and related impacts in air, water, and soil.

Again it is possible to use specific models for energy production, waste treatment, transport and ancillary materials production. It is also possible to use and compare different environmental impact assessment methodologies (Ecoindicator, CML, EPS, Ecopoint…) performing sensitivity analysis. Again in this software many databases are included in a form to be used for a same ecobalance (avoiding double sum of an impact or loss of data).

Using SimaPro it is possible to simulate the LCA of objects or services according to the ISO14040 standards.

A.2 INPUT DATA IN SIMAPRO

Table A.13: COLD 7 average model – INPUT data in SimaPro SW - ASSEMBLING

SimaPro 7.1	***Phase product***		
Project	EupProject		
Nome			
COLD7 assembling	as average on data from producers		
Materials/assembly			Note
Crude iron I	16024,94	g	ferrous metals
Crude iron I	746,34	g	iron
Steel I	7,35	g	steel + plastic
X5CrNi18 (304) I	902,58	g	Stainless Steel
Steel I	3494	g	steel
Steel I	1441,23	g	Steel other
Steel I	9657,9	g	Steel strip
Aluminium rec. I	1356,27	g	
Copper I	1911,57	g	
Zinc I	170,49	g	
Cardboard duplex/tripl	2699,94	g	for packaging
PS (EPS) B250 (1998)	1250,89	g	for packaging
PE (LDPE) I	259,52	g	for packaging (PE foil) + laminating
PP granulate average B250	35,26	g	
Poplar I	10,1	g	wood
ABS I	858,26	g	
EPDM rubber ETH U	4,1	g	

SimaPro 7.1	*Phase product*		
PS (EPS) B250 (1998)	39	g	
PA 6 I	20,1	g	
PC I	5,31	g	
PE (HDPE) I	37,29	g	as PE
PE (HDPE) I	46,39	g	as PE foil + laminating
PET amorph I	2,6	g	
HDPE B250	4,73	g	as POM
PP I	1582,4	g	
PS (EPS) B250 (1998)	9090,09	g	
PUR semi rigid foam I	6356,2	g	PU foam - insulation
PUR semi rigid foam I	1748,86	g	
PVC B250	359,65	g	
adhesive - glue	14,38	g	as adhesive
Paint ETH S	8,95	g	white painting powder (53 g)
Glass (white) B250	6281,51	g	
adhesive - glue	127,83	g	
Kraft paper, bleached, at plant/RER U	274,28	g	
Refrigerant R134a, at plant/RER U	49,2	g	
EPDM rubber ETH U	204,06	g	
Electronics for control units/RER U	147,15	g	AS THERMOSTAT (10 g)
Copper I	275,33	g	AS WIRe + wiring
Electronics for control units/RER U	156,65	g	electronics
Lubricating oil, at plant/RER U	191,58	g	
Water demineralized ETH U	228	kg	consumption in assembling phase
Lubricating oil, at plant/RER U	27	g	
Nitrogen, liquid, at plant/RER U	84	g	
Argon, liquid, at plant/RER U	5	g	
Oxygen, liquid, at plant/RER U	27	g	cotton+resins noise adsorbers
Processes			
Electricity MV use in UCPTE U	25,34	kWh	during assembling
Heat gas B250	15,69	MJ	
Truck 28t B250	68	tkm	transport for assembling
Sea ship B250	29	tkm	transport for assembling
Hot rolling, steel/RER U	2923	g	
Sheet rolling, steel/RER U	4829	g	
Extruding alum I	678	g	
Wire drawing, copper/RER U	1092	g	
Foaming, expanding/RER U	12940	g	
Injection moulding/RER U	2001	g	
Extrusion PVC I	251	g	

Table A.14: COLD 7 average model – INPUT data in SimaPro SW – SPARE PARTS

SimaPro 7.1	***Phase product***	
Project	EupProject	
Assembly:		
Nome		
COLD7 use materials (per LC)		
Materials/assembly		
COLD7 assembling	0,45	p

Table A.15: COLD 7 average model – INPUT data in SimaPro SW – LIFE CYCLE

SimaPro 7.1	***Phase product***	
Project	EupProject	
Life Cycle:		
Nome		
cold 7		
Assembly		
COLD7 assembling	1	p
Processes		
Electricity LV use UCPTE U	4697	kWh
Delivery van (<3.5t) B250	0,94	tkm
Scenario waste disposal/end of life		
cold 7 EoL		
Supplementary Life Cycle		
cold 7 use materials (per LC)	1	

Table A.16: COLD 7 average model – INPUT data in SimaPro SW – END OF LIFE

SimaPro 7.1	***Phase product***
Project	EupProject
Scenario di fine vita:	
Nome	
cold 7 EoL	

SimaPro 7.1	***Phase product***
Referred to assembly	
COLD7 assembling	1
Processes	
Scenario of waste treatment	
Recycling only B250 avoided	81
Incineration 2000 B250 (98) avoided	13
Landfill B250 (98)	6

A.3 ECO-INDICATOR 95 - REV EUP V2.03

SimaPro 7.1	***Method***	***Data:***	***08/08/2007***	***Period:***	***16.11.31***
Project	EupProject				

Nome Eco-indicator 95 - rev EuP V2.03

Comment Revised by Laura Cutaia (29.07.07) to convert output in form of the software EuP Ecoreport

The Eco-indicator 95 method was developed under the Dutch NOH programme by PRé consultants in a joint project with Philips Consumer Electronics, NedCar, Océ Copiers, Schuurink, CML Leiden, TU-Delft, IVAM-ER (Amsterdam) and CE Delft.

This V2 version is adapted for SimaPro 6.0. All characterisation factors in this method are entered for the 'unspecified' sub-compartment of each compartment (Raw materials, air, water, soil) and thus applicable on all sub-compartments.

Other adaptations (V2.1):

- Solid waste expanded with all mass waste flows in SimaPro 6 database
- Energy expanded with energy resources in SimaPro 6 database
- Pesticides to water expanded with pesticides to water in SimaPro 6 database
- Carbon dioxide, biogenic and uptake from carbon dioxide from air (Carbon dioxide, in air) are added to the methodology. Similar for 'Carbon monoxide, fossil' and 'Carbon monoxide, biogenic'.

Other adaptations (August 2004):

- Energy expanded with energy resources in SimaPro not adapted in V2.1 (values taken from Cumulative energy demand V1.2 method)
- Greenhouse, Summer smog: Methane, biogenic and Methane, fossil added
- Euthrophication: phosphorus compounds completed.
- Acidification, Euthrophication: nitrogen compounds completed.
- Acidification: sulphur compounds completed.
- "Particulates, > 2.5 um, and < 10um" added with the assumption that the characterization factor is the same as for "Particulates, < 10 um"

Other adaptations (March 2005):

- Eutrophication: Dinitrogen monoxide removed. Nitrogen, to water added (equal to nitrogen, total, to water).
- Solid waste: Waste, from drilling, unspecified added.

Other adaptations (August 2005, v2.03):

- In impact category Energy resources the characterisation value for "Gas, natural in ground" has been changed from 40,3 to 38.3 MJ LHV/m3 following the ecoinvent 1.2 update.

This method is NOT fully adapted for inventory data from the ecoinvent library and the USA Input Output Database 98, and therefore omits emissions that could have been included in impact assessment.

The characterisation conforms to the CML guide used in the SimaPro2 method; however the toxicity scores are specified into heavy metals, carcinogenic substances, pesticides and winter smog.

Normalisation is based on 1990 levels for Europe excl. former USSR. In Europe g missing data was extrapolated using GNP's (Gross national product). In Europe e missing data was extrapolated using energy use. The Europe e normalisation is used in the Eco-indicator method.

Weighting is based on distance to target. Criteria for target levels are:

- One excess death per million per year
- 5% ecosystem degradation.
- Avoidance of smog periods

Due to continual adjustments of the method and/or inventory data sets the Eco-indicator 95 in SimaPro will not give the same result as the original printed version.

See database manual for further information. More information and the "Manual for Designers" can also be downloaded from http://www.pre.nl

Use Damage Assessment	No
Use Normalization	Yes
Use Weighting	Yes
Use Addition	Yes
Weighting unit	Pt

Categories of Impact	greenhouse	kg CO2			
Air	(unspecified)	Carbon dioxide	000124-38-9	1	kg CO2 / kg
Air	(unspecified)	Carbon dioxide, biogenic	000124-38-9	1	kg CO2 / kg
Air	(unspecified)	Carbon dioxide, fossil	000124-38-9	1	kg CO2 / kg
Prima	(unspecified)	Carbon dioxide, in air	000124-38-9	-1	kg CO2 / kg
Air	(unspecified)	Carbon monoxide	000630-08-0	1,57	kg CO2 / kg
Air	(unspecified)	Carbon monoxide, biogenic	000630-08-0	1,57	kg CO2 / kg
Air	(unspecified)	Carbon monoxide, fossil	000630-08-0	1,57	kg CO2 / kg
Air	(unspecified)	Chlorinated fluorocarbons, hard		7100	kg CO2 / kg
Air	(unspecified)	Chlorinated fluorocarbons, soft		1600	kg CO2 / kg
Air	(unspecified)	Chloroform	000067-66-3	25	kg CO2 / kg
Air	(unspecified)	Dinitrogen monoxide	010024-97-2	296	kg CO2 / kg
Air	(unspecified)	Ethane, 1-chloro-1,1-difluoro-, HCFC-142	000075-68-3	1800	kg CO2 / kg
Air	(unspecified)	Ethane, 1,1-dichloro-1-fluoro-, HCFC-141b	001717-00-6	580	kg CO2 / kg
Air	(unspecified)	Ethane, 1,1-difluoro-, HFC-152a	000075-37-6	150	kg CO2 / kg
Air	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	000071-55-6	100	kg CO2 / kg
Air	(unspecified)	Ethane, 1,1,1-trifluoro-, HCFC-143a	000420-46-2	3800	kg CO2 / kg
Air	(unspecified)	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	000811-97-2	1300	kg CO2 / kg
Air	(unspecified)	Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	000076-13-1	4500	kg CO2 / kg
Air	(unspecified)	Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	000076-14-2	7000	kg CO2 / kg
Air	(unspecified)	Ethane, 2-chloro-1,1,1,2-tetrafluoro-, HCFC-124	002837-89-0	440	kg CO2 / kg

SimaPro 7.1	Method	Data:	08/08/2007	Period:	16.11.31
Air	(unspecified)	Ethane, 2,2-dichloro-1,1,1-trifluoro-, HCFC-123	000306-83-2	90	kg CO2 / kg
Air	(unspecified)	Ethane, chloropentafluoro-, CFC-115	000076-15-3	7000	kg CO2 / kg
Air	(unspecified)	Ethane, hexafluoro-, HFC-116	000076-16-4	9200	kg CO2 / kg
Air	(unspecified)	Ethane, pentafluoro-, HFC-125	000354-33-6	3400	kg CO2 / kg
Air	(unspecified)	Methane	000074-82-8	21	kg CO2 / kg
Air	(unspecified)	Methane, biogenic	000074-82-8	21	kg CO2 / kg
Air	(unspecified)	Methane, bromochlorodifluoro-, Halon 1211	000353-59-3	4900	kg CO2 / kg
Air	(unspecified)	Methane, bromotrifluoro-, Halon 1301	000075-63-8	4900	kg CO2 / kg
Air	(unspecified)	Methane, chlorodifluoro-, HCFC-22	000075-45-6	1600	kg CO2 / kg
Air	(unspecified)	Methane, chlorotrifluoro-, CFC-13	000075-72-9	13000	kg CO2 / kg
Air	(unspecified)	Methane, dichloro-, HCC-30	000075-09-2	15	kg CO2 / kg
Air	(unspecified)	Methane, dichlorodifluoro-, CFC-12	000075-71-8	7100	kg CO2 / kg
Air	(unspecified)	Methane, fossil	000074-82-8	11	kg CO2 / kg
Air	(unspecified)	Methane, tetrachloro-, CFC-10	000056-23-5	1300	kg CO2 / kg
Air	(unspecified)	Methane, tetrafluoro-, FC-14	000075-73-0	6500	kg CO2 / kg
Air	(unspecified)	Methane, trichlorofluoro-, CFC-11	000075-69-4	3400	kg CO2 / kg
Impact Category	ozone layer	kg CFC11			
Air	(unspecified)	Chlorinated fluorocarbons, hard		1	kg CFC11 / kg
Air	(unspecified)	Chlorinated fluorocarbons, soft		0,055	kg CFC11 / kg
Air	(unspecified)	Ethane, 1-chloro-1,1-difluoro-, HCFC-142	000075-68-3	0,065	kg CFC11 / kg
Air	(unspecified)	Ethane, 1,1-dichloro-1-fluoro-, HCFC-141b	001717-00-6	0,11	kg CFC11 / kg
Air	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	000071-55-6	0,12	kg CFC11 / kg
Air	(unspecified)	Ethane, 1,1,1-trifluoro-2,2-chlorobromo-, Halon 2311	000151-67-7	0,14	kg CFC11 / kg
Air	(unspecified)	Ethane, 1,1,1,2-tetrafluoro-2-bromo-, Halon 2401	000124-72-1	0,25	kg CFC11 / kg
Air	(unspecified)	Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	000076-13-1	1,07	kg CFC11 / kg
Air	(unspecified)	Ethane, 1,2-dibromotetrafluoro-, Halon 2402	000124-73-2	7	kg CFC11 / kg
Air	(unspecified)	Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	000076-14-2	0,8	kg CFC11 / kg
Air	(unspecified)	Ethane, 2-chloro-1,1,1,2-tetrafluoro-, HCFC-124	002837-89-0	0,022	kg CFC11 / kg
Air	(unspecified)	Ethane, 2,2-dichloro-1,1,1-trifluoro-, HCFC-123	000306-83-2	0,02	kg CFC11 / kg
Air	(unspecified)	Ethane, chloropentafluoro-, CFC-115	000076-15-3	0,5	kg CFC11 / kg
Air	(unspecified)	Methane, bromo-, Halon 1001	000074-83-9	0,6	kg CFC11 / kg
Air	(unspecified)	Methane, bromochlorodifluoro-, Halon 1211	000353-59-3	4	kg CFC11 / kg
Air	(unspecified)	Methane, bromodifluoro-, Halon 1201	001511-62-2	1,4	kg CFC11 / kg
Air	(unspecified)	Methane, bromotrifluoro-, Halon 1301	000075-63-8	16	kg CFC11 / kg
Air	(unspecified)	Methane, chlorodifluoro-, HCFC-22	000075-45-6	0,055	kg CFC11 / kg
Air	(unspecified)	Methane, chlorotrifluoro-, CFC-13	000075-72-9	1	kg CFC11 / kg
Air	(unspecified)	Methane, dibromodifluoro-, Halon 1202	000075-61-6	1,25	kg CFC11 / kg
Air	(unspecified)	Methane, dichlorodifluoro-, CFC-12	000075-	1	kg CFC11 / kg

			71-8		
Air	(unspecified)	Methane, tetrachloro-, CFC-10	000056-23-5	1,08	kg CFC11 / kg
Air	(unspecified)	Methane, trichlorofluoro-, CFC-11	000075-69-4	1	kg CFC11 / kg
Air	(unspecified)	Propane, 1,3-dichloro-1,1,2,2,3-pentafluoro-, HCFC-225cb	000507-55-1	0,033	kg CFC11 / kg
Air	(unspecified)	Propane, 3,3-dichloro-1,1,1,2,2-pentafluoro-, HCFC-225ca	000422-56-0	0,025	kg CFC11 / kg
Impact Category	acidification	kg SO2			
Air	(unspecified)	Ammonia	007664-41-7	1,88	kg SO2 / kg
Air	(unspecified)	Ammonium carbonate	000506-87-6	0,67	kg SO2 / kg
Air	(unspecified)	Ammonium nitrate	006484-52-2	0,4	kg SO2 / kg
Air	(unspecified)	Ammonium, ion	014798-03-9	1,78	kg SO2 / kg
Air	(unspecified)	Dinitrogen monoxide	010024-97-2	1,78	kg SO2 / kg
Air	(unspecified)	Hydrogen chloride	007647-01-0	0,88	kg SO2 / kg
Air	(unspecified)	Hydrogen fluoride	007664-39-3	1,6	kg SO2 / kg
Air	(unspecified)	Hydrogen sulphide	007783-06-4	1,88	kg SO2 / kg
Air	(unspecified)	Nitric acid	007697-37-2	0,51	kg SO2 / kg
Air	(unspecified)	Nitric oxide	010102-43-9	1,07	kg SO2 / kg
Air	(unspecified)	Nitrogen dioxide	010102-44-0	0,7	kg SO2 / kg
Air	(unspecified)	Nitrogen oxides	011104-93-1	0,7	kg SO2 / kg
Air	(unspecified)	Sulphur dioxide	007446-09-5	1	kg SO2 / kg
Air	(unspecified)	Sulphur oxides		1	kg SO2 / kg
Air	(unspecified)	Sulphur trioxide	007446-11-9	0,8	kg SO2 / kg
Air	(unspecified)	Sulphuric acid	007664-93-9	0,65	kg SO2 / kg
Impact Category	eutrophication	kg PO4			
Land	(unspecified)	Ammonia	007664-41-7	0,33	kg PO4 / kg
Water	(unspecified)	Ammonia	007664-41-7	0,33	kg PO4 / kg
Air	(unspecified)	Ammonia	007664-41-7	0,33	kg PO4 / kg
Air	(unspecified)	Ammonium carbonate	000506-87-6	0,12	kg PO4 / kg
Land	(unspecified)	Ammonium nitrate	006484-52-2	0,074	kg PO4 / kg
Air	(unspecified)	Ammonium nitrate	006484-52-2	0,074	kg PO4 / kg
Water	(unspecified)	Ammonium, ion	014798-03-9	0,33	kg PO4 / kg
Land	(unspecified)	Ammonium, ion	014798-03-9	0,33	kg PO4 / kg
Air	(unspecified)	Ammonium, ion	014798-03-9	0,33	kg PO4 / kg
Water	(unspecified)	BOD5, Biological Oxygen Demand		0,11	kg PO4 / kg
Water	(unspecified)	COD, Chemical Oxygen Demand		0,05	kg PO4 / kg
Water	(unspecified)	DOC, Dissolved Organic Carbon		0,066	kg PO4 / kg
Water	(unspecified)	Kjeldahl-N		0,42	kg PO4 / kg
Air	(unspecified)	Nitrate	014797-55-8	0,1	kg PO4 / kg
Land	(unspecified)	Nitrate	014797-55-8	0,1	kg PO4 / kg

Water	(unspecified)	Nitrate	014797-55-8	0,1	kg PO4 / kg
Land	(unspecified)	Nitric acid	007697-37-2	0,093	kg PO4 / kg
Water	(unspecified)	Nitric acid	007697-37-2	0,093	kg PO4 / kg
Air	(unspecified)	Nitric acid	007697-37-2	0,093	kg PO4 / kg
Air	(unspecified)	Nitric oxide	010102-43-9	0,2	kg PO4 / kg
Water	(unspecified)	Nitrite	014797-65-0	0,13	kg PO4 / kg
Air	(unspecified)	Nitrite	014797-65-0	0,13	kg PO4 / kg
Water	(unspecified)	Nitrogen	007727-37-9	0,42	kg PO4 / kg
Air	(unspecified)	Nitrogen dioxide	010102-44-0	0,13	kg PO4 / kg
Air	(unspecified)	Nitrogen oxides	011104-93-1	0,13	kg PO4 / kg
Land	(unspecified)	Nitrogen oxides	011104-93-1	0,13	kg PO4 / kg
Water	(unspecified)	Nitrogen oxides	011104-93-1	0,13	kg PO4 / kg
Land	(unspecified)	Nitrogen, total		0,42	kg PO4 / kg
Water	(unspecified)	Nitrogen, total		0,42	kg PO4 / kg
Air	(unspecified)	Nitrogen, total		0,42	kg PO4 / kg
Land	(unspecified)	Phosphate	014265-44-2	1	kg PO4 / kg
Air	(unspecified)	Phosphate	014265-44-2	1	kg PO4 / kg
Water	(unspecified)	Phosphate	014265-44-2	1	kg PO4 / kg
Land	(unspecified)	Phosphoric acid	007664-38-2	0,97	kg PO4 / kg
Air	(unspecified)	Phosphoric acid	007664-38-2	0,97	kg PO4 / kg
Water	(unspecified)	Phosphoric acid	007664-38-2	0,97	kg PO4 / kg
Water	(unspecified)	Phosphorus	007723-14-0	3,06	kg PO4 / kg
Land	(unspecified)	Phosphorus	007723-14-0	3,06	kg PO4 / kg
Air	(unspecified)	Phosphorus	007723-14-0	3,06	kg PO4 / kg
Land	(unspecified)	Phosphorus pentoxide	001314-56-3	1,34	kg PO4 / kg
Water	(unspecified)	Phosphorus pentoxide	001314-56-3	1,34	kg PO4 / kg
Air	(unspecified)	Phosphorus pentoxide	001314-56-3	1,34	kg PO4 / kg
Land	(unspecified)	Phosphorus, total		3,06	kg PO4 / kg
Water	(unspecified)	Phosphorus, total		3,06	kg PO4 / kg
Air	(unspecified)	Phosphorus, total		3,06	kg PO4 / kg
Water	(unspecified)	Suspended solids, inorganic		0,08	kg PO4 / kg
Water	(unspecified)	Suspended solids, unspecified		0,08	kg PO4 / kg
Water	(unspecified)	TOC, Total Organic Carbon		0,066	kg PO4 / kg
Impact Category	heavy metals	kg Pb			
Water	(unspecified)	Antimony	007440-36-0	2	kg Pb / kg
Water	(unspecified)	Arsenic, ion	017428-41-0	1	kg Pb / kg
Water	(unspecified)	Barium	007440-39-3	0,014	kg Pb / kg
Water	(unspecified)	Boron	007440-42-8	0,03	kg Pb / kg
Air	(unspecified)	Cadmium	007440-43-9	50	kg Pb / kg
Air	(unspecified)	Cadmium oxide	001306-	50	kg Pb / kg

SimaPro 7.1	***Method***	***Data:***	***08/08/2007***	***Period:***	***16.11.31***
			19-0		
Water	(unspecified)	Cadmium, ion	022537-48-0	3	kg Pb / kg
Water	(unspecified)	Chromium	007440-47-3	0,2	kg Pb / kg
Water	(unspecified)	Copper, ion	017493-86-6	0,005	kg Pb / kg
Air	(unspecified)	Heavy metals, unspecified		1	kg Pb / kg
Water	(unspecified)	Lead	007439-92-1	1	kg Pb / kg
Air	(unspecified)	Lead	007439-92-1	1	kg Pb / kg
Water	(unspecified)	Manganese	007439-96-5	0,02	kg Pb / kg
Air	(unspecified)	Manganese	007439-96-5	1	kg Pb / kg
Water	(unspecified)	Mercury	007439-97-6	10	kg Pb / kg
Air	(unspecified)	Mercury	007439-97-6	1	kg Pb / kg
Water	(unspecified)	Metallic ions, unspecified		0,002223	kg Pb / kg
Air	(unspecified)	Metals, unspecified		0,03867	kg Pb / kg
Water	(unspecified)	Molybdenum	007439-98-7	0,14	kg Pb / kg
Water	(unspecified)	Nickel, ion	014701-22-5	0,5	kg Pb / kg
Impact Category	carcinogens	kg B(a)P			
Air	(unspecified)	Acrylonitrile	000107-13-1	0,00022	kg B(a)P / kg
Air	(unspecified)	Arsenic	007440-38-2	0,044	kg B(a)P / kg
Air	(unspecified)	Benzene	000071-43-2	0,000044	kg B(a)P / kg
Air	(unspecified)	Benzene, ethyl-	000100-41-4	0,000044	kg B(a)P / kg
Air	(unspecified)	Benzo(a)pyrene	000050-32-8	1	kg B(a)P / kg
Air	(unspecified)	Chromium VI	018540-29-9	0,44	kg B(a)P / kg
Air	(unspecified)	Ethene, chloro-	000075-01-4	0,000011	kg B(a)P / kg
Air	(unspecified)	Fluoranthene	000206-44-0	1	kg B(a)P / kg
Air	(unspecified)	Hydrocarbons, aromatic		0,000044	kg B(a)P / kg
Air	(unspecified)	Metals, unspecified		0,000179	kg B(a)P / kg
Air	(unspecified)	Nickel	007440-02-0	0,0044	kg B(a)P / kg
Air	(unspecified)	PAH, polycyclic aromatic hydrocarbons	130498-29-2	0,4792	kg B(a)P / kg
Air	(unspecified)	Tar	008007-45-2	0,000044	kg B(a)P / kg
Impact Category	winter smog - P.M.	kg SPM			
Air	(unspecified)	Carbon black	001333-86-4	1	kg SPM / kg
Air	(unspecified)	Iron dust		1	kg SPM / kg
Air	(unspecified)	Particulates, < 10 um		1	kg SPM / kg
Air	(unspecified)	Particulates, < 10 um (mobile)		1	kg SPM / kg
Air	(unspecified)	Particulates, < 10 um (stationary)		1	kg SPM / kg
Air	(unspecified)	Particulates, < 2.5 um		1	kg SPM / kg
Air	(unspecified)	Particulates, > 2.5 um, and < 10um		1	kg SPM / kg
Air	(unspecified)	Particulates, diesel soot		1	kg SPM / kg
Air	(unspecified)	Particulates, SPM		1	kg SPM / kg
Air	(unspecified)	Soot		1	kg SPM / kg

SimaPro 7.1	*Method*	*Data:*	*08/08/2007*	*Period:*	*16.11.31*
Air	(unspecified)	Sulfur dioxide	007446-09-5	1	kg SPM / kg
Air	(unspecified)	Sulfur oxides		1	kg SPM / kg
Impact Category	summer smog - VOCs	kg C2H4			
Air	(unspecified)	2-Propanol	000067-63-0	0,196	kg C2H4 / kg
Air	(unspecified)	Acetaldehyde	000075-07-0	0,527	kg C2H4 / kg
Air	(unspecified)	Acetone	000067-64-1	0,178	kg C2H4 / kg
Air	(unspecified)	Acetonitrile	000075-05-8	0,416	kg C2H4 / kg
Air	(unspecified)	Acrolein	000107-02-8	0,603	kg C2H4 / kg
Air	(unspecified)	Acrylonitrile	000107-13-1	0,416	kg C2H4 / kg
Air	(unspecified)	Alcohols, unspecified		0,196	kg C2H4 / kg
Air	(unspecified)	Aldehydes, unspecified		0,443	kg C2H4 / kg
Air	(unspecified)	Benzaldehyde	000100-52-7	0,334	kg C2H4 / kg
Air	(unspecified)	Benzene	000071-43-2	0,189	kg C2H4 / kg
Air	(unspecified)	Benzene, ethyl-	000100-41-4	0,593	kg C2H4 / kg
Air	(unspecified)	Benzo(a)pyrene	000050-32-8	0,761	kg C2H4 / kg
Air	(unspecified)	Biphenyl	000092-52-4	0,761	kg C2H4 / kg
Air	(unspecified)	Biphenyl, hexachloro-	026601-64-9	0,761	kg C2H4 / kg
Air	(unspecified)	Butane	000106-97-8	0,41	kg C2H4 / kg
Air	(unspecified)	Butene	025167-67-3	0,992	kg C2H4 / kg
Air	(unspecified)	Caprolactam	000105-60-2	0,761	kg C2H4 / kg
Air	(unspecified)	Chloroform	000067-66-3	0,021	kg C2H4 / kg
Air	(unspecified)	Crude oil		0,398	kg C2H4 / kg
Air	(unspecified)	Diethyl ether	000060-29-7	0,398	kg C2H4 / kg
Air	(unspecified)	Ethane	000074-84-0	0,082	kg C2H4 / kg
Air	(unspecified)	Ethane, 1,1,1-trichloro-, HCFC-140	000071-55-6	0,021	kg C2H4 / kg
Air	(unspecified)	Ethane, 1,2-dichloro-	000107-06-2	0,021	kg C2H4 / kg
Air	(unspecified)	Ethanol	000064-17-5	0,268	kg C2H4 / kg
Air	(unspecified)	Ethene	000074-85-1	1	kg C2H4 / kg
Air	(unspecified)	Ethene, chloro-	000075-01-4	0,021	kg C2H4 / kg
Air	(unspecified)	Ethene, tetrachloro-	000127-18-4	0,005	kg C2H4 / kg
Air	(unspecified)	Ethene, trichloro-	000079-01-6	0,021	kg C2H4 / kg
Air	(unspecified)	Ethylene glycol	000107-21-1	0,196	kg C2H4 / kg
Air	(unspecified)	Ethylene oxide	000075-21-8	0,377	kg C2H4 / kg
Air	(unspecified)	Ethyne	000074-86-2	0,168	kg C2H4 / kg
Air	(unspecified)	Formaldehyde	000050-00-0	0,421	kg C2H4 / kg
Air	(unspecified)	Heptane	000142-82-5	0,529	kg C2H4 / kg
Air	(unspecified)	Hexane	000110-54-3	0,421	kg C2H4 / kg
Air	(unspecified)	Hydrocarbons, aliphatic, alkanes, cyclic		0,398	kg C2H4 / kg

SimaPro 7.1	*Method*	*Data:*	*08/08/2007*	*Period:*	*16.11.31*
Air	(unspecified)	Hydrocarbons, aliphatic, alkanes, unspecified		0,398	kg C2H4 / kg
Air	(unspecified)	Hydrocarbons, aliphatic, alkenes, unspecified		0,906	kg C2H4 / kg
Air	(unspecified)	Hydrocarbons, aliphatic, unsaturated		0,398	kg C2H4 / kg
Air	(unspecified)	Hydrocarbons, aromatic		0,761	kg C2H4 / kg
Air	(unspecified)	Hydrocarbons, chlorinated		0,021	kg C2H4 / kg
Air	(unspecified)	Hydrocarbons, halogenated		0,021	kg C2H4 / kg
Air	(unspecified)	Hydrocarbons, unspecified		0,398	kg C2H4 / kg
Air	(unspecified)	Hydroxy compounds, unspecified		0,377	kg C2H4 / kg
Air	(unspecified)	Kerosene	064742-81-0	0,398	kg C2H4 / kg
Air	(unspecified)	Ketones, unspecified		0,326	kg C2H4 / kg
Air	(unspecified)	Methane	000074-82-8	0,007	kg C2H4 / kg
Air	(unspecified)	Methane, biogenic	000074-82-8	0,007	kg C2H4 / kg
Air	(unspecified)	Methane, dichloro-, HCC-30	000075-09-2	0,021	kg C2H4 / kg
Air	(unspecified)	Methane, fossil	000074-82-8	0,007	kg C2H4 / kg
Air	(unspecified)	Methane, tetrachloro-, CFC-10	000056-23-5	0,021	kg C2H4 / kg
Air	(unspecified)	Methanol	000067-56-1	0,123	kg C2H4 / kg
Air	(unspecified)	Methyl ethyl ketone	000078-93-3	0,473	kg C2H4 / kg
Air	(unspecified)	Methyl mercaptan	000074-93-1	0,377	kg C2H4 / kg
Air	(unspecified)	Naphthalene	000091-20-3	0,761	kg C2H4 / kg
Air	(unspecified)	NMVOC, non-methane volatile organic compounds, unspecified origin		0,416	kg C2H4 / kg
Air	(unspecified)	PAH, polycyclic aromatic hydrocarbons	130498-29-2	0,04932	kg C2H4 / kg
Air	(unspecified)	Pentane	000109-66-0	0,408	kg C2H4 / kg
Air	(unspecified)	Petrol	008006-61-9	0,398	kg C2H4 / kg
Air	(unspecified)	Phenol	000108-95-2	0,761	kg C2H4 / kg
Air	(unspecified)	Phenol, chloro-	025167-80-0	0,021	kg C2H4 / kg
Air	(unspecified)	Phenol, pentachloro-	000087-86-5	0,021	kg C2H4 / kg
Air	(unspecified)	Phthalic anhydride	000085-44-9	0,761	kg C2H4 / kg
Air	(unspecified)	Propane	000074-98-6	0,42	kg C2H4 / kg
Air	(unspecified)	Propene	000115-07-1	1,03	kg C2H4 / kg
Air	(unspecified)	Propionic acid	000079-09-4	0,377	kg C2H4 / kg
Air	(unspecified)	Styrene	000100-42-5	0,761	kg C2H4 / kg
Air	(unspecified)	Tar	008007-45-2	0,416	kg C2H4 / kg
Air	(unspecified)	Terpentine		0,377	kg C2H4 / kg
Air	(unspecified)	Toluene	000108-88-3	0,563	kg C2H4 / kg
Air	(unspecified)	Vinyl acetate	000108-05-4	0,223	kg C2H4 / kg
Air	(unspecified)	VOC, volatile organic compounds		0,398	kg C2H4 / kg
Impact Category	pesticides	kg act.subst			
Water	(unspecified)	2,4-D	000094-75-7	1	kg act.subst / kg
Water	(unspecified)	2,4,5-T	000093-76-5	1	kg act.subst / kg
Water	(unspecified)	Acephate	030560-19-1	1	kg act.subst / kg

SimaPro 7.1	*Method*	*Data:*	*08/08/2007*	*Period:*	*16.11.31*
Water	(unspecified)	Aldicarb	000116-06-3	1	kg act.subst / kg
Water	(unspecified)	Aldrin	000309-00-2	1	kg act.subst / kg
Water	(unspecified)	Anilazine	000101-05-3	1	kg act.subst / kg
Water	(unspecified)	Atrazine	001912-24-9	1	kg act.subst / kg
Water	(unspecified)	Azinphos-ethyl	002642-71-9	1	kg act.subst / kg
Water	(unspecified)	Azinphos-methyl	000086-50-0	1	kg act.subst / kg
Water	(unspecified)	Benomyl	017804-35-2	1	kg act.subst / kg
Water	(unspecified)	Bentazone	025057-89-0	1	kg act.subst / kg
Water	(unspecified)	Bifenthrin	082657-04-3	1	kg act.subst / kg
Water	(unspecified)	Bis(2-chloroethyl)ether	000111-44-4	1	kg act.subst / kg
Water	(unspecified)	Bis(chloromethyl)ether	000542-88-1	1	kg act.subst / kg
Water	(unspecified)	Captafol	002939-80-2	1	kg act.subst / kg
Water	(unspecified)	Captan	000133-06-2	1	kg act.subst / kg
Water	(unspecified)	Carbaryl	000063-25-2	1	kg act.subst / kg
Water	(unspecified)	Carbendazim	010605-21-7	1	kg act.subst / kg
Water	(unspecified)	Carbofuran	001563-66-2	1	kg act.subst / kg
Water	(unspecified)	Chlordane	012789-03-6	1	kg act.subst / kg
Water	(unspecified)	Chlorfenvinphos	000470-90-6	1	kg act.subst / kg
Water	(unspecified)	Chloridazon	001698-60-8	1	kg act.subst / kg
Water	(unspecified)	Chlorothalonil	001897-45-6	1	kg act.subst / kg
Water	(unspecified)	Chlorpropham	000101-21-3	1	kg act.subst / kg
Water	(unspecified)	Chlorpyrifos	002921-88-2	1	kg act.subst / kg
Water	(unspecified)	Coumafos	000056-72-4	1	kg act.subst / kg
Water	(unspecified)	Cyanazine	021725-46-2	1	kg act.subst / kg
Water	(unspecified)	Cypermethrin	052315-07-8	1	kg act.subst / kg
Water	(unspecified)	Cyromazine	066215-27-8	1	kg act.subst / kg
Water	(unspecified)	DDT	000050-29-3	1	kg act.subst / kg
Water	(unspecified)	Deltamethrin	052918-63-5	1	kg act.subst / kg
Water	(unspecified)	Demeton	008065-48-3	1	kg act.subst / kg
Water	(unspecified)	Desmetryn	001014-69-3	1	kg act.subst / kg
Water	(unspecified)	Diazinon	000333-41-5	1	kg act.subst / kg
Water	(unspecified)	Dichlorprop	000120-36-5	1	kg act.subst / kg
Water	(unspecified)	Dichlorvos	000062-73-7	1	kg act.subst / kg
Water	(unspecified)	Dieldrin	000060-57-1	1	kg act.subst / kg
Water	(unspecified)	Dimethoate	000060-51-5	1	kg act.subst / kg
Water	(unspecified)	Dinoseb	000088-85-7	1	kg act.subst / kg
Water	(unspecified)	Dinoterb	001420-07-1	1	kg act.subst / kg
Water	(unspecified)	Diquat dibromide	000085-	1	kg act.subst / kg

			00-7		
Water	(unspecified)	Disinfectants, unspecified		1	kg act.subst / kg
Water	(unspecified)	Disulfothon	000298-04-4	1	kg act.subst / kg
Water	(unspecified)	Diuron	000330-54-1	1	kg act.subst / kg
Water	(unspecified)	DNOC	000534-52-1	1	kg act.subst / kg
Water	(unspecified)	Endosulfan	000115-29-7	1	kg act.subst / kg
Water	(unspecified)	Endrin	000072-20-8	1	kg act.subst / kg
Water	(unspecified)	Ethoprop	013194-48-4	1	kg act.subst / kg
Water	(unspecified)	Fenitrothion	000122-14-5	1	kg act.subst / kg
Water	(unspecified)	Fenthion	000055-38-9	1	kg act.subst / kg
Water	(unspecified)	Fentin acetate	000900-95-8	1	kg act.subst / kg
Water	(unspecified)	Fentin chloride	000639-58-7	1	kg act.subst / kg
Water	(unspecified)	Fentin hydroxide	000076-87-9	1	kg act.subst / kg
Water	(unspecified)	Folpet	000133-07-3	1	kg act.subst / kg
Water	(unspecified)	Fungicides, unspecified		1	kg act.subst / kg
Water	(unspecified)	Glyphosate	001071-83-6	1	kg act.subst / kg
Water	(unspecified)	Heptachlor	000076-44-8	1	kg act.subst / kg
Water	(unspecified)	Heptenophos	023560-59-0	1	kg act.subst / kg
Water	(unspecified)	Herbicides, unspecified		1	kg act.subst / kg
Water	(unspecified)	Insecticides, unspecified		1	kg act.subst / kg
Water	(unspecified)	Iprodione	036734-19-7	1	kg act.subst / kg
Water	(unspecified)	Isoproturon	034123-59-6	1	kg act.subst / kg
Water	(unspecified)	Lindane	000058-89-9	1	kg act.subst / kg
Water	(unspecified)	Lindane, alpha-	000319-84-6	1	kg act.subst / kg
Water	(unspecified)	Lindane, beta-	000319-85-7	1	kg act.subst / kg
Water	(unspecified)	Linuron	000330-55-2	1	kg act.subst / kg
Water	(unspecified)	Malathion	000121-75-5	1	kg act.subst / kg
Water	(unspecified)	Maneb	012427-38-2	1	kg act.subst / kg
Water	(unspecified)	MCPA	000094-74-6	1	kg act.subst / kg
Water	(unspecified)	Mecoprop	000093-65-2	1	kg act.subst / kg
Water	(unspecified)	Metamitron	041394-05-2	1	kg act.subst / kg
Water	(unspecified)	Metazachlor	067129-08-2	1	kg act.subst / kg
Water	(unspecified)	Methabenzthiazuron	018691-97-9	1	kg act.subst / kg
Water	(unspecified)	Methomyl	016752-77-5	1	kg act.subst / kg
Water	(unspecified)	Metobromuron	003060-89-7	1	kg act.subst / kg
Water	(unspecified)	Metolachlor	051218-45-2	1	kg act.subst / kg
Water	(unspecified)	Metribuzin	021087-64-9	1	kg act.subst / kg
Water	(unspecified)	Mevinfos	007786-34-7	1	kg act.subst / kg
Water	(unspecified)	Monolinuron	001746-81-2	1	kg act.subst / kg

Water	(unspecified)	Oxamyl	023135-22-0	1	kg act.subst / kg
Water	(unspecified)	Oxydemethon methyl	000301-12-2	1	kg act.subst / kg
Water	(unspecified)	Parathion	000056-38-2	1	kg act.subst / kg
Water	(unspecified)	Parathion, methyl	000298-00-0	1	kg act.subst / kg
Water	(unspecified)	Permethrin	052645-53-1	1	kg act.subst / kg
Water	(unspecified)	Pesticides, unspecified		1	kg act.subst / kg
Water	(unspecified)	Phoxim	014816-18-3	1	kg act.subst / kg
Water	(unspecified)	Pirimicarb	023103-98-2	1	kg act.subst / kg
Water	(unspecified)	Propachlor	001918-16-7	1	kg act.subst / kg
Water	(unspecified)	Propoxur	000114-26-1	1	kg act.subst / kg
Water	(unspecified)	Pyrazophos	013457-18-6	1	kg act.subst / kg
Water	(unspecified)	Simazine	000122-34-9	1	kg act.subst / kg
Water	(unspecified)	Thiram	000137-26-8	1	kg act.subst / kg
Water	(unspecified)	Tolclophos-methyl	057018-04-9	1	kg act.subst / kg
Water	(unspecified)	Triallate	002303-17-5	1	kg act.subst / kg
Water	(unspecified)	Triazofos	024017-47-8	1	kg act.subst / kg
Water	(unspecified)	Trichlorfon	000052-68-6	1	kg act.subst / kg
Water	(unspecified)	Trifluralin	001582-09-8	1	kg act.subst / kg
Water	(unspecified)	Zineb	012122-67-7	1	kg act.subst / kg

Impact Category	energy resources	MJ LHV			
Prima	(unspecified)	Biomass, feedstock		1	MJ LHV / MJ
Prima	(unspecified)	Coal, 18 MJ per kg, in ground		18	MJ LHV / kg
Prima	(unspecified)	Coal, 26.4 MJ per kg, in ground		26,4	MJ LHV / kg
Prima	(unspecified)	Coal, 29.3 MJ per kg, in ground		29,3	MJ LHV / kg
Prima	(unspecified)	Coal, brown, 10 MJ per kg, in ground		10	MJ LHV / kg
Prima	(unspecified)	Coal, brown, 8 MJ per kg, in ground		8	MJ LHV / kg
Prima	(unspecified)	Coal, brown, in ground		10	MJ LHV / kg
Prima	(unspecified)	Coal, feedstock, 26.4 MJ per kg, in ground		26,4	MJ LHV / kg
Prima	(unspecified)	Coal, hard, unspecified, in ground		19,1	MJ LHV / kg
Prima	(unspecified)	Energy, from biomass		1	MJ LHV / MJ
Prima	(unspecified)	Energy, from coal		1	MJ LHV / MJ
Prima	(unspecified)	Energy, from coal, brown		1	MJ LHV / MJ
Prima	(unspecified)	Energy, from gas, natural		1	MJ LHV / MJ
Prima	(unspecified)	Energy, from hydro power		1	MJ LHV / MJ
Prima	(unspecified)	Energy, from hydrogen		1	MJ LHV / MJ
Prima	(unspecified)	Energy, from oil		1	MJ LHV / MJ
Prima	(unspecified)	Energy, from peat		1	MJ LHV / MJ
Prima	(unspecified)	Energy, from sulfur		1	MJ LHV / MJ
Prima	(unspecified)	Energy, from uranium		1	MJ LHV / MJ
Prima	(unspecified)	Energy, from wood		1	MJ LHV / MJ
Prima	(unspecified)	Energy, geothermal		1	MJ LHV / MJ
Prima	(unspecified)	Energy, gross calorific value, in biomass		1	MJ LHV / MJ
Prima	(unspecified)	Energy, kinetic, flow, in wind		1	MJ LHV / MJ
Prima	(unspecified)	Energy, potential, stock, in barrage water		1	MJ LHV / MJ
Prima	(unspecified)	Energy, recovered		1	MJ LHV / MJ

SimaPro 7.1	*Method*	*Data:*	*08/08/2007*	*Period:*	*16.11.31*
Prima	(unspecified)	Energy, solar		1	MJ LHV / MJ
Prima	(unspecified)	Energy, unspecified		1	MJ LHV / MJ
Prima	(unspecified)	Gas, mine, off-gas, process, coal mining/kg	008006-14-2	49,8	MJ LHV / kg
Prima	(unspecified)	Gas, mine, off-gas, process, coal mining/m3	008006-14-2	39,8	MJ LHV / m3
Prima	(unspecified)	Gas, natural, 30.3 MJ per kg, in ground	008006-14-2	30,3	MJ LHV / kg
Prima	(unspecified)	Gas, natural, 35 MJ per m3, in ground	008006-14-2	35	MJ LHV / m3
Prima	(unspecified)	Gas, natural, 36.6 MJ per m3, in ground	008006-14-2	36,6	MJ LHV / m3
Prima	(unspecified)	Gas, natural, 46.8 MJ per kg, in ground	008006-14-2	46,8	MJ LHV / kg
Prima	(unspecified)	Gas, natural, feedstock, 35 MJ per m3, in ground	008006-14-2	35	MJ LHV / m3
Prima	(unspecified)	Gas, natural, feedstock, 46.8 MJ per kg, in ground	008006-14-2	46,8	MJ LHV / kg
Prima	(unspecified)	Gas, natural, in ground	008006-14-2	38,3	MJ LHV / m3
Prima	(unspecified)	Gas, off-gas, oil production, in ground	008006-14-2	40,9	MJ LHV / m3
Prima	(unspecified)	Gas, petroleum, 35 MJ per m3, in ground		35	MJ LHV / m3
Prima	(unspecified)	Methane	000074-82-8	35,9	MJ LHV / kg
Prima	(unspecified)	Oil, crude, 38400 MJ per m3, in ground		38400	MJ LHV / m3
Prima	(unspecified)	Oil, crude, 41 MJ per kg, in ground		41	MJ LHV / kg
Prima	(unspecified)	Oil, crude, 42 MJ per kg, in ground		42	MJ LHV / kg
Prima	(unspecified)	Oil, crude, 42.6 MJ per kg, in ground		42,6	MJ LHV / kg
Prima	(unspecified)	Oil, crude, 42.7 MJ per kg, in ground		42,7	MJ LHV / kg
Prima	(unspecified)	Oil, crude, feedstock, 41 MJ per kg, in ground		41	MJ LHV / kg
Prima	(unspecified)	Oil, crude, feedstock, 42 MJ per kg, in ground		42	MJ LHV / kg
Prima	(unspecified)	Oil, crude, in ground		45,8	MJ LHV / kg
Prima	(unspecified)	Peat, in ground		13	MJ LHV / kg
Prima	(unspecified)	Steam from waste incineration		1	MJ LHV / MJ
Prima	(unspecified)	Uranium ore, 1.11 GJ per kg, in ground		1110	MJ LHV / kg
Prima	(unspecified)	Uranium, 2291 GJ per kg, in ground	007440-61-1	2291000	MJ LHV / kg
Prima	(unspecified)	Uranium, 451 GJ per kg, in ground	007440-61-1	451000	MJ LHV / kg
Prima	(unspecified)	Uranium, 560 GJ per kg, in ground	007440-61-1	560000	MJ LHV / kg
Prima	(unspecified)	Uranium, in ground	007440-61-1	560000	MJ LHV / kg
Prima	(unspecified)	Water, barrage		0,01	MJ LHV / kg
Prima	(unspecified)	Wood and wood waste, 9.5 MJ per kg		9,5	MJ LHV / kg
Prima	(unspecified)	Wood, feedstock		15,3	MJ LHV / kg
Prima	(unspecified)	Wood, unspecified, standing/kg		15,3	MJ LHV / kg
Impact Category	solid waste	kg			
Waste	(unspecified)	Aluminium waste		1	kg / kg
Waste	(unspecified)	Asbestos		1	kg / kg
Waste	(unspecified)	Asphalt waste		1	kg / kg
Waste	(unspecified)	Bilge oil		1	kg / kg
Waste	(unspecified)	Bitumen waste		1	kg / kg
Waste	(unspecified)	Bulk waste, unspecified		1	kg / kg
Waste	(unspecified)	Calcium fluoride waste		1	kg / kg
Waste	(unspecified)	Cardboard waste		1	kg / kg
Waste	(unspecified)	Carton waste		1	kg / kg
Waste	(unspecified)	Catalyst waste		1	kg / kg
Waste	(unspecified)	Cathode iron ingots waste		1	kg / kg
Waste	(unspecified)	Cathode loss		1	kg / kg

SimaPro 7.1	***Method***	***Data:***	***08/08/2007***	***Period:***	***16.11.31***
Waste	(unspecified)	Chemical waste, inert		1	kg / kg
Waste	(unspecified)	Chemical waste, regulated		1	kg / kg
Waste	(unspecified)	Chemical waste, unspecified		1	kg / kg
Waste	(unspecified)	Chromium waste		1	kg / kg
Waste	(unspecified)	Coal ash		1	kg / kg
Waste	(unspecified)	Coal tailings		1	kg / kg
Waste	(unspecified)	Construction waste		1	kg / kg
Waste	(unspecified)	Copper absorbent waste		1	kg / kg
Waste	(unspecified)	Copper waste		1	kg / kg
Waste	(unspecified)	Dross		1	kg / kg
Waste	(unspecified)	Dross for recycling		1	kg / kg
Waste	(unspecified)	Dust, break-out		1	kg / kg
Waste	(unspecified)	Dust, unspecified		1	kg / kg
Waste	(unspecified)	E-saving bulb plastic waste		1	kg / kg
Waste	(unspecified)	E-saving bulb waste		1	kg / kg
Waste	(unspecified)	Electronic waste		1	kg / kg
Waste	(unspecified)	Electrostatic filter dust		1	kg / kg
Waste	(unspecified)	Fluoride waste		1	kg / kg
Waste	(unspecified)	Fly ash		1	kg / kg
Waste	(unspecified)	Gas pipe waste		1	kg / kg
Waste	(unspecified)	Glass waste		1	kg / kg
Waste	(unspecified)	Ion exchanger sludge		1	kg / kg
Waste	(unspecified)	Iron waste		1	kg / kg
Waste	(unspecified)	Light bulb waste		1	kg / kg
Waste	(unspecified)	Limestone waste		1	kg / kg
Waste	(unspecified)	Metal waste		1	kg / kg
Waste	(unspecified)	Mineral waste		1	kg / kg
Waste	(unspecified)	Mineral waste, from mining		1	kg / kg
Waste	(unspecified)	Mineral wool waste		1	kg / kg
Waste	(unspecified)	Oil separator sludge		1	kg / kg
Waste	(unspecified)	Oil waste		1	kg / kg
Waste	(unspecified)	Packaging waste, paper and board		1	kg / kg
Waste	(unspecified)	Packaging waste, plastic		1	kg / kg
Waste	(unspecified)	Packaging waste, steel		1	kg / kg
Waste	(unspecified)	Packaging waste, unspecified		1	kg / kg
Waste	(unspecified)	Packaging waste, wood		1	kg / kg
Waste	(unspecified)	Paint waste		1	kg / kg
Waste	(unspecified)	Photovoltaic cell waste		1	kg / kg
Waste	(unspecified)	Photovoltaic panel waste		1	kg / kg
Waste	(unspecified)	Photovoltaic production waste		1	kg / kg
Waste	(unspecified)	Photovoltaic/EVA cell waste		1	kg / kg
Waste	(unspecified)	Plastic waste		1	kg / kg
Waste	(unspecified)	Polyethylene waste		1	kg / kg
Waste	(unspecified)	Polystyrene waste		1	kg / kg
Waste	(unspecified)	Polyvinyl chloride waste		1	kg / kg
Waste	(unspecified)	Printed circuitboards waste		1	kg / kg
Waste	(unspecified)	Process waste		1	kg / kg
Waste	(unspecified)	Production waste		1	kg / kg
Waste	(unspecified)	Production waste, not inert		1	kg / kg
Waste	(unspecified)	Propylene glycol waste		1	kg / kg
Waste	(unspecified)	Refinery sludge		1	kg / kg
Waste	(unspecified)	Rejects		1	kg / kg
Waste	(unspecified)	Rejects, corrugated cardboard		1	kg / kg
Waste	(unspecified)	Residues		1	kg / kg

Waste	(unspecified)	Slags		1	kg / kg
Waste	(unspecified)	Slags and ashes		1	kg / kg
Waste	(unspecified)	Sludge		1	kg / kg
Waste	(unspecified)	Soot		1	kg / kg
Waste	(unspecified)	Steel waste		1	kg / kg
Waste	(unspecified)	Stones and rubble		1	kg / kg
Waste	(unspecified)	Tin waste		1	kg / kg
Waste	(unspecified)	Tinder from rolling drum		1	kg / kg
Waste	(unspecified)	Waste in bioactive landfill		1	kg / kg
Waste	(unspecified)	Waste in incineration		1	kg / kg
Waste	(unspecified)	Waste in inert landfill		1	kg / kg
Waste	(unspecified)	Waste to recycling		1	kg / kg
Waste	(unspecified)	Waste, final, inert		1	kg / kg
Waste	(unspecified)	Waste, from drilling, unspecified		1	kg / kg
Waste	(unspecified)	Waste, from incinerator		1	kg / kg
Waste	(unspecified)	Waste, industrial		1	kg / kg
Waste	(unspecified)	Waste, inorganic		1	kg / kg
Waste	(unspecified)	Waste, nuclear, unspecified/kg		1	kg / kg
Waste	(unspecified)	Waste, solid		1	kg / kg
Waste	(unspecified)	Waste, toxic		1	kg / kg
Waste	(unspecified)	Waste, unspecified		1	kg / kg
Waste	(unspecified)	Welding dust		1	kg / kg
Waste	(unspecified)	Wood ashes		1	kg / kg
Waste	(unspecified)	Wood waste		1	kg / kg
Waste	(unspecified)	Wood, sawdust		1	kg / kg
Waste	(unspecified)	Zeolite waste		1	kg / kg
Waste	(unspecified)	Zinc waste		1	kg / kg
Impact Category	Heavy metals (air)	kg Ni eq			
Air	(unspecified)	Arsenic	007440-38-2	3,33	kg Ni eq / kg
Air	(unspecified)	Cadmium	007440-43-9	5	kg Ni eq / kg
Air	(unspecified)	Chromium	007440-47-3	0,5	kg Ni eq / kg
Air	(unspecified)	Chromium-51	014392-02-0	0,5	kg Ni eq / kBq
Air	(unspecified)	Chromium VI	018540-29-9	0,5	kg Ni eq / kg
Air	(unspecified)	Copper	007440-50-8	0,5	kg Ni eq / kg
Air	(unspecified)	Lead	007439-92-1	0,04	kg Ni eq / kg
Air	(unspecified)	Mercury	007439-97-6	5	kg Ni eq / kg
Air	(unspecified)	Nickel	007440-02-0	1	kg Ni eq / kg
Air	(unspecified)	Zinc	007440-66-6	0,04	kg Ni eq / kg
Impact Category	PAHs (air)	kg PAH/20 eq			
Air	(unspecified)	Carbon monoxide	000630-08-0	0,000002	kg PAH/20 eq / kg
Air	(unspecified)	Hydrocarbons, aromatic, naphthalenes, C13, trisubstituted		20	kg PAH/20 eq / kg
Air	(unspecified)	Hydrocarbons, aromatic, styrenes, C10		20	kg PAH/20 eq / kg
Air	(unspecified)	Hydrocarbons, aromatic, styrenes, C9		20	kg PAH/20 eq / kg
Air	(unspecified)	Polycyclic organic matter, as 15-PAH		20	kg PAH/20 eq / kg
Air	(unspecified)	Polycyclic organic matter, as 7-PAH		20	kg PAH/20 eq /

					kg
Air	(unspecified)	Polycyclic organic matter, unspecified		20	kg PAH/20 eq / kg
Impact Category	Heavy metals (water)	kg Hg/20 eq			
Water	(unspecified)	Arsenic, ion	017428-41-0	3	kg Hg/20 eq / kg
Water	(unspecified)	Cadmium, ion	022537-48-0	7	kg Hg/20 eq / kg
Water	(unspecified)	Chromium	007440-47-3	0,4	kg Hg/20 eq / kg
Water	(unspecified)	Copper, ion	017493-86-6	2,8	kg Hg/20 eq / kg
Water	(unspecified)	Lead	007439-92-1	0,5	kg Hg/20 eq / kg
Water	(unspecified)	Mercury	007439-97-6	20	kg Hg/20 eq / kg
Water	(unspecified)	Nickel	007440-02-0	7	kg Hg/20 eq / kg
Water	(unspecified)	Zinc	007440-66-6	0,2	kg Hg/20 eq / kg
Water	(unspecified)	Zinc, ion	023713-49-7	0,2	kg Hg/20 eq / kg
Impact Category	POP (air)	kg TE eq			
Air	(unspecified)	Dioxin, 1,2,3,7,8,9-hexachlorodibenzo-	019408-74-3	0,1	kg TE eq / kg
Air	(unspecified)	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin		1	kg TE eq / kg
Air	(unspecified)	Furan	000110-00-9	0,1	kg TE eq / kg
Impact Category	POP (water)	kg TE eq			
Water	(unspecified)	Dioxin, 1,2,3,7,8,9-hexachlorodibenzo-	019408-74-3	0,1	kg TE eq / kg
Water	(unspecified)	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin		1	kg TE eq / kg
Water	(unspecified)	Furan	000110-00-9	0,1	kg TE eq / kg
Normalization-Weighting set	Europe g				

Normalizzazione	
greenhouse	7,42E-05
ozone layer	1,24
acidification	0,00888
eutrophication	0,0262
heavy metals	17,8
carcinogens	106
winter smog - P.M.	0,0106
summer smog - VOCs	0,0507
pesticides	1,21
energy resources	6,29E-06
solid waste	0
Heavy metals (air)	0
PAHs (air)	0

Heavy metals (water)	0
POP (air)	0
POP (water)	0
Weight	
greenhouse	2,5
ozone layer	100
acidification	10
eutrophication	5
heavy metals	5
carcinogens	10
winter smog - P.M.	5
summer smog - VOCs	2,5
pesticides	25
energy resources	0
solid waste	0
Heavy metals (air)	0
PAHs (air)	0
Heavy metals (water)	0
POP (air)	0
POP (water)	0
Normalization-Weighting set	Europe e
Normalizzazione	
greenhouse	7,65E-05
ozone layer	1,08
acidification	0,00888
eutrophication	0,0262
heavy metals	18,4
carcinogens	92
winter smog - P.M.	0,0106
summer smog - VOCs	0,0558
pesticides	1,04
energy resources	6,29E-06
solid waste	0
Heavy metals (air)	18,4
PAHs (air)	92
Heavy metals	18,4

(water)	
POP (air)	0
POP (water)	0
Weight	
greenhouse	2,5
ozone layer	100
acidification	10
eutrophication	5
heavy metals	5
carcinogens	10
winter smog - P.M.	5
summer smog - VOCs	2,5
pesticides	25
energy resources	0
solid waste	0
Heavy metals (air)	5
PAHs (air)	10
Heavy metals (water)	5
POP (air)	0
POP (water)	0

A.4 SIMAPRO VS EUP-ECOREPORT OUTPUT

According to "MEUUP Report" by R. Kemna on methodology used in the EuP-Ecoreport method, it was possible to have SimaPro outputs in compliance with EuP ones (MEEuP Methodology Report, Final, table 25 and Eco-indicator 95 - rev EuP V2.03).

In 8.4 Eco-indicator 95 - rev EuP V2.03 methodology was fully reported, while in the following table the main indicators used for Simapro outputs, in compliance with EuP- Ecoreport outputs, were reported.

Table A.17: Output indicators in Ecoindicator95-rev EuP method

Eco-indicator 95 - rev EuP V2.03 (Revised by Laura Cutaia)

Environmental impact	*Unit*
greenhouse	kg CO2
ozone layer	kg CFC11
acidification	kg SO2
eutrophication	kg PO4
heavy metals	kg Pb
carcinogens	kg B(a)P
winter smog - P.M.	kg SPM
summer smog - VOCs	kg C2H4
pesticides	kg act.subst
energy resources	MJ LHV

Environmental impact	*Unit*
solid waste	kg
Heavy metals (air)	kg Ni eq
PAHs (air)	kg PAH/20 eq
Heavy metals (water)	kg Hg/20 eq
POP (air)	kg TE eq
POP (water)	kg TE eq

Hereinafter outputs from COLD 7 have been reported, using SimaPro SW and revised Ecoindicator 95 methodology explained before.

In summary using SimaPro it was possible:

- To use quite all inventory data from producers (BOM) ;
- To use data input in the software in compliance with that available by producers (SimaPro data base contains many more data than EuP and makes possible the "simulation" of new record with new "components" or "materials" – as for detergents and washing agents according to data from producers) ;
- To have compliance between outputs from characterization phase of Eco-Indicator 95 (one of the most used methodology in impact assessment) and EuP-Ecoreport outputs, according to the "characterization factors" used in this method (MEEuP by R. Kemna) . See following figure.

Figure A.1: MEEuP Report – Summary of MEEUP weighting factors used to adapting Ecoindicator 95 to EuP-Ecoreport evaluating method.

Table 25. Summary MEEUP weighting factors

GHG emissions (air)	CO_2	CO	N_2O	CH_4	CF_4	C_2F_6	SF_6	R134a	other
weighting → CO_2 eq. GWP-100	**1**	**1.57**	**296**	**21**	**6500**	**9200**	**22200**	**1300**	**IPCC**

Acidification emissions (air)	SO_X	NO_X	N_2O	NH_3	HF	HCl	H_2S	H_2SO_4
AP weighting → SO_2 equivalent	**1**	**0.7**	**1.78**	**1.88**	**1.6**	**0.88**	**1.88**	**0.65**

Heavy Metals (air)	Cd	Hg	As	HMU	Ni	Cr	Cu	Pb	Zn	MU
HM weighting -> Ni eq.	**5**	**5**	**3.33**	**2**	**1**	**0.5**	**0.5**	**0.04**	**0.04**	**0.01**

PAHs (air)	PAHs	C6H6	CO
HM weighting -> Ni eq.	**20**	**0.004**	**0.000002**

MU= Metals Unspecified
HMU= Heavy Metals Unspecified. *=preliminary factors

Heavy Metals (water)	Hg	Cd	Ni*	As	HMU	Cu*	Pb*	Cr	Zn
HM Weighting factor → Hg/20 eq.	**20**	**7**	**7**	**3**	**3**	**2.8**	**0.5**	**0.4**	**0.2**

Eutrophication (water)	P	P_2O_5	PO_4	N	$NH_{4}+$	$NO_{3}-$	BOD	Suspended Solids	DOC	TOC	COD
EP weighting → PO_4 equivalent	**3.07**	**1.34**	**1**	**0.42**	**0.33**	**0.1**	**0.11**	**0.08**	**0.066**	**0.066**	**0.05**

EC Directives and official EU references with threshold and conversion values from which the weighting factors are derived: *IPCC* (GWP), *EC 850/2004* (POP), *2001/81/EC* (SO_x, NO_x, NH_3, VOC), *1999/30/EC* (SO_2, NO_x, PM and Pb), *2000/69/EC* (aromatics, CO), *COM(2003)423* (As, Cd, Hg, Ni, PAHs), *1999/13/EC* & 2002/3/EC (VOC), *EC 2037/2000* (ODP), *91/271/EC & 98/15/EEC* (BOD, COD, P, N, susp. Solids to water), *76/464/EEC* (Metals etc. to water).

In any case in SimaPro it was not possible to "simulate" the distribution phase for final products, for lack of data from producers or from other sources; on the contrary in EuP-Ecoreport simulation of impacts due to distribution is considered by an "internal system".

In the following table outputs for COLD 7 base model have been reported. In order to compare it with that from EuP-Ecoreport outputs it has to be underlined:

- "COLD 7 assembling" in Simapro corresponds to "Production total" in EuP; "assembling" for Simapro includes materials production, transport, forming and assembling also if these items have been calculated separately as in the outputs in 8.6;

- "Electricity LV use UCPTE U"+ "Delivery van (<3.5t) B250" + "COLD 7 Use consumables (per LC)" corresponds to "Use" in EuP;
- "COLD7 EoL" corresponds to "End of Life".

According to the methodology described and to the correspondence of the outputs (as in the first row - Row in EuP-Ecoreport) it has been possible to render comparable the SimaPro and EuP-Ecoreport outputs.

The main results are in the following table (LCA output by SimaPro according to Ecoindicator 95).

Table A.18: COLD 7 – LCA output (Ecoindicator95-rev EuP method)

Row in EuP-Ecoreport	Impact category	Unit	Total	COLD7 assembling	Electricity LV use UCPTE U	Delivery van (<3.5t) B250	cold 7 EoL	cold 7 use materials (per LC)
14	greenhouse	kg CO2	3.626,95	600,20	2.815,55	0,54	-59,43	270,09
15	ozone layer	kg CFC11	0,00	0,00	0,00	0,00	-0,00	0,00
16	acidification	kg SO2	29,37	6,29	20,51	0,00	-0,26	2,83
22	eutrophication	kg PO4	1,09	0,29	0,69	0,00	-0,02	0,13
	heavy metals	kg Pb	0,03	0,01	0,02	0,00	-0,00	0,00
	carcinogens	kg B(a)P	0,00	0,00	0,00	0,00	-0,00	0,00
20	winter smog - P.M.	kg SPM	24,13	4,89	17,19	0,00	-0,16	2,20
17	summer smog - VOCs	kg C2H4	1,11	0,37	0,63	0,00	-0,07	0,17
	pesticides	kg act.subst	0,00	0,00	0,00	0,00	0,00	0,00
8	energy resources	MJ LHV	82.304,50	11.512,99	66.711,95	6,94	-1.108,22	5.180,84
12 (+13)	solid waste	kg	520,15	331,22	85,00	0,00	-45,12	149,05
19	Heavy metals (air)	kg Ni eq	0,01	0,00	0,01	0,00	-0,00	0,00
19,1	PAHs (air)	kg PAH/20 eq	0,00	0,00	0,00	0,00	-0,00	0,00
21	Heavy metals (water)	kg Hg/20 eq	0,03	0,00	0,03	0,00	-0,00	0,00
18	POP (air)	kg TE eq	0,00	0,00	0,00	0,00	0,00	0,00
23	POP (water)	kg TE eq	0	0	0	0	0	0

In the following table the same LCA output by SimaPro according to Ecoindicator 95, revised accordingly to EuP-Ecoreports outputs, is reported.

Table A.19: COLD 7– LCA output (Ecoindicator95-rev EuP method) adapted to them of EuP-Ecoreport

Row in EuP-Ecoreport	Impact category	Unit	COLD7 assembling	Use	cold 7 EoL	Total	Total - EoL
8	energy resources	MJ LHV	11513	71900	-1108	82304	83413
12 (+13)	solid waste	kg	331,22	235,05	-45,12	520,15	566,27
14	greenhouse	kg CO2	600,20	3086,19	-59,43	3626,95	3686,38
15	ozone layer	kg CFC11	6,36E-04	2,11E-03	-2,77E-05	2,72E-03	2,75E-03
16	acidification	kg SO2	6,29	23,34	-0,26	29,37	29,64
17	summer smog - VOCs	kg C2H4	0,373	0,802	-0,068	1,107	1,175

18	POP (air)	kg TE eq	1,52E-09	1,28E-09	4,60E-11	2,85E-09	2,81E-09
19	Heavy metals (air)	kg Ni eq	6,82E-04	5,65E-03	-1,83E-05	6,32E-03	6,34E-03
19,1	PAHs (air)	kg PAH/20 eq	2,13E-06	2,77E-06	-7,91E-07	4,11E-06	4,90E-06
20	winter smog - P.M.	kg SPM	4,89	19,40	-0,16	24,13	24,29
21	Heavy metals (water)	kg Hg/20 eq	4,82E-03	3,07E-02	-8,49E-04	3,46E-02	3,55E-02
22	eutrophication	kg PO4	0,29	0,82	-0,02	1,09	1,11
23	POP (water)	kg TE eq	0	0	0	0	0
	heavy metals	kg Pb	0,005028606	0,024384899	-0,000358783	0,029054722	0,029413505
	carcinogens	kg B(a)P	3,05035E-05	8,14643E-05	-4,2362E-05	6,96059E-05	0,000111968
	pesticides	kg act.subst	0	0	0	0	0

In the following table, outputs by EuP-Ecoreport method has been reported, in a comparable way.

Table A.20: COLD 7 – LCA output from EuP-Ecoreport

			Production	Distribution	Use	End of Life	Total	Total - EoL - Distribution
8	Total Energy (GER)	MJ	4669	1115	49414	-459	54738	54082
12 (+13)	waste	kg	85,41	0,58	59,18	5,98	151,13	144,58
14	Greenhouse Gases in GWP100	kg CO2 eq.	257,00	67,00	2158,00	10,00	2493,00	2416,00
15	Ozone Depletion, emissions	mg R-11 eq.						0
16	Acidification, emissions	kg SO2 eq.	2,03	0,21	12,72	0,03	14,99	14,76
17	Volatile Organic Compounds (VOC)	kg	0,006	0,016	0,019	0,003	0,045	0,026
18	Persistent Organic Pollutants (POP)	kg i-Teq	4,08E-10	3E-12	3,27E-10	2,6E-11	7,65E-10	7,36E-10
19	Heavy Metals	kg Ni eq.	1,07E-03	2,90E-05	8,67E-04	1,29E-04	2,09E-03	1,94E-03
19,1	PAHs	kg Ni eq.	1,41E-03	3,70E-05	1,21E-04	-3,00E-06	1,57E-03	1,54E-03
20	Particulate Matter (PM, dust)	kg	0,46	2,68	0,44	0,98	4,55	0,90
21	Heavy Metals	kg Hg/20	9,88E-04	1,00E-06	3,28E-04	3,10E-05	1,35E-03	1,32E-03
22	Eutrophication	kg PO4	0,061	0	0,002	0	0,063	0,063
23	Persistent Organic Pollutants (POP)	ng i-Teq						0

A.5 SIMAPRO OUTPUTS

Table A.21: COLD 7 – Assembling phase – Output of SimaPro with “Ecoindicator 95 rev EuP method”

Impact category	*greenhouse*	*ozone layer*	*acidification*	*eutrophication*	*heavy metals*	*carcinogens*	*winter smog - P.M.*	*summer smog - VOCs*	*pesticides*	*energy resources*	*solid waste*	*Heavy metals (air)*	*PAHs (air)*	*Heavy metals (water)*	*POP (air)*	*POP (water)*
Unit	kg CO2	kg CFC11	kg SO2	kg PO4	kg Pb	kg B(a)P	kg SPM	kg C2H4	kg act.subst	MJ LHV	kg	kg Ni eq	kg PAH/20 eq	kg Hg/20 eq	kg TE eq	kg TE eq
Total	6,00E+02	6,36E-04	6,29E+00	2,88E-01	5,03E-03	3,05E-05	4,89E+00	3,73E-01	0,00E+00	1,15E+04	3,31E+02	6,82E-04	2,13E-06	4,82E-03	1,52E-09	0,00E+00
Crude iron I	1,77E+01	8,19E-08	1,84E-01	1,64E-02	1,94E-04	1,16E-05	1,13E-01	8,48E-03	0,00E+00	4,01E+02	4,00E+00	3,31E-05	7,25E-07	2,56E-05	2,09E-14	0,00E+00
Crude iron I	8,23E-01	3,82E-09	8,57E-03	7,66E-04	9,02E-06	5,41E-07	5,26E-03	3,95E-04	0,00E+00	1,87E+01	1,86E-01	1,54E-06	3,37E-08	1,19E-06	9,72E-16	0,00E+00
Steel I	7,88E-03	3,65E-11	7,51E-05	6,68E-06	1,64E-07	5,34E-09	4,92E-05	3,56E-06	0,00E+00	1,55E-01	8,40E-05	2,39E-08	4,96E-10	1,30E-08	7,35E-13	0,00E+00
X5CrNi18 (304) I	3,32E+00	6,34E-09	1,29E-01	1,16E-03	1,14E-05	3,61E-07	1,27E-01	4,23E-04	0,00E+00	4,81E+01	1,11E-02	1,66E-06	3,42E-08	1,49E-06	4,95E-11	0,00E+00
Steel I	3,74E+00	1,74E-08	3,57E-02	3,18E-03	7,80E-05	2,54E-06	2,34E-02	1,69E-03	0,00E+00	7,39E+01	3,99E-02	1,14E-05	2,36E-07	6,16E-06	3,49E-10	0,00E+00
Steel I	1,54E+00	7,16E-09	1,47E-02	1,31E-03	3,22E-05	1,05E-06	9,65E-03	6,97E-04	0,00E+00	3,05E+01	1,65E-02	4,69E-06	9,73E-08	2,54E-06	1,44E-10	0,00E+00
Steel I	1,03E+01	4,80E-08	9,87E-02	8,78E-03	2,15E-04	7,01E-06	6,46E-02	4,67E-03	0,00E+00	2,04E+02	1,10E-01	3,14E-05	6,52E-07	1,70E-05	9,66E-10	0,00E+00
Aluminium rec. I	1,81E+00	0,00E+00	3,03E-02	3,94E-04	4,14E-09	1,49E-10	2,97E-02	2,29E-03	0,00E+00	2,40E+01	2,67E-01	1,89E-07	3,35E-09	0,00E+00	0,00E+00	0,00E+00
Copper I	1,44E+01	8,92E-10	1,32E+00	6,10E-03	2,17E-07	9,93E-10	1,29E+00	5,30E-04	0,00E+00	1,81E+02	2,56E+02	6,49E-08	1,24E-08	1,41E-07	2,27E-16	0,00E+00
Zinc I	7,96E-01	5,04E-08	1,11E-02	3,86E-04	8,28E-06	2,22E-08	9,35E-03	1,52E-04	0,00E+00	1,07E+01	1,71E-01	1,76E-06	7,41E-10	8,27E-06	1,28E-14	0,00E+00
Cardboard duplex/tripl	1,75E+00	4,45E-07	8,56E-03	8,65E-04	8,39E-06	1,10E-07	6,24E-03	6,62E-04	0,00E+00	3,33E+01	3,30E-01	3,32E-06	1,78E-09	2,51E-06	0,00E+00	0,00E+00
PS (EPS) B250 (1998)	3,30E+00	1,80E-06	2,43E-02	2,04E-03	7,15E-06	9,12E-08	1,38E-02	2,75E-03	0,00E+00	9,64E+01	5,23E-02	1,18E-06	2,40E-09	2,66E-06	0,00E+00	0,00E+00
PE (LDPE) I	2,92E-01	0,00E+00	4,53E-03	4,32E-04	1,94E-07	2,32E-10	3,11E-03	2,17E-03	0,00E+00	2,16E+01	1,02E-02	0,00E+00	4,67E-10	0,00E+00	0,00E+00	0,00E+00
PP granulate average B250	6,61E-02	5,19E-08	6,37E-04	4,86E-05	1,57E-07	4,90E-10	3,88E-04	1,42E-04	0,00E+00	2,58E+00	1,10E-03	4,18E-08	4,94E-11	1,43E-07	0,00E+00	0,00E+00
Poplar I	1,24E-03	2,52E-11	1,59E-05	2,58E-06	2,16E-09	1,44E-11	3,54E-06	1,85E-06	0,00E+00	2,54E-01	1,05E-03	4,38E-09	8,13E-12	4,00E-09	6,43E-18	0,00E+00
ABS I	2,89E+00	8,58E-07	1,52E-02	1,63E-03	9,15E-07	1,76E-08	8,58E-03	1,80E-03	0,00E+00	7,44E+01	1,04E-01	0,00E+00	6,52E-09	0,00E+00	0,00E+00	0,00E+00
EPDM rubber ETH U	1,31E-02	4,30E-08	1,10E-04	8,26E-06	3,55E-07	1,38E-09	9,11E-05	6,33E-05	0,00E+00	4,25E-01	0,00E+00	6,65E-08	1,13E-11	2,64E-07	5,27E-15	0,00E+00
PS (EPS) B250 (1998)	1,03E-01	5,62E-08	7,58E-04	6,38E-05	2,23E-07	2,84E-09	4,29E-04	8,58E-05	0,00E+00	3,01E+00	1,63E-03	3,69E-08	7,49E-11	8,29E-08	0,00E+00	0,00E+00
PA 6 I	1,59E-01	0,00E+00	3,40E-04	5,03E-05	2,18E-07	7,82E-10	1,01E-04	1,27E-04	0,00E+00	3,18E+00	2,57E-04	1,38E-07	3,67E-11	0,00E+00	0,00E+00	0,00E+00
PC I	2,91E-02	1,06E-08	1,48E-04	1,71E-05	6,16E-09	2,36E-11	6,90E-05	1,19E-05	0,00E+00	5,58E-01	1,10E-03	0,00E+00	3,82E-11	0,00E+00	0,00E+00	0,00E+00

Impact category	***greenhouse***	***ozone layer***	***acidification***	***eutrophication***	***heavy metals***	***carcinogens***	***winter smog - P.M.***	***summer smog - VOCs***	***pesticides***	***energy resources***	***solid waste***	***Heavy metals (air)***	***PAHs (air)***	***Heavy metals (water)***	***POP (air)***	***POP (water)***
PE (HDPE) I	3,51E-02	0,00E+00	4,86E-04	4,96E-05	2,63E-08	6,66E-12	2,98E-04	3,12E-04	0,00E+00	2,82E+00	1,19E-03	0,00E+00	4,47E-11	0,00E+00	0,00E+00	0,00E+00
PE (HDPE) I	4,37E-02	0,00E+00	6,05E-04	6,17E-05	3,27E-08	8,29E-12	3,71E-04	3,88E-04	0,00E+00	3,51E+00	1,49E-03	0,00E+00	5,57E-11	0,00E+00	0,00E+00	0,00E+00
PET amorph I	1,19E-02	0,00E+00	1,50E-04	7,06E-06	2,19E-08	9,96E-11	1,14E-04	1,47E-05	0,00E+00	1,90E-01	2,93E-04	0,00E+00	1,20E-10	0,00E+00	0,00E+00	0,00E+00
HDPE B250	1,01E-02	5,07E-09	6,18E-05	6,35E-06	1,64E-08	4,75E-11	2,84E-05	3,42E-05	0,00E+00	3,50E-01	1,51E-04	4,49E-09	5,68E-12	1,52E-08	0,00E+00	0,00E+00
PP I	1,74E+00	0,00E+00	2,86E-02	2,15E-03	1,36E-06	1,41E-09	2,06E-02	8,19E-03	0,00E+00	1,25E+02	4,91E-02	0,00E+00	2,22E-09	0,00E+00	0,00E+00	0,00E+00
PS (EPS) B250 (1998)	2,39E+01	1,31E-05	1,77E-01	1,49E-02	5,20E-05	6,62E-07	1,00E-01	2,00E-02	0,00E+00	7,00E+02	3,80E-01	8,61E-06	1,75E-08	1,93E-05	0,00E+00	0,00E+00
PUR semi rigid foam I	2,90E+01	1,94E-07	2,62E-01	3,58E-02	1,37E-03	1,02E-07	2,01E-01	3,99E-02	0,00E+00	5,74E+02	4,94E+00	1,87E-06	3,13E-08	3,07E-05	4,94E-14	0,00E+00
PUR semi rigid foam I	7,98E+00	5,33E-08	7,20E-02	9,86E-03	3,77E-04	2,81E-08	5,52E-02	1,10E-02	0,00E+00	1,58E+02	1,36E+00	5,13E-07	8,62E-09	8,44E-06	1,36E-14	0,00E+00
PVC B250	7,43E-01	2,13E-07	8,79E-03	8,23E-04	3,67E-06	5,13E-09	4,68E-03	2,16E-03	0,00E+00	2,22E+01	4,66E-02	3,98E-07	1,94E-09	6,76E-06	0,00E+00	0,00E+00
adhesive - glue	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Paint ETH S	1,60E-02	1,36E-08	1,13E-04	4,47E-06	1,85E-06	1,13E-08	9,69E-05	7,28E-06	0,00E+00	3,06E-01	0,00E+00	6,18E-07	1,11E-11	1,19E-07	8,22E-16	0,00E+00
Glass (white) B250	4,81E+00	4,37E-06	2,81E-02	2,10E-03	2,90E-04	3,12E-08	1,69E-02	4,34E-03	0,00E+00	7,59E+01	4,28E-01	1,42E-05	9,89E-09	4,92E-06	0,00E+00	0,00E+00
adhesive - glue	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Kraft paper, bleached, at plant/RER U	-1,29E-01	4,62E-08	2,67E-03	1,34E-03	6,23E-06	4,61E-08	1,58E-03	1,58E-04	0,00E+00	2,22E+01	0,00E+00	8,57E-07	0,00E+00	2,04E-05	1,42E-12	0,00E+00
Refrigerant R134a, at plant/RER U	3,95E+00	5,45E-04	3,58E-03	2,59E-04	6,58E-06	1,92E-08	3,09E-03	1,51E-04	0,00E+00	6,30E+00	0,00E+00	6,63E-07	0,00E+00	9,12E-06	3,11E-14	0,00E+00
EPDM rubber ETH U	6,54E-01	2,14E-06	5,48E-03	4,11E-04	1,76E-05	6,89E-08	4,53E-03	3,15E-03	0,00E+00	2,12E+01	0,00E+00	3,31E-06	5,61E-10	1,31E-05	2,62E-13	0,00E+00
Electronics for control units/RER U	1,38E+00	7,43E-08	1,13E-02	2,02E-03	1,90E-04	9,00E-07	9,91E-03	5,22E-04	0,00E+00	3,22E+01	0,00E+00	5,30E-05	0,00E+00	3,10E-04	1,27E-12	0,00E+00
Copper I	2,07E+00	1,28E-10	1,90E-01	8,79E-04	3,13E-08	1,43E-10	1,85E-01	7,64E-05	0,00E+00	2,61E+01	3,69E+01	9,35E-09	1,78E-09	2,03E-08	3,27E-17	0,00E+00
Electronics for control units/RER U	1,47E+00	7,91E-08	1,20E-02	2,15E-03	2,02E-04	9,58E-07	1,06E-02	5,55E-04	0,00E+00	3,42E+01	0,00E+00	5,64E-05	0,00E+00	3,30E-04	1,36E-12	0,00E+00
Lubricating oil, at plant/RER U	1,86E-01	1,61E-07	1,67E-03	9,04E-04	2,62E-06	1,57E-08	1,35E-03	9,69E-04	0,00E+00	1,53E+01	0,00E+00	6,04E-07	0,00E+00	4,99E-06	4,57E-14	0,00E+00
Water demineralized ETH U	1,28E-01	1,69E-07	9,76E-04	3,83E-05	1,31E-06	3,23E-09	7,78E-04	4,08E-05	0,00E+00	2,92E+00	0,00E+00	6,42E-07	1,03E-10	2,79E-06	8,42E-15	0,00E+00
Lubricating oil, at plant/RER U	2,63E-02	2,27E-08	2,36E-04	1,27E-04	3,69E-07	2,21E-09	1,90E-04	1,37E-04	0,00E+00	2,16E+00	0,00E+00	8,52E-08	0,00E+00	7,04E-07	6,45E-15	0,00E+00
Nitrogen, liquid, at plant/RER U	3,25E-02	1,44E-09	1,71E-04	1,26E-05	2,12E-07	2,08E-09	1,36E-04	2,98E-06	0,00E+00	7,91E-01	0,00E+00	4,27E-08	0,00E+00	2,39E-07	2,86E-15	0,00E+00
Argon, liquid, at plant/RER U	1,39E-03	6,07E-	7,29E-06	5,42E-07	9,09E-	8,82E-11	5,77E-	1,34E-	0,00E+0	3,46E-	0,00E+0	1,83E-	0,00E+00	1,04E-	1,21E-16	0,00E+0

Impact category	***greenhouse***	***ozone layer***	***acidification***	***eutrophication***	***heavy metals***	***carcinogens***	***winter smog - P.M.***	***summer smog - VOCs***	***pesticides***	***energy resources***	***solid waste***	***Heavy metals (air)***	***PAHs (air)***	***Heavy metals (water)***	***POP (air)***	***POP (water)***
		11			09		06	07	0	02	0	09		08		0
Oxygen, liquid, at plant/RER U	9,85E-03	4,37E-10	5,17E-05	3,81E-06	6,44E-08	6,31E-10	4,12E-05	9,05E-07	0,00E+00	2,40E-01	0,00E+00	1,29E-08	0,00E+00	7,26E-08	8,66E-16	0,00E+00
Electricity MV use in UCPTE U	1,35E+01	6,65E-06	9,62E-02	3,27E-03	9,13E-05	3,01E-07	8,04E-02	2,94E-03	0,00E+00	3,18E+02	0,00E+00	2,30E-05	6,56E-09	1,34E-04	8,35E-13	0,00E+00
Heat gas B250	9,50E-01	1,09E-08	1,17E-03	1,49E-04	3,55E-07	7,04E-08	5,03E-04	1,09E-04	0,00E+00	1,60E+01	0,00E+00	1,84E-07	7,57E-10	4,41E-07	0,00E+00	0,00E+00
Truck 28t B250	1,08E+01	1,20E-05	1,46E-01	2,46E-02	1,64E-05	8,41E-08	1,56E-02	2,70E-02	0,00E+00	1,41E+02	0,00E+00	5,68E-06	1,13E-07	4,51E-06	0,00E+00	0,00E+00
Sea ship B250	2,48E-01	2,76E-07	3,77E-03	8,45E-05	5,24E-06	1,15E-08	3,33E-03	2,42E-04	0,00E+00	3,41E+00	0,00E+00	2,27E-06	1,66E-10	1,99E-07	0,00E+00	0,00E+00
Hot rolling, steel/RER U	7,13E-01	5,87E-08	2,42E-03	1,07E-03	7,54E-05	8,26E-08	2,37E-03	5,18E-04	0,00E+00	1,51E+01	0,00E+00	2,10E-06	0,00E+00	7,70E-05	1,05E-12	0,00E+00
Sheet rolling, steel/RER U	1,46E+00	1,05E-07	6,80E-03	2,66E-03	1,98E-04	1,82E-07	6,51E-03	4,00E-04	0,00E+00	3,14E+01	0,00E+00	2,09E-06	0,00E+00	1,49E-03	3,24E-12	0,00E+00
Extruding alum I	4,19E+02	4,52E-05	3,27E+00	1,32E-01	1,31E-03	2,38E-06	2,41E+00	1,40E-01	0,00E+00	7,65E+03	2,57E+01	3,14E-04	1,31E-07	2,11E-03	3,75E-12	0,00E+00
Wire drawing, copper/RER U	2,13E+00	1,15E-07	1,55E-02	1,18E-03	1,83E-04	5,45E-07	1,33E-02	6,36E-04	0,00E+00	5,01E+01	0,00E+00	6,94E-05	0,00E+00	1,02E-04	9,50E-13	0,00E+00
Foaming, expanding/RER U	8,30E+00	1,10E-06	4,49E-02	3,22E-03	3,97E-05	4,54E-07	3,57E-02	8,10E-02	0,00E+00	1,68E+02	0,00E+00	2,72E-05	0,00E+00	3,79E-05	5,10E-13	0,00E+00
Injection moulding/RER U	2,34E+00	1,46E-06	1,08E-02	1,57E-03	1,85E-05	1,68E-07	7,90E-03	6,08E-04	0,00E+00	5,86E+01	0,00E+00	3,48E-06	0,00E+00	3,35E-05	3,03E-13	0,00E+00
Extrusion PVC I	9,85E-02	0,00E+00	1,51E-03	1,11E-04	9,71E-09	4,48E-11	1,22E-03	2,89E-04	0,00E+00	1,39E+00	4,24E-03	1,08E-12	9,54E-11	0,00E+00	0,00E+00	0,00E+00

Table A.22: COLD 7 – EoL phase – Output of SimaPro with "Ecoindicator 95 rev EuP method"

Impact category	*Unit*	*Total*	*Recycling only B250 avoided*	*Incineration 2000 B250 (98) avoided*	*Landfill B250 (98)*
greenhouse	kg CO2	-5,94E+01	-6,65E+01	6,51E+00	5,74E-01
ozone layer	kg CFC11	-2,79E-05	-2,75E-05	-3,94E-07	3,20E-08
acidification	kg SO2	-2,64E-01	-2,55E-01	-9,04E-03	5,52E-04
eutrophication	kg PO4	-2,34E-02	-2,34E-02	-1,48E-04	2,06E-04
heavy metals	kg Pb	-3,57E-04	-3,68E-04	1,03E-05	6,01E-07
carcinogens	kg B(a)P	-4,24E-05	-4,23E-05	-4,90E-08	2,46E-10
winter smog - P.M.	kg SPM	-1,56E-01	-1,47E-01	-8,42E-03	2,59E-04
summer smog - VOCs	kg C2H4	-6,86E-02	-6,86E-02	-2,47E-04	2,06E-04
pesticides	kg act.subst	0,00E+00	0,00E+00	0,00E+00	0,00E+00
energy resources	MJ LHV	-1,12E+03	-1,08E+03	-4,32E+01	4,19E-01
solid waste	kg	-4,51E+01	-4,51E+01	0,00E+00	0,00E+00
Heavy metals (air)	kg Ni eq	-1,81E-05	-2,12E-05	2,96E-06	1,48E-07
PAHs (air)	kg PAH/20 eq	-7,91E-07	-7,93E-07	1,38E-09	3,13E-10
Heavy metals (water)	kg Hg/20 eq	-8,47E-04	-8,46E-04	-9,61E-06	8,81E-06
POP (air)	kg TE eq	4,67E-11	0,00E+00	4,66E-11	7,59E-14
POP (water)	kg TE eq	0,00E+00	0,00E+00	0,00E+00	0,00E+00

Table A.23: COLD 7 – Life Cycle – Output of SimaPro with "Ecoindicator 95 rev EuP method"

Impact category	*Unit*	*Total*	*COLD7 assembling*	*Electricity LV use UCPTE U*	*Delivery van (<3.5t) B250*	*cold 7 EoL*	*cold 7 use materials (per LC)*
greenhouse	kg CO2	3.626,95	600,20	2.815,55	0,54	-59,43	270,09
ozone layer	kg CFC11	0,00	0,00	0,00	0,00	-0,00	0,00
acidification	kg SO2	29,37	6,29	20,51	0,00	-0,26	2,83
eutrophication	kg PO4	1,09	0,29	0,69	0,00	-0,02	0,13
heavy metals	kg Pb	0,03	0,01	0,02	0,00	-0,00	0,00
carcinogens	kg B(a)P	0,00	0,00	0,00	0,00	-0,00	0,00
winter smog - P.M.	kg SPM	24,13	4,89	17,19	0,00	-0,16	2,20
summer smog - VOCs	kg C2H4	1,11	0,37	0,63	0,00	-0,07	0,17
pesticides	kg act.subst	0,00	0,00	0,00	0,00	0,00	0,00
energy resources	MJ LHV	82.304,50	11.512,99	66.711,95	6,94	-1.108,22	5.180,84
solid waste	kg	520,15	331,22	85,00	0,00	-45,12	149,05
Heavy metals (air)	kg Ni eq	0,01	0,00	0,01	0,00	-0,00	0,00
PAHs (air)	kg PAH/20 eq	0,00	0,00	0,00	0,00	-0,00	0,00
Heavy metals (water)	kg Hg/20 eq	0,03	0,00	0,03	0,00	-0,00	0,00
POP (air)	kg TE eq	0,00	0,00	0,00	0,00	0,00	0,00
POP (water)	kg TE eq	0	0	0	0	0	0