Topten Product Criteria Paper on

Domestic Cold Appliances

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Supported by

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The Project in brief

Topten is part of the international Euro-Topten Plus initiative supported by the European programme Intelligent Energy Europe and several national institutions (energy agencies, WWF, consumer associations, research institutes). On global level, Topten is coordinated by TIG, the Topten International Group. This association promotes to the Topten Charter, TIG statutes and Rules of Procedure (www.topten.info).

Topten is a service that supports the market for energy efficient products. It aims at making energy efficient products the first choice for consumers, by offering them a user-friendly tool for product comparison and selection. The key element is an online information platform for consumers presenting the most energy efficient appliances currently available in various product categories, including household appliances, office equipment, consumer electronics and cars. Information on energy consumption and performance of products as well as several other characteristics (i.e. brand, model, price, picture) is provided. Product data is based on labels and standardized declarations as well as tests from accepted well-known institutions. The service is independent of manufacturers and retailers.

Consortium

The project is co-ordinated by the Agence de l'Environnement et de la Maitrise de l'Energie (ADEME). The other 19 project partners are:

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1 Introduction

Criteria papers provide a central tool for the Euro-Topten Plus partners to collect and analyse product data and to establish a national Topten selection. Appropriate selection criteria and technical specifications are a crucial precondition for meaningful and well-accepted Topten websites. The purpose of this criteria paper is to provide a common basis for the definition of technical specifications of domestic cold appliances. Obviously, the range of products differs significantly in European member States in terms of price level, configuration, energy classes and energy consumption corresponding to levels of purchasing power and behavioural aspects (mentality, customs, etc.).

Within the Europe-wide Topten project, an aligned approach for technical specifications for all national Topten websites is aimed at. A high level of uniformity and congruency of the different national websites will enhance the awareness amongst manufacturers. Good-quality product data at national level furthermore allows to analyse the situation at European level and to make policy recommendations, which are shown on www.topten.info.

This paper contains the product specification for Topten Cold Appliances. A product should meet all criteria described in Chapter 4 in order to be listed on www.topten.info as a Best Available Technology.

If possible / ideally, criteria are based on international or European standards. Within the methodology of WP3, it was intended to use the implementation measures of the Ecodesign directive as a basis for the criteria definition. The information in this criteria paper is therefore mainly based on the “Preparatory studies for Eco-design Requirements of EuPs – Lot 13: Domestic Refrigerators and freezers” and the corresponding implementing measure.

The importance of refrigerators in terms of energy consumption is due to the high number of devices. It can be assumed that every household has at least a refrigerator and freezer or refrigerator-freezer combination. According to the EuP study about 23.3 million units were produced in 2005, thereof 18 million refrigerators and refrigerator-freezers and 5.3 million freezers. Due to the uncertainty of the data, these numbers are likely to be underestimated.

2 General Product Information

2.1 Product Definition

Domestic cold appliances, also known as “refrigerator and freezers”, have been the most studied energy using products in the European Union, with the goal to reduce their energy consumption. A device described as a "refrigerator" maintains a temperature a few degrees above the freezing point of water (from +5 to 0 °C) whereas a device which maintains a temperature below the freezing point of water is called a "freezer”. Most freezers operate around 0 °F (−18 °C). Domestic freezers can be included as a separate compartment in a refrigerator, or can be a separate appliance. Domestic freezers are generally upright units, or chest-type units laid on their back.

Within this paper “cold appliance” means a refrigerator or freezer, referring to Definitions outlined in the Commission Regulation (EC) No 643/2009 [L2]:

“This Regulation establishes ecodesign requirements for the placing on the market of electric mains-operated household refrigerating appliances with a storage volume up to 1 500 litres. (…) including those sold for non-household use or for the refrigeration of items other than foodstuffs. It shall also apply to electric mains-operated household refrigerating appliances that can be battery-operated.”

In addition to the definitions set out in Directive 2005/32/EC, the following definitions shall apply:

- ‘refrigerator’ means a refrigerating appliance intended for the preservation of foodstuffs with at least one compartment suitable for the storage of fresh food and/or beverages, including wine;

- ’refrigerator-freezer’ means a refrigerating appliance with at least one fresh-food storage compartment and at least one other compartment suitable for the freezing of fresh food and the storage of frozen foodstuffs under three-star storage conditions (the food-freezer compartment);

- ‘foodstuffs’ means food, ingredients, beverages, including wine, and other items primarily intended for consumption which require refrigeration at specified temperatures;

- ‘frozen-food storage cabinet’ means a refrigerating appliance with one or more compartments suitable for the storage of frozen foodstuffs;

- ‘food freezer’ means a refrigerating appliance with one or more compartments suitable for freezing foodstuffs with temperatures ranging from ambient temperature down to – 18 °C, and which is also suitable for the storage of

frozen foodstuffs under three-star storage conditions; a food freezer may also include two-star sections and/or compartments within the compartment or cabinet;

- 'wine storage appliance' means a refrigerating appliance that has no compartment other than one or more wine storage compartments.

2.2 Product Category

Basically the main appliance catagories are:

- A refrigerator: refrigeration appliance for the preservation of food and fresh food
- A refrigerator-freezer combination: refrigerating appliance having at least one compartment suitable for the storage of fresh food and at least one other compartment for the freezing and storage of food.
- A freezer: refrigerating appliance having one or more compartments for freezing foodstuffs from ambient temperature down to a temperature of -18°C and which is also suitable for the storage of frozen food.

Topten presents the following main categories and subcategories of cold appliances in comparison to the categorization within the EUP study:

Table 1 Comparison cold appliance categories EUP and topten.info

Catagories topten.info	Basic appliance catagories EUP study
▪ 1-door refrigerator-freezers o Freestanding o Built-in	refrigerator-freezer
▪ 2-door refrigerator-freezers o Freestanding o Built-in	refrigerator-freezer
▪ Upright freezers ▪ Chest freezers	freezers

Table 2 shows an example of the different catagories.

Tabelle 2 – From left to right: 1-door refrigerator, 2-door refrigerator, upright freezer, chest freezer (Source: www.topprodukte.at)

Within this criteria paper the catagorisation of Topten.info will be retained. There have not been any new design trends in the recent past that would require an update of the catagories for cold appliances. At national level it is possible that additional categories do exist according to the amount of top appliances available. In Austria for example, an additional seperation according to the hight of the appliance is made.

2.3 Product Types

For technical purposes the two main types of refrigerating appliances are defined by EN ISO 15502:2005:

- compression-type refrigerating appliance: refrigerating appliance in which refrigeration is effected by means of a motor-driven compressor
- absorption-type refrigerating appliance: refrigerating appliance in which refrigeration is effected by an absoprtion process using heat as energy source.

Because of using heat for changing the refrigerating fluid from gas back into liquid, the absorption-type refrigerater consumes far more energy and is less efficient than the compression-type.

The compression-type refrigerator is the most common one and is used in almost every household. Additional types of refrigerators are for example a Peltier-effect-based refrigerator. The Peltier effect uses electricity to pump heat directly. This type of refrigerator is sometimes used for camping, or where noise is not acceptable. They can be totally silent (if they don't include a fan for air circulation) but are less energy-efficient than other types.

Other alternatives to the compression-type refrigerator but not in current use include thermionic, vortex tube, air cycle, magnetic cooling, Stirling cycle, Malone refrigeration, acoustic cooling, pulse tube and water cycle systems. Due to their low usage, these alternatives they are not considered further within this paper.

2.4 Climate Classes

An important aspect of refrigerators, freezers and refrigerator-freezers are the climate classes. Cold appliances should have a climate class printed on their rating plate (or maybe in the instruction manual). This class indicates the minimum and maximum temperatures that the appliance is suitable to work at. The climate classes are shown in the following figure.

Class	Symbol	Ambient average temperature °C
Extended temperate	SN	+ 10 to + 32
Temperate	N	+ 16 to + 32
Subtropical	ST	+ 16 to + 38
Tropical	T	+ 16 to + 43

Figure 1 Climate classes [L2]

It is important to communicate to the end consumer that he has to take into account the climate classes during the purchasing procedure. The “climate class”, or more often simply “class”, determines in what ambient temperature range (the surrounding air or room temperature) the cold appliance can be used. The climate class is important for the efficiency of the product. E.g., if you cannot keep a normal device (“class N”) in a normal room with an average 18-22°C room temperature, you should rather switch to another product in a more appropriate climate class. Otherwise you run the risk of serious decrease of efficiency.

As an example, one can imagine a refrigerator of the subtropical class is placed in a garage. When winter comes, the refrigerator is not capable of running properly. This is

because if the ambient temperature of the room gets below 16°C, the fridge thermostat is likely to shut off. When this happens with appliances with only one thermostat the freezer also shuts off. If the temperature remains cold for several hours then the fridge thermostat will not come back on. It does not need to because the fridge compartment will be cold enough. In really cold weather it is possible for the fridge thermostat to stay off for a long time. Whilst ever the thermostat for the fridge remains off the compressor will stop running and the freezer will eventually start to warm up, at least to roughly the ambient temperature of the garage, which although cold, is not cold enough for frozen food.

2.5 Freezing Stars

European freezers, and refrigerators with a freezer compartment, have a four star rating system to grade freezers.

- 1 *: min temperature = −6 °C (21.2 °F). Maximum storage time for frozen food is 1 week
- 2 **: min temperature = −12 °C (10.4 °F). Maximum storage time for frozen food is 1 month
- 3 ***: min temperature = −18 °C (−0 °F). Maximum storage time for frozen food is 3 months
- 4 *(***): min temperature = −18 °C (−0 °F). Maximum storage time for frozen food is up to 12 months

Although both the three and four star ratings specify the same minimum temperature of -18 °C, only a four star freezer is intended to be used for freezing fresh food. Three (or fewer) stars are used for frozen food compartments which are only suitable for storing frozen food; introducing fresh food into such a compartment is likely to result in unacceptable temperature rises.

2.6 Best Available Technology

The principle of a refrigerator is to use the evaporation of a liquid to absorb heat. There are five basic parts of any refrigerator:

- Compressor
- Heat exchanging pipes – outside the unit to release the heat
- Expansion valve
- Heat exchanging pipes – inside the unit to absorb the heat
- Refrigerant – liquid that evaporates inside the ferigerator

Figure 1 gives an owerview of the basic mechanism of a refrigerator:

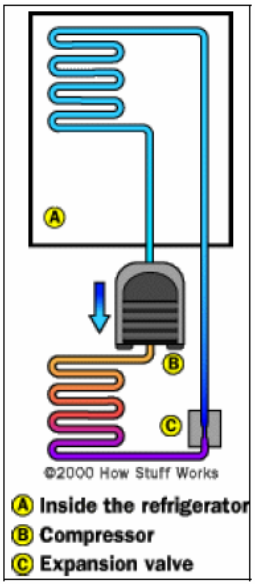


Figure 2 – Basic mechanism of a refrigerator (Source: L1)

The technological improvement options for cold appliances and the new trends concern to the optimization of these basic compartments in addition to a efficient control system. These improvement options are for example:

- Options to improve insulation and reduce heat losses
- High efficiency heat exchangers
- High efficiency compressors/motors
- Improvement to the control system
- Design options

Cold appliances efficiency is defined using Energy Efficiency Index (EEI) which is intended to allow comparison of different technologies and design options whilst removing the impact of a number of factors including the size, temperature and functions. The more efficient the technology, the closer to Zero is the value of EEI. The method for calculating the EEI is mentioned in chapter 2.7.2.1.

At the time when ecodesign regulation entered into force (22.07.2009), the best available technology (BAT) on the market for household refrigerating appliances in terms of their Energy Efficiency Index (EEI) and noise was identified by the EUP study as follows[1]:

[1] COMMISSION REGULATION (EC) No 643/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for household refrigerating appliances, page 16.

- Refrigerators, compression-type: EEI = 29.7 and energy consumption of 115 kWh/year for a total storage volume of 300 litres in a freshfood compartment plus a 25 litres chill compartment, and T (tropical) climate class, Noise: 33 dB(A).

- Refrigerators, absorption-type: EEI = 97.2 and energy consumption of 245 kWh/year for a total storage volume of 28 litres in a fresh-food compartment, and N (temperate) climatic class, Noise ≈ 0 dB(A).

- Refrigerator-freezers, compression-type: EEI = 28,0 and energy consumption of 157 kWh/year for a total storage volume of 255 litres, thereof 236 litres in a fresh-food compartment and 19 litres in a four-star freezer compartment, and T (tropical) climate class, Noise = 33 dB(A).

- Upright freezers, compression-type: EEI = 29.3 and energy consumption of 172 kWh/year for a total storage volume of 195 litres in a four-star freezer compartment, and T (tropical) climate class, Noise = 35 dB(A).

- Chest freezers, compression-type: EEI = 27.4 and an annual energy consumption of 153 kWh/year for a total storage volume of 223 litres in a four-star freezer compartment, and T (tropical) climate class, Noise = 37 dB(A).

Today the BAT which are listed on topten.info have a far better EEI (up to 16%) than stated in the EUP study! A market analysis by topten in 2007 showed that 115 different A++ cold appliance models were on the European market and this number has increased to 286 by June 2009 (topten.info). This market analysis covered 23 European countries (including Switzerland), and the 286 A++ cold appliance models (refrigerators and freezers) were of 31 different brands. Already today before implementing the new label there are A+++ chest- and upright freezers models on the market. Thus, one can judge the presentet BAT values and the setting of limits by the regulation as not being too ambitious at all. See therefore our recommendation for selection criteria in chapter 5 (specially 5.3).

The information about the EEI should be considered with due care. As you will see in chapter 2.7.2.1 the value of the EEI is highly depending on which climate class was used for the calculation. Most of the time, it referes to the climate class T (tropical) which is not necessarily adapted to most of the european countries. The common climate class for central Europe is N (temperate). Producers use the climate class to be better classifyed in the energy label because T and ST gives them a bonus in the calculation of the EEI. But it makes no sense to account the most efficient appliance for the tropical climate class for countries in northern Europe. Some of the products also have a so called “multiclass” climate class (Two or more climate classes). This only expresses the fact that these products can operate in a wider temperature range. Note

that the manufacturers will always tend to use the higher temperature range for getting a bonus in the EEI calculation (ST or T).

Another important fact is that cold appliances with a higher volume are also prefered by the calculation method of the EEI which is shown in chapter 2.7.2.1. In terms of energy efficiency, a larger refrigerator might be more efficient than a small one. But in reality a large refrigerator (even with energy efficiency class A++) uses more power than a small refrigerator which leads to an increase in total energy consumption for the larger appliance.

3 Legislation

3.1 Label

3.1.1 Current Criteria

The current criteria to be selected as an energy efficient cold appliance on topten.info is the energy class of the appliance according to the EU energy label according to the European Commission Directive 2003/66/EC of 3 July 2003. This energy label defines the energy classes from A++ (very energy efficient), A+, A, B to G (very inefficient). In order to be selected as a top-product on topten.info, the energy class of the cold appliance has to be at least A++ [2]. The products are ranked according to their energy efficiency index.

Cold appliances	
Class	Energy efficiency index
A++	< 30%
A+	30% - 42%
A	42% - 55%
B	55% - 75%
C	75% - 90%
D	90% - 100%
E	100% - 110%
F	110% - 125%
G	> 125%

Figure 3 - Energy Efficiency Index Label 2003

3.1.2 Future Label

In September 2010, the Regulatory Committee updated the energy labelling directive for refrigerators and freezers. According to the new specification, the labels are based on the present labelling scheme, with levels from A to G and have additional classes for products that are more efficient than an A-marked product: A+, A++ and A+++. The Energy Efficiency Index (EEI) as set out in Figure 3 shall apply from 30 November 2011, and in Figure 4 from 1 July 2014[3].

[2] For comparison, the average EEI for models put on the market in 1994 was C or D.

[3] It may be possible that manufacturers and retailers start using the new label before this date and that there might be a transition period with both labels beeing in use.

Energy Efficiency Class	Energy Efficiency Index
A+++	$EEI < 22$
A++	$22 \leq EEI < 33$
A+	$33 \leq EEI <$ **44**
A	**44** $\leq EEI < 55$
B	$55 \leq EEI < 75$
C	$75 \leq EEI < 95$
D	$95 \leq EEI < 110$
E	$110 \leq EEI < 125$
F	$125 \leq EEI < 150$
G (least efficient)	$EEI \geq 150$

Figure 4 – Energy efficiency classes from 30 November 2011 to 30 June 2014 [L3]

Energy Efficiency Class	Energy Efficiency Index
A+++	$EEI < 22$
A++	$22 \leq EEI < 33$
A+	$33 \leq EEI <$ **42**
A	**42** $\leq EEI < 55$
B	$55 \leq EEI < 75$
C	$75 \leq EEI < 95$
D	$95 \leq EEI < 110$
E	$110 \leq EEI < 125$
F	$125 \leq EEI < 150$
G (least efficient)	$EEI \geq 150$

Figure 5 – Energy efficiency classes from 1 July 2014 [L3]

3.1.2.1 Calculation Method of the EEI

The minimum performance requirements and proposed energy labelling scale are built on an "energy efficiency index" (EEI), which is the ratio between annual consumption of the appliance and a standard consumption of a typical similar model. The calculation method is similar to the one described in the amended Directive of 2003 (2003/66/EC) where the classes A+ and A++ have been introduced except that now the calculation method is similar for all energy classes (A+++ → G, class G will be only relevant for the absorption type Refrigerators). In simple terms, the volume largely determines the

result of the EEI, as you can see from the calculation for the S_{AE}. The volume V_{eq} is adjusted by correction factors which take into account the climate class, frost free compartments and if it is a “built in appliance”.

The Energy Efficiency Index (EEI) is calculated as:

$$EEI = \frac{AE_C}{SAE_C} * 100$$

where:

– AEc = Annual Energy Consumption of the household refrigerating appliance

– SAEc = Standard Annual Energy Consumption of the household refrigerating appliance.

The Annual Energy Consumption (AEC) is calculated in kWh/year as:

$AEc = E_{24h} * 365$

where:

– E_{24h} is the energy consumption of the household refrigerating appliance in kWh/24h.

The Standard Annual Energy Consumption (SAEC) is calculated in kWh/year as:

$SAEc = V_{eq} * M + N + CH$

where:

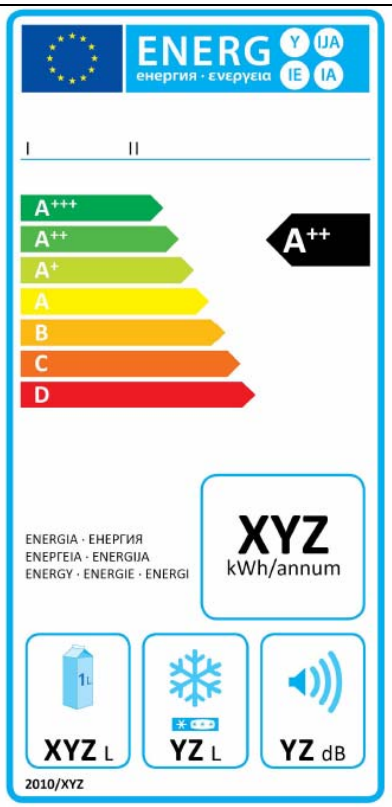
– V_{eq} is the equivalent volume of the household refrigerating appliance

– CH is equal to 50 kWh/year for household refrigerating appliances with a chill compartment with a storage volume of at least 15 litres

– the M and N values are given for each household refrigerating appliance category

The calculation method can be studied in detail under: Regulation Label

3.1.2.2 Label Scheme

<table>
<tr><th>Compression-Type</th><th>Absoprtin-Type</th></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td colspan="2">I. supplier’s name or trade mark
II. supplier’s model identifier
III. the energy efficiency class
IV. annual energy consumption (AEC) in kWh per year
V. sum of the storage volumes of all compartments that do not merit a star rating (i.e. operating temperature > − 6 ºC)
VI. sum of the storage volumes of all frozen-food storage compartments that merit a star rating (i.e. operating temperature ≤ − 6 ºC)
VII. noise emissions expressed in dB(A) re1 pW</td></tr>
</table>

3.2 Ecodesign Directive

The major European policy measures already in place are the mandatory energy labelling (Directive 94/2/EC), including the Amended Directive of 2003 (2003/66/EC) to introduce the A+ and A++ classes [EU 2003], and the unilateral agreement of the European Association of Household Appliance Manufacturers (CECED]. Within this voluntary commitment in October 2002 it was concluded to reduce the energy consumption of household refrigerators, freezers and their combinations. In July 2009,

the Regulatory Committee adopted new minimum energy performance requirements for refrigerators and freezers. Final regulation for domestic cold appliances entered into force on August 12, 2009.

The new regulation[4] includes general requirements, specific requirements, measurement requirements and requirements for information and labeling. This new regulation will be described below in detail.

3.2.1 General Ecodesign Requirements

From 1 July 2010:

- For wine storage appliances, the following information shall be displayed in the instruction booklet provided by manufacturers: "This appliance is intended to be used exclusively for the storage of wine".
- For household refrigerating appliances, information shall be provided in the instruction booklet provided by manufacturers concerning:
    - the combination of drawers, baskets and shelves that result in the most efficient use of energy for the appliance, and
    - how to minimise the energy consumption of the household refrigerating appliance in the use-phase.

2. From 1 July 2013:

- The fast freezing facility, or any similar function achieved through modification of the thermostat settings, in freezers and freezer compartments, shall, once activated by the end-user according to the manufacturer's instructions, automatically revert to the previous normal storage temperature conditions after no more than 72 hours. This requirement does not apply to refrigerator-freezers with one thermostat and one compressor which are equipped with an electromechanical control board.
- Refrigerator-freezers with one thermostat and one compressor which are equipped with an electronic control board and can be used in ambient temperatures below +16 °C according to the manufacturer's instructions shall be such that any winter setting switch or similar function guaranteeing the correct frozen-food storage temperature is automatically operated according to the ambient temperature where the appliance is installed.
- Household refrigerating appliances with a storage volume below 10 litres shall automatically enter in an operating condition with a power consumption of 0.00

[4] COMMISSION REGULATION (EC) No 643/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for household refrigerating appliances

Watt after no more than 1 hour when empty[5]. The mere presence of a hard off switch shall not be considered sufficient to fulfil this requirement.

3.2.2 Specific Ecodesign Requirements

Household refrigerating appliances within the scope of this Regulation with a storage volume equal to or higher than 10 litres shall comply with the energy efficiency index limits described below.

The specific ecodesign requirements described below shall not apply to:

- wine storage appliances or
- absorption-type refrigerating appliances and other-type refrigerating appliances belonging to Refrigerator with a 1-star, 2-star or 3-star compartment, Refrigerator-freezer, Upright freezer or Chest freezer.

Requirements for compressor-type appliances (95% of the market) are:

- From 1st July 2010: The current Class A becomes the new minimum energy performance requirement (EEI>55).
- From 1st July 2012: The current Class A+ becomes the new minimum energy performance requirement (EEI>44).
- From 1st July 2014: Somewhat stricter requirements than the current Class A+ becomes the new minimum energy performance requirement (EEI>42)[6]

(According to benchmarks the best appliances today reach EEI<30).

Requirements for absorption-type and other-type refrigerating appliances are:

- From 1st July 2010: EEI < 150
- From 1st July 2012: EEI < 125
- From 1st July 2015: EEI < 110

(According to benchmarks the best appliances today reach EEI<100).

When the energy labelling and performance requirements for fridges and freezers reach their full impact, they are estimated to save 6 TWh per year within the EU by 2020.

[5] This will lead to a phase out of those appliances

[6] This will be decided after a revision of the measure

Information to be provided by Manufacturers:

NOTE: Nowhere within the Regulation it is mentioned which and in what form information should be provided by the manufacturer. Nevertheless, for the purpose of conformity assessment, technical documentation must be available for enforcement authorities and shall contain the following elements:

- Technical parameters referred to above
- The result of the calculations of the Energy Efficiency Index

The full text of the Regulation can be downloaded from the official Journal: ECO-Design Regulation

4 Economic and Market Analysis

Information is based on the “Preparatory studies for Eco-design Requirements of EuPs – Lot 13: Domestic Refrigerators and freezers” of 2005 and the DEFRA study “Factors influencing the penetration of energy efficient electrical appliances into national markets in Europe” of 2009. The DEFRA study covers only the following nine countries: Switzerland (CH), Germany (DE), Denmark (DK), France (FR), United Kingdom (UK), Italy (IT), Netherlands (NL), Poland (PL) and Portugal (PT).

4.1.1 Production and Import/Export

“The production of cold appliances for the household appliances industry and market in the EU 27 is estimated to about 23.3 million units in 2005. However, since data relevant to some producing countries are missing this number is likely to be underestimated. The European non-EU countries for which data were collected (Turkey, Iceland, Norway, Switzerland, Russia and Ukraine) are responsible for 9 million cold appliances. The estimated overall European production of cold appliances is about 32,3 million units, of which roughly 26,1 million refrigerators and 6,2 million freezers. Again the uncertainty of these figures is not known”, [L1] page 6.

Country	Refrigerators	Freezers	Total
AT	**260**	**270**	530
BE	**600**	**75**	675
BG (1997)	21	0,8	21,8
CY	--	--	--
CZ	**480**	--	480
DE	1 500	550	2 050
DK (2004)	1 100	400	1 500
EE (2003)	n.a.	n.a.	n.a.
EL	140*		140
ES	1 841	379	2 220
FI	**15**	**20**	35
FR	**60**	**40**	100
IE		**5**	5
IT	5 496	1 890	7 386
LV	n.a	n.a	n.a.
LT	500*		500
LU	--	--	--
HU	**1 310**	**780**	2 090
MT	--	--	--
NL	--	--	--
PL	**1 460**	**100**	1 560
PT (2006)	300*		300
RO (2006)	**800**	**100**	900
SI (2003)	1 100	250	1 350
SK	n.a	n.a	n.a.
SE	**305**	**165**	470
UK	721	325	1 046
EU27	18 009	5 350	23 337
TR	**5 538**	**440**	5 978
IS	n.a	n.a	n.a.
NO	**20**	**30**	50
CH	125	48	173
RU	**2 050**	**355**	2 405
UKR	400*	n.a	400
non-EU	8 133	873	9 006
Total	26 142	6 223	32 343

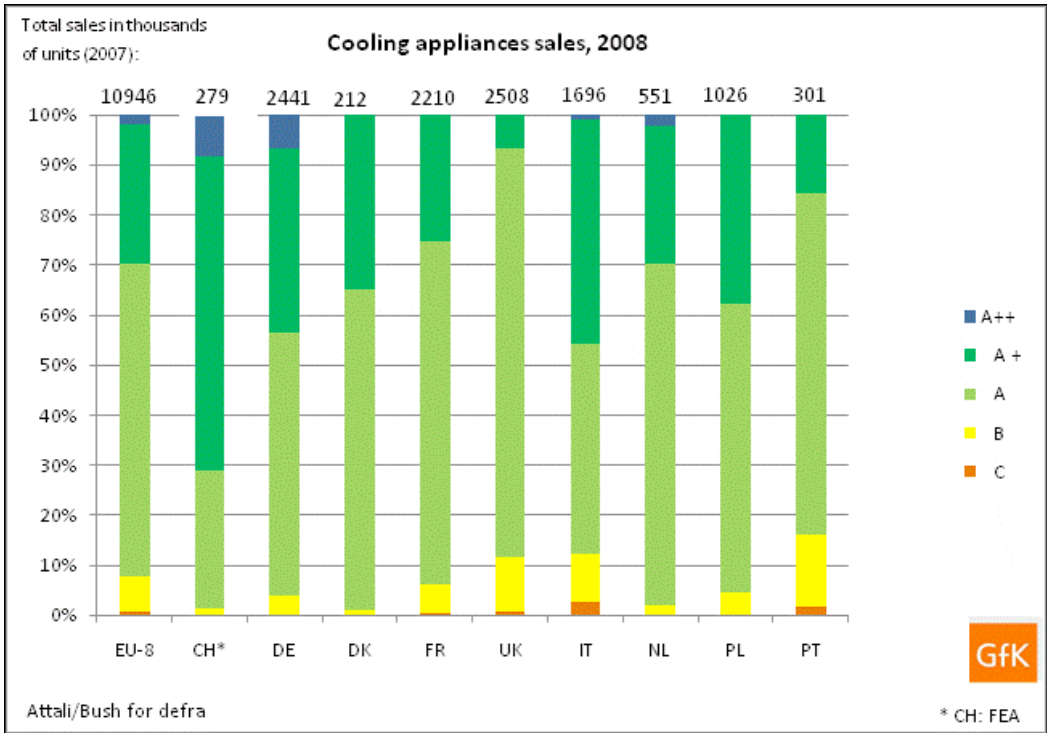
Figure 6 – Production of refrigerators and freezers (10^3 units), EU 2005 [L1]

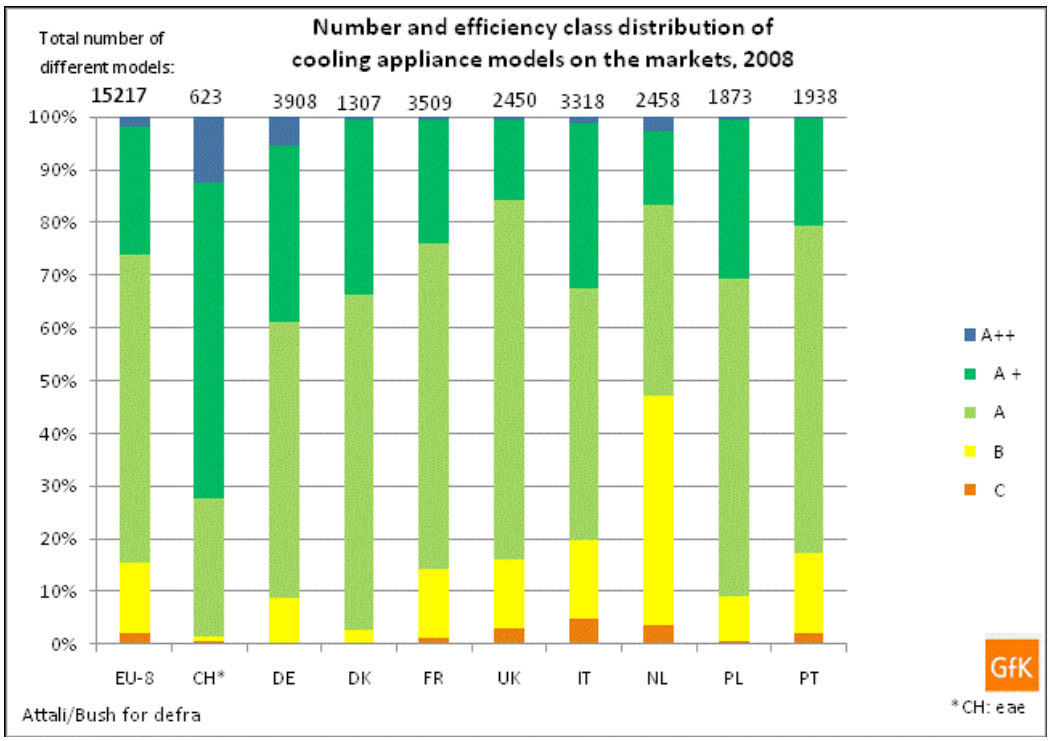
The import/export information given by the EUP LOT 13 study are provided by Eurostat (data on “refrigerator/freezer with separate external doors” and “freezers” are missing. The following table gives an overview of the import/export of EU25 in 2005:

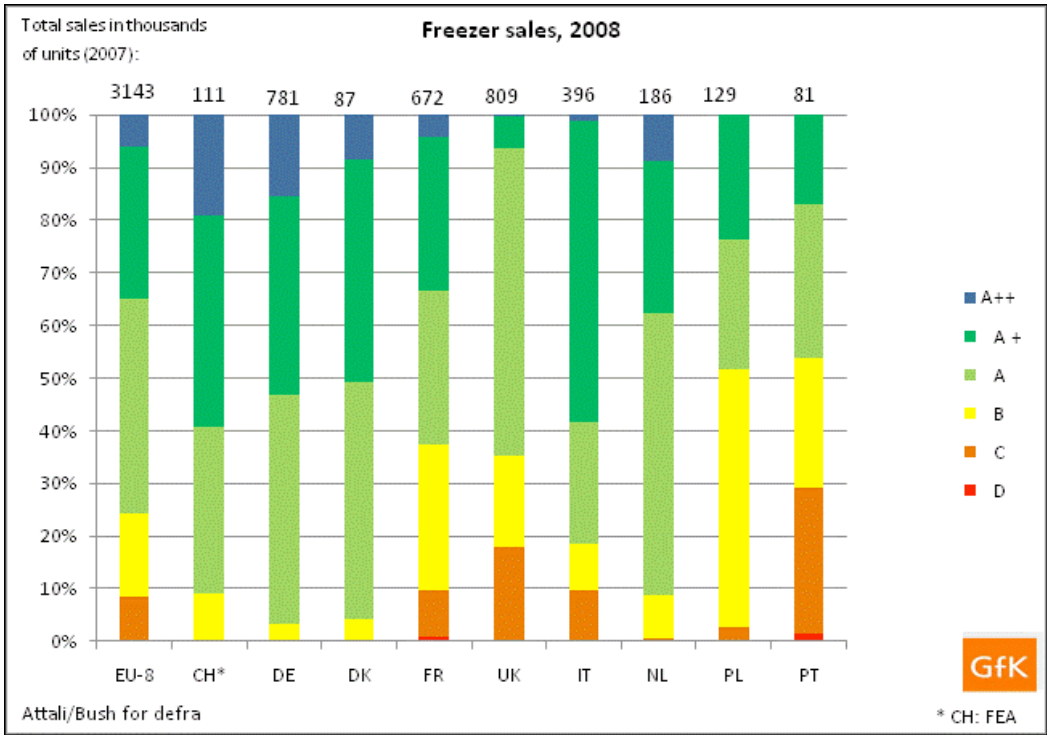
Table 3 Import & Export of refrigerators [L1]

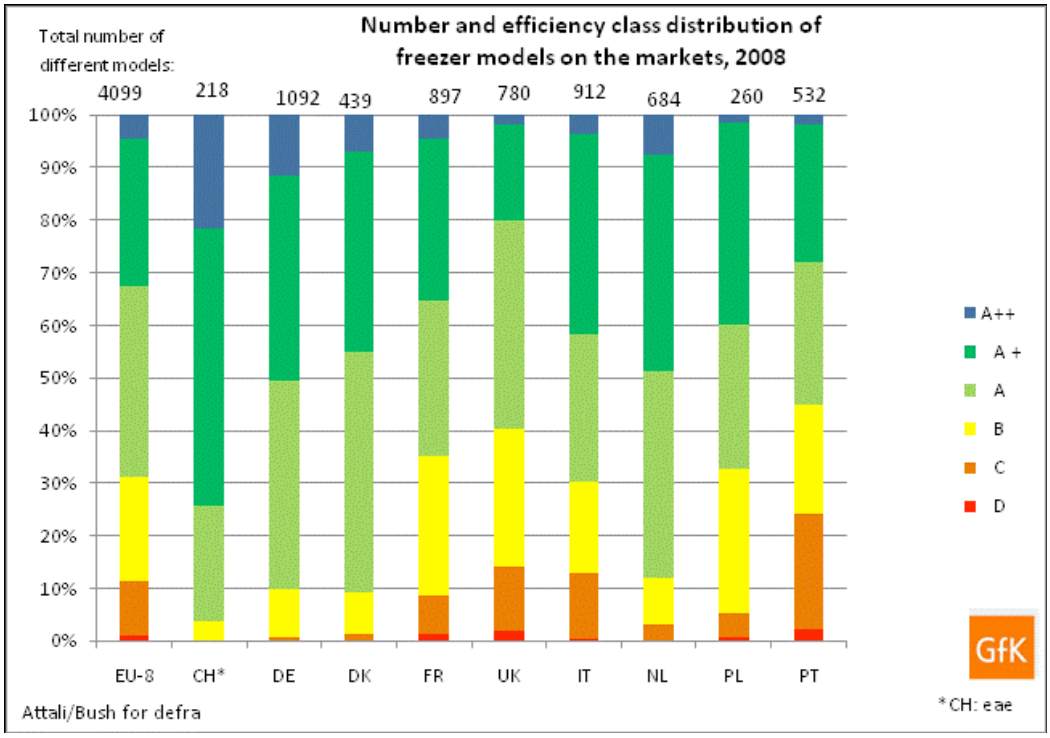
Technology	Import	Export
Compression-type built-in refrigerators	296.568	137.732
Household-type refrigerators (including compression-type electrical absorption) (excluding built-in)	7.527.507	3.243.919

The graphs below are taken out of the DEFRA study. They show the 2008 (10 months, from January to October) sales share and the number of models available by energy class. For the comparisons between countries, the numbers given are those of 2007, the last year for which full data was available.


Total sales in thousands of units (2007):
Cooling appliances sales, 2008
10946
279
2441
212
2210
2508
1696
551
1026
301
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
EU-8
CH*
DE
DK
FR
UK
IT
NL
PL
PT
A++
A +
A
B
C
GfK
Attali/Bush for defra
* CH: FEA


Total number of different models:
Number and efficiency class distribution of cooling appliance models on the markets, 2008
15217
623
3908
1307
3509
2450
3318
2458
1873
1938
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
EU-8
CH*
DE
DK
FR
UK
IT
NL
PL
PT
A++
A +
A
B
C
GfK
Attali/Bush for defra
*CH: eae





Although the nine countries studied are governed by the same basic legislation on energy labelling and minimum energy performance standards, and are supplied by the same manufacturers, there are remarkable national differences in the market share of efficient models across all product categories. This suggests that contextual factors like different tax systems, different electricity prices, different stimuli for energy saving,

different consumer cultures regarding product preference, sensitivity to environmental issues, etc. are of crucial importance[7].

4.2 Growth and Trends

The household appliance market of refrigerators and freezers is characterized by a high saturation. This especially applies to refrigerators with nearly 100% in some European countries. In Germany for example, 99% of all households possess a refrigerator. In some other European countries comparable data are noticed. The freezer market is lower and has decreased during the last decade due to the increase use of combined refrigerator/freezer devices.

Following trends on the market of refrigerator and freezers can be identified:

- Nowadays 80% of all appliances are in class A or better[8]
- Increase of capacity of refrigerators ~ 10%
- Annual energy consumption reduced
- Almost 4 catagories of cold appliances are left – refrigerator/freezer combination, standalone freezer upright/chest, multiuse and other appliances
- Chest freezers are less represented in efficiency class A and better
- Drastic increase in fridge-freezers with only one compressor and one thermostat
- Small changes in freezing capacity and temperature rise time
- Replacement of HFCs and HCFCs by hydrocarbons as refrigerant [9]. Hydrocarbons are for example Isobutan (R600a), Propan (R290) and Propen (R1270).

The number of models offered has increased, whereas the number of different catagories offered has decreased in the last 10 years to merely 4 categories where the combination of refrigerator/freezer is dominant in the market. These appliances work mostly with one compressor and one thermostat which limits them in adjustability[10]. Storage capacaty has stayed relatively constant with a slight increase of about 10%. Annual energy consumption has decereased also about 7% compared to 1995. In

[7] Source: DEFRA study, “Factors influencing the penetration of energy efficient electrical appliances into national markets in Europe”, 2009.

[8] Therefore one can conclude that the EEI reference values of the EUP directive are not ambitious (compare with chapter 3.2.2)

[9] Following the ban on chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), substances used as substitute refrigerants such as fluorocarbons (FCs) and hydrofluorocarbons (HFCs) have also come under criticism. They are currently subject to prohibition discussions on account of their harmful effect on the climate. In 2006, the EU adopted a Regulation on fluorinated greenhouse gases (regarding the use of FCs and HFCs) with the intention of reducing their emissions.

[10] The refrigerator-freezer combination with the freezer at the bottom can happen to have 2 compressors.

2005 about 80% of cold appliances were declared A and better. The most inefficient classes have disappeared from the market.

From the manufacturers' point of view, future cold appliances are not only characterized by good energy efficiency. In fact improved functionality, comfort and design attributes are emphasized. A visible trend is to accelerate the process of cooling and freezing of stored food and to achieve that food can be kept fresh longer. In this context the plurality of different foodstuffs is observed and because of that, different cooling zones with different atmospheric conditions are offered to the consumer.

There is a trend towards slightly larger-volume refrigerators and freezers. This trend seems to follow a behavioural change of the consumer for buying and storing more food products at a time. In terms of energy efficiency, a larger refrigerator might be more efficient than a small one. But the big disadvantage is the increase in energy consumption for the larger appliance.

The technological trends of cold appliances are based on the correct food preservation (in respect to hygiene), practical and comfort use, flexibility of the inner space, different temperatures areas within the appliance and the integration with other electronic appliances.

4.3 Manufacturers and Distributors

4.3.1 List of Manufacturers

The following manufacturers cover most of the EU cold appliance market:

Table 4 Cold Appliance Manufacturers

Manufacturers	Website	EU-Headquarter
ARCELIK	www.arcelik.com.tr	Istanbul
ARISTON THERMO Group	www.aristonthermo.com	Italy
BSH BOSCH UND SIEMENS HAUSGERÄTE GmbH	http://www.bsh-group.de	Germany
CANDY Hoover Group Srl	www.candy.it	Italy
DE LONGHI SpA	www.delonghi.com	Italy
AB ELECTROLUX	www.electrolux.com	Sweden
FAGOR Group	www.fagor.com	Spain
GORENJE d.d.	www.gorenje.si	Slovenia
INDESIT COMPANY SpA	www.indesitcompany.com	Italy
LIEBHERR HAUSGERÄTE	www.liebherr.com	Germany
MIELE & Cie. GmbH & Co.	www.miele.de	Germany

WHIRLPOOL EUROPE Srl	www.whirlpoolcorp.com	Italy

As you can see, there are few international manufacturers. These few large manufacturing companies are present in all countries and are also able to supply all countries with generally similar products from a technical point of view. There is also a trend towards the merging of individual brands. Nevertheless, there are significant national differences in terms of the market share and supply strategies for efficient appliances. This paradox can be partly explained by the market structure, which is less international than it initially seems. On the manufacturing side – especially in the white goods sector – sister companies or subsidiaries are often independently managed and, together with retailers, they choose the products they want to sell, influence the marketing of the various brands they manage, and set the price.

5 Selection Criteria

The proposed selection criteria are based on the EU Regulation (EC) No 643/2009 and the Draft Labelling Delegated Regulation for household refrigerating appliances as described in chapter 3.

5.1 Quality related product features

The following additional product features are recommended for additional quality criteria and should be provided in the Topten product tables. These information should not be used for the selection of the products:

- Annual energy consumption
- Climate Class
- Fresh and frozen food storage volumes
- Noise emissions
- Dimensions of the appliance
- "No Frost" and "low frost" attributes[11]

5.2 Energy Efficiency Criteria

The energy efficiency criteria shall include:

- Energy Efficiency Index

5.3 Recommendation for value setting

We suggest the following value setting:

- EEI < 33 % → acc. A++ upwards

[11] Ice deposits in freezing appliances caused by wet air lead to increased power consumption. Low-frost devices reduce the inflow of humid from the outside air without additional power consumption and make defrosting largely unnecessary. No-frost devices prevent ice deposits by a constant air flow through a continuously running fan.

6 Additional Considerations

When planning on buying a new appliance, most consumers get information from sales staff, advertisements and brochures. The primary aspect for the decision on a certain appliance is its price and size and arrangement of the interior followed by energy consumption. But most people are aware that there is an energy label for cold appliances and are familiar with the energy classes. The energy label for refrigerators and freezers is a bit confusing, because although there are no more appliances available today with class C till G, these classes are still mentioned. Cooling devices of class B have become extremely rare and will not be manufactured any longer. So today class A appliances are standard and therefore considering the energy label class A is the lowest energy class, so to speak. The class A is marked green on the label, but a Class A + + consumes only about half as much as a unit of energy class A.

An important aspect which influences the present and future energy consumption of cold appliances is the user behavior. The most crucial elements are keeping old appliances, the ambient temperature and door opening. Also putting hot food inside the refrigerator and not cleaning the evaporating grid can increase the energy consumption. Energy consumption is very sensitive to the ambient temperature: a 1°C reduction in ambient temperature produces a 6% decrease in electricity consumption. A surprising result from the survey undertaken in the EUP study was that the average ambient temperature given by respondents was reported at a quite low 19.5°C which is considerably below the 25°C used in standard test procedures. Similarly with freezers. The concern is that some users may purchase appliances in an inappropriate climate class underestimating their room temperature, which in some cases may not be the kitchens. Increased emphasis should be given to the choice of appropiate climate class of appliances including all forms of consumer information/advice before the purchase.

It is also important not to buy a refrigerator bigger than needed. When considering how much space is appropriate, it depends on whether the consumer buys a lot of frozen food or mostly fresh products. The capacity of fridges and freezers is typically measured in litres with the smallest available starting at around 100L and the largest domestic models around 438L. On average a capacity of around 113–140L is optimal for single person households with families requiring 254–311L depending on their size and appetite. If the consumer buys a lot of frozen food, a model with a 50/50 split between the fridge and freezer compartments might be a good option. If he has a lot of fresh products, then the more usual 70/30 split will be more appropriate. Combination fridge freezers, by far the most popular models, can nowadays be found with the freezer compartment located at either the bottom or the top of the unit.

Two refrigerators use more electricity than a single large refrigerator with equivalent storage space. And it is never a good idea to keep a half-empty refrigerator in the garage, while another refrigerator is in the kitchen with room to spare.

Whilst design and technological innovation can be highly seductive, one must not neglect basic issues. Adjustable glass shelving, for instance, is versatile and easy to clean. Bottle racks and clear fronted storage boxes are also practical options.

Refrigerators should be required to have at least two extra-features (as listed below) that help saving energy apart from the general energy efficiency requirements:

- Degree-precise adjustment of temperature
- Warning system in case the temperature gets too high (e.g. door open for too long)
- Automatic door-closure
- Special holiday-mode for longer terms of absence

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 product. Improvements will therefore take more than 10 years to get fully effective in the market

7 Bibliography

[L1] Preparatory studies for Eco-design Requirements of EuPs – Lot 13: Domestic Refigerators and freezers

[L2] COMMISSION REGULATION (EC) No 643/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for household refrigerating appliances

[L3] COMMISSION DELEGATED REGULATION (EU) implementing Directive 2010/…/EU of the European Parliament and of the Council with regard to energy labelling of household refrigerating appliances