Energy

Preparatory Studies for Eco-design Requirements of EuPs

(Tender TREN/D1/40-2005)

LOT 13: Domestic Refrigerators & Freezers

Final Report

Draft Version
Tasks 1 -2

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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

Refrigerators and freezers, also known as "cold appliances", have been the first and the most studied EuP in the European Union with the goal to reduce their energy consumption. In 1993, the study of the Group for Efficient Appliances (GEA, 1993) provided the technical basis for both the energy labelling and the energy efficiency requirements Directives, and later also partially for the eco-label awarding criteria. Its results and methodology were the starting point for the second study (ADEME, 2000, colloquially known as the COLD-II study) promoted by DG TREN in 1998 which took into consideration the methodological, technical, economical and market developments and proposed a new structure for a revised label and a new set of efficiency targets which then for various reasons were not fully accepted by Member States.

Contemporarily, the European Eco-label Board started to address this product group more from the environmental impact point of view with other studies, which resulted in the definition of a series of -labelling awarding criteria for refrigerators and freezers, the latest being established in 2004 and valid from May 1st 2004 until May 31st 2007.

In the meantime, a series of four monitoring studies were promoted by the SAVE Programme to evaluate the impact of the EU legislation on the market transformation of cold appliances and energy consumption (ADEME, 1998; ADEME, 2000; ADEME, 2001). More recently, the European Association of Household Appliance Manufacturers (CECED) issued in October 2002 a Voluntary Commitment on reducing energy consumption of household refrigerators, freezers and their combinations.

Since markets and technologies change continually, including in response to past policy settings, the present study proposal takes the results and methodology defined in the last decade of studies as the starting point to be updated and upgraded where necessary to evaluate the technical, economic and market developments of cold appliances and the new aspects of these products to be covered following the indications of the eco-design directive 2005/32/EC[1]. This is necessary in order to define the need of implementing measures and possible targets for voluntary or mandatory policies.

The study is divided in two working phases and seven Tasks or Chapters:

Part I: Present Situation, that envisages the following five Tasks:

- Task 1 - General Situation
- Task 2 - Economic and Market Analysis
- Task 3 - Consumer Behaviour
- Task 4 - Product System Analysis
- Task 5 - Definition of base case

Part II : Improvement Potential, with the following two Tasks:

- Task 6 - Technical Analysis
- Task 7 - Scenario, Policy, Impact and Sensitivity analysis.

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[1] Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for Energy-Using Products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council.

Within the first part (Present Situation) the project team will set the study boundaries (Task 1), collect and organise the data for the economic, market (Task 2) and consumers behaviour analysis (Task 3), analyse the interaction of the studied appliances on the energy system to which the product belongs (Task 4) and set up the reference parameters, material, energy and costs inputs to define the starting base case (Task 5). All the data and information analysed within the first part of the study will serve as an input for the second part (Improvement Potential) during which the project team will carry out the technical and economic analysis to set up the optimal eco-design options of the analysed appliance (Task 6) and finally suggest the most suitable policies to achieve the recommended energy and ecological improvements (Task 7). A Glossary and References will be also included in the study.

A summary of the tasks included in this second part of the interim report on the cold appliances study (tasks 1 and 2) is outlined in the following paragraphs

0.1 DESCRIPTION OF TASK 1

In the first Task of the study the product category is defined along with the "system boundaries" for the application of the eco-design concept. This definition in fact is relevant both for a realistic definition of the base-case in Task 5 and the design options and corresponding improvement potential in Task 6 and for the scenarios in Task 7.

0.1.1 Subtask 1.1: Product Groups, Product Categories and Performance Assessment

The definition of the product group and categories can be found in commercial protocols in standards or in legislation (European directives or national laws). In particular:

- EUROSTAT defines only macro-categories used for commercial trade purposes, so it is less useful in the context of this specific Task of the study.
- The definition of the product groups "refrigerators" and "freezers" can be found in the European measurement standard EN 153:2005, referring to EN 15502 the new standard created combining and updating the specific EN standards addressing the different appliance types. The EN 15502 standard is the European implementation of a worldwide standard issued by ISO (International Standardisation Organisation).
- For the EU, the definition of 10 product categories can be found in the energy labelling Directive 94/2/EC, confirmed in the more recent Directive 2003/66/EC, dealing with the revision of the energy labelling scheme for cold appliances. However, some product types (even if a small minority) are not covered by the EU legislation, for example the "absorption refrigerators" (where the principle of cold generation is not the more traditional "vapour compression" but the "gas absorption") and - at least partly - the more recent commercial category of "wine coolers" or "wine cellars". In addition a number of new products are starting to be manufactured which are not easily and/or not completely referable to the more "traditional" ten appliance labelling categories, such as "convertible appliance" (where the compartments can be converted from refrigerators to freezers by the users).
- Directive 96/57/EC defines energy efficiency requirements and Eco-label Decision 2000/40/EC establishes the ecolabel awarding criteria for refrigerators and freezers, but the product categories are referred to as given in the energy labelling directive 94/2/EC.

Refrigerators and freezers are not covered by the European Energy Star Programme as set in Council Decision 2001/469/EC[2], but they are among the products covered in the US-EPA Energy Star. The relevant criteria will be therefore described in Subtask 3.1.3.

The primary product performance parameter for refrigerator and freezers, the so-called "functional unit" is the volume, expressed in litre of the appliance, or of its compartments, when more than one is present. The volume is expressed as actual volume and through the so-called "adjusted volume" (named "equivalent volume" in this study) defined in directive 94/2/EC as a way to normalise the different compartment temperature characteristics.

The secondary product performance parameter is the minimum temperature to be reached inside the different compartments (if more than one is present), which in turn defines the "service" provided by the appliance, mainly as fresh food refrigeration or freezing, or frozen food conservation, which in turn determines the amount of time (hours, days, months, years) the food can be preserved. This secondary product performance is also quantified through the so-called "star system".

0.1.2 Subtask 1.2: Existing Standards

The main harmonised standard for refrigerators and freezers is EN 153 "Methods of measuring the energy consumption of electric mains operated household refrigerators, frozen food storage cabinets, food freezers and their combinations, together with associated characteristics" which, until 2005, referred to other specific EN standards: EN ISO 28187: 1991 for refrigerator-freezers; EN ISO 5155: 1995 for freezers; EN ISO 7371: 1995 for refrigerators; EN ISO 8561:1995 for No-frost appliances)[3]. The European and international standards define the main product groups (refrigerators, freezers and refrigerator-freezers), the measurement of the energy consumption and the appliance volume, the refrigeration performance (depending on the internal compartment temperature) through the so called "star rating" system, the appliance volume, etc. EN 153:1995 was under revision and the new standard prEN153 was under public enquiry stage at the time the study proposal was presented. The new edition of the standard EN 153:2005 has been approved by CEN in December 2005 and supersedes EN153:1995, it refers to another new standard EN ISO 15502:2005 "Household refrigerating appliances – Characteristics and test methods"

EN I53 presents a 15% uncertainty in the verification of the rated value for the energy consumption, that is the maximum acceptable difference between the measured and the rated values. In case a higher difference is found, three extra samples should be measured for which on average a maximum difference of 10% is accepted. Some stakeholders and Member States consider this percentage too high. The problem of the "uncertainty" in the verification of the declared energy consumption (and also other parameters, such as the appliance volume) will be addressed, taking into consideration the latest developments in the management of the measurement uncertainty and the results of the European ring test on refrigerators (TNO, 2001).

In addition refrigerators should fulfil the requirements of safety standards (EN 60335 series and ISO 5149) and standards about the materials coming into contact with foodstuffs.

As far as the stand-by issue is concerned, in 1999 the International Energy Agency published the document "*Things that go Blip in the Night – Standby Power and How to Limit It*", addressing the problem of the increasing standby power in the OECD Member countries and proposing some

[2] Council Decision of 14 May 2001 concerning the conclusion on behalf of the European Community of the Agreement between the Government of the United States of America and the European Community on the coordination of energy-efficient labelling programs for office equipment, OJ L 172, 26.06.2001
[3] Amendments to the basic EN standards are not mentioned.

initiatives to decrease it. The standby consumption of household electrical appliances can be measured according to the European standard EN 62301:2005 recently prepared by Technical Committee CENELEC TC59X and including the common modification to the international standard IEC 62301:2005[4] prepared by TC59/WG9. The informative Annex A of IEC/EN 62301 provides some guidance on the expected modes that would be found for various common appliance configurations and designs: in particular cold appliances are listed among "Type A" appliances, where there is no standby power.

A short description of other relevant standards, such as noise measurement standard EN ISO 28960:1993, or the recent CEN/TR 14739:2004 "*Scheme for carrying out a risk assessment for flammable refrigerants in case of household refrigerators and freezers*", and the standard for absorption refrigerators EN 732:2001 will be also provided.

0.1.3 Subtask 1.3: Existing Policies & Measures

The legislation covering refrigerators and freezers will be identified and briefly described for the three levels: EU, Member States and extra-EU.

The starting point is the COLD-II report and IEA work within the Energy Efficiency Working Party and last publications where a comprehensive analysis of the worldwide (especially extra-EU) legislation and voluntary measures are reported and when possible compared.

Fiscal incentives, procurement actions etc. will be also mentioned. Additional efforts will be carried out to identify new measures and countries addressing refrigerators and freezers. The standard product quality requirements (failure rates, proven design, etc.) required by the market will be also analysed and taken into account.

0.2 DESCRIPTION OF TASK 2

0.2.1 Subtask 2.1: Generic Economic Data

Generic economic data (mainly production import and export) for refrigerators and freezers have been collected in this Subtask. Data are related to the latest full year (2005). To this respect, two portraits, one for the EU countries and the other for the rest of the word, concerning a detailed overview on the cold and wash appliances production and market situation of the analysed countries, have been also produced and posted in the studies web sites (see http://www.ecocold-domestic.org/index.php?option=com_docman&task=cat_view&gid=15&Itemid=49 or http://www.ecowet-domestic.org/index.php?option=com_docman&task=cat_view&gid=15&Itemid=49)

0.2.2 Subtask 2.2: Market and Stock Data

[4] IEC 60302: 2005 "Household Electrical Appliances – measurement of the standby power, 2005.

Market and stock have been provided for each of the defined product categories for the following years:
- 1970 - 1995 (aggregated data from the stock model),
- 2002-2004 (from the stock model and in deeper detail from the GfK data, see below)
- 2010-2012 (forecast, to be provided),
- 2020-2025 (forecast, to be provided)

The GFK panel data, analysed in paragraphs 2.2.1 (sales) and 2.2.2 (prices), provide the physical yearly sales by energy efficiency categories, volumes, energy star categories and corresponding values for the years 2002-2004 and for 21 EU countries, including the Baltic countries, Slovenia and Slovakia[5].

The historical and forecast data have been, and will be, provided by using the stock model developed within this project on the basis of the CECED and Wuppertal Institute models structure and data (see paragraph 2.2.3).
The stock model calculates the future stock, sales and energy consumption data for the years 1970–2025 on the basis of the following assumptions (endogenous inputs):

- Household growth rates;
- Appliances penetration rates (historical data till 2004, after estimates)
- Average Product Life (based on a symmetric spread of 15 ± 4 years)
- Appliances specific consumption (by unit and by energy efficiency category)
- Yearly sales by energy efficiency categories (observed data till 2002-2004 and then estimated on the basis of the historical trends

On the basis of these settings, the following data have been and will be provided (historical data and forecast)

- Installed base
- Penetration rates
- Annual sales (calculated in the forecast period according to the penetration rate trends)
- Replacement sales (calculated)
- New sales (calculated)
- Total (stock) energy consumption trend (base case, without technological improvements)
- Total sales/real EU-consumption in physical units and in values (the objective is to define the actual consumption as reliably as possible for the categories defined in Subtask 1.1, for the latest full year for which consistent data could be retrieved).

0.2.3 Subtask 2.3: Market Trends

Trends on the market have been analysed in different ways:

1. Identifying major trends by analysing product brochures and advertisements for new products.

2. Interviewing the sales or marketing directors of the major European refrigerator and freezer brands

[5] Malta, Cyprus, Luxemburg and Ireland are missing. Moreover the coverage of the eastern countries is rather partial for the year 2002: data are provided for only 4 eastern countries for the refrigerators and for no countries for the freezers. See also paragraph 2.2.1.1

3. Analysing all major consumer tests on refrigerators and freezers from the last 5 years and identifying changes in product design and features offered and tested.

4. Analysing questions included in the consumer survey (see Task 3) to identify consumer requirements and preferences.

The analysis provides the following outputs:

- Description of the market development
- General trends in product-design and product-features (from the marketing point of view)
- Specific trends of ecological relevant features
- Hypothesis on the duration of redesign cycle of the EuP.

0.2.4 Subtask 2.4: Consumer Expenditure Base Data

In this Subtask the following data concerning the appliances market price, the running costs and disposal tariffs, per EU Member State have been collected, to provide basic input to the LLCC analysis (see Subtask 6.2):

- Electricity rates (€/ kWh)
- Water (and sewage) rates (€/m3)
- Repair and Maintenance costs (€/product life)
- Installation costs (for installed appliances only) (€/product)
- Disposal tariffs/ taxes (€/product)
- Interest and inflation rates (%).

The consumer expenses like the repair and maintenance costs will be collected the consumers' specialised magazines and possibly through direct interviews to shops and service agencies.

The electricity rates as well as the disposal tariffs will be provided by the specialised literature and the interest and inflation rates by EUROSTAT.

1 Task 1: Definitions

1.1 THE STUDY TASKS

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In the meantime, a series of four monitoring studies were promoted by the SAVE Programme to evaluate the impact of the EU legislation on the market transformation of cold appliances and energy consumption (ADEME, 1998; ADEME, 2000; ADEME, 2001). More recently, the European Association of Household Appliance Manufacturers (CECED) issued in October 2002 a Voluntary Commitment on reducing energy consumption of household refrigerators, freezers and their combinations.

Since markets and technologies change continually, including in response to past policy settings, the present study proposal takes the results and methodology defined in the last decade of studies as the starting point to be updated and upgraded where necessary to evaluate the technical, economic and market developments of cold appliances and the new aspects of these products to be covered following the indications of the eco-design directive 2005/32/EC[6]. This is necessary in order to define the need of implementing measures and possible targets for voluntary or mandatory policies.

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[6] Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for Energy-Using Products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council.

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This report refers to Task 1: Definitions.

1.2 DESCRIPTION OF TASK 1

In the first Task of the study the product category is defined along with the "system boundaries" for the application of the eco-design concept. This definition in fact is relevant both for a realistic definition of the base-case in Task 5 and the design options and corresponding improvement potential in Task 6 and for the scenarios in Task 7.

1.2.1 Subtask 1.1: Product Groups, Product Categories and Performance Assessment

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- The definition of the product groups "refrigerators" and "freezers" can be found in the European measurement standard EN 153:2005, referring to EN 15502 the new standard created combining and updating the specific EN standards addressing the different appliance types. The EN 15502 standard is the European implementation of a worldwide standard issued by ISO (International Standardisation Organisation).
- For the EU, the definition of 10 product categories can be found in the energy labelling Directive 94/2/EC, confirmed in the more recent Directive 2003/66/EC, dealing with the revision of the energy labelling scheme for cold appliances. However, some product types (even if a minority) are not covered by the EU legislation, for example "absorption refrigerators" (where the principle of cold generation is not the more traditional "vapour compression" but the "gas absorption") for those appliances that may also use other energy sources, and - at least partly - the more recent commercial category of "wine coolers" or "wine cellars". In addition a number of new products are starting to be manufactured which are not easily and/or not completely referable to the more "traditional" ten appliance labelling categories, such as "convertible appliance" (where the compartments can be converted from refrigerators to freezers by the users).
- Directive 96/57/EC defines energy efficiency requirements and Eco-label Decision 2000/40/EC establishes the ecolabel awarding criteria for refrigerators and freezers, but the product categories are referred to as given in the energy labelling directive 94/2/EC. Absorption refrigerators are exempted from this directive.

Refrigerators and freezers are not covered by the European Energy Star Programme as set in Council Decision 2001/469/EC[7], but they are among the products covered in the US-EPA Energy Star. The relevant criteria will be therefore described in Subtask 3.1.3.

The primary product performance parameter for refrigerator and freezers, the so-called "functional unit" is the volume, expressed in litre of the appliance, or of its compartments, when more than one is present. The volume is expressed as actual volume and through the so-called "adjusted volume" (named "equivalent volume" in this study) defined in directive 94/2/EC as a way to normalise the different compartment temperature characteristics.

The secondary product performance parameter is the minimum temperature to be reached inside the different compartments (if more than one is present), which in turn defines the "service" provided by the appliance, mainly as fresh food refrigeration or freezing, or frozen food conservation, which in turn determines the amount of time (hours, days, months, years) the food can be preserved. This secondary product performance is also quantified through the so-called "star system".

1.2.2 Subtask 1.2: Existing Standards

The main harmonised standard for refrigerators and freezers is EN 153 "*Methods of measuring the energy consumption of electric mains operated household refrigerators, frozen food storage cabinets, food freezers and their combinations, together with associated characteristics*" which, until 2005, referred to other specific EN standards: EN ISO 28187: 1991 for refrigerator-freezers; EN ISO 5155: 1995 for freezers; EN ISO 7371: 1995 for refrigerators; EN ISO 8561:1995 for No-frost appliances)[8]. The European and international standards define the main product groups (refrigerators, freezers and refrigerator-freezers), the measurement of the energy consumption and the appliance volume, the refrigeration performance (depending on the internal compartment temperature) through the so called "star rating" system, the appliance volume, etc. EN 153:1995 was under revision and the new standard prEN153 was under public enquiry stage at the time the study proposal was presented. The new edition of the standard EN 153:2005 has been approved by CEN in December 2005 and supersedes EN153:1995, it refers to another new standard EN ISO 15502:2005 "*Household refrigerating appliances – Characteristics and test methods*"

EN I53 presents a 15% uncertainty in the verification of the rated value for the energy consumption, that is the maximum acceptable difference between the measured and the rated values. In case a higher difference is found, three extra samples should be measured for which on average a maximum difference of 10% is accepted. Some stakeholders and Member States consider this percentage too high. The problem of the "uncertainty" in the verification of the declared energy consumption (and also other parameters, such as the appliance volume) will be addressed, taking into consideration the latest developments in the management of the measurement uncertainty and the results of the European ring test on refrigerators (TNO, 2001).

In addition refrigerators should fulfil the requirements of safety standards (EN 60335 series and ISO 5149) and standards about the materials coming into contact with foodstuffs.

As far as the stand-by issue is concerned, in 1999 the International Energy Agency published the document "*Things that go Blip in the Night – Standby Power and How to Limit It*", addressing the

[7] Council Decision of 14 May 2001 concerning the conclusion on behalf of the European Community of the Agreement between the Government of the United States of America and the European Community on the coordination of energy-efficient labelling programs for office equipment, OJ L 172, 26.06.2001

[8] Amendments to the basic EN standards are not mentioned.

problem of the increasing standby power in the OECD Member countries and proposing some initiatives to decrease it. The standby consumption of household electrical appliances can be measured according to the European standard EN 62301:2005 recently prepared by Technical Committee CENELEC TC59X and including the common modification to the international standard IEC 62301:2005[9] prepared by TC59/WG9. The informative Annex A of IEC/EN 62301 provides some guidance on the expected modes that would be found for various common appliance configurations and designs: in particular cold appliances are listed among "Type A" appliances, where there is no standby power.

A short description of other relevant standards, such as noise measurement standard EN ISO 28960:1993, or the recent CEN/TR 14739:2004 "*Scheme for carrying out a risk assessment for flammable refrigerants in case of household refrigerators and freezers*", and the standard for absorption refrigerators EN 732:2001 will be also provided.

1.2.3 Subtask 1.3: Existing Policies & Measures

The legislation covering refrigerators and freezers will be identified and briefly described for the three levels: EU, Member States and extra-EU.

The starting point is the COLD-II report and IEA work within the Energy Efficiency Working Party and last publications where a comprehensive analysis of the worldwide (especially extra-EU) legislation and voluntary measures are reported and when possible compared.

Fiscal incentives, procurement actions etc. will be also mentioned. Additional efforts will be carried out to identify new measures and countries addressing refrigerators and freezers. The standard product quality requirements (failure rates, proven design, etc.) required by the market will be also analysed and taken into account.

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[9] IEC 60302: 2005 "Household Electrical Appliances – measurement of the standby power, 2005.

1.3 SUBTASK 1.1: PRODUCT GROUPS, PRODUCT CATEGORIES AND PERFORMANCE ASSESSMENT

1.3.1 Product groups

The definition of the product group is included in the scope of the European standard used for the conformity assessment EN 153: 2006 "*Methods of measuring the energy consumption of electric mains operated household refrigerators, frozen food storage cabinets, food freezers and their combinations, together with associated characteristics*", as "**electric mains operated household refrigerating appliances**", where the definition of "refrigerating appliances" is included in the standard EN ISO 15502:2005 "*Household refrigerating appliances – Characteristics and test methods*" (mentioned in EN 153 normative references[10]) as: "factory-assembled insulated cabinet with one or more compartments and of suitable volume and equipment for household use, cooled by natural convection or a frost-free system whereby the cooling is obtained by one or more energy-consuming means".

EN ISO 15502:2005[11] defines then *inter alia*:
the two main types of refrigerating appliances:

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 absorption process using heat as energy source

- the main appliance categories as:

refrigerator: refrigerating appliance intended for the preservation of food, one of whose compartments is suitable for the storage of fresh food

refrigerator-freezer: refrigerating appliance having at least one compartment suitable for the storage of fresh food (the fresh-food storage compartment) and at least one other (the food freezer compartment) suitable for the freezing of fresh food and the storage of frozen food under three-star storage conditions. Refrigerator-freezers are then classified in:

a) refrigerator-freezer type I — having a single, user-adjustable temperature control device for regulating the temperatures of the fresh-food storage compartment and of the food freezer compartments;

b) refrigerator-freezer type II — having user-adjustable means for the separate regulation of the temperatures of the fresh-food storage compartment and of the food freezer compartments.

frozen-food storage cabinet: refrigerating appliance having one or more compartments suitable for the storage of frozen food

food freezer: refrigerating appliance having one or more compartments suitable for freezing foodstuffs from ambient temperature down to a temperature of − 18 °C and which is also suitable for the storage of frozen food under three-star storage conditions

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[10] The European Standards incorporate, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter; for dated references, subsequent amendments to or revisions of any of these publications apply to the relevant European Standards only when incorporated in them by amendment or revision; for undated references the latest edition of the publication referred to applies.

[11] The first edition of the parallel ISO standard ISO 15502 cancels and replaces ISO 5155:1995, ISO 7371:1995, ISO 8187:1991 and ISO 8561:1995, of which it constitutes a technical revision. It also incorporates the amendments ISO 7371:1995/Amd.1:1997, ISO 8187:1991/Amd.1:1997 and ISO 8561:1995/Amd.1:1997.

- and the “installation” category of **built-in appliance**: fixed refrigerating appliance intended to be installed in a cabinet, in a prepared recess in a wall or similar location.

PRODCOM list 2007[12] defines for commercial trade purposes some macro-categories of cold appliances, included under the codes (1) **29.71** – Manufacture of electric domestic appliances, and (2) **29.71.11** – Refrigerators and freezers, of the household type:
- **29.71.11.10** – Combined refrigerators-freezers, with separate external doors
- **29.71.11.33** – Household-type refrigerators (including compression-type, electrical absorption-type, excluding built-in)
- **29.71.11.35** – Compression-type built-in refrigerators
- **29.71.11.50** – Chest freezers of a capacity ≤ 800 litre
- **29.71.11.70** – Upright freezers of a capacity ≤ 900 litre.

For the EU, the definition of 10 product categories can be found in the energy labelling Directive 94/2/EC[13] (specifically in Annex IV), confirmed in the more recent Directive 2003/66/EC, dealing with the revision of the energy labelling scheme for cold appliances:
Household refrigerators, without low temperature compartments
Household refrigerator/chillers, with compartments at 5 °C and/or 10 °C
Household refrigerators, with no-star low temperature compartments (< 0 °C or “ice box”)
Household refrigerators, with low temperature compartments (*), (i.e. ≤ -6 °C)
Household refrigerators, with low temperature compartments (**) (≤ -12 °C)
Household refrigerators, with low temperature compartments (***) (≤ -18 °C)
Household refrigerator/freezers, with low temperature compartments *(***) (≤-18°C and a freezing capacity of 10kg/100 litre in 24h)
Household food freezers, upright
Household food freezers, chest
Household refrigerators and freezers with more than two doors, or other appliances not covered above.

Directive 96/57/EC defining energy efficiency requirements and Eco-label Decision 2000/40/EC establishing the eco-label awarding criteria for refrigerators and freezers, refer to product categories as given in the energy labelling directive 94/2/EC[14]. Absorption appliances are exempted from directive 96/57/EC while all appliances that may also use other energy sources (such as battery operated appliances or gas fired/mixed fuel absorption refrigerators) are excluded from the energy labelling directive.

A comparison of the different classifications is reported in Table 1.1.

Some product types are not covered by the EU legislation, for example the above mentioned “*absorption-type refrigerating appliances*” or the “*mixed fuel refrigerators*” and - at least partly - the more recent new commercial product types. An example is give by the action of the UK Market Transformation Programme[15] which classified in 2006 five different types of small non-traditional cold appliances currently available on the UK market:
- *mini drinks chillers*

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[12] Source: List of PRODucts of the European COMmunity, 2007 version, downloadable from: http://ec.europa.eu/eurostat/ramon
[13] O.J. L 45, 17 February 1994
[14] With the only exception of the temperature of refrigerator/chillers (Category 2 appliances) which is at 5°C and or 12°C in directive 96/57/EC.
[15] “Small, non-traditional refrigerated appliances on the UK market”, BNC15, version 1.1, 21 November 2006, downloadable at: www.mtprog.com

- *non-compressor mini fridges* (these are the before mentioned absorption refrigerators)
- *wine cellars/chillers*

Table 1.1: Comparison of the different classification scheme for cold appliances at European level

EN 153	electric mains operated household refrigerating appliances		
Directives 94/2EEC, 2003/66/EEC, 96/57/EC and Decision 2000/40/EC		**PRODCOM**	**EN ISO 15502** (EN 153)
Category (number)	Description	**29.71.11** - Refrigerators and freezers, of the household type	factory-assembled insulated cabinet with one or more compartments and of suitable volume and equipment for household use, cooled by natural convection or a frost-free system whereby the cooling is obtained by one or more energy-consuming means
1	Household refrigerators, without low temperature compartments	**29.71.11.33** – Household-type refrigerators (including compression-type, electrical absorption-type, excluding built-in) **29.71.11.35** – Compression-type built-in refrigerators	**refrigerator:** refrigerating appliance intended for the preservation of food, one of whose compartments is suitable for the storage of fresh food
2	Household refrigerator/chillers, with compartments at 5 °C and/or 10 °C		
3	Household refrigerators, with no-star low temperature compartments		n.a.
4	Household refrigerators, with low temperature compartments (*)		**frozen-food storage cabinet**: refrigerating appliance having one or more compartments suitable for the storage of frozen food
5	Household refrigerators, with low temperature compartments (**)		
6	Household refrigerators, with low temperature compartments (***)		**refrigerator-freezer**: refrigerating appliance having at least one compartment suitable for the storage of fresh food (the fresh-food storage compartment) and at least one other (the food freezer compartment) suitable for the freezing of fresh food and the storage of frozen food under three-star storage conditions
7	Household refrigerator/freezers, with low temperature compartments (***)*	**29.71.11.10** – Combined refrigerators-freezers, with separate external doors	
8	Household food freezers, upright	**29.71.11.70** – Upright freezers of a capacity ≤ 900 litre	**food freezer**: refrigerating appliance having one or more compartments suitable for freezing foodstuffs from ambient temperature down to a temperature of − 18 °C and which is also suitable for the storage of frozen food under three-star storage conditions
9	Household food freezers, chest	**29.71.11.50** – Chest freezers of a capacity ≤ 800 litre	
10	Household refrigerators and freezers with more than two doors, or other appliances not covered above	**29.71.11.10** – Combined refrigerators-freezers, with separate external doors	n.a.

- *mini fridges/chillers*
- *mini fridge with ice compartment*.

According to MTP documents, discussions with some UK manufacturers suggest that they do not give energy labels to the appliances they sell as drinks fridges because, they argue, the definition of a household refrigerator given in the reference standard EN ISO 7371 (see paragraph 1.4) requires the appliance to have one or more compartments intended for the preservation of food, one at least of which is suitable for the storage of fresh food. Thus, categories 2 and 10 refer to household refrigerators and chillers suitable for fresh food. The manufacturers also argue that drinks are not food, so the appliances should not be classified under categories 2 or 10. In addition, since chillers have a temperature range of -2°C to +3°C they are unsuitable for storing drinks, which should be stored at warmer temperatures. MTP checked some appliances in 2005 and found they had user instructions that stated the product should not be used for food. However, others had conflicting advice such as “designed for storing drinks and other small items, not food” in the user instructions and “beer safe, dairy safe, food safe” on the box. Clarity in the purpose of these items would help to inform consumers and the debate as to whether these items should be covered by the energy label.

In addition a number of new products are starting to be manufactured which are not easily and/or not completely referable to the ten energy labelling categories or to other classification schemes, such as “*convertible appliance*” (where the compartments can be converted from refrigerators to freezers by the users) or “*bottom tilt-out freezer*s” (where the bottom mounted freezer compartment is tilting and slide opening, but the food in loaded from the top).

For this study on cold appliances the classification of the EU directive 94/2/EC will be followed, eventually integrated – when necessary and possible - with new categories, resulting from the market/technology innovations, to be proposed to the Commission in Task 7.

Other niche appliances[16]

There are niche markets where good temperature control can establish a market, an example is the Korean *Kimchi refrigerator*. Kimchi is the most popular side dish in Korea, a fermented product that relies on lactic acid production at low temperatures to ensure proper ripening and preservation. Very good temperature control is required to allow consumers to have fresh Kimchi for 2-3 months. In fact, Kimchi contains 3-5% salt and its structure deteriorates if kept below –2°C, but also if kept at temperatures above +1,5°C its storage life is substantially reduced.
Special Kimchi refrigerators are now produced that maintain average product temperatures in the range –1°C to –0,5°C with a maximum temperature of +1,5°C within the storage compartment. Currently the refrigerators cost 50% more than standard systems and are only sold in Korea. Despite these restrictions the market in 2003 is estimated to rise to 1,5 million appliances worth 1,3 billion US dollars. Currently, 30% of Korean homes own both a Kimchi and a standard refrigerator. The main manufacturers, LG, Samsung and Mando, provide premium, chest and drawer type versions.

Another growth market in the domestic refrigeration sector is the gadget or ‘*boy’s toys*’ area. Increasingly in the developed world, well-off individuals are looking for ways of spending their money. The purchase of designer gadgets is rising. In the domestic refrigeration market, the gadgets are typically stylish *wine coolers, icemakers, ice cream makers* and *individual refrigerators for drink cans*. Since the market is not price-sensitive, alternative refrigeration systems such as Peltier ones are often used (Figures 1.1 and 1.2).

[16] Source: S. James, Developments in domestic refrigeration and consumer attitudes, Bulletin of the IIR, No 5, 2003.

Figure 1.1: Wine chiller

Figure 1.2: Peltier refrigerator for drink cans

1.3.2 *Product Performance Assessment*

The primary product performance parameter for refrigerator and freezers, the so-called "functional unit" is the **volume** - in litre - of each appliance, or of its compartments, when more than one is present. The volume is expressed as actual volume and through the so-called "adjusted volume" (named "equivalent volume" in this study) defined in directive 94/2/EC as a way to normalise the different compartment temperature characteristics. Volume measurement method is defined in the international standard ISO 15502 and in European standard EN 153. Equivalent (adjusted) volume is defined in directive 92/2/EC.
The secondary product performance parameter is the **minimum temperature** (and the associated number of "**stars**") to be reached inside the different compartments (if more than one is present), which in turn defines the "service" provided by the appliance, mainly as fresh food refrigeration or freezing, or frozen food conservation, which in turn determines the amount of time the food can be preserved.

Directive 94/2/EEC defines the temperature and "star" classification of the compartments in Table 3 of Annex V then describes the temperature of the coldest compartment for Category 10 appliances:

temperature of coldest compartment	equivalent appliance category
> -6 °C	1-3
≤ -6 °C	4
≤ -12 °C	5
≤ -18 °C	6
≤ -18 °C with freezing capacity	7

International standard ISO 15502 and European standard EN 15502/EN 153 define the compartments types and sets the storage temperatures to be maintained in them (see following paragraph).

1.4 SUBTASK 1.2: EXISTING STANDARDS

International standards exist for all major household appliances, typically originating with manufacturers' associations, government agencies, or professional societies, and are eventually adopted by a national or international standardisation bodies. The leading international standard-setting bodies for energy tests are the International Organization for Standardization (ISO) which mainly focuses on mechanical performance, and its sister organization, the International Electro technical Commission (IEC), which mainly focuses on electrical performance.

Implementation and refinement of international standards (adaptation to local conditions) is left to national and regional counterparts of ISO and IEC. Thus the European Committee for Standardization (CEN) and the European Committee for Electro technical Standardization (CENELEC) have assumed responsibility for developing EU-wide standards, respectively for mechanical and electrical performance. The Japan Industrial Standards Association (JIS) is responsible for developing all appliance test methods in that country. In the United States several organisations are involved in developing standards: among these are the American National Standards Institute (ANSI), the Air-conditioning and Refrigerating Institute (ARI), and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), although final responsibility for the appliance energy standards in policy measures resides with the Department of Energy.

Geographic, climatic and cultural differences among countries further complicate efforts to develop internationally standardised test methods that are sufficiently flexible to reflect local conditions while still allowing results from different countries to be compared. Beyond these basic differences, appliances often vary greatly in their configurations and the range of options on offer. This variety in configurations and options, because it can affect energy efficiency and functional performance, often necessitated, and still probably necessitates, the creation of separate regional standards.

Interest in making measurement methods better reflect local conditions and available appliance models has on one side led many countries to develop national standards, but on the other side many other countries tend to align with ISO/IEC standards, with only minor differences. In general:

- European, including Russia, align their standards with ISO/IEC ones;
- African and most Asian countries including China align their standards with ISO/IEC ones;
- Japan and Korea are often aligned with ISO/IEC but some significant differences exist for certain products;
- India, the Philippines, and Sri Lanka base most of their national standards on ISO/IEC ones, but sometimes there are important differences;
- Chinese Taipei often uses similar test methods to ISO/IEC but frequently introduces significant variations;
- In the Americas, the United States uses its own test procedures, which occasionally align to ISO/IEC tests;
- Because of the economic dominance of the U.S. market in NAFTA, it is not surprising that standards used in Canada and Mexico are substantially similar to those used in the U.S.;
- Most South American countries including Brazil use ISO/IEC standards but some (e.g. Venezuela) use variants or U.S. standards;
- Australia and New Zealand use harmonised standards, which despite being loosely based on ISO/IEC ones often exhibit significant differences.

White goods such as refrigerators, washing machines and dishwashers tend to exhibit the largest differences in standards, product categorisation and energy performance requirements applied from one region to another, possibly because they were the first group of products covered by national/regional policies and measure aimed at reducing their energy consumption. Individual countries have typically taken into consideration country-specific variables such as domestic energy prices and climatic conditions, as well as the features and configurations that describe the appliances sold in their markets. These differences are also reflected in the standards, many of which were first developed nationally and may have been established more than two decades ago.

In recent years there has been a tendency for countries developing new standards to harmonise them with existing ones, as have Argentina, China, Russia, South Africa, Tunisia and Turkey with the EN standards for refrigerators and freezers. In addition, regional activities directed at harmonizing energy efficiency requirements and labels, and the relevant standards that underlies both these measures, are being undertaken by the Asia-Pacific Economic Cooperation (APEC), the South Asia Regional Initiative for Energy Cooperation and Development (SARI), the Pan American Standards Commission (COPANT), the Asia and South East Asia Network (ASEAN), the North American Energy Working Group (NAEWG), and the first of several emerging UNDP/GEF projects in the Andean Region of South America. The European Union has a rich history of regional coordination from individual country requirements and labels to unified EU-wide programs. Also policies and measures using those harmonised standards are undertaking a lively harmonisation process. In particular:

- In Europe, the EU25 countries were working with the new Member States (Bulgaria and Romania) and Accession Countries (Croatia and Turkey) to assist them in introducing EU appliance energy efficiency policies. This mirrors the process which previously took place in the 10 new Member States prior to their becoming EU members, and even before the enlargement process from EU12 to EU15;
- Australia and New Zealand have a formal arrangement to develop common energy efficiency requirements for energy using products and apply harmonised standards;
- ASEAN countries are working together to develop a common regional endorsement energy label for energy-using products;.
- Six countries in and around the Indian sub-continent have been co-operating through the auspices of the South Asian Regional Initiative programme to share experiences and possibly co-operate in the development of regional appliance efficiency requirements;
- Members of the ANDEAN pact countries are co-operating in a regional initiative to develop energy efficiency labels and efficiency requirements for energy using appliances.

Standards for cold appliances developed at international, European and other non-European country levels will be described and where possible compared.

1.4.1 The International Standards

1.4.1.1 The new standard ISO 15502

The main international standard for cold appliances is **ISO 15502: 2005**, "*Household refrigerating appliances - Characteristics and test methods*", prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 5, *Testing and rating of household refrigeration appliances*. This first edition, published in 2005 cancels and replaces ISO 5155:1995, ISO 7371:1995, ISO 8187:1991 and ISO 8561:1995, of which it constitutes a technical revision. It also incorporates the amendments ISO 7371:1995/Amd.1:1997, ISO 8187:1991/ Amd.1:1997 and

ISO 8561:1995/Amd.1:1997. **ISO 15502: Corrigendum 1** was in the publication stage at the end of 2006.

This standard is the first overall standard for cold appliances collecting in a new and coherent structure all the provisions previously spread in different ISO standards and their amendment. The new standard:

- **specifies the essential characteristics of household refrigerating appliances, factory-assembled and cooled by internal natural convection or forced air circulation**:
  - refrigerating appliance types (see paragraph 1.3.1 for definitions):
  - compartments and sections:
    - ✓ fresh food compartment
    - ✓ cellar compartment
    - ✓ chill compartment
    - ✓ ice-making compartment
    - ✓ frozen food compartment
      - one star compartment
      - two star compartment
      - three star compartment
      - food freezer compartment/four star compartment: freezing capacity of at least 4,5 kg of test packages per 100 l of its storage volume in 24 h, and in no case less than 2 kg.
    - ✓ two star section (part of a food freezer compartment or cabinet, or three-star compartment or cabinet)
  - *physical aspects and dimensions*: including: top-opening type (appliance in which the compartment(s) are accessible from the top), upright type (appliance in which the compartment(s) are accessible from the front), gross volume, storage volume and storage plan
  - definitions relating to performance characteristics, including:
    - ✓ freezing capacity
    - ✓ ice-making capacity
    - ✓ defrost types (automatic, semi-automatic, manual, adaptive, etc.
  - definitions relating to refrigerating system
  - symbols
  - classification
    - ✓ in climatic classes: SN, N, ST, T

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

    - ✓ refrigerator-freezers “type I” and “type II” (depending if the number of user-adjustable temperature control devices)
  - materials, design and manufacture characteristics
  - storage temperatures:

°C							
Fresh-food storage compartment		Food freezer and three-star compartment/ cabinet	Two-star compartment/ section	One-star compartment	Cellar compartment	Chill compartment
t_{1m}, t_{2m}, t_{3m}	t_{ma}	t^{***}	t^{**}	t^{*}	t_{cm}	t_{cc}
$0 \leqslant t_{1m}, t_{2m}, t_{3m} \leqslant 8$	$\leqslant +4$	$\leqslant -18$ [a]	$\leqslant -12$ [a]	$\leqslant -6$	$+8 \leqslant t_{cm} \leqslant +14$	$-2 \leqslant t_{cc} \leqslant +3$

[a] as a result of a defrost cycle, the storage temperatures of frost free and/or adaptive defrost refrigerating appliances are permitted to rise by no more than 3 K during a period not greater than 4 hours or 20 % of the duration of the operating cycle, whichever is the shorter.

t_{cc} instantaneous temperature value (chill compartment); t_{ma} arithmetic average of t_{1m}, t_{2m}, t_{3m};

- **establishes test methods** for the determination of:
  - linear dimensions, volumes and areas:
    - ✓ linear dimensions (shall be measured to the nearest millimetre)
    - ✓ volumes of compartments and sections (shall be expressed to the nearest whole number of cubic decimetres or of litres): gross volume, total storage volume, storage volume of fresh-food storage, chill, cellar, ice-making compartments; food freezer compartments/cabinets and frozen-food storage compartments/cabinets; two-star sections;
    - ✓ volumes of shelves and partitions
    - ✓ storage shelf area;
  - *air tightness of seals* of doors, lids and drawers
  - *mechanical strength* of shelves and similar components
  - storage temperatures
  - *water vapour condensation*: to determine the extent of condensation of water on the external surface of the cabinet under specified ambient conditions (temperature and relative humidity)
  - *energy consumption*: to measure the energy consumption of refrigerating appliances under specified test conditions, calculated for a period of exactly 24 h from the measured value, and expressed in kilowatt-hours per 24 h (kW h/24 h), to two decimal places.
  - *temperature rise time*: to check the time for the temperature rise of test packages from – 8°C to –9°C;
  - *freezing capacity*: of food freezers and food freezer compartments, loaded with test packages
  - *ice making*: to determine the ice-making capacity of the appliance, in the ice tray or in the automatic ice-maker, in kilograms, of ice produced in 24h
- **including the specification of the test conditions:**
  - ambient temperature and humidity:
    - ✓ for checking the storage temperatures, the ambient temperature shall be:
      +10°C and +32°C for appliance in class SN
      +16°C and +32°C for appliance in class N
      +16°C and +38°C for appliance in class ST
      +16°C and +43°C for appliance in class T
    - ✓ for checking the energy consumption, temperature rise time, freezing capacity and ice-making capacity of all cold appliances the ambient temperature shall be +25°C for class SN, N, ST and + 32°C for class T;
    - ✓ for all other tests: at the temperature stated in the test specifications;
  - installation of the test appliances
  - test packages

- operating requirements of the test appliances
- measuring instruments
- final test report requirements

- **specifies the type of marking and the information to be included in the rating plate:** one or more per appliance, to be securely fastened on it and including permanently and legibly information about:

  a) the indication of the type of refrigerating appliance: “refrigerator”, frozen-food storage cabinet”, “food freezer”, “refrigerator-freezer Type I” or “refrigerator-freezer Type II”, with the designation being prefixed by the term “frost-free” if applicable;
  b) the trademark or name of the manufacturer or responsible vendor;
  c) the model reference;
  d) the serial number and/or date of manufacture, which may be coded;
  e) the rated total gross volume, either in cubic decimetres or in litres;
  f) the rated storage volume, either in cubic decimetres or in litres, of
    1) the food freezer and three-star cabinet (excluding any two-star section therein),
    2) the food freezer compartment (excluding any two-star section or compartment therein),
    3) the three-star frozen-food storage compartment(s), if any (excluding any two-star section or compartment therein),
    4) the two-star section(s) or compartment(s), if any, within the food freezer and three-star frozen-food storage compartment or cabinet,
    5) the two-star compartment(s),
    6) the one-star compartment(s),
    7) the fresh-food storage compartment,
    8) the cellar compartment(s),
    9) the chill compartment(s), and
    10) ice-making compartment(s);
  g) the letters indicating the climatic class or classes (SN, N, ST, T);
  h) the designation (chemical name, chemical formula or refrigerant number) and (total) mass, in grams, of the refrigerant (see ISO 817);
  i) information relating to the energy source;
  j) the rated freezing capacity, in kilograms;
  k) Type I or Type II, if applicable
  The manufacturer is free to show any other information considered desirable.
  - The identification of food freezers and freezer compartments and of frozen-food storage compartments or cabinets with the star rating

- **specifies the technical and commercial product information:** to be in accordance with the standard whenever technical and commercial product information is supplied, and should contain all the previous information plus additional ones;

- **specifies the instructions for users:** every appliance shall be accompanied on delivery by instructions for its installation, use and user maintenance, in the language of the country where it is for sale. A list of mandatory information is also specified;

- **includes specific informative and normative Annexes**, in particular:
  - **Annex A** (informative) about “**Conditions particular to certain countries**”, where owing to national regulations, special conditions exist; two countries were identified
    - ✓ France: where there is a specific (i) symbol identifying cold zone of compartment intended for storage of fresh food and (ii) the thermometer or temperature indicator has to present specific characteristics;
    - ✓ Japan: where the storage temperature of the chill compartment is required to be $-3° \leq t_{cc} \leq +3°C$.
  - **Annex C** (informative) “**Test for absence of taste and odour**”, describing a test for the evaluation of foreign taste and odour, where at least six analytical samples of potable water

and slices of fresh unsalted butter are compared with the same number of check samples by least three expert assessors familiar with the test method using a scale of 4 levels;

- **Annex D** (normative) "**Built-in refrigerating appliances**", describing the test conditions for built in appliances. Appliances intended only for "building-in" or for "placing under a counter" or "under a worktop", or "between cabinets (under-counter types)", shall be built-in or placed in a test enclosure of dull black-painted, approximately 20 mm thick, plywood, with a facia door if a manufacturer requires
- **Annex E** (informative) **"rated characteristic and control procedure**" for:
  - ✓ **volumes and areas**:
    - the measured value of the *gross volume*, the *storage volume* shall not be less than the rated (stated by the manufacturer) value by more than 3% or 1litre, whichever is the greater value. The measured *storage shelf area* shall not be less than the rated storage shelf area by more than 3%;
    - if the previous requirements are not met on a single appliance, the measurements shall be made on a further three, randomly selected, appliances; the arithmetical mean of the measured values of these three appliances shall be in accordance with the requirements;
  - ✓ and **performance characteristics**:
    - *storage temperature*: the values measured on the first appliance tested shall comply with the requirements. If any result is outside the specified values, the test shall be carried out on a further three, randomly selected, appliances; all the values on these three refrigerating appliances tested shall comply with the requirements;
    - *freezing capacity*: the value measured on the first appliance tested shall be not less than the rated value by more than 15%. If the result is less the test shall be carried out on a further three, randomly selected, appliances. The arithmetical mean of the values of these three refrigerating appliances shall be greater than or equal to the rated value minus 10%. The value obtained either on the first appliance tested or the arithmetical mean value obtained on a further three appliances shall be in accordance with the minimum stated values;
    - *energy consumption*: the value measured shall not be greater than the rated value by more than 15 %. If the result of the test carried out on the first appliance is greater the test shall be carried out on a further three, randomly selected, appliances; the arithmetical mean of the values of these three refrigerating appliances shall be less than or equal to the rated value plus 10%.
    - *ice-making*: the measured value shall not be less than the rated value by more than 15%. If the value obtained from the first test is less than the rated value minus 15%, the test shall be carried out on a further three, randomly selected, appliances; the arithmetical mean of the values of these three appliances shall be greater than or equal to the rated value minus 10%;
    - *temperature rise time*: the measured value shall not be shorter than the rated value by more than 15%. If the result of the test on the first appliance is less than the rated value minus 15% , the test shall be carried out on a further three, randomly selected, appliances; the arithmetical mean of the values of these three refrigerating appliances shall be greater than or equal to the rated value minus 10%.

a) Future developments of ISO 15502 and transfer to IEC of cold appliance standards

Beyond the 2005 edition (and its Corrigendum) the work on the next edition of the standard has already initiated. The new 2[nd] edition will be more global and will probably include provisions about:

- frost free systems (compared to dynamic systems) and new technologies (e.g. inverters, multiple defrost systems etc.);
- lower cost alternatives for the frozen food packs (which are considered difficult to obtain and expensive especially for use in large freezers by some of the stakeholders); the new energy consumption test will be done with the empty appliance (without test packs);
- energy consumption measurement with door(s) opening and with an internal heat source
- new compartments other than those defined: it is claimed by manufacturers that there are now many commercial refrigerators that have special functions, or compartments with multiple functions, and the current standard is unable to properly test these products. For example “wine storage” and “wine maturation” systems are now very common and these need to be included, or - as alternative - to be specifically excluded from the standard;
- energy consumption measurement to be done at one or two different temperatures (for example +16°C and +32°C) and then the results somehow “averaged” to give a better representation of the effective consumption of the tested appliance in different ambient conditions; the discussion about how many and the values of the temperatures is on-going;
- average temperature of the fresh food and frozen food compartments, with a potential revision of the entire “star” system

Following a formal request started in 2003 by some Member countries to transfer the cold appliance performance standards from ISO to IEC, ISO agreed to the transfer, which was confirmed by IEC with AC/28/2006, in September 2006. A creation of a new Sub-Committee is forecast within IEC TC59 (the Technical Committee already addressing other home appliances). Also the transfer of the management of the former ISO standards (ISO 15502:2005 and ISO 8960:1991) to IEC is needed.

The transfer of the cold appliance from ISO to IEC does not imply that at European level the technical work will be moved from CEN to CENELEC. At present this has not been taken into consideration nor proposed by CEN/CENELC members.

1.4.1.2 The standards about safety

Safety is dealt in two standards, issued respectively by IEC and ISO.

The general part **IEC 60335-1 Household and similar electrical appliances - Safety - Part 1: General requirements** that it is common to all the electric motor appliances and a set of **Part 2** documents addressing the different specific products.

IEC 60335-2-24:2006, *Household and similar electrical appliances - Safety - Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and icemakers*. The 6^{th} Edition has been published in November 2006 and deals the safety of the following appliances, their rated voltage being not more than 250 V for single-phase appliances, 480 V for other appliances and 24 V DC for appliances when battery operated:

- refrigerating appliances for household and similar use;
- ice-makers incorporating a motor-compressor and ice-makers intended to be incorporated in frozen food storage compartments;
- refrigerating appliances and ice-makers for use in camping, touring caravans and boats for leisure purposes.

It also deals with compression-type appliances for household and similar use, which use flammable refrigerants, but does not cover features of the construction and operation of those refrigerating appliances which are dealt with in ISO standards.

Appliances not intended for normal household use but which nevertheless may be a source of danger to the public, such as appliances intended to be used in shops, in light industry and on farms, are within the scope of this standard. As far as is practicable, the standard deals with the common hazards presented by appliances that are encountered by all persons in and around the home. However, in general, it does not take into account the use of appliances by young children or infirm persons without supervision and playing with the appliance by young children. It does not apply to appliances intended to be used in the open air and appliances designed exclusively for industrial purposes.

Future developments of the IEC 60335 will possibly include an amendment, where relevant of Part 1 and Parts 2, with respect to reasonably foreseeable situations where children, older people and people with disabilities come into contact with electrical household appliances. The Mandate on this matter was finalised in the European Commission and sent to CENELEC CS to be discussed at the BT (Bureau Technique) meeting in December 2006. CENELEC TC61 WG4 “Use of appliances by vulnerable people, including children” has been created for this purpose.

ISO 5149:1993, *Mechanical refrigerating systems used for cooling and heating – Safety requirements*. This standard specifies the requirements relating to the safety of persons and property for the design, construction, installation and operation of refrigerating systems. Gives a classification of the refrigerating systems and applies to all types of refrigerating systems in which the refrigerant is evaporated and condensed in a closed circuit, including heat pumps and absorption systems, except for systems using water or air as the refrigerant. It is applicable to new refrigerating systems, extensions and modifications of already existing systems and for used systems.

1.4.1.3 Airborne acoustical noise

Cold appliance noise is measured using **ISO 8960:1991**, *Refrigerators, frozen-food storage cabinets and food freezers for household and similar use – Measurement of emission of airborne acoustical noise*, prepared by ISO/TC86/SC5. It relates to the main standard for the noise measurement, IEC 60704-1 with replacements or additions dealing specifically with cold appliances. The ISO 8960 standard is under revision and the draft document was approved for registration at the end of 2005.

In Annex 1 to this document a brief description of sound and noise in household appliances is given.

a) General requirements for noise measurement

In general, noise is measured according to the specifications given in IEC 60704-1, 2nd edition, 1997 *Household and similar electrical appliances – Test code for the determination of airborne acoustical noise – Part 1: General requirements*, prepared by IEC technical committee 59: “Performance of household electrical appliances”. A series of Part 2 documents address the individual appliances describing specific test conditions. Finally, IEC 60704-3: 2006, Ed. 2, *Household and similar electrical appliances - Test code for the determination of airborne acoustical noise – Part 3: Procedure for determining and verifying declared noise emission values*, gives values of standard deviations of reproducibility for several categories of appliances.

IEC 60704-1 permits the use of “semi-anechoic rooms”, “special reverberation test rooms” and “hard-walled test rooms” for the measurement of the sound power level of the appliance based on acoustic measuring methods described in ISO 3743-1[17], ISO 3743-2 and ISO 3744[18]. Within the

[17] ISO 3743-1:1994, ed. 1, “Acoustics – Determination of sound power levels of noise sources - Engineering methods for small movable sources in reverberant fields – Part 1: Comparison methods for hard-walled test rooms” and ISO

measuring uncertainty specific to the three possible methods described in the standard, the results from the determination under free-field conditions over a reflecting plane are equal to those obtained in reverberant fields.

This standards is concerned with airborne noise only, while in some cases, structure-borne noise, for example transmitted to the adjoining room, may be of importance. A classification of different types of noise is given in ISO 12001[19]. The methods specified in mentioned ISO standards are suitable for all types of noise, except for sources of impulsive noise consisting of short duration noise bursts, taken into account in Parts 2.

Part 1 of IEC 60704 applies to electric appliances (including their accessories or components) for household and similar use, supplied from mains or from batteries. By similar use is understood the use in similar conditions as in households, for example in inns, coffee-houses, tea-rooms, hotels, barber or hairdresser shops, launderettes, etc., if not otherwise specified in Part 2. It does not apply to appliances, equipment or machines designed exclusively for industrial or professional purposes, appliances which are integrated parts of a building or its installations, such as equipment for air conditioning, heating and ventilating (with some exceptions) oil burners for central heating, pumps for water supply and for sewage systems, separate motors or generators and appliances for outdoor use.

Generally, the determination of noise levels is only part of a comprehensive testing procedure covering many aspects of the properties and performances of the appliance. When preparing the standard it was therefore considered important to keep at a modest level the requirements for noise measurements such as test environment, instrumentation, and amount of labour involved; this resulted in Part 1 methods with an “engineering accuracy” (or “grade 2” according to ISO 12001). The resulting airborne acoustical noise is measured as sound power levels (L_W), expressed in decibels (dB) with reference to a sound power of one picowatt (1 pW), within the specified frequency range of interest (generally including the octave bands with centre frequencies from 125 to 8 000 Hz), and for prescribed operating conditions of the appliance to be measured.

The estimated values of the standard deviations of reproducibility of sound power levels determined according Part 1 are given in ISO 3743-1, ISO 3743-2, and of ISO 3744. But for a particular family of appliances of similar size with similar operating conditions, the standard deviations of reproducibility may be smaller than these values. Hence, in Part 2 series, standard deviations smaller than those listed in ISO standards may be stated if substantiation is available from the results of suitable inter-laboratory tests. In case of discrepancies between the measurements where the results normally remain inside the foreseen standard deviation, it will be necessary to perform measurements according to the upper grade of accuracy (or “grade 1”, laboratory or precision according to ISO 12001) as described in ISO 3741 or ISO 3745.

a) Specific requirements for cold appliances

3743-2, “Acoustics - Determination of sound power levels of noise sources using sound pressure – Engineering methods for small movable sources in reverberant fields – Part 2: Methods for special reverberation test rooms” (both prepared by ISO TC43/SC1).

[18] ISO 3744:1994, Ed. 2, “Acoustics – Determination of sound power levels of noise sources using sound pressure – Engineering method in an essentially free field over a reflecting plane” (prepared by ISO TC43/SC1).

[19] ISO 12001:1996, Ed. 1, “Acoustics – Noise emitted by machinery and equipment – Rules for the drafting and presentation of a noise test code” (prepared by ISO TC43/SC1).

ISO 8960:1991, specifies methods for measuring airborne acoustical noise emitted by electric refrigerators, frozen-food storage cabinets, food freezers and their combinations for household and uses under conditions similar to those in a household, supplied from the mains or from batteries.

This standard does not include methods with precision accuracy, but only with engineering accuracy for the determination of sound power levels, L_W, expressed in decibels with reference to a sound power of 1 pW, of airborne acoustical noise within the specified frequency range and for specified operating conditions of the appliance to be measured. In particular: the frequency range of interest includes the octave bands with centre frequencies between 125 Hz and 8000 Hz (this interval is for practical reasons narrower than the frequency range of audible sound) and the noise measurements are made while the compressors are running. The noise values obtained under the described conditions will not necessarily correspond with the noise experienced under the operational conditions of practical use. For noise control purposes (e.g. development of quieter appliances, insulation of equipment, etc.), other measurement methods using, for example, narrow-band frequency analyses will usually have to be applied which are not covered in this standard.

Prior to noise measurements, the appliance must have been in operation for at least 16h for running-in at a room temperature of 25°C ±5 K. For the measurement, the appliance is operated without loading (i.e. empty) and with some compartment temperature limitations: for fresh-food storage compartment 5°C ±2 K and for food freezer compartment with separate thermostat: -22°C ±2 K (this temperature is the air temperature and not the temperature that is measured in test packages, because an air temperature of -22°C approximately corresponds to a test package temperature of -18°C); loose components inside the appliance which create undue vibrations (e.g. shelves or ice-trays) are secured or adjusted; adjustable feet (if any) are adjusted to attain minimum noise emission; doors or lids are closed.

The uncertainties of measurement according to this standard usually result, for A-weighted sound power levels, in standard deviations generally not exceeding approximately 2 dB, provided that the noise spectrum does not contain pronounced discrete frequencies; if it does, the magnitude of the uncertainties is larger. The standard deviations referred to reflect the cumulative effects of all causes of measurement uncertainties, excluding variations in the noise level of the appliance from test to test.

The standard is under revision and its draft was approved for registration at the end of 2005.

1.4.1.4 Standby measurement

The standby consumption of household electrical appliances is measured according to the standard IEC 60301, Ed. 1, 06.2005 "*Household Electrical Appliances – measurement of the standby power*, 2005. prepared by IEC TC 59 "Performance of Household Electrical Appliances". Standby is defined as:

- **Standby mode:** the lowest power consumption mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when an appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions. The standby mode is usually a non-operational mode when compared to the intended use of the appliance's primary function.
- **Standby power:** average power in standby mode measured in Watts.

Annex A (informative) provides some guidance on the expected modes that would be found for various common appliance configurations and designs based on their circuitry and layout, but the standard does not define these modes. Refrigerators are considered among "Type A" appliances: the appliance has no subsidiary load and no power switch. The appliance operates whenever plugged in. There may be some internal regulation of the load (e.g. thermostat or temperature control device). There is no standby power. **Examples are: electric storage water heaters, refrigerators**.

Since its publication, the standard has been used in Australia and Korea and now forms a fundamental element in the development of policies to influence standby power in these countries. The standard has also been adopted by the US EPA as the base method of test for determination of all low power modes for the International Energy Star program and is also cited under the US Presidential Executive Order for 1 Watt standby power levels as part of the Federal Energy Management Program. An IEA sponsored international conference on standby power in Seoul in November 2005 as a side event held a workshop on the use of IEC 62301.
As a result the worldwide living discussion about this standard and the EC founded study on standby[20] a number of recommendations were made regarding refinements to the IEC 62301 mainly regarding (i) the refinement of the definition of standby mode and (ii) data collection and analysis methods and defining stable conditions, which would improve its accuracy and practical application

A number of changes to both definitions and test conditions of IEC 62301 are under preparation by TC 59/WG 9 "Standby", which were only partially known when this Task Report was prepared.

1.4.1.5 The future of International Standardisation and WTO

The adoption of the WTO (World Trade Organization) Technical Barriers to Trade Agreement (TBT) places an obligation on IEC to ensure that the International Standards it develops, adopts and publishes are globally relevant. International Standards and other type of Publications are globally relevant when they can be used or implemented as broadly as possible by all stakeholders in markets around the world.

According to WTO[21], in order to serve the interests of the WTO membership in facilitating international trade and preventing unnecessary trade barriers, international standards need to be relevant and to effectively respond to regulatory and market needs, as well as scientific and technological developments in various countries. They should not distort the global market, have adverse effects on fair competition, or stifle innovation and technological development. In addition, they should not give preference to the characteristics or requirements of specific countries or regions when different needs or interests exist in other countries or regions. Whenever possible, international standards should be performance based rather than based on design or descriptive characteristics.

1.4.2 The European Standards

1.4.2.1 The measurement of energy consumption and other characteristics

The main standard for refrigerators and freezers is **EN ISO 15502** "*Household refrigerating appliances - Characteristics and test methods*", the new overall standard for cold appliances

[20] Tender TREN/D1/40/Lot 6, "Standby and Off-mode Losses, 2005.
[21] Source: WTO second triennial review of the operation and implementation of the agreement on Technical Barriers to Trade, Annex 4.

published in October 2005 by CEN/TC44 “Household refrigerating appliances” and collecting and re-structuring all the elements included in previous European standard EN ISO 28187: 1991 for refrigerator-freezers; EN ISO 5155: 1995 for freezers; EN ISO 7371: 1995 for refrigerators; EN ISO 8561:1995 for No-frost appliances) and all applicable Amendments which were published over time. In addition to the definition of product groups (refrigerators, freezers and refrigerator-freezers), the measurement of the energy consumption and the appliance volume, the refrigeration performance (depending on the internal compartment temperature) through the so called “star rating” system, the appliance volume, etc.

The content of EN ISO 15502 is the same as the previously described ISO 15502.

The main European harmonised standard for the measurement of the energy consumption of refrigerators and freezers is **EN 153:2006** “*Methods of measuring the energy consumption of electric mains operated household refrigerators, frozen food storage cabinets, food freezers and their combinations, together with associated characteristics*” also prepared by CEN/TC44 and published in May 2006, superseding the EN 153:1995.

The reference to this European Standard is mentioned in the Commission Directive 94/2/EC as amended by Commission Directive 2003/66/EC implementing Council Directive 92/75/EEC with regard to energy labelling of household electric refrigerators, freezers and their combinations. EN 153 specifies the test method to be applied in accordance with these directives and defines also control procedures for checking values declared by the manufacturers. For household refrigerators, household frozen food storage cabinets and their combinations these methods are specified in EN ISO 15502, but since EN ISO 15502 has a wider field of application, the revision of EN 153:1995 has become necessary to conform its requirements to the European legislation on rational use of energy.

EN 153:2006 makes specific reference to the above mentioned EN ISO 15502, including some modification to the described test methods. In particular:

- in *Clause 5 – Design*, only clause 5.1 and 5.6 of EN ISO 15502 apply. To enable direct comparison between all climate class appliances, for the checking the energy consumption the test temperature is always set at +25°C for all class (SN, N, ST and T);
- the refrigerating appliance with a rated voltage within the range between 220V and 240V shall be tested at 230V ± 1% with a frequency of 50 Hz ±1%;
- a specific normative Annex C - “*Rated characteristics and control procedure*”, was set, which has an informative nature in EN/ISO 15502, and deals with the control procedure of the declared values, which is fundamental for the verification of the compliance to the energy labelling and other EU legislation on cold appliances.

a) The differences with EN 153:1995 and previous EN ISO standards

The main changes in EN 153:2006 compared to the previous 1995 edition are:

- the rated voltage to test the refrigerating appliances, changed from 220 V to 230 V;
- inclusion of a correction formula for the energy consumption measured value, to be normalised at ambient temperature = 25°C sharp; when possible ambient temperature range is from 24,5 °C to 25,5 °C;
- addition of a normative annex on built-in refrigerating appliances;
- (editorial) addition of reference to Directives 94/2/EC and 92/75/EEC;
- editorial modifications to be consistent with EN ISO 15502.

The significant changes in EN ISO 15502: 2005 compared to the previous EN ISO standards (EN ISO 28187: 1991, EN ISO 5155: 1995, EN ISO 7371: 1995 and EN ISO 8561:1995) are:
- definition of "operating cycle", now is the period between two successive stops of the system;
- frost-free (no-frost) appliance definition, such as simple refrigerators can not be named frost-free;
- definition of adaptive defrost added
- lower temperature limit for ST and T climatic classes changed from +18°C to +16°C
- average fresh food storage compartment temperature change from +5°C to +4°C with the three specific values to be included in the range 0-8°C (before in the range 0-10°C);
- tolerance on the measured linear dimensions ±5%;
- ambient humidity not exceeding 75% (before to be included in the range 45-75%);
- testing platform definition and dimensions improved, and temperature under the platform to be measured and kept at ambient temperature ±1°C when starting the test;
- air flow measurement better defined;
- allowed test packages of 250g and "flat" 500g test packages;
- brass weight tolerance ±5% included;
- overall uncertainty of the temperature measuring instrument chain to be ± 0,5°C, with regular calibration required;
- maximum data recording interval not grater that 1 min;
- readability of the Wh-meter for the energy consumption measurement improved to 0,001 kWh (before 0,01 kWh), calibration is required, accuracy of the system to be declared in the test report;
- cellar and fresh food compartments in all appliances (frost-free included) to be measured through brass cylinders;
- stable operating conditions definition changed and better specified: storage temperature (±0,5°C) and energy consumption (±3%) to be stable before starting the testing period (the latter to be not longer than 48h, with some exceptions for food freezers)
- gross volume definition changed, to be the total volume inside the liner instead of being determined subtracting the volume of Air Duct etc. from total volume inside the liner; the effect of this change is that the gross volume will be larger than in previous ISO standards;
- for the energy consumption measurement, the fresh food compartment has to be kept at +5°C with the three specific temperatures in the range 0-10°C (to keep the measured energy consumption in line with the energy labelling).

b) Further developments of EN 153 and EN ISO 15502

Further development of EN 153 might be related to its capability to reflect the real usage of cold appliances by consumer. The main critic to the European standard is that the opening of the doors is not included in the test conditions for the measurement of the energy consumption, while it is considered in the Japanese standard. A first answer to this critic is already included in the MEEUP – Product Cases Report[22], where the Author states that the higher testing temperature (+25°C) foreseen by EN 153 compared to an estimated European average ambient temperature of 20 °C, has been chosen to take into consideration - and therefore compensate - the door opening and the insertion of warm foodstuff of real life usage; the author estimates that the higher ambient testing temperature accounts for a 15-20% higher energy consumption, which is more than enough to compensate the 1-2% energy loss due to door opening and the 4-10% due to insertion of warm load. The final conclusion is that the exaggerated ambient temperature under EN 153 is not a bad representation of the real-life.

[22] VHK, MEEUP – Product Cases Report, Chapter 3 – Consumer behaviour and local infrastructure, point 3.1 – Real-life usage, 28.11.2006, pp. 6.1-6-40.

COLD-II study also addressed the issue of the correspondence between the energy consumption measured according to EN 153 and the actual *in situ* energy consumption for the same appliance. The conclusion was that the equivalence of the two consumptions is a simplification and is likely to lead to some important under- or over-estimates for some Member States, depending most critically on the year-round average kitchen temperature. However, this simplification has been obliged as a result of a lack of reliable data to determine the real correspondence between actual and tested cold appliance energy consumption. Nevertheless, in the sole case known to that study where an attempt had been made through extensive detailed end-use metering to make a comparison (ECUEL 2000), it was found that the average *in situ* annual energy consumption of almost 100 cold appliances was in remarkably close agreement with the average declared energy consumption under EN 153; however, this case applied to central France and may not be representative of the EU, or even of France, as a whole.

Further development of EN ISO 15502 will follow the evolution of the corresponding IEC standard, described in paragraph 1.4.1.1.a. and EN 153 will be also modified accordingly.

c) The CECED "Operational Code for Appliance Testing"

Following the results of the European ring test on refrigerators, which highlighted a spread of the values measured in the participating laboratories, the ring test participants identified a number of causes of differences between different test lab procedures and differences of interpretation of the standard EN153:1995 and relevant ISO standards (TNO, 2001[23]). A proposal came to minimise differences by clarifying specific test conditions in a common set of guidelines.

Test methods guidelines were detailed in CECED's Operational Code published in 2000, which are mentioned also in Commission Decision 2004/669/EC establishing revised the eco-label criteria for refrigerators. The declared purpose of this code[24] is "to arrive at a commonly accepted practice for cold appliance testing between manufacturers organised in CECED. Furthermore, the operational code is offered as the CECED standpoint to the SAVE "Ringtest group". Finally the operational code is used as input to the discussions within the relevant ISO committee for the revision of the present standards".

Some of the proposed modifications/clarifications are now included in the new standard EN ISO 15502:2005 (see before).

1.4.2.2 Safety Standards

Safety for cold appliances is mainly dealt by the general part **EN 60335-1** *Household and similar electrical appliances - Safety - Part 1: General requirements* that it is common to all the electric motor appliances "**Part 2"** document addressing the different specific products and components:

- **EN 60335-2-24**: Particular requirements for refrigerating appliances, ice-cream appliances and ice-makers
- **EN 60335-2-34**: Particular requirements for motor-compressors
- **EN 60335-2-89**: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor.

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[23] S.M. van der Sluis, TNO-Report R2001/108 (version 2), Cold Appliance European ring test – Final Report and testing guide, December 2001.

[24] CECED, "Operational Code for Appliance Testing for refrigerators and freezers", final version, 6 December 2000,

Of the above mentioned standards, clauses which need particular attention are

- in EN 60335-2-24: clauses about marking and instructions, abnormal use, construction, clearances creepage distances and solid insulation, resistance to heat and fire;
- in EN 60335-2-34: clauses about abnormal operation, construction, components, provision for hearthing, clearances creepage distances and solid insulation, resistance to heat and fire
- in EN 60335-2-89: see EN 60335-2-24.

EN 60335-2-24: 2003/prA2:2006, is the European version of the IEC standard described in the previous paragraph, prepared by TC 61 "Safety of household and similar electrical appliances". In addition, it is necessary to mention **CEN/TR 14739:2004** "*Scheme for carrying out a risk assessment for flammable refrigerants in case of household refrigerators and freezers*", prepared by CEN/TC182 "Refrigerating systems. Safety and environmental requirements". This Technical Report gives a scheme for carrying out risk assessment for flammable refrigerants in case of household refrigerators and freezers with refrigerants of group A3 (ethane, butane, isobutane, pentane, isopentane, propane, etc.) according to EN 378-1, taking into consideration a sealed system and a refrigerant charge of not more than 150g. Sealed systems are refrigerating systems in which all refrigerant containing parts are made tight by welding, brazing or similar permanent connection. At least the probability of deflagration is the product of multiplication of probability of defects of different components and the probability of the presence of explosive atmosphere and the probability for the ignition sources.

1.4.2.3 Noise measurement

Noise measurement standard **EN ISO 28960**:1993 *Refrigerators, frozen-food storage cabinets and food freezers for household and similar use. Measurement of emission of airborne acoustical noise*, implements without any modifications the International Standard ISO 8960:1991 (see previous paragraph).

1.4.2.4 Standby measurement

The standby consumption of household electrical appliances is measured according to the European standard EN 62301:2005 including the common modification agreed at European level to the international standard IEC 62301:2005, prepared by Technical Committee CENELEC TC59X "Consumer information related to household electrical appliances". The latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) is 1st June 2006, the latest date by which the national standards conflicting with the EN have to be withdrawn (dow) is 1st July 2008. The common modification to IEC 60301 refer to the definition of the power supply and the control procedure:

- specification **power supply**: where the test voltage and frequency are not defined by an external standard, the test voltage and test frequency shall be 230V ± 1% and 50Hz ± 1%. If the appliances are to be connected to three phases and the test voltage and frequency are not defined by an external standard the test voltage and test frequency shall be 400V ± 1% and 50Hz ± 1%;
- addition of a specific clause on **tolerances and control procedure**: where tolerances and control procedures are not defined by an external standard, the tolerances and control procedures are:
  - for **power consumption >1W**: the standby power measured on the first appliance shall not be greater than the value declared by the manufacturer plus 15%. If the result of the test carried out on the first appliances is greater than the value declared plus 15%, the test for standby power shall be carried out on a further three appliances, which shall be randomly selected from the market. The arithmetic mean of the values of these three appliances for the standby power shall not be greater than the declared value plus 10%.
  - for **power consumption ≤ 1W**: the measured standby power shall not be greater than the value declared by the manufacturer plus 0,15W. If the result of the test carried out on the first appliance is greater than the declared value plus 0,15W, the test shall be carried out on a further three appliances, which shall be randomly selected from the market. The arithmetic mean of the values of these three appliances shall not be greater than the declared value plus 0,1 W.

This European standard will follow the modifications of the corresponding IEC standard in due course.

1.4.2.5 Absorption refrigerators

A part from the before mentioned standard for safety and noise, EN 732:1998 *Specifications for dedicated liquefied petroleum gas appliances - Absorption refrigerators* applies. The standard establishes the technical characteristics, safety requirements, test methods and marking of absorption refrigerating appliances using commercial butane and propane (liquefied petroleum gases). As far as the energy consumption is concerned, EN153 (and EN ISO 15502) is used.

1.4.3 The Standards used in Other Countries

In **Australia and New Zealand** cold appliances are addressed by the standard AS/NZS 4474:1997 *Performance of household electrical appliances - Refrigerating appliances*, prepared by the Joint Standards Australia/Standards New Zealand Committee EL-015, *Quality and Performance of Household Electrical Appliances*. This standard is divided in two Parts:

- **4474.1 Part 1**: *Energy consumption and performance*. This part includes all test conditions, requirements for temperature performance and the method for determination of energy consumption. Since the year of publication, three amendments have been issued to Part 1, the last in December 2004;
- **4474.2 Part 2**: *Energy labelling and minimum energy performance standard requirements*. This second part includes algorithms for the calculation of the energy efficiency rating, star rating and comparative energy consumption, performance requirements, details of the energy label and requirements for the valid application thereof. It also contains the minimum energy performance standards for refrigerators and freezers (see paragraph 1.5.3.1 for the description of the Australia and new Zealand policy measures for cold appliances).

In the **USA** cold appliances are measured according to the AHAM standard HRF-1-1988. However, most energy-consumption data in the USA are measured under the US Department of Energy (US DOE) Code of Federal Regulations (CFR Part 430 Subpart V Appendices A1 and B1), which draws in parts of the AHAM standard but also modifies parts. DOE regulations have precedence regarding all mandatory US government requirements for energy labelling and energy efficiency requirements. Note that DOE regulations cite AHAM HRF-1-1979 and not the 1988 version.

India is using the AS/NZS 4474.1:1997 test procedures in the interim, till the relevant Indian standards are developed/revised;

Japan established in 2006 a revised version of JIS C 9801, but the previous standard edition JIS 9801:1999 will be used until 2009 for the measurement of the cold appliance energy consumption within the Top-Runner scheme.

China is using the ISO (and therefore EU) standards for cold appliances.

1.4.3.1 The comparison of major cold appliance standards worldwide

The comparison of the different efficiency requirements for cold appliances around the world with those applied in the EU could be an interesting exercise in order to see if there are any major differences in performance. However, often the standard used to measure the energy consumption and the other parameters included in various labelling scheme and/or efficiency requirements are based on different measurement methods as is applied in Europe, which makes comparison difficult o even impossible. In particular:

- The NAFTA economies use a test procedure that has a 32,2 °C ambient test temperature and different internal operating temperatures than required in the EU.
- Australia and New Zealand also test at an ambient temperature of 32 °C and have a number of other differences compared to the ISO and European test procedures.
- Korea and Taiwan both apply an ambient temperature of 30 °C.
- Japan now uses a test procedure that is very similar to EN 153 except that it includes door openings.

- Most of the other countries mentioned use the ISO test procedures, which are identical to EN 153 except that the former allows tropical climate-class models to have their energy consumption tested at 32 °C, while under EN 153:2005 all appliances have their energy tested at 25 °C regardless of their climate class.

The comparison of the main features of the AS/NZS 4474.1-97, Amendments 1, 2 and 3 of 2004, ISO15502/EN 153 and ANSI/AHAM standards is presented in Table 1.2. Only the main differences are highlighted in the Table, a comprehensive comparison of the standards is out of the scope of the present study. The Japanese standard JIS C9801:1999 has not been compared since it is identical to ISO (and hence EN 153), except that it includes door openings in a controlled humidity environment, the pull-down test (not included in the ISO standard) and the freezer is loaded only for natural convection appliances. The method of computing the equivalent volume is identical to that used in the EU. It should be noted that the ISO "star" rating system, the purpose of which is to indicate the freezing capability of the freezer compartment(s), is not used in Australia, New Zealand and US. These countries use 'star' as a measure of the relative energy efficiency of cold appliances.

Table 1.2: Main features of the AS/NZS 4474.1-97 (incorporating A1,2 and 3), ISO/EN 153 and ANSI/AHAM standards

Test condition	AS/NZS 4474.1-97, A1,2,3	ANSI/AHAM[1]	ISO/EN 153[2]
Energy consumption, ambient temperature	(32 °C ± 0,5) °C	(32,3 °C ± 0,6) °C	(25 ± 0,5) °C[3]
Energy consumption, fresh-food temperature	3°C	3,3-7,22 °C[4]	5 °C
Energy consumption, freezers (frozen food storage temperature)[5]	–15 °C	–15/–17,8 °C[6]	–18 °C[6]
Energy consumption, freezers (frozen food storage) loading	Unloaded	Sometimes loaded[7]	Loaded
Operation test, ambient temperatures[8]	10/32/43 °C	21,1/32,2/43,3 °C[9]	10/32°C, 16/32-38-43 °C[10]
Operation test, fresh-food temperatures[11]	0,5 – 6 °C	1,1 – 5 °C	+4 °C[12] (0 - 8) °C
Operation test, frozen food storage temperatures[13]	≤ –15 °C	≤ –15/–17,8 °C[6]	≤ –18 °C[14]
Pull-down test	Yes	Yes	No
Freezing-capacity test	No	No	Yes
Ice-making capacity	Yes	Yes	Yes
Temperature-rise time	No	No	Yes
Other characteristics tests	No	Yes[15]	Yes[16]
Gross volume[17]	Compartment (including sub-compartment)	Not specified	Total only (not specified at sub-compartment level)
Storage volume[18]	All levels	All levels	All levels
Volume used for efficiency requirements and energy labelling	Gross	Storage	Storage (in EU)
Freezer compartment adjustment factor (equivalent volume definition)	1,6	1,63	2,15
Separate freezer energy adjustment	No	0,7/0,85[19]	No

Energy sources and refrigeration systems covered	Mains-powered electric vapour compression[20]	All electric AC single-phase systems[21]	Any[22]
Humidity	Not specified	Not specified[23]	≤75%
Anti-sweat heaters during energy-consumption tests	On	Average on and off	only when needed

Notes:

1 The AHAM refrigerator standard is AHAM HRF-1-1988. However, most energy-consumption data in the USA aremeasured under the US Department of Energy (US DOE) Code of Federal Regulations (CFR Part 430 Subpart V Appendices A1 and B1), which draws in parts of the AHAM standard but also modifies parts. DOE regulations have precedence regarding all mandatory US government requirements for energy labelling and energy efficiency requirements. Note that DOE regulations cite AHAM HRF-1-1979 and not the 1988 version.

2 The main ISO standards for refrigerator performance and energy consumption, ISO 5155 (freezers), ISO 7371 (refrigerators without freezers), ISO 8187 (refrigerator-freezers) and ISO 8561 (forced-air/frost-free units) were combined in the new standard ISO 15502:2005.

3 Ambient test temperature for energy consumption under ISO is +25°C for all climate classes except tropical, which is tested at +32°C. In EN standard the testing temperature is always +25°C to allow climatic classes comparison.

4 AHAM and DOE regulations only specify a fresh-food compartment temperature of 3,3 °C for 'all refrigerators' (i.e. fresh-food compartments with either no freezer or with a small ice-making sub-compartment of <14,2 litre). For tests on refrigerator-freezers, the fresh-food temperature only has to be below 7,22 °C.

5 Freezer compartments in this table refer to compartments intended for the long-term storage of frozen food. The definition of freezers is different in ISO, where the capability for freezing foodstuffs from ambient temperature down to -18 °C is required for a compartment to be considered a "freezer". There are numerous other frozen and unfrozen compartment types not covered by this table. AS/NZS4474.1 freezer-compartment temperature is determined from the average of the warmest 4 of the 5 air temperature sensors. ISO reports compartment temperatures as the warmest test package position at the warmest part of the cycle for all tests (AS/NZS4474.1 also uses this method for loaded operation tests). ANSI/DOE compartment temperatures are the average of all temperature points taken at ≤ 4 minute intervals over the test period (excluding defrost cycles).

6 A frozen food storage temperature of –15 °C applies to refrigerator-freezers, while –17,8 °C applies to separate freezers. ISO defines a "freezer" compartment as not only suitable for the storage of frozen food under 3-star storage conditions but is also suitable for freezing foodstuffs from ambient temperature down to -18°C and is rated 4 stars.

7 HRF-1-1979 specifies that for energy-consumption tests all freezer compartments shall be loaded. However, the DOE CFR 430 test procedures specify that freezer packs are not to be used in the determination of energy consumption for automatic-defrost (frost-free) refrigerator-freezers (the most common appliance type in the USA) or 'all refrigerators' with ice-makers. In these cases, freezer-compartment temperatures are measured with thermocouples inside metallic cylinders of 29 mm ± 6 mm (the metal is not specified, but if it were copper, this would equate to a thermal mass of between 8 g and 28 g water equivalent). All other appliance types under AHAM (including all separate freezers) are tested with the freezer compartment loaded. The freezer test packs used under AHAM measure 130 × 100 × 40 mm and contain sawdust or spinach. Under the AHAM standard the freezer compartment is loaded to only 75% of its capacity. AHAM test packs are different from the test packs specified in ISO, which have different dimensions and contain oxy-ethyl-methylcellulose. AS/NZ4474.1 specifies test packs that are identical to ISO –1 °C packs. Under ISO and ANZ the freezer compartments are fully loaded (except for specified air gaps). ANZ specifies 15 mm air gaps between test packs and the freezer walls, while ISO specifies that they should be in contact.

8 Temperature operation tests are conducted with freezer test packs for all three standards.

9 The 'simulated load test' under AHAM has only recommended levels of performance and is not a mandatory requirement for refrigerators in the USA under DOE regulations for labelling or energy efficiency requirements.

10 The indicated temperature ranges refer to the possible climatic classes under ISO/EN, respectively Extended Temperate and Temperate, Sub-tropical and Tropical.

11 Fresh-food temperatures in all standards are averages. AS/NZS 4474.1 specifies that thermocouples shall be placed inside copper or brass cylinders with a thermal mass of between 10 and 20 g water equivalent, while ISO usually specifies cylinders which have 2,3 g water equivalent. AHAM allows thermocouples to be weighted or un-weighted, but where weighted, the thermal mass shall not be greater than 20 g of water equivalent.

12 ISO average fresh-food compartment temperatures are to remain at ≤4 °C, but this may rise of 3K during defrosting in a frost-free appliance. In addition to this requirement, the temperatures at each of the measuring points in the fresh-food compartments (generally three points) must remain within the range 0–8 °C throughout the test.

13 Allowable freezer pack temperature ranges for an operation test are generally less than or equal to the target temperature for energy consumption.

14 Test pack temperatures are allowed to rise to –15 °C during defrosting cycles for no more than 20% of the time or 4h.

[15] AHAM tests for other characteristics are related to durability and include handling and storage test (for packaging), external surface condensation test, internal moisture accumulation test, environmental cracking resistance test and bottom breaker strip impact test. AHAM does not recommend minimum requirements for these tests.
[16] ISO tests include for other characteristics are door air-tightness, door opening force, durability of hinges and doors and mechanical strength of shelves. ISO specifies minimum requirements for each of these tests.
[17] Gross volumes for AS/NZS differ from ISO in a number of minor areas. However, the previously reported most significant difference (that the volume of air ducts in a frost-free system within the liner shape is counted as part of the gross volume accepted in ANZ but not allowed under ISO) is now overcome.
[18] The only volume specified in AHAM ('refrigerated volume') is essentially a storage volume equivalent under ISO and ANZ. However, there are minor differences in the determination of storage volume under all of these standards.
[19] The US DOE Code of Federal Regulations specifies that the measured energy consumption is adjusted by a factor of 0,7 for chest freezers and 0,85 for vertical freezers 'to adjust for average household usage'.
[20] This is the scope of AS/NZS 4474.2 which covers government requirements for energy labelling and energy efficiency requirements. The scope of AS/NZS 4474.1 includes all electric powered units but excludes low-voltage DC, portable and multi-fuel systems.
[21] This is the scope of the US DOE Code of Federal Regulations for the purposes of energy labelling and energy efficiency requirements. The AHAM standard includes all electric units (but excludes gas-powered types).
[22] The EU legislation on energy labelling and energy efficiency requirements applies only to electric mains operated appliances; appliances that may also use other energy sources, such as batteries, are excluded.
[23] Humidity is specified for some of the other performance tests such as external condensation and internal moisture accumulation (at 75% ± 2%), but not for energy consumption or operation tests.

1.4.3.2 The latest development in cold appliance testing in Australia and Japan

a) Australia

In 2006 the Australian Greenhouse Office was informed that cold appliance could have an electric anti-sweat heater that operates at all ambient temperatures from 10°C to 43°C, but turns off when the ambient temperature is 32°C without door openings (as required in the standard AS/NZS 4474.1). The result is a reduction on annual energy consumption of about 20%. With the advent of "smart" electronics, it seems some suppliers can use control strategies to reduce the apparent energy used to obtain a favourable label in comparison with competitor products. As consequence, AGO informed stakeholders that AS/NZS 4474 Part 1 standard should be revised.

In August 2007[25] the new edition of AS/NZS 4474.1:2007 was published. This revision was not believed to introduce substantive technical changes and in most cases the results would be the same as under the 1997 edition. However, many loopholes and inadequacies in the 1997 edition of the standard have been addressed. A large number of minor technical points have been tidied up and many changes have been made in the light of cabinet designs that have appeared on the market in recent years:

- the definitions of a chest type have been amended to include rules about combination configurations that have now appeared on the market;
- there are also revised rules to cover appliances with frozen food compartments with different defrost types;
- although the standard is not intended to cover wine storage cabinets, a definition covering them has been introduced to clarify the demarcation between cabinets specifically designed for wine storage and those covered by the standard. Refrigerating appliances that are not specifically

[25] AS/NZS 4474.1:2007, Performance of household electrical appliances— Refrigerating appliances Part 1: Energy consumption and performance, published on 15 August 2007; preview downloadable form www.saiglobal.com .

designed for wine storage but that may be nevertheless used for this purpose are covered by the standard, as well as appliances that have a wine storage compartment combined with any other compartment type defined in the standard. Separate wine storage cabinets are not included but may be tested using the specified methods as a cellar or special (unfrozen) compartment depending on the claimed temperature range but excluding any pull down requirement;

- the most significant technical change in this draft is the alteration of the temperature determination period to align with the energy determination period. The average compartment temperature now includes any defrost and recovery operation. This will impact on the average temperature results for some refrigerators and compartment types that have automatic defrost and provides some incentive for manufacturers to minimise any temperature rise in compartments during a defrost, which will result in improved conditions for the storage of foodstuffs;

- with the advent of microprocessors and electronic controls, refrigerating appliances have emerged with various unusual operating patterns. These are patterns that were not displayed by appliances managed by electromechanical controls. The emergence of these patterns has necessitated the tightening of test specifications to detect and deal with those patterns that would consequently provide poor food care. It has also been necessary to deal with patterns that give abnormally low energy consumption in an energy test by modifying or eliminating functions that are otherwise operational in normal use such as anti-sweat heaters.

  Should products appear in the marketplace that meet the letter but not the intent of this Standard, then this Standard will be amended accordingly;

- electronically controlled systems are often such that it is not possible to disable defrost heaters without the system detecting that as a fault and responding. To overcome this problem the temperature performance test has been modified to also take into account defrost that can neither be disabled nor avoided during testing. A test procedure and pass criteria for each alternative is now included;

- methods for the determination of energy consumption where there are multiple cooling systems has been modified to also apply to cabinets with multiple independent defrost systems. It is envisaged that, with future revisions of this Standard, the two-part method may be required for selected tests;

- Annex Q introduces a 2 part energy test procedure. Based on the US DOE test method, this sets out a procedure for the calculation of average energy consumption from two (or more) components of energy consumption of a frost free refrigerating appliance. It combines the rate of use during normal running with the rate during an automatic defrost cycle. This allows an accurate estimate of the total energy consumption to be calculated for any elapsed time between defrosts.

  For this edition of the standard this method has been provided to give users experience with its application with real test data and appliances. Apart from some of the cases where there are two or more defrost systems in operation, at this stage it is informative only. It is envisaged that in future editions this procedure may become mandatory for other energy testing.

b) Japan

A new Japanese standard JIC C9801:2006 will be used to test appliances from 2010[26]. The previous JIS 9801:1999 has been modified so that testing conditions more closely resembled actual use conditions. Two features of the revision (Table 1.3) are especially noteworthy:

- two testing conditions (15°C and 30°C) are foreseen;
- the placement of load in the fresh food and freezer compartments in process of testing.

Table 1.3: Comparison of the testing conditions under JIS C 9801:1999 and JIS C 9801:2006

		JIS C9801(old)		JIS C9801 (revised)	
Year		1999		2006	
Type		Forced circulation	Natural convection	Forced circulation	Natural convection
Ambient temperature		25°C		30°C : 180days 15°C : 185days	
Relative humidity		70%±5%		30°C : 70%±5% 15°C : 55%±5%	
Installation	back	On the wall		On the wall	
	sides	300mm away from walls		50mm away from walls	
Load	fresh food	No	No	Put in during testing	No
	freezer	No	Yes		Yes
Storage temperature	fresh food	≦ 5°C		≦ 4°C	
	freezer (***)	≦ -18°C		≦ -18°C	
	vesitable	Set to minimize energy use		Set to factory preset mode	
Open/close door	fresh food	25 times		35 times	No
	freezer	8 times		8 times	No
Automatic ice making		Off		On	Off
Other optional function such as deodorizing		Off (if users can turn on/off)		Set to factory preset mode	

It is considered that these complicated conditions make it virtually impossible for an embedded program to distinguish the testing from the actual use. This new standard will be used for the Top-Runner scheme from 2010.

1.4.4 Food Storage Temperature at Retail and Domestic Level

The COLD-II study spent few sentences in considering the possible energy savings deriving from the reduction of the food storage temperature to an intermediate temperature between -18°C and -10°C, especially in the freezer appliances/compartments. The reason for this proposal was that since bacteria does not propagate in foodstuffs stored below –10 °C there is no biological risk in such temperature increase, only enzymatic degradation continues, decreasing the food long term storage, which may in turn encourage consumers to hoard less. To realise these savings would require modification of the existing frozen-food storage rules, which could not be achieved without a substantial technical review and appreciable institutional effort[27].

[26] Source: T. Tsurusaki, Y. Iwafune, Y. Shibata, C. Murakoshi, H. Nakagami, Actual Energy Consumption of Top-Runner Refrigerators in Japan, Jyukankyo Research Institute, Inc., downloadable from: http://mail.mtprog.com/CD_Layout/Day_1_21.06.06/1400-1545/ID63_Tsurusaki_final.pdf .

[27] COLD-II study: "Furthermore it is worth noting that substantial energy savings could be achieved were changes to be allowed in the existing food-preservation rules. Bacteria does not propagate in foodstuffs stored below –10 °C yet the current definition of a 3- and 4-star frozen-food compartment is one where the warmest food in the compartment is not above –18 °C. This requirement means that the average 3- or 4-star frozen-food compartment temperature is actually ~–21°C, which is some 6°C less than the average freezer-compartment temperature in a US refrigerator-freezer, for

A part from any consideration about "food hoarding" by people through just extending the lifetime of frozen food, fresh and frozen food storage temperature at home is deeply influence by the European and national legislation and by international agreements, which will be very briefly described.

1.4.4.1 The "Cold Chain"

Refrigeration is an appealing food preservation process, because it is one of the few that preserves the original properties of foodstuffs[28]. Its main field of application is the preservation of foodstuffs of animal origin: meat, dairy and seafood products. However, the process is also used to freeze foodstuffs of plant origin, or to chill them, in which case the purpose is to extend their storage life and to maintain their freshness. The protective action of refrigeration lasts only as long as it is applied. It is therefore necessary to keep products refrigerated, from production to consumption. Some products, such as ice cream, owe their very existence to refrigeration. The three basic rules of refrigeration are:

- wholesome food
- early refrigeration
- permanent refrigeration

The third rule, which refers to the continuity of refrigeration, is commonly known as the "cold chain", which is defined as the means successively employed to ensure the refrigerated preservation of perishable foodstuffs from the production to the consumption stage. If a break in the cold chain occurs, the consequences may take various forms, from early wilting of foodstuffs of plant origin, particularly vegetables, to the development of spoilage flora, or, even worse, of pathogenic flora or toxins, which may cause food-borne diseases. However, it took about 30 years in most developed countries (1945-1975 in Europe for example) to set up reliable cold chains.

Food-borne disease is defined as any disease of an infectious or toxic nature caused, or thought to be caused, by the consumption of food or water. Most food-borne disease is thought to be of microbial origin. Microorganisms cause food-borne illness by one of essentially two mechanisms: *infection,* when viable organisms (bacteria, viruses or parasites) are present in food and enter the body, where their growth and metabolism produce the disease response; and *intoxication*. when the presence and (usually) growth of an organism in the food because of incorrect storage are accompanied by the accumulation of a toxin that is ingested with the food and causes illness.

Under optimal conditions, bacteria divide every 20 minutes: therefore, within 8 hours under optimal temperature conditions and where the medium is of optimal composition, one bacterium will have generated over 16 million descendants. This confirms that temperature is a fundamental factor enabling the control of microbial risks.

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example. Providing food is frozen rapidly the size of ice crystals is minimised and the longevity of food preservation is maximised. Therefore, from a public health perspective, it is only important for the foodstuffs to be rapidly frozen and stored below –10°C. Enzyme activity, which causes foodstuffs to degrade but poses no biological risk, still occurs at lower temperatures than this and is retarded the lower the storage temperature. However, were an intelligent freezing system that cooled rapidly before allowing the food storage temperature to rise to an intermediate level of between –18°C and –10 °C permissible, it would save a considerable amount of energy compared to the current situation. Any associated reduction in the long-term storage time of food without degradation in food quality may encourage consumers to hoard less, but should not pose a biological risk. To realise these savings would require modification of the existing frozen-food storage rules, which could not be achieved without a substantial technical review and appreciable institutional effort" :

[28] Source: "New Developments in the Cold Chain: Specific Issues in Warm Countries", François Billiard, Director of the International Institute of Refrigeration, ECOLIBRIUM, July 2003.

1.4.4.2 Energy and economical considerations

Although lower temperatures may lead to higher quality and value, they lead also to increased cost. In an economic study of frozen food, Poulsen and Jensen (1978)[29] used the concepts of supply and demand to describe the optimum frozen storage temperature. The supply curve, represented by the cost of energy to drive refrigeration machinery, increases with decreasing temperature. The demand curve, represented by losses of quality and value while in storage, decreases with decreasing temperature. The intersection of these curves represents the optimum temperature. While this approach provides some insight into the nature of the quality–cost question, temperature optimization in frozen food inventory is a more dynamic concept. It will depend also on length of time in storage. Inventory levels of many frozen food products are highly seasonal. Any setting of an optimal temperature will be a forward-looking concept that incorporates an expected rate of inventory dissipation. This expectation is critical in determining optimum temperature since quality is deteriorating over time, costs are accumulating over time, and the optimal temperature must balance these changes against the expected rate of inventory dissipation.

1.4.4.3 The EU legislation

a) The legislation about "frozen" food

When the term "frozen food" is used it very often means or includes "quick-frozen foods", however, in legislation and also according the ATP agreement frozen foods and quick-frozen foods are two different types of products.

Council Directive 89/108 of 21 December 1989 *on the approximation of the laws of the member states relating to quick-frozen foodstuffs intended for human consumption*, defines 'quick-frozen foodstuffs' those foodstuffs which have undergone a suitable freezing process known as 'quick freezing' whereby the zone of maximum crystallization is crossed as rapidly as possible, depending on the type of product, and the resulting temperature of the product (after thermal stabilization) is continuously maintained at a level of −18 ºC or lower at all points, and which are marketed in such a way as to indicate that they possess this characteristic. But ice-cream and other edible ices are not considered as quick-frozen foodstuffs.

The temperature of quick-frozen foodstuffs must be stable and maintained, at all points in the product, at −18 ºC or lower, with possibly brief upward fluctuations of no more than 3 ºC during transport. However, tolerances in the temperature of the product in accordance with good storage and distribution practice are permitted during local distribution and in retail display cabinets provided these tolerances shall not exceed 3 ºC. Higher tolerances, up to 6 ºC were also permitted in specific cases for 8 years after the implementation of the directive. In addition, minimum durability, period during which quick-frozen products may be stored by the purchaser and the storage temperature and/or type of storage equipment required must be indicated along with a clear message of not refreeze after defrosting.

The definition of "frozen food", compared to "quick-frozen food" is not quite clear. Frozen food con be sold to consumer provided it is labelled as "frozen" (to distinguish it from quick-frozen

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[29] Source: Poulsen, K.P. and S.L. Jensen, "Quality-Economy Relations of Frozen Foods", Proceedings of the IIR, Budapest, 1978.

food), and the storage temperature must be -12°C or colder. In Denmark frozen food must not be sold in supermarkets, while in Australia the two terms are synonymous[30].

Other applicable EU Directives are:

- Directive 92/1/EEC of the Commission of 13 January 1992 on the monitoring of temperatures in the means of transport, warehousing and storage of quick-frozen foodstuffs intended for human consumption,
- Directive 92/2/EEC of the Commission of 13 January 1992 on the sampling procedure and the Community method of analysis for the official control of the temperatures of quick-frozen foodstuffs intended for human consumption,

Other information about the EU, national and international legislation on the temperature of frozen food can be found in the IIR Bulletin 2002-4.

b) EC Regulation 852/2004 and HACCP[31]

All European food businesses are required by law to have food safety management systems based on the principles of HACCP (Hazard Analysis and Critical Control Point). This is now covered by European legislation on the hygiene of foodstuffs, which came into effect on the 1st January 2006 (Regulation (EC) No. 852/2004). Food businesses are required to ensure that all steps in the activities of their business critical to food safety are identified and to ensure that adequate safety procedures are put in place. Primary responsibility for food safety lies with the food business operator.

HACCP is a systematic and scientific approach to identifying and controlling hazards and is generally regarded as the most effective means of minimising the levels of contamination on many food products, however, reports indicate that European food businesses are still struggling to implement the principles of HACCP. Among those, produce requiring chilled storage should be stored at refrigeration temperatures generally between 0°C and 5°C; frozen foods should be stored in freezer units at -18°C. Temperature checks of chill and freezer units should be carried out regularly to ensure storage is at the correct temperature. The monitoring of these can be considered as part of the retail HACCP plan.

1.4.4.4 Refrigeration, freezing and frozen food temperature worldwide

In 1993, the Food and Drug Administration (FDA) recommended that supermarkets lower the core temperature of certain refrigerated foods from 45 °F (7°C) to 41°F (5°C). This temperature reduction, for meat, dairy, deli, fish, poultry and cut produce, was intended to reduce the transmission of food-borne diseases.

Freezing does not destroy spoilage organisms; it merely stops their growth temporarily[32]. During the freezing process, microbial growth can occur under the following circumstances: (i) when freezing does not take place rapidly; (ii) when freezer temperature is above 0°F [(corresponding to

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[30] Source: L. Sørensen, “Frozen food legislation”, Bulletin of the IIR, 2002-4.

[31] Source: R. Pearce, B. Maunsell, D.J. Bolton, “Guidelines for Food Safety Control in Retail Establishments”, Teagasc-Ashtown Food Research Centre, February 2006; downloadable from www.eu-rain.com/publications/

[32] Source: Barbara J. Willenberg, “Food preservation. Freezing Basics”, Department of Food Science and Human Nutrition, University of Missouri-Columbia. For more information on this subject and many others, visit the MU Extension Publications Web site at: http://muextension.missouri.edu/explore. More extensive information on the recommended storage time for freezer foods, see MU publication GH 1505, Freezing Home Prepared Foods.

-17,8°C]. Keep the freezer temperature at or below 0°F to prevent the growth of spoilage organisms and to minimize changes in flavour, texture and nutritive value of food.

To maintain top quality, store frozen foods at 0°F or lower. This temperature can be maintained in separate freezer units and in some combination refrigerator-freezers. A freezer thermometer can help determine the actual temperature of your freezer. Spoilage occurs more quickly and shelf life is shorter when you store frozen foods at a temperature higher than °F. For example, the same loss of quality in frozen beans stored at 0°F for one year will occur in three months at 10°F [corresponding to -12,2°C], in three weeks at 20°F [corresponding to -6,7°C] and in five days at 30°F [corresponding to -1,1°C]. **Do not attempt to save energy in your home by raising the temperature of frozen food storage above 0°F** is the clear advice of the University of Missouri-Columbia. The same advice of not attempting energy savings by increasing the temperature of the frozen food storage is also given by another US University[33]

According to Food Science Australia[34], freezing food and storing it at a low temperature, around -18°C, significantly extends its storage life. Growth of microbes is stopped (although the microbes are not killed) and the chemical and enzymatic changes, which cause loss of quality, are slowed. However, if the temperature of frozen food is allowed to rise for any length of time a series of changes such as the growth of microbes, chemical reactions and physical changes can occur.

Many frozen foods contain fat which can become rancid during storage. The higher the temperature and the fattier the food, the faster rancidity will develop. Cooked meats and meats containing high levels of salt, such as cured meats, tend to go rancid more quickly and have a shorter storage life. At higher storage temperatures some vitamins may also be lost. The growth of ice crystals is another detrimental change which occurs during frozen storage. Large ice crystals cause damage to food by changing its texture and resulting in greater loss of liquid on thawing. Temperature fluctuations during storage and handling promote ice crystal growth, therefore temperatures should be kept as constant as possible. Dehydration of frozen foods can also reduce quality. Tears in packaging or incomplete covering of a food during frozen storage cause drying of the surface and changes to the appearance and texture. Frost inside a package is a result of dehydration and can be minimised by avoiding air gaps inside the package.

The above changes limit the time a frozen food will remain acceptable. A frozen food of initially high quality will retain almost all of its original properties when stored at -18°C or below for many months. In some cases much longer storage times can be achieved. Foods stored for longer periods may still be judged as acceptable by many people. Frozen foods do not become unsafe to eat even when held for years at -18°C. The changes affect the sensory and nutritional properties of the food rather than its safety. If the temperature of frozen foods is allowed to rise much above -18°C the shelf life will be shortened (Table 1.4). This is often the case in home freezers and allowance must be made for this during home storage.

The Canadian document "Food Safety Guidelines for Food Banks"[35], is the result of a collaboration between community food providers (or "food banks"), Environmental Health Officers throughout

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[33] William Schafer and Shirley T. Munson, "Freezing Fruits and Vegetables", University of Minnesota, Reviewed 1990, http://www.extension.umn.edu/index.html
[34] Source: http://www.foodscience.afisc.csiro.au/storagelife2.htm
[35] This publication may be viewed on the internet at http://www.hlth.gov.bc.ca/protect/food.html . Potentially hazardous foods are considered for example dairy products, eggs and egg products, tofu products, meat and meat products, from a commercial processor or retailer or a licensed restaurant, due to the specific nature of a food bank, i.e. a non-profit organization that operates with the exclusive intent of feeding the hungry, and receives, holds, packages, repackages and distributes food to be consumed off the premises, but does not process food.

the province, and the Ministry of Health's Food Protection Program. According to these guidelines, food must be protected from physical, chemical, and microbiological contamination at all times. All potentially hazardous foods must be maintained at a safe temperature less than 4°C (40°F) if refrigerated or greater than 60°C (140°F) if warmed. To make sure that potentially hazardous foods are not temperature-abused, the following temperatures must be maintained:

- refrigeration storage temperatures 4°C (40°F) or colder
- frozen food temperature -18°C (0°F) or colder.

The same values are shown in "Food Safety Guidelines for Soup Kitchens" prepared by the same authors. The maximum recommended storage time is presented in Table 1.5.

Table 1.4: Effect of storage temperature on storage life (in months) of frozen foods. Adapted from International Institute of Refrigeration (1986)

Product	**Storage life** (months)	
Temperature	**-12 °C**	**-18 °C**
Raspberries, strawberries, raw	5	24
Peaches, apricots, cherries, raw	4	18
Green asparagus, blanched	3	12
Green beans, blanched	4	15
Brussels sprouts, blanched	6	15
Carrots, blanched	10	18
Prawns, cooked and peeled	2	5
Fatty fish, glazed, raw	3	5
Lean fish, single fillets, raw	6	9
Chicken, raw	9	18
Pork, raw	6	10
Lamb, raw	12	18
Beef, raw	8	18
Liver, raw	4	12

Table 1.5: Maximum recommended storage time for refrigerated and frozen food (Canada)

Refrigerated food (0-4°C or 32-40°F)	days	**Frozen food (-18°C or 0°F)**	months
Ground meat	2-3	Roasts/steaks	3
Roasts/steaks	3-5	Bacon/wieners	6
Bacon/wieners	6-7	Poultry	3
Poultry	2-3	Giblets	3
Fish/Shellfish	1-2	Fatty fish (salmon, mackerel)	3
Leftover egg yolk/white	1-2	Shellfish	3
Luncheon meats	3-5	Other fish	6
Leftover cooked meats/gravy	1-2	Leftover meats/gravy	3
Stuffing	1-2	Precooked combination dishes	6
		Bread dough containing yeast	1
		Cake batter	4

1.4.4.5 The International Institute of Refrigeration

The International Institute of Refrigeration (IIR)[36] is a scientific and technical intergovernmental organization enabling pooling of scientific and industrial know-how in all refrigeration fields on a worldwide scale. Its mission is to promote progress and expansion of knowledge and to disseminate information on refrigeration technology and all its applications. The IIR is committed to improving both quality of life and the environment, and thus contributes to sustainable development. Currently 61 countries are members of IIR. The services provided by IIR include education and training, information resources, a database, several periodicals, and publications and proceedings of conferences; among these, there are books on food technologies concerning all products (chilled, frozen) and specific products (fish, fruit and vegetables, meat and milk), their storage, transport and distribution. The IIR has been asked by FAO to revise the *Code of Practice for the Processing and Handling of Quick Frozen Foods* of the *Codex Alimentarius* (joint FAO/WHO Food Standards Programme).

At the FAO/WHO Global Forum of Food Safety Regulators, Marrakech, Morocco, 28 - 30 January 2002, Agenda Item 4.2 b) “Food Safety and Refrigeration” IIR main recommendations were:

- the implementation of refrigeration technology that is suitable for the preservation and retail sale of perishable foods;
- that all possible means be employed in order to set up reliable cold chains in developing countries; introducing, where this has not already been achieved, maximum recommended temperatures for food storage and distribution, in specific codes of practice governing products;
- harmonizing, on a global level, regulatory or recommended temperatures for the storage of perishable foodstuffs (such harmonization has already been achieved in the refrigerated-transport field thanks to the ATP Agreement set up by the Economic Commission for Europe of the United Nations);
- using air-temperature measuring instruments (such as thermometers in small cold rooms, refrigerated display cabinets and domestic refrigerators), in order to improve cold chains from the producer to the consumer. These tools provide a good indication of how well refrigerating equipment is operating;
- stricter monitoring of the interfaces between various links in the cold chain and the development of good practices. Regulations, standards, and codes of practice play key roles in this respect, for instance by recommending the use of insulated or refrigerated shopping bags at consumer level;
- implementation of stricter measures governing foods prone to contamination with psychrotrophic bacteria such as *Listeria monocytogenes* or *Yersinia enterocolitica*: lower temperatures and hurdle technology are effective in this context.
- incorporating the HACCP (Hazard Analysis and Critical Control Point) approach in training in good refrigeration practice, and vice versa incorporating good refrigeration practice in training HACCP for food safety regulators;
- raising consumer awareness: it has been demonstrated that the average temperatures inside domestic refrigerators are above the maximum recommended temperatures and that consumers do not always comply with use-by (expiry) dates.

1.4.4.6 The ATP agreement for food transport

The *Agreement on the international carriage of perishable foodstuffs and on the special equipment to be used for such carriage* or “ATP Agreement” was drawn up by the Inland Transport

[36] information is available on the IIR's web site: http://www.iifiir.org

Committee of the United Nations Economic Committee for Europe and presented in Geneva on September 1, 1970. It entered into force on November 21, 1976, and was amended on 7 November 2003.[37]

Currently, there are 41 contracting parties including Russia and USA. The Agreement and its annexes have been regularly amended and updated since their entry into force by the Working Party on the Transport of Perishable Foodstuffs (WP.11) of the Economic Commission for Europe's Inland Transport Committee in order to take into account technological evolutions. Inter alia, the Agreement lists foodstuffs to be carried in accordance with the ATP agreement and sets the warmest permissible temperature of the load (Tables 1.6 and 1.7). If the requirements of the ATP agreement are not met, the food being transported (in particular frozen or deep-frozen foods as well as butter, game, poultry, fish) may have to undergo special checking.

Table 1.6: Examples of maximum temperatures for chilled and frozen products

Product	Maximum temperature
Read meal offal	+ 3 °C
Butter	+ 6 °C
Game	+ 4 °C
Tank milk (fresh or pasteurised)	+ 4 °C
Industrial milk	+ 6 °C
Dairy products	+ 4 °C
Fish, molluscs and shellfish	Ice slurry
Prepared meat products	+ 6 °C
Meat (except red meat offal	+ 7 °C
Poultry and rabbit	+ 4 °C
Ice cream	- 20 °C
Fish, frozen or deep-frozen molluscs and shellfish and all other deep-frozen foodstuffs	- 18 °C
All frozen products (except butter)	- 12 °C
Butter	- 10 °C

Table 1.7: Examples of maximum temperatures for quick-frozen and frozen products

Product	Maximum temperature
Ice cream	- 20 °C
Fish, frozen or deep-frozen molluscs and shellfish and all other deep-frozen foodstuffs	- 18 °C
All frozen products (except butter)	- 12 °C
Butter	- 10 °C

1.4.4.7 International Code of Practice for the Processing and Handling of Quick Frozen Foods

The Recommended International Code of Practice for the Processing and Handling of Quick Frozen Foods is developed by the *Codex Alimentarius*[38]. The Codex was created in 1963 by the United

[37] downloadable from http://www.unece.org/trans/main/wp11/atp.html

Nation's Food and Agriculture Organisation and the World Health Organisation to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme.

Section IV – Storage states *inter alia* that cold stores should be operated so as to maintain a product temperature of – 18°C (0°F) or lower with a minimum of fluctuation. Excessive product temperature fluctuations either in range or frequency are undesirable. They may lead to serious dehydration in susceptible products and to other forms of quality deterioration. Although temperature fluctuations are generally less harmful at lower storage temperatures, variations greater than 2°C (4°F) in the air temperature should, so far as possible, be avoided.

1.4.4.8 Conclusions

In conclusion, the presented short worldwide review of freezing and food storage shows that the worldwide accepted temperature for freezing food and for (quick) frozen food preservation is -18°C (0°F). A warning came also of not attempting to save energy home by raising the temperature of frozen food storage above -18°C/0° F.

1.5 SUBTASK 1.3: EXISTING POLICIES & MEASURES

1.5.1 The EU policies and measures

1.5.1.1 Introduction

Main general horizontal legislation applying to cold appliances includes:

- the directives (and the standards) needed for the CE-marking, such as LVD and EMC directives;
- the regulations on the protection of the ozone layer and lastly the Regulation (EC) no 842/2006 on fluorinated greenhouse gases;
- the RoHS and WEEE directives on restriction of hazardous substances presence and the management of the electric and electronic equipment at the end of their life.

As far as product specific policies and measures are concerned, refrigerators and freezers, have been the first and the most studied EuP in the European Union with the goal to reduce their energy consumption and environmental impact. Both mandatory and voluntary measures address this product group since 1994. Mandatory measures are directive 94/2/EC of 21.1.94 *with regard to energy labelling of household electric refrigerators, freezers and their combination*" which established the first mandatory European labelling scheme for cold appliances, followed by Directive 96/57/EC of 3.9.96 *on efficiency requirements for household electric refrigerators, freezers and their combinations*. In 2003 Directive 2003/66/EC updated the labelling scheme. Voluntary policy measures include eco-labelling awarding criteria for refrigerators and freezers, the latest being defined by the European Eco-label Board in 2004 and valid until May 31st 2007[39], and the Voluntary Commitment *on reducing energy consumption of household refrigerators, freezers and their combinations*, issued by the European Association of Household Appliance Manufacturers (CECED) in October 2002.

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[38] See: http://www.codexalimentarius.net/

[39] Commission Decision 2004/669/EC of 6 April 2004 establishing revised ecological criteria for the award of the Community eco-label to refrigerators and amending Decision 2000/40/EC, OJ L 306/16, 2 October 2004.

1.5.1.2 The Low Voltage and the Electromagnetic Compatibility Directives

The Directive 2006/95/EC[40] of the European Parliament and of the Council of 12 December 2006 on the *harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits* (or LVD directive) entered into force on 16 January 2006. The old Directive 73/23/EEC was repealed on the same date. The Council Directive 89/336/EEC of 3 May 1989 *on the approximation of the laws of the Member States relating to electromagnetic compatibility* (or EMC directive) governs the electromagnetic emissions of equipments in order to ensure that, in their intended use they do not disturb radio and telecommunication as well as other equipments, and also governs the immunity of such equipments to interference. The Directive 89/336/EEC will be repealed as from 20 July 2007 by the new Directive 2004/108/EC[41] *of the European Parliament and of the Council, of 15 December 2004, on the approximation of the Laws of Member States relating to electromagnetic compatibility*. The revised directive will greatly simplify regulatory procedures and reduce costs for manufacturers, while increasing information and documentation on products for inspection authorities. It abolishes two cumbersome conformity assessment procedures for producers which required the mandatory involvement of an independent inspection and verification body, thus reducing costs. Manufacturers will be solely responsible for establishing the conformity of their products and for the "CE" marking.

1.5.1.3 The prevention and minimisation of emissions of fluorinated greenhouse gases

Regulation (EC) no 842/2006 of the European parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases[42] has as primary objective the reduction of the emissions of the fluorinated greenhouse gases covered by the Kyoto Protocol. It addresses the containment (Article 3), use, recovery (Article 4) and destruction of the fluorinated greenhouse gases hydrofluorocarbons (HFCs, including R134a), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) listed in Annex I; the labelling (Article 7) and disposal of [stationary] products and equipment containing those gases (refrigeration and air conditioning products and equipment other than those contained in motor vehicles, heat pumps, fire protection systems and fire extinguishers, vehicle tyres); the reporting of information on those gases; the control of uses (Article 8) and the placing on the market prohibitions of specific products and equipments (Article 9 and Annex II); and the training and certification of personnel and companies involved in activities related to the Regulation. In particular:

- operators of refrigeration, air conditioning and heat pump equipment (including their circuits) and fire protection systems, which contain covered fluorinated greenhouse gases shall prevent leakage of these gases and as soon as possible repair any detected leakage, using all measures which are technically feasible and do not entail disproportionate cost. This point **does not apply** to equipment with hermetically sealed systems, which are labelled as such and contain less than 6 kg of fluorinated greenhouse gases, i.e. to domestic cold appliances;
- operators of the cooling circuits of refrigeration, air-conditioning and heat pump equipment are responsible for putting in place arrangements for the recovery, by certified personnel, of fluorinated greenhouse gases to ensure their recycling, reclamation or destruction;
- a label will be placed on the product or equipment, adjacent to the service points for charging or recovering the fluorinated greenhouse gas, or on that part of the product or equipment which contains the fluorinated greenhouse gas, indicating the chemical names of the fluorinated greenhouse and that the product or equipment contains fluorinated greenhouse gases covered by the Kyoto Protocol. Hermetically sealed systems (i.e. cold appliances) are labelled as such;

[40] OJ L 374 of 27.12.2006, p. 10-19.
[41] OJ L 390 of 21 December 2004p. 24.
[42] OJ L 161, 14.06.2006, p. 1.

- information on the fluorinated greenhouse gases, including their GWP, will be included in the instruction manuals for such products and equipment (other than those contained in motor vehicles), if the respective type of product or equipment contains hydro-fluorocarbons or preparations containing hydro-fluorocarbons;
- the placing on the market of products and equipments containing one component foams, except when required to meet national safety standards, is prohibited starting from 4 July 2008.

The Regulation entered into force on the 20th day following its publication in the OJ and will be effective from 4 July 2007, with the exception of the prohibition of placing on the market of specific products and equipment (listed in Annex II) which applies from 4 July 2006.

1.5.1.4 The Directives about the materials coming into contact with foodstuffs

In the category of products intended for contact with foodstuffs (FCMA) are included all materials and objects that intentionally come into contact with foodstuffs, raw foodstuff material and meals in the course of the whole manufacturing process including their weighing and measuring, wrapping and packaging, storage, transport and serving. Thus FCMA includes:

- wrapping and packaging material of all kind (wrapper foil, cups and other vessels, lids and caps)
- parts of food industry machinery and other equipment that comes in contact with foodstuffs
- vessels, utensils and other aids of polymerized materials, paper, cork, glass, ceramics, porcelain,
- enamels, metals and alloys
- lacquers and surface finishes of metal or wooden racks and stands or other parts of furniture in which there are stored or transported unwrapped foodstuffs of all kind
- oven trays including their anti-adhesive finish
- equipment of catering facilities
- kitchen appliances (e.g. blenders, percolators), beverage dispensers, etc.

The most important requirement on FCMA is their safety to health. Articles intended for contact with foodstuffs have to meet a number of concrete requirements to avoid that they unfavourably affect the safety and quality of foodstuffs and thereby also the health of the consumer. Attention is mainly focused on problems of microbiology, sensory properties, and on the danger of food contamination with chemical substances present in the material the object is made of.

Commission Directive 90/128/EEC[43] of 23 February 1990 *relating to plastics materials and articles intended to come into contact with foodstuffs* contains requirements relating to plastics and lists the ingredients and monomers for production of plastics and articles intended to come into contact with foodstuffs. This directive has been repeatedly amended through a series of other Directives[44] finally coded in directive 2002/72/EC concerning plastics materials and articles intended to come into contact with foodstuffs – codification of directive 90/128/EEC plus the seven amendments. For plastic material used for the inner-lining of cold appliances and the internal food containers, shelves, etc., halogenated flame retardants are not allowed.

A document summarising the EU legislation (and implementation at Member states level) about materials and articles intended to come into contact with foodstuffs, updated to April 2003, has been prepared by DG Health & Consumer protection, Directorate D - Food Safety: production and

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[43] OJ L 75, of 21.03.1990, p.19.

[44] directive 92/39/EEC 1st amendment, 93/9/EEC 2nd amendment, 95/3/EC 3rd amendment, 96/11/EC 4th amendment, 1999/91/EC 5th amendment , 2001/62/EC 6th amendment, 2002/17/EC 7th amendment.

distribution chain[45]. Another collection of EU legislation about food safety (from the farm to the fork) can be found at: http://ec.europa.eu/food/food/chemicalsafety/foodcontact/legisl_list_en.htm .

1.5.1.5 The EU energy labelling scheme

The EU adopted in 1994 a categorical system of comparative energy labelling wherein cold appliances are assigned to one of 7 different energy efficiency classes from A the most efficient, to G, the least efficient. The labelling scheme entered into force starting 1st January 2005, although only mid 2008 the last Member Stated completed its transposition into their national legislation. The cold appliance label was also the first of the EU's energy labels being revised, through directive 2003/66/EC, entered into force end June 2004.

a) The provisions of directive 94/2/EC

The labelling scheme distinguishes between 10 categories of cold appliances (Table 1.8) and defines average energy consumption reference lines (Table 1.9) as a function of equivalent volume (named "adjusted volume" in the directive) for each of the categories.

Table 1.8: Cold appliance categories in the energy labelling directive 94/2/EC

Primary category	Subcategories (number)	Description
1	1	Household refrigerators, without low temperature compartment
2	1	Household refrigerator/chillers with compartment at 5 °C and or 10 °C
3	1	Household refrigerators, with no-star low temperature compartment
4	1	Household refrigerators, with low temperature compartment (*)
5	1	Household refrigerators, with low temperature compartment (**)
6	1	Household refrigerators, with low temperature compartment (***)
7	2	Household refrigerator/freezers, with low temperature compartment *(***)
8	2	Household food freezers, upright
9	2	Household food freezers, chest
10	+10	Household refrigerators and freezers with more than two doors, or other appliances not covered above

"Subcategories" arise under the labelling Directive because different adjusted-volume coefficients apply to no-frost appliances in Categories 7, 8, 9 and 10. The energy consumption of any given appliance is compared to the reference energy consumption of the same category of appliance with an identical equivalent volume in order to calculate its energy label class.

The energy labelling Directive 94/2/EC has a prescriptive definition of the Ω_c term as its values are stated directly for each cold appliance category (except Category 7 and Category 10) and thereby removes the freedom to calculate the value depending on the exact design temperature of the compartment. In most cases this does not matter as the prescriptive values agree with the values that would be computed; however, it could be relevant for at least (a) US-made refrigerator-freezers that have not had the freezer compartment converted to 3- or 4-star capability, (b) refrigerator/chillers, (c) cellar compartment.

[45] European Commission, HEALTH & CONSUMER PROTECTION DIRECTORATE-GENERAL, Directorate D - Food Safety: production and distribution chain, D3 - Chemical and physical risks; surveillance, "References Of The European And National Legislations", File: INT/REF_LEG(04/2003).

Some inconsistencies in the scheme set by the directive 94/2/EC were already highlighted in previous COLD-II study:

- the definition given in the labelling Directive for Category 2 (refrigerator/chillers) is a "*household refrigerator/chiller, with compartments at 5 °C and/or 10 °C*". The use of plural 'compartments' gives rise to an interpretation problem: a strict interpretation of the labelling Directive would imply that an appliance comprising a single chiller compartment (i.e. a single compartment designed to operate at +10 °C) would be classified not as a "Category 2 - refrigerator/chiller", as it only has one compartment, but as "Category 10 - *multi-door or other appliance*". But Category 10 appliances are the only group in the labelling Directive where the value of Ω_c is not prescribed but is calculated, so in this case the manufacturer would have the freedom to specify the actual design temperature. If the design temperature is +12°C (as is defined for this compartment type in directive 96/57/EC on the energy efficiency requirements for cold appliances) then the calculated Ω_c value is 0,65. While Ω_c in the labelling Directive is fixed at 0,75 for the +10°C compartment;

Table 1.9: Comparison of the reference lines for cold appliances in the EU energy labelling schemes in directive 94/2/EC and 2003/66/EC

Description	Category	Ω_c	Reference lines for directive 94/2/EC	Reference lines for directive 2003/66/EC[12]
Household refrigerators, without low temperature compartment	1	1,00	0,233*Veq+245	(0,233*Veq+245) + 50[13]
Household refrigerator/chillers with compartment at 5 °C and or 10 °C [1]	2	0,75	0,233*Veq+245	(0,233*Veq+245) + 50
Household refrigerators, with no-star low temperature compartment [2]	3	1,25	0,233*Veq+245	(0,233*Veq+245) + 50
Household refrigerators, with low temperature compartment (*)[3]	4	1,55	0,643*Veq+191	(0,643*Veq+191) + 50
Household refrigerators, with low temperature compartment (**)[4]	5	1,85	0,450*Veq+245	(0,450*Veq+245) + 50
Household refrigerators, with low temperature compartment (***)[5]	6	2,15	0,657*Veq+235	(0,777*Veq+303) + 50
Household refrigerator/freezers, with low temperature compartment *(***)[6]	7	2,15	0,777*Veq+303	
Household food freezers, upright	8	2,15	0,472*Veq+286	(0,539*Veq+315) + 50
Household food freezers, chest	9	2,15	0,446*Veq+181	(0,472*Veq+286) + 50
Household refrigerators and freezers with more than two doors, or other appliances not covered above	10	$= \frac{25 - T_c}{20}$	0,233*Veq+245[7] 0,643*Veq+191[8] 0,450*Veq+245[9] 0,657*Veq+245[10] 0,777*Veq+303[11]	(0,233*Veq+245) + 50[14] (0,643*Veq+191) + 50[15] (0,450*Veq+245) + 50[16] (0,777*Veq+303) +50[17]

[1] Refrigerator/chillers a compartment designed to operate at internal temperatures of 12 °C; they may or may not include a 5 °C refrigerator compartment.
[2] 0-star compartments are designed to operate at –6 °C < T_c < 0 °C.
[3] 1-star compartments are designed to operate at T_c ≤ –6 °C.
[4] 2-star compartments are designed to operate at T_c ≤ –12 °C.
[5] 3-star compartments are designed to operate at T_c ≤ –18 °C.
[6] 4-star compartments are designed to operate at T_c ≤ –18 °C and to be able to freeze more then 4,5 kg of food per 100 litres of storage capacity from 25 °C to –18 °C within 24 hours.
[7,14] For multi-door models where the temperature of the coldest compartment is >–6 °C.
[8,15] For multi-door models where the temperature of the coldest compartment is ≤–6 °C.
[9,16] For multi-door models where the temperature of the coldest compartment is ≤–12 °C.
[10,17] For multi-door models where the temperature of the coldest compartment is ≤–18 °C.
[11,17] For multi-door models where the temperature of the coldest compartment is ≤–18 °C and the compartment can freeze >4,5 kg of food per 100 litre of volume within 24 hours.
[12] For A+ and A++ appliances only.
[13] 50 kWh/year are added to the annual average standard energy consumption for appliances with a chill compartment of at least 15 litres.

- for a 2-compartment refrigerator/chiller appliance, comprising a standard +5 °C refrigerator compartment and a warmer +10 °C compartment, and belonging to Category 2, the value of Ω_c for the warmer +10°C compartment in the labelling Directive is fixed at 0,75. For a 3-compartment appliance (comprising a standard +5 °C refrigerator, a -18°C frozen food compartment and a warmer cellar compartment) the Ω_c for the latter can be 0,65 or 0,75 depending on the manufacturer decision about the compartment design temperature.

  In practice, the difference found when calculating the appliance equivalent volume and the consequent standard energy consumption is minor, but still enough, for an appliance close to the EEI threshold between two energy efficiency classes, to be classified in either one or the other class. The conclusion is that there is a need to clarify the definition of the specific compartment characteristics;
- the name of the compartments is misleading: taking into consideration the previous example, the Category 2 appliance named "*household refrigerator/chiller*" includes (or in made only by) a +10°C compartment which is generally known as "*cellar compartment*", because it mimics the temperature and the conservation properties of a "house cellar". On the other side, one of the possible compartments in a refrigerator is the "*chiller (or chill) compartment*" designed to have a temperature of 0 °C (and an Ω_c= 1,15). The so called "chill compartment" is not defined in EN 153 standard, but the name is commonly used.

The main component of the equivalent volume (for Category 7 and Category 10) in directive 94/2/EC is defined by the temperature difference between the internal design temperature of a compartment and the ambient temperature under standard test conditions (25 °C) expressed as a ratio of the same difference for a pure refrigerator compartment at +5 °C as:

$$V_{eq} = \sum_{c=1}^{c=n} V_c \times \Omega_c \times F_c \qquad \text{(eq. 1)}$$

where n is the number of compartments, and Ω_c is the term relating the interior-exterior temperature difference for the specific compartment in question to the same difference for a +5 ºC refrigerator compartment as:

$$\Omega_c = (25 - T_c)/(25-5) = (25 - T_c)/20 \qquad \text{(eq. 2)}$$

where T_c is the design temperature of the compartment in degrees Celsius. The term F_c is a correction term for the presence of a 'no frost' function, set to 1,2 for no-frost compartments and 1 for all other types. The same 1,2 factor is applied also to no-frost upright and chest freezers.

b) The modifications in directive 2003/66/EC

The success of the labelling scheme introduced by Directive 94/2/EC, in conjunction with Directive 96/57/EC led to a rise of the efficiency index of new refrigerators and freezers by over 30% between 1996 and 2000. About 20% of the cold appliances sold in 2000 were in the most efficient class A, and in some markets the proportion was more than 50% with rapidly rising market shares. Consequently, two additional classes, designated as A+ and A++, as an interim arrangement until a comprehensive revision of the energy labelling classes takes place, were introduced by directive 2003/66/EC, which contemporarily addressed also other changes of the previous labelling scheme to take into consideration the evolution of the cold appliance market and the evolution of internet and e-commerce.

A part from the introduction of the two new energy efficiency classes, the main modification introduced in directive 2003/66/EC refer to the reference lines, the formula to calculate the equivalent volume and the standard annual energy consumption of an appliance, **to be applied solely to the models reaching the energy efficiency classes A+ and A++**.

The reference lines of directive 94/2/EC and directive 2003/66/EC are compared in previous Table 9. The reference line for Category 6 is set equal to that of Category 7 and the reference lines for upright and chest freezers (Categories 8 and 9) are increased of 10%.

The equivalent volume is calculated through the following equation:

$$V_{eq} = \sum_{c=1}^{c=n} V_c \times \frac{(25 - T_c)}{20} \times FF \times CC \times BI \qquad \text{(eq. 3)}$$

where *n* is the number of compartments, T_c is the design temperature of the compartment in degrees Celsius; the term *FF* is a correction term for the presence of a 'no frost' function, set to 1,2 for no-frost frozen food compartments and 1 otherwise; *CC* is a correction term for the climate class of the appliance, ranging from 1 to 1,2 depending on the climate class and compartment type and BI is a correction term for built in appliances (Table 1.10).

Table 1.10: correction factors in directive 2003/66/EC for A+ and A++ energy efficiency classes

Correction factor	Value	Condition
FF (frost-free)	1,2	For "frost-free" (ventilated) frozen food compartments
	1	Otherwise
CC (climate class)	1,2	For "tropical" appliances
	1,1	For "subtropical" appliances
	1	Otherwise
BI (built-in)	1,2	For built-in appliances (1) of under 58 cm in width.
	1	Otherwise
CH (chill compartment)	50 Kwh/y	For appliances with a chill compartment of at least 15 litres
	0	Otherwise

(1) An appliance is "built-in" only if it is designed exclusively for installation within a kitchen cavity with a need of furniture finishing, and tested as such.

The main new element is that for A+ and A++ the value of the Ω_c term is stated depending on the exact design temperature of the compartment and not pre-set for each cold appliance category. The second new element is that the standard annual energy consumption of an appliance is calculated as:

$$SC_{\alpha} = V_{eq} \times N + CH \qquad \text{(eq. 4)}$$

where CH is a correction term (an allowance) equal to 50 kWh/year given to appliances with a chill compartment of at least 15 litres. In directive 94/2/EC this factor was not considered, nor it is for appliances belonging to energy efficiency classes different from A+ and A++.

The differences between the scheme set in directive 94/2/EC and the revised labelling defined in directive 2003/66/EC are:

- the reference line for Category 6 is set equal to that of Category 7 and the reference lines for upright and chest freezers (Categories 8 and 9) are increased of 10%
- the introduction of a correction term of 50 kWh/year given to appliances with a chill compartment of at least 15 litres
- in the equivalent volume calculation:
  - the Ω_c term is stated depending on the exact design temperature of the compartment and not pre-set for each cold appliance category
  - the introduction of correction factors for climate classes
  - the introduction of correction factors for built-in appliances under 58 cm in width

No attentions was given to the difference between the top-mounted compared to bottom-mounted freezer compartment for refrigerator-freezers and to through-the-door ice-delivery feature. This was based on the outcome of COLD-II study.

In fact, the analysis performed in 2000 showed that there was no significant difference in the average energy efficiency of refrigerator-freezers where the freezer compartment makes up 20–50% of the total net volume. At the lower end these appliances will mostly be top-mounted refrigerator-freezers and at the higher end they will mostly be bottom-mounted, suggesting that there is no significant difference in the behaviour of top- and bottom-mounted units.

The through-the-door ice-delivery feature (and other similar features) is almost solely found in some US- and Korean-made refrigerator-freezers, mainly of side-by-side design. They deliver ice into a glass if it is pressed against a lever, without requiring the door to be opened. This feature is quite popular in the USA, where crushed ice is used in many drinks, but is a rarity in the EU. Two otherwise-identical side-by-side US refrigerator-freezers were tested in the course of COLD-II study, one with a TTD ice-maker and the other without. The difference in energy consumption between them was about 93-97 kWh/year. Technically the primary reason why TTD ice-makers increase energy consumption is that they create a significant thermal bridge between the freezer compartment and the ambient. It is possible to have an ice-maker that is housed inside the appliance without using an opening in the door insulation to the ambient space with very little increase in energy demand under standard test conditions, but they do require the door to be opened and hence are less convenient. Also opening the door (to take ice cube from the freezer compartment) will use energy, but not as much as having a permanent thermal bridge into the freezer.

c) Calculating the Energy Efficiency Classes in the energy labelling directives

The (A++) A to G efficiency classes are defined for each cold appliance category in terms of the Energy Efficiency Index "I" in directive 94/2/EC and "I_α" in directive 2003/66/EC (defined as the measured model's electricity consumption divided by the energy consumption for a unit of the same equivalent volume, derived from the reference line given in Table 9 and expressed as a percentage), as given in Table 11. A G-class model uses 125% or more of the energy used by an average cold appliance of the same type and the same equivalent volume, while an A-class model uses less than 55% of the energy of an average appliance of the same type and equivalent volume, and an A++ model uses less than 30% of the energy of an average appliance of the same type and equivalent volume. The energy consumed by an average appliance of a given type and equivalent volume is calculated from the appropriate reference line equation given in Table 1.9, which is based on the values measured under the European standard EN 153.

Table 1.11: Relative efficiency grades used in the EU energy label for cold appliances

Energy-efficiency index, I and I_α(%)	Energy efficiency class
$I_\alpha < 30$	A++ (2003/66/EC)
$30 \leq I_\alpha < 42$	A+ (2003/66/EC)
$42 \leq I < 55$	A
$55 \leq I < 75$	B
$75 \leq I < 90$	C
$90 \leq I < 100$	D
$100 \leq I < 110$	E
$110 \leq I < 125$	F
$125 \leq I$	G

1.5.1.6 The EU energy efficiency requirements

The Directive 96/57/EC of the European Parliament and of the Council of 3 September 1996 *on energy efficiency requirements for household electric refrigerators, freezers and combinations thereof*[46] classifies the products available on the market into broadly the same fundamental categories used in the energy labelling directive (Table 1.12).

The main difference is that the energy efficiency requirements directive, rather than formally defining appliances with more than two doors or other appliances not covered in the preceding nine categories as a distinct tenth category, relates the applicable limits back to the first 7 categories according to the temperature of the coldest compartment. “Subcategories” shown in Table 12 arise under the directive because different equivalent-volume coefficients apply to no-frost, subtropical and tropical climate-class appliances. Category 10 is a catch-all category containing at least 5 primary subcategories based on the lowest operating temperature of any compartment in the appliance and has the usual subcategories depending on climate class and the presence of a no-frost function.

Table 1.12: Cold appliance categories in the energy efficiency requirements directive 96/57/EC

Primary category	Subcategories (number)	Description
1	6	Refrigerator without low temperature compartment
2	6	Refrigerator/chiller with compartment at 5 °C and or 12 °C
3	6	Refrigerator with no-star low temperature compartment
4	6	Refrigerator with low temperature compartment (*)
5	6	Refrigerator with low temperature compartment (**)
6	6	Refrigerator with low temperature compartment (***)
7	6	Refrigerator/freezer with low temperature compartment (****)
8	6	Food freezer, upright
9	6	Food freezer, chest
10	+30	Refrigerator/freezer with more than two doors, or other appliances not covered above

[46] OJ L 236, 18.9.1996, p. 36.

For each category, a single straight line defines the maximum permissible energy consumption level as a function of the equivalent volume (named adjusted volume in the directive), with defined values for the slope and the intercept (Table 1.13).

Table 1.13: Product categories and energy efficiency requirements for cold appliances in the EU

Description	Category	W_c	Efficiency requirements directive 96/57/EC
Refrigerator without frozen food compartment	1	1,00	0,207*Veq+218
Refrigerator/chiller[1]	2	0,75	0,207*Veq+218
Refrigerator with 0-star[2] frozen food compartment	3	1,25	0,207*Veq+218
Refrigerator with 1-star[3] frozen food compartment	4	1,55	0,557*Veq+166
Refrigerator with 2-star[4] frozen food compartment	5	1,85	0,402*Veq+219
Refrigerator with 3-star[5] frozen food compartment	6	2,15	0,573*Veq+206
Refrigerator with 4-star[6] frozen food compartment	7	2,15	0,697*Veq+272
Chest freezers	9	2,15	0,480*Veq+195
Upright freezers	8	2,15	0,434*Veq+262
Refrigerators and other appliances with more than two doors	10	$= \frac{25 - T_c}{20}$	0,207*Veq+218[7] 0,557*Veq+166[8] 0,402*Veq+219[9] 0,573*Veq+206[10] 0,697*Veq+272[11]

Notes:

1 Refrigerator/chillers a compartment designed to operate at internal temperatures of 12 °C; they may or may not include a 5 °C refrigerator compartment.
2 0-star compartments are designed to operate at –6 °C < T_c < 0 °C.
3 1-star compartments are designed to operate at T_c ≤ –6 °C.
4 2-star compartments are designed to operate at T_c ≤ –12 °C.
5 3-star compartments are designed to operate at T_c ≤ –18 °C.
6 4-star compartments are designed to operate at T_c ≤ –18 °C and to be able to freeze more then 4,5 kg of food per 100 litres of storage capacity from 25 °C to –18 °C within 24 hours.
7 For multi-door models where the temperature of the coldest compartment is >–6 °C.
8 For multi-door models where the temperature of the coldest compartment is ≤–6 °C.
9 For multi-door models where the temperature of the coldest compartment is ≤–12 °C.
10 For multi-door models where the temperature of the coldest compartment is ≤–18 °C.
11 For multi-door models where the temperature of the coldest compartment is ≤–18 °C and the compartment can freeze >4,5 kg of food per 100 litre of volume within 24 hours.

The main component of the equivalent volume is defined by the temperature difference between the internal design temperature of a compartment and the ambient temperature under standard test conditions (25 °C) expressed as a ratio of the same difference for a pure refrigerator compartment at +5 °C as follows:

$$V_{eq} = \sum_{c=1}^{c=n} V_c \times W_c \times F_c \times C_c \qquad \text{(eq. 5)}$$

where n is the number of compartments, and W_c is the term relating the interior-exterior temperature difference for the specific compartment in question to the same difference for a +5 ºC refrigerator compartment as:

$$W_c = (25 - T_c)/(25 - 5) = (25 - T_c)/20 \qquad \text{(eq. 6)}$$

where T_c is the design temperature of the compartment in degrees Celsius. The term F_c is a correction term for the presence of a 'no frost' function, set to 1,2 for no-frost compartments and 1 for all other types. C_c is a correction term for the climate class of the appliance, ranging from 1,05 to 1,35 depending on the climate class and compartment type (Table 1.14).

Table 1.14: X_c and Y_c values for compartment types in directive 96/57/EC

Compartment type	**X_c**	**Y_c**
Chiller compartment (designed to operate at 12 °C)	1,25	1,35
Fresh-food compartment (designed to operate at 5 °C)	1,20	1,30
0 °C compartment	1,15	1,25
0-star compartment (designed to operate at –6 °C<T_c<0 °C)	1,15	1,25
1-star compartment (designed to operate at $T_c \leq -6$ °C)	1,12	1,20
2-star compartment (designed to operate at $T_c \leq -12$ °C)	1,08	1,15
3- and 4-star compartment (designed to operate at $T_c \leq -18$ °C)	1,05	1,10

The values given by the formulae in Table 13 are to be compared against the measured energy consumption under the standard EN 153:1995.

The major differences between the energy labelling directives and the efficiency requirement one are:

- *climate-class rating*: the correction factor coefficients for ST- and T-class appliances which have an impact on the calculated equivalent volume are different between the energy labelling 2003/66/EC and the efficiency requirements directives;
- *no-frost* and *partial-defrost features*: under the current energy-labelling scheme, no-frost appliances with a 4-star freezer compartment (both refrigerator-freezers and freezers) are awarded a correction factor on the adjusted volume of 1,2. Under the energy efficiency requirements directive all no-frost appliances, regardless of their category, are awarded a correction factor on the adjusted volume of 1,2;
- *built-in appliances*: no distinction is made between free-standing and built-in appliances under energy efficiency requirements directive, but this distinction has been introduced in directive 2003/66/EC for the A+ and A++ classes;
- correction factor W_c for the nominal compartment temperature: is calculated through the above described formula depending on the exact design temperature of the compartment;
- appliance categories: the energy efficiency requirements directive, rather than formally defining appliances with more than two doors or other appliances not covered in the preceding nine categories as a distinct tenth category, relates the applicable limits back to the first 7 categories according to the temperature of the coldest compartment.

A comparison of the labelling directives and the efficiency requirement directive is presented in Table 1.15.

Table 1.15: Comparison of the reference lines for cold appliances in the EU energy labelling schemes in directive 94/2/EC and 2003/66/EC

Description	Category	Ω_c/W_c	Reference lines for directive 94/2/EC	Reference lines for directive 2003/66/EC	Reference lines for directive 96/57/EC[2]
Household refrigerators, without low temperature compartment	1	1,00	0,233*Veq+245	(0,233*Veq+245) + 50	0,207AV+218 (C)
Household refrigerator/chillers with compartment at 5 °C and or 10 °C (12°C)[1]	2	0,75	0,233*Veq+245	(0,233*Veq+245) + 50	0,207AV+218 (C)
Household refrigerators, with no-star low temperature compartment[2]	3	1,25	0,233*Veq+245	(0,233*Veq+245) + 50	0,207AV+218 (C)
Household refrigerators, with low temperature compartment (*)	4	1,55	0,643*Veq+191	(0,643*Veq+191) + 50	0,557AV+166 (C)
Household refrigerators, with low temperature compartment (**)	5	1,85	0,450*Veq+245	(0,450*Veq+245) + 50	0,402AV+219 (C)
Household refrigerators, with low temperature compartment (***)	6	2,15	0,657*Veq+235	(0,777*Veq+303) + 50	0,573AV+206 (C)
Household refrigerator/freezers, with low temperature compartment *(***)	7	2,15	0,777*Veq+303		0,697AV+272 (C)
Household food freezers, upright	8	2,15	0,472*Veq+286	(0,539*Veq+315) + 50	0.434AV+262 (D)
Household food freezers, chest	9	2,15	0,446*Veq+181	(0,472*Veq+286) + 50	0.480AV+195 (E)
Household refrigerators and freezers with more than two doors, or other appliances not covered above	10	$=\frac{25-T_c}{20}$	0,233*Veq+245 0,643*Veq+191 0,450*Veq+245 0,657*Veq+245 0,777*Veq+303	(0,233*Veq+245) + 50 (0,643*Veq+191) + 50 (0,450*Veq+245) + 50 (0,777*Veq+303) +50	0.207AV+218 (C) 0.557AV+166 (C) 0.402AV+219 (C) 0.573AV+206 (C) 0.697AV+272 (C)

[1] The temperature of the chill compartment is considered 12°C in directive 96/57/EC.

[2] Letters in brackets give the associated energy labelling class for models which exactly meet the energy requirement and have conventional defrost and N (temperate) or SN (extended temperate) climate class.

1.5.1.7 The Industry Voluntary Commitment

In November 2002, CECED notified to DG Competition a Unilateral Industry Commitment[47] aiming at improving energy efficiency of domestic refrigerators and freezers, whose provisions were modified in February 2004[48] due to the delayed implementation of the directive 2003/66/EC and the application of the correction factors and new reference lines for chest freezers only to new energy efficiency classes A+ and A++. It forecasts:

- *Hard target*: participants will stop producing for and importing (including under own brands and private labels) in the Community Market electric compressor based household refrigerating appliances having an EEI = 75 by the 31st December 2004;
- *Fleet target*: each participant will reduce its own production - weighted average energy efficiency index - to a value of 55 for production and importation into the EU market by the year 2006. In the case EU and national authorities fail to develop in this time frame effective market transformation tools, participants however commit to achieve a fleet target by 57 (weighted average energy efficiency index);
- *Soft target*: in addition to the above commitments, starting from year 2004 all participants commit themselves to strengthen their overall activities to achieve further energy savings and to educate consumer on the way to save energy, in particular:
  - by giving information on the appropriate size of a refrigerators with regard to the household size;
  - by co-operating with National Energy Authorities in view of common programmes to promote the efficient use of refrigerators;
  - by giving information about the rational use of the appliance in order to reduce energy consumption.

In addition:

- CECED will establish a list of participants and keep it updated to be provided to the European Commission and available to the public free of charge; will set up and maintain a database for refrigerators to be updated each calendar year; entrusts, from the year 2001 on, a Notary to monitor the overall production weighted average energy consumption and will publish every year a report based on the Notary calculation. Starting from the production year 2001 each participant will provide the independent consultant (notary) appointed by CECED, with production weighted energy efficiency data in each refrigeration energy class and for each product category during the previous calendar year. This monitoring of progress achieved in the market, is extended till production data of the year 2010.
- Signatories shall continue to provide the notary with reporting and technical database updates up to year 2010. This will enable Authorities to monitor the evolution of market trends. Would the trends show a deviation from expected results, CECED's signatories are ready to discuss with the Authorities the definition of further fleet targets beyond 2006 on the basis of national/EU market transformation initiatives and the dynamics of candidate countries access.

The Commitment was extended to the new Member States in 2004.

1.5.1.8 The EU eco-label

a) The EU eco-label scheme

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[47] CECED Voluntary Commitment on Reducing Energy Consumption of Household Refrigerators, Freezers and their Combinations (2002-2010), 31 October, 2002, downloadable from www.ceced.org .

[48] Update of cold appliances Unilateral Commitment target values according the new Labelling Directive formulas.

The EU eco-label was initially set in Council Regulation (EEC) No 880/92 on a *Community eco-label award scheme*, revised by Regulation (EC) No 1980/2000 of the European Parliament and of the Council of 17 July 2000 *on a revised Community Eco-label Award Scheme*. The Eco-label scheme has to be seen together with five other decisions on procedures and fees (European Eco-labelling board - EUEB, Consultation Forum, Standard Contract, Fees, Eco-label working plan).

The key elements of this new Regulation, which entered into force on 24 September 2000, include:
- widening the scope to cover services as well as products
- reinforced stakeholder participation, in particular in developing the environmental criteria
- the creation of the EU Eco-labelling Board, comprising of the Eco-label Competent Bodies and interest groups, whose main role is to develop the Eco-label criteria
- reduced fees for SMEs and developing countries
- introduction of a ceiling on the annual fee
- reinforced transparency and methodology
- renewed emphasis on the promotion of the scheme
- reinforced co-operation and co-ordination with the national Eco-label schemes
- more information on the label
- possibility for traders and retailers to apply directly for their own brand products
- possibility for non-EU producers to apply directly.

The application of the eco-label scheme has always been critical for household appliances, although the scheme has been successful for other non-EUP products. After very few models of cold and wash appliances being submitted and awarded the label in the first years of the eco-label life, then no supplier (manufacturer or importer) applied for the eco-label for such product groups. This situation is at present persisting, probably due to the complexity and costs of the required criteria/awarding procedure compared to the lack of market value of the ecological label compared to the energy label. Some studies[49] promoted by the Commission addressed this issue, which was also considered in the Community Eco–Label Working Plan set in Commission Decision 2002/18/EC[50].

The Regulation instituting the European Eco-label is at present under further review following the results of the EVER (Evaluation of EMAS and Eco-label for their Revision) study published in December 2005[51]. The study has been carried out on behalf DG Environment by a consortium of consultants. The fundamental aim of the EVER study has been to provide recommendations for the revision of the two voluntary schemes EMAS and the EU Eco-label. The options and recommendations proposed for the schemes are based on the evidence collected in the different phases of the study, presented, discussed and enriched through two workshops held in September 2005, that involved experts, institutions, companies, practitioners and NGOs. The whole process led to the defining of options and recommendations the revision process, where a major issue for the revision of both the schemes is integrating and linking them with existing legislation and environmental policies (to a wider extent).

b) The eco-label for cold appliances

The product group “refrigerators” comprises all electric, mains-operated household refrigerators,

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[49] Some of the studies are downloadable at http://ec.europa.eu/environment/ecolabel/documents/studies_en.htm

[50] Commission Decision 2002/18/EC of 21 December 2001 establishing the Community eco-label working plan, OJ L 7, 11.01.2002.

[51] The executive summary is downloadable at: http://www.ioew.de/home/downloaddateien/ever_executive%20summary.pdf .

frozen food storage cabinets, food freezers and their combinations; appliances that may also use other energy sources, such as batteries, are excluded.

Since 1992, the European Eco-label Board started addressing cold appliances more from the environmental impact point of view with a series of studies, which resulted in the definition of a voluntary scheme of eco-labelling awarding criteria for refrigerators and freezers. The latest criteria are valid from May 1st 2004 until May 31st 2007, and were established in Commission Decision 2004/669/EC of 6 April 2004 *establishing revised ecological criteria for the award of the Community eco-label to refrigerators* and amending Decision 2000/40/EC. Eco-label awarding criteria are claimed to aim at promoting:

- reduction of environmental damage or risks related to the use of energy (global warming, acidification, depletion of non renewable energy sources) by reducing energy consumption,
- reduction of environmental damage or risks related to the use of potentially ozone-depleting and other hazardous substances by reducing the use of these substances,
- reduction of environmental damage or risks related to the use of substances that may have a global-warming potential;
- encourage the implementation of best practice (optimal environmental use) and enhance consumers' environmental awareness
- aid the machine's recycling by marking the plastic components.

In addition, when assessing producers' applications for the award of the eco-label for refrigerators and monitoring compliance to the criteria, the Competent Bodies are recommended to take into account the implementation of recognised environmental management schemes, such as EMAS or ISO 14001, although the implementation of such management schemes is not required.

In order to be awarded an eco-label, the appliance shall comply with a series of "key" and "additional" criteria:

- Key criteria are:
  - *Energy savings*: the appliance must have an energy efficiency class of A+ or A++ as defined in Directives 94/2/EC and 2003/66/EC;
  - *Reduction of ODP of refrigerants and foaming agents*: the refrigerants in the refrigerating circuit and foaming agents used for the insulation of the appliance shall have an ozone depletion potential equal to zero;
  - *Reduction of GWP of refrigerants and foaming agents*: the refrigerants in the refrigerating circuit and foaming agents used for the insulation of the appliance, shall have a global warming potential equal to, or lower than, 15 (rated as CO_2 equivalents over a period of 100 years). This criteria excludes in practice from the eco-label cold appliances using HFCs or their blends as refrigerants and foaming agents.
- Additional criteria are:
  - *life time extension*
  - *take-back and recycling*: a set of sub-criteria also apply
  - *User instructions*, a set of sub-criteria also apply
  - *Limit noise emissions*
  - *Packaging*
  - *Consumer information*.

An overall picture of awarding criteria by life cycle phase is given in Figure 1.3. It should be noted that some criteria are now overcome by the entering into force of the RoHS and WEEE directives.

After few years when the Danish manufacturer Vest Frost was the only applicant for the eco-label, at present no cold appliances have been asked for or awarded the eco-label.

Figure 1.3: Eco-label awarding criteria for refrigerators

Life Cycle Step	Criterion	Expectations
Manufacturing	Limitation of the use of substances harmful to the environment and health	• Plastic parts heavier than 25 g shall not contain flame retardant substances or preparations that are assigned any of the following risk phrases: R45, R46, R60, R61, R50, R50/53, R51/53 as defined in Council Directive 67/548/EEC and its amendments. • Plastic parts shall not contain PBB or PBDE flame retardants, nor chloroparaffin flame retardants with chain length 10-13 carbon atoms and chlorine content >50% by weight.
Use	Energy saving	• The appliance must have an energy efficiency class of A+ or A++ as defined in Directive 94/2/EC, and amended by Directive 2003/66/EC.
Use	Reduction of noise	• Noise ≤ 40dB(A). • Information about the noise level of the appliance provided in a clearly visible way to the consumer.
Use	User instructions for environmental use	The following information shall come with the product: • Guidelines on optimal installation of the appliance. • The consumer should avoid placing the appliance next to any heat source or in direct sunlight. • Thermostat setting dependant on the ambient temperature. • Hot foodstuffs shall be allowed to cool down before placing in the appliance. • Evaporator unit should be kept clean from thick ice layers and frequently defrosted. • Door seal to be replaced when deficient. • When moving the appliance, sufficient time should be allowed before switching it on again. • Condenser and appliance to be kept clean. • Information that ignoring the above-mentioned instructions will lead to higher energy consumption. • Damage to the condenser (with sharp objects) to be avoided because of environmental and health risks. • Presence of fluids and materials that are reusable and/or recyclable.
End of life	Eco-design to facilitate recycling	• Easy disassembly of the machine taken into account in the design. • A disassembly report shall be provided. • Plastic parts heavier than 50 g: permanent marking identifying the material, in conformity with ISO 11469 standard. • Clear indication of the type of refrigerant and foaming agent used in order to facilitate the recovery.
End of life	Reduction of ecological damage related to substances with ODP and GWP	Refrigerants and foaming agents: • Ozone Depletion Potential (OPD) = 0. • Global Warming Potential (GWP) ≤ 15 (CO_2 equivalent on 100 years).
End of life	Reduction of solid waste	• Take-back for recycling free of charge. • Information on take-back policy. • All packaging components shall be easily separable by hand into individual materials to facilitate recycling. • Cardboard packaging shall consist of at least 80% recycled material.
End of life	Durability	• Lifetime extension: the availability of compatible replacement parts and service shall be guaranteed for 12 years from the time that production ceases.

1.5.1.9 The influence of the EU policies and measures

The influence of EU mandatory and voluntary policies and measures on cold appliance design and market is analysed in Task 2.

1.5.2 The Policies & Measures in EU Member States

Legislation at Member States level has been replaced by the EU legislation for household appliances, only in some national voluntary (eco) labels are set for this product group. In addition The Dutch incentive scheme and the Italian fiscal system will be described. Finally the French specific mandatory legislation referring to cold appliances will be mentioned.

1.5.2.1 The national (eco) label schemes for household appliances

a) National eco-labelling schemes

A compilation of the product groups addressed in the different eco-labelling schemes in Member States and Accession countries in 2002 resulted (Table 1.16) in 6 schemes covering refrigerators (the Nordic Swann, the German, Austrian, Hungary, Slovakia and Poland), 6 schemes covering washing machines (the Nordic Swann, the German, Austrian, Slovakia Czech Republic and Poland) and 2 schemes covering dishwashers (the Nordic Swann and Poland).

A new research on the national scheme websites collected in the EU Ecolabel website page about other eco-labels[52] resulted in only the Nordic Swann, the Hungarian, the Czech Republic and the Slovak Republic schemes addressing cold and/or wash appliances in later years (2004-2007). The available information are summarised in Table 1.17. The awarding criteria for the different schemes are very close or overlapping with the criteria set in the EU eco-label, with some differences such as the rinsing performance requested to washing machines under the Nordic Swann.

In particular, the Nordic Swann applies to electric, mains-operated household refrigerators and freezers and their combinations[53]. Appliances that may use other energy sources, such as batteries cannot be labelled. The requirements for the labelling of refrigerators and freezers are almost identical to the Commission Decision of 6 April 2004 establishing revised ecological criteria for the award of the Community eco-label to refrigerators. Criteria differ in requirement levels regarding flame retardants, life time extension and requirements to analysis laboratories and test institutions. The Nordic Swan also has quality and regulatory requirements and requirements on marketing. These requirements are fulfilled if the manufacturer's environmental management system is certified to ISO 14 001 or EMAS, and the following procedures implemented.

The application has to be sent to Nordic Ecolabelling in the country in which the refrigerator or freezer is sold. The application documents comprise an application form and documentation demonstrating fulfilment of the requirements (specified in the criteria). Before a license is granted, normally an onsite inspection is performed to ensure adherence to the requirements.

An application fee is charged to companies applying for a license. There is an additional annual fee based on the turnover of the Swan labelled refrigerator/freezer.

The Nordic Swann ecolabel license is valid providing the criteria are fulfilled and until the criteria expire. The validity period of the criteria may be extended or adjusted, in which case the license is automatically extended and the licensee informed. Revised criteria shall be published at least one year prior to the expiry of the present criteria. The licensee is then offered the opportunity to renew their license.

b) The Energy Saving Recommended label in UK

The Energy Saving Trust (EST) is a non-profit organization funded by the British Government and the private sector. EST develops and runs programs (mostly awareness-raising campaigns) on behalf of the government and serves as a consultants. The goal is to give consumers verified and unbiased information about the advantages of energetically sustainable products and services. It is also in charge of efficient product/service accreditation.

EST issues the "Energy Saving Recommended"[54] product labelling scheme (formerly known as the

[52] See http://ec.europa.eu/environment/ecolabel/other/int_ecolabel_en.htm .
[53] Source: Swan labelling of refrigerators and freezers, Version 4.0, 19 October 2004 – 31 October 2008.
[54] See: www.energusavingstrust.co.uk/myhome/efficientproducts/recommended/.

Table 1.16: Eco-labelling schemes product groups in the different schemes in the EU addressing household appliances in 2002[55]

Category	Subcategory	EU-Flower	Nordic Sw	Spain	Catalonia	France	Germany	Austria	Netherland	Good env choice	TCO	Croatia	Hungary	Slovakia	Czech Rep	Poland	Subtotal	Total (out of 379)
HouseholdM	Dishwashers	X	X													X	3	
HouseholdM	Dryer for wash						X										1	
HouseholdM	Hand dryers, hot air						X										1	
HouseholdM	Mechanical washaid					X											1	
HouseholdM	Refrigerators	X	X				X	X					X	X		X	7	
HouseholdM	Vacuum cleaners					X											1	
HouseholdM	Washing Machines	X	X				X	X						X	X	X	7	21

[55] Source: Compilation of the eco-labelling product groups in the different schemes in the EU and Candidate Countries, downloadable from: http://ec.europa.eu/environment/ecolabel/pdf/work_plan/mtggroups/coop/pdgpsinotherschemes.pdf

Table 1.17: National eco-labelling schemes addressing household appliances in 2004-2007

Ecolabel	Countries	EUP covered (type)	Validity period (from/to)	Licences (number)	Criteria
Nordic Swan	Finland, Sweden, Denmark, Norway, Iceland	Refrigerators and freezers	19 October 2004 31 October 2008	none	Requirements almost identical to the EU eco-label with some differences and additional criteria
		washing machines (washer dyers excluded)	18 march 2004 19 June 2009	1	• electricity and water consumption • the reduced use of certain materials that are hazardous to health and the environment • the recycling of materials • washing and rinsing performance
Environmental Friendly products	Czeck Republic	Washing machines	not available	not available	not available
		Dishwashers	not available	not available	not available
The Hungarian Eco-label	Hungary	Refrigerators	06 April 2005 2007 and beyond	not available	The appliance must gradually reach the energy efficiency class of A+ or A++ as follows: - until 30.04.2007. the lower limit of energy efficiency shall be 47 % i.e. $I_\alpha < 47$. - from 30.04.2007. the lower limit of energy efficiency shall be 42 % i.e. $I_\alpha < 42$. Other criteria as in the EU Ecolabel
(NPEHOV)	Slovak Republic	Refrigerators and freezers	September 1999 - September 2001 Final proposal, 2002	none	not available
		washing machines	April 1997- Apr.1999 June 2001- June 2004	none	not available

Energy Efficiency Recommended scheme), a registered certification mark (shown in Figure 1.4) allowing consumers to spot the most energy-efficient products available on the market. Products carrying the mark meet or exceed the Energy Saving Trust's established criteria.

Figure 1.4: The "Energy Saving Recommended" mark

The Energy Saving Recommended scheme covers 24 products groups, including the following major appliances:

- washing machines
- dishwashers
- refrigerators, freezers and their combinations
- tumble dryers (including gas fired ones)
- appliances producing and storing hot water.

The scheme aims to review the criteria on an annual basis as the efficiency of appliances improves, to maintain 'best practice' recognition for recommended appliances. This mark is a guarantee that the product will help to reduce energy wastage in the home, as well as benefiting the environment and costing less to run. The Energy Saving Trust's criteria are set to award the label to the top 20% energy efficient products, using the energy efficiency classes set in the EU energy labelling directives as indicator.

For the large household appliances to which Energy Saving Recommended scheme applies, the requirements are:

- washing machines: models rated AAA rated (class A for energy consumption, class A for washing performance, and class A for spin drying efficiency)
- refrigerators, freezers and refrigerator-freezers: models rated class A+ or A++
- dishwashers: models rated class AAA (class A for energy consumption, class A for washing performance, and class A for drying efficiency) plus the eco-label requirement for water consumption
- tumble driers: models rated class B or better, and products that are rated class C if they feature an automatic drying function.

The EST website shows also an on-line database including products types and models complying with the set criteria

1.5.2.2 Economic incentives for efficient appliances

Economic incentives in the form of rebate schemes or tax deduction have been enforced in some EU countries. Only the successful case of the Netherlands and the new scheme in Italy are described.

a) The Netherlands[56,57]

Energy labels for household appliances were first introduced in the Netherlands in 1995. From the beginning the energy label in the Netherlands had a strong relation with the following energy policy instruments: the MAP (Environmental Action Plan from 1991 to 2000) and the EPR (Energy Premium Regulation from 2000 to 2003). Only a MAP or EPR subsidy could be received when the appliance had an A class label. The EPR started in 2000 and aimed to stimulate households to take energy saving measures and to buy energy efficient appliances. Until October 2003, consumers could get an EPR subsidy for appliances with an energy efficiency class A. For some appliances additional conditions where set to receive the subsidy. The EPR subsidy scheme is financed through the Regulating Energy Levy (Regulerende EnergieBelasting) REB, a levy on the electricity, natural gas and oil products sold to the households and SME's.

The MAP was aimed at a CO_2 reduction within households, governmental and the tertiary sector. Several actions where taken by energy distribution companies who where responsible for the implementation. The most important actions within consumers focussed on a change of behaviour and the purchase of energy efficient appliances by subsidising them (since 1995 linked to the energy label).

In total an amount of 25 million Euro subsidy was provided within the framework of MAP and about 159 million Euro EPR subsidy was provided. The total costs for the government for the implementation of the MAP and EPR were: 15 million Euro for MAP and 34 million Euro for EPR. As it is not exactly clear how much costs are made within MAP an estimation is made based on the amount of MAP subsidy received by consumers.

The first round of EPR - Energiepremieregeling (Energy Premium Regulation) scheme started 1st January 2000 and gives households and landlords the possibility to apply for a subsidy when purchasing an energy efficient household appliance or taking energy efficient actions such as roof-insulation. The goal of the EPR was to channel the funds from the Regulating Energy Tax or REB (Regulerende Energiebelasting) back to the citizen through subsidies on the purchase of energy efficient products and services.

In 2000 75% of REB-funds were thus used and in 2001 113%. The amount of funds available to the citizen for 2000 plus 2001 was 158.714.914 Euro, of which 97 % was actually spent. Certain groups of purchasers, such as companies or people who buy the appliance for their holiday homes, were excluded from the EPR subsidy.

The proportion between implementation costs and actual subsidies was 31% in 2000 (39% for appliances and 7% for other items). In 2001 it was 24% (37% for appliances and 6% for other items). In the same year, the largest part of the subsidies went to refrigerators/freezers plus washing machines (42%, Table 1.18), followed by insulation measures (25%) and High Efficiency (HR++) glazing (13%). After some initial hick-ups, utilities and the Tax Office did not encounter problems in handling the subsidy applications by the consumer and within 6 weeks all complete applications could be processed.

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[56] Source: Maxim Luttmer, Evaluation of Labelling of Appliances in the Netherland, Case Study executed within the framework of the AID-EE project, FINAL DRAFT, contract number EIE-2003-114, April 2006.

[57] Source: "Evaluation of the Netherlands energy efficiency subsidy scheme EPR", Tax Office/Centre for process- and product development, 21 June 2002. English summary by VHK, René Kemna, 8 October 2002. Original title "Rapportage van Onderzoeksbevindingen in Het Kader van de Evaluatie van de Energiepremieregeling, Belastingdienst/Centrum voor proces- en productont-wikkeling, 21 juni 2002

Table 1.18: Energy saving measures for appliances to which a subsidy was given in 2001

EPR-measure	Subsidy (number)	(Euro)	(%)
Refrigerators & Freezers	504 952	24.367.094	22
Washing machines	441 385	22.175.922	20
Dishwashers	145 768	6.614.664	6
Laundry driers	4 488	661.500	0,6
LCD-monitor	12 917	586.148	0,5
Domestic lighting fixture	17	771	<0,01
Simultaneous purchase	113 528	2.575.838	2

In November 2001, almost two years after the start of the EPR, one third of Dutch households had applied for the EPR, and of this, around two thirds concerned domestic appliances. The subsidy was requested for respectively 36%, 47% and 49% of all the sold A class dishwashers, fridge/freezers and washing machines.

The introduction of the EPR has led to an enormous growth of the supply of A labelled appliances (Table 1.19). The market share of A class washing machines grew from 40 to 71% over the 1999-2000 period and 26% to 55% for refrigerators. This increase is most likely due to the EPR and has led to a situation where retailers very often advice their customers to buy an A class appliance as the best on offer.

Table 1.19: Share of A labelled appliance: NL and EU (*source GfK*)

Appliance	1999	2000	2001
Refrigerators			
NL	26%	55%	67%
EU*	12%	19%	27%
Freezers			
NL	29%	55%	69%
EU*	12%	16%	n.a.
Washing machines			
NL	40%	71%	88%
EU*	15%	26%	45%
Dishwashers			
NL	27%	55%	73%
EU*	n.a.	n.a.	n.a.

*EU = Germany, UK, Ireland, France, Austria, Belgium, Netherlands, Portugal, Sweden, Spain

The 1999-2000 sales of A class refrigerators, freezers, washing machines and dishwashers (Table 1.20) have increased by 116%, 95%, 95% and 117% respectively, while in the second year (2000-2001) sales increases were 22%, 35%, 28% and 32% respectively. The absolute level of sales of these appliances has also increased, namely by 4%, 3%, 7% and 6% over the 1999-2000 period. For 2000-2001, when economic crisis set in, sales of refrigerators (-2%) and dishwashers (-0,3%) decreased, but sales of upright freezers (+8%) and washing machines (+3%) continued to rise.

Table 1.20: Sales of A class appliances in The Netherlands in 1999-2001 (units)

Appliances	1999	2000	2001
Refrigerators	645 000	671 000	658 000
of which A class	167 700	362 340	440 860
Freezers	200 000	206 000	222 000
of which A class	58 00	113 300	153 180
Washing machines	565 000	605 000	623 000
of which A class	220 350	429 550	548 240
Dishwashers	330 000	350 000	349 000
of which A class	89 100	193 600	254 770

In the consumer surveys the advice by the retailer was mentioned most often as reason for the purchase (36% of 1195 appliances bought by the sample group). Second reason (35%) was that the appliance or provision 'was best' (quality). Third reason was the energy saving (22%) and in 62 cases (5,3%) the EPR-subsidy was mentioned as the main reason to buy a particular appliance. In 77% of the cases the purchaser did not consider buying another appliance, after having applied for a subsidy. Some 84% of those purchasers claims the EPR-subsidy did not influence their buying decision (they say they would have bought the appliance anyway), and 83% of the purchasers who did take some time to reflect, decided that their first choice was the right one. These data appear to be pointing at a so-called 'free rider' effect, meaning that consumers would have bought the appliance or provision regardless of the subsidy. On the other hand this is not in line with the drastic rise – much more than in other EU countries - in market share of A class appliances. These high market shares of 70-80% in 2001, caused by the EPR, have led retailers to advice an A class appliance to their customers as being 'the best', which in turn led to the purchase of more efficient appliances.

Savings on CO_2 emissions were calculated for each EPR-item, using reference situations proposed by the Energie Onderzoek Centrum Nederland (ECN). The total calculated emission saving over 2000 and 2001 amounted to 210.333 ton (the total CO_2 saving over the lifetime of the appliances that were bought with an EPR-subsidy was not calculated), due to insulation-measures 30%, glazing 18%, PV systems 18% and condensing CH boilers 15%. Refrigerators/freezers plus washing machines contributed for 15%, although they took up 46% of funds. The savings did not lead to a general decrease of residential energy consumption: between 1999 and 2000 the average electricity consumption per household rose from 3 165 kWh to 3 197 kWh.

The average energy consumption of refrigerators, freezers, washing machines and dishwashers sold in 1999, 2000 and 2001 clearly decreased. Econometric studies have assessed that the Regulating Energy Tax (REB) has led to a lower energy consumption of households than in a Business-as-Usual scenario. These studies estimate that a 10% energy price rise leads to a 4% lower consumption. On the other hand there is a rebound-effect whereby people start using efficient appliances more. This takes away around one sixth of the energy saving achieved through the efficiency improvement, meaning that 5/6of the savings is effective.

From 1st January 2002 a second step of EPR subsidy was launched. Subsidies for that year are given in Table 1.21. The REB generated a state income of 2 383 million Euro in 2002.

Table 1.21: Subsidies for household appliances in the Dutch EPR 2002 scheme

Code	Item	Subsidy (€/unit)
1010	Fridge/freezer A-label	50
1011	Fridge/freezer A-label with EEI =0,42 (e.g. A+)	100
1020	Dishwasher A (energy), A or B for performance and drying	50
1030	Dishwasher A-label for energy	50
1031	Washing machine, A, A, A	100
1041	Electrical tumble drier A-label for energy	160
1050	Gas-fired tumble drier	160
1060	Washer-drier with A-label for energy	205
1080	Lighting fixture with dedicated CFL >30 Watt	50
1090	Stand-alone LCD-monitor with diagonal >35 cm	50

In Table 1.22 the overall market share of the energy efficiency classes A and better is presented for the period 1996-2004. The differences with the data presented in previous Table 19 depend from the different source of the information, which in any case are in good agreement. The market share for both refrigerators and freezers increased considerably since 1996. In the years 2003 and 2004 the market share of energy efficiency classes A, A+ and A++ decreased a little due probably to the fact that since 2003 no EPR subsidy is given anymore for these appliances.

Table 1.22: Marker share of A and better classes for white goods in the Netherlands in 1996-2004

EE Classes	1996 (%)	1997 (%)	1998 (%)	1999 (%)	2000 (%)	2001 (%)	2002 (%)	2003 (%)	2004 (%)
Refrigerators									
A	7	10	14	23	54	70	71	75	68
A+	--	--	--	--	2	6	13	23	19
A++	--	--	--	--	--	--	1	0	1
Freezers									
A	3	13	18	26	53	n.a.	74	60	58
A+	--	--	--	--	--	--	14	22	21
A++	--	--	--	--	--	--	--	2	3
Washing machines									
A	0	3	19	37	67	91	95	99	99
Dryers									
A					0,5	0,5	0,4	0,3	0,3

source: VLEHAN 2005, VROM 2005, MilieuCentraal 2005

b) Italy

In Italy, according to the Financial Law 2007 (Law 27 December 2006, No 296), Art.1, point 353 a detraction is possible from the personal income taxation, of 20% of the price effectively paid for the purchasing of a refrigerator, freezer or their combination, belonging to the energy efficiency class A+ or better, up to a maximum of 200 Euro per appliance. The competent Ministry will publish guidelines on how this fiscal incentive could be effectively used not later than the end of February 2007.

1.5.2.3 Specific national legislation for cold appliances

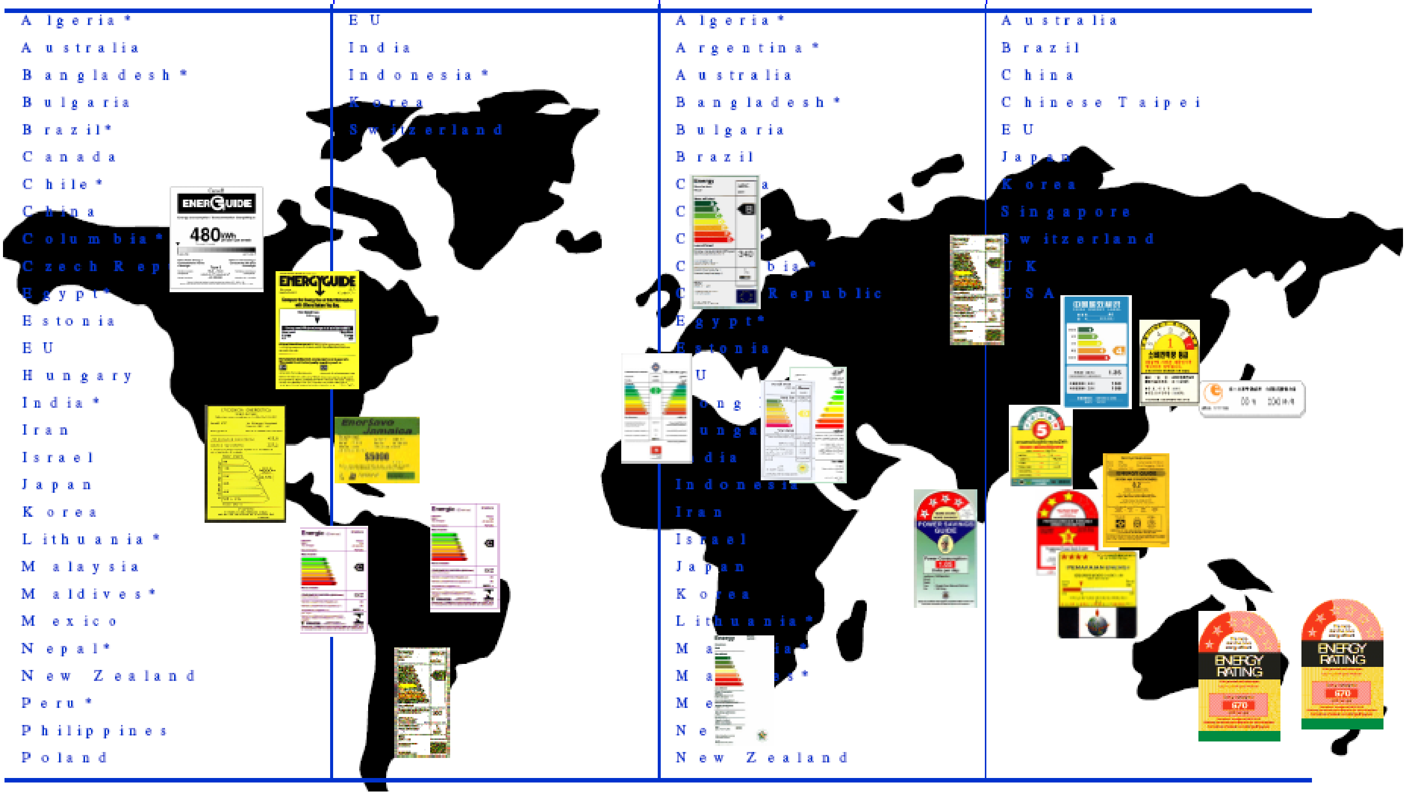
A specific French regulation on refrigerators was issued in 2002, titled *"Décret 2002-478 du 3 avril 2002 relatifs aux réfrigérateurs à usage domestique, aux thermomètres et autres dispositifs destinés à indiquer la température dans ces appareils"*. It requires a specific symbol identifying cold zone of compartment intended for storage of fresh food at temperature ≤4 °C and that the thermometer or temperature indicator has to present specific characteristics.

It is mentioned in international standard ISO 15502:2005 among the conditions particular to certain countries.

1.5.3 International Policies & Measures

The number of nations adopting energy efficiency requirements and labels for EUPs is growing rapidly, from 9 in 1984 to 36 in 1994 to over 54 in 2006 (Figure 1.5). The number of regulations worldwide on individual appliances and equipment is growing even more rapidly, increasing from 543 to 878 between 2000 and 2004[58].

Figure 1.5: International use of mandatory and voluntary policy measures in 2006[59]



Mandatory requirements	Voluntary Commitments	Comparative Label	Endorsement Label
Algeria*	EU	Algeria*	Australia
Australia	India	Argentina*	Brazil
Bangladesh*	Indonesia*	Australia	China
Bulgaria	Korea	Bangladesh*	Chinese Taipei
Brazil*	Switzerland	Bulgaria	EU
Canada		Brazil	Japan
Chile*		C[illegible]a	Korea
China		C[illegible]	Singapore
Columbia*		C[illegible]	Switzerland
Czech Rep		C[illegible]bia*	UK
Egypt*		C[illegible] Republic	USA
Estonia		Egypt*	
EU		Estonia	
Hungary		[illegible]U	
India*		[illegible]ong[illegible]	
Iran		[illegible]unga[illegible]	
Israel		[illegible]dia	
Japan		Indonesia	
Korea		Iran	
Lithuania*		Israel	
Malaysia		Japan	
Maldives*		Korea	
Mexico		Lithuania*	
Nepal*		Ma[illegible]ia*	
New Zealand		Ma[illegible]s*	
Peru*		Me[illegible]	
Philippines		Ne[illegible]	
Poland		New Zealand	

The most common policies and measure for cold appliances outside the EU are labelling (efficiency or other type) and efficiency requirements, implemented in many countries, as described in Table 1.23. (IEA and OECD Secretariats, based on various sources). In addition to these countries, other

[58] Source: APEC," A Strategic Vision for International Cooperation on Energy Standards and Labeling", June 2006.
[59] Source: P. Waide, EEDAL End of Term Report, EEDAL 06, London, June 2006.

Table 1.23: Labelling schemes and energy requirements for refrigerators and freezers around the world[60]

Country	Refrigerators and refrigerator-freezers			Freezers		
	Min. eff. requirements	labelling		Min. eff. requirements	labelling	
		comparative	endorsement		comparative	endorsement
Algeria	**M**[1]	**M**[1]	**--**	**M**[1]	**M**[1]	**--**
Argentina	UC	**M**[1,2]	--	UC	**M**[1,2]	**--**
Australia	**M**[5]	**M**[5]	V	**M**[5]	**M**[5]	V
Bolivia	UC	UC	--		UC	UC
Brazil	UC	V[3]	V	UC	V[3]	V
Bulgaria	UC[2]	UC[2]	UC[2]	UC[2]	UC[2]	UC[2]
Canada	**M**[4]	**M**[4]	V[4]	**M**[4]	**M**[4]	V[4]
Chile	UC	UC	UC	UC	UC	UC
China	**M**[3]	**M**[3]	V	**M**[3]	**M**[3]	V
Columbia	**M**[1]	**M**[3]	--	**M**[1]	**M**[3]	--
Costa Rica	V	**M**	**--**	V	**M**	**--**
Croatia	UC[2]	UC[2]	UC[2]	UC[2]	UC[2]	UC[2]
Ecuador	UC	UC	--	UC	UC	--
Egypt	UC	UC[3]	--	UC	UC[3]	--
EU-25/27	**M**	**M**	V	**M**	**M**	V
Ghana	UC	UC[2]	--	UC	UC[2]	--
Hong Kong (CN)	UC	V	V	UC	--	V
Iceland	**M**[2]	**M**[2]	V[2]	**M**[2]	**M**[2]	V[2]
India	**M**	(V)	V	--	--	--
Indonesia	UC	V	V	--	--	--
Iran	**M**	**M**[3]	--	--	--	--
Israel	**M**	**M**[3]	**--**	**M**	**M**[3]	--
Jamaica	**--**	**M**	**--**	**--**	**M**	**--**
Japan	**M**[6]	**M**	--	**M/V**[6]	**M**	**--**
Korea	**M**	**M**	**--**	**M**	**M**	**--**
Lichtenstein	**M**[2]	**M**[2]	V[2]	**M**[2]	**M**[2]	V[2]
Malaysia		(M)	--	--	(M)	--
Mexico	**M**[4]	**M**[4]	V	**M**[4]	**M**[4]	V
New Zealand	**M**[5]	**M**[5]	--	**M**[5]	**M**[5]	--
Norway	**M**[2]	**M**[2]	V	**M**[2]	**M**[2]	V
Peru	UC	UC	--	UC	UC	--
Philippines	UC	**M**	--	UC	**M**	**--**
Romania	UC[2]	UC[2]	UC[2]	UC[2]	UC[2]	UC[2]
Russia	**M**	M[2]	**--**	**M**	M[2]	--
Singapore	--	--	V	--	--	V
South Africa	UC	M[2]	--	UC	M[2]	--
Switzerland	--	V[2]	V	--	V[2]	V
Chinese Taipei	**M**	--	V	--	--	V
Thailand	M	M	V	--	--	--
Tunisia	**M**[3]	**M**[3]	--	**M**[3]	**M**[3]	--
Turkey	UC[2]	**M**[2]	UC[2]	UC[2]	**M**[2]	UC[2]
United States	**M**	**M**	V	**M**	**M**	V
Uruguay	UC	UC	--	UC	UC	--
Venezuela	V[4]	**M**[4]	--	V[4]	**M**[4]	--
Vietnam	UC	UC	--	UC	UC	--

M = Mandatory, V = voluntary, UC = under consideration

[1] Framework legislation is passed but the implementing legislation is believed to still be under consideration.

[2] Harmonised with EU; [3]Partially harmonised with EU; [4] Partially or fully harmonised with USA

[5] Harmonised between Australia and New Zealand; [6] Japan requires the sales-weighted average efficiency of any suppliers' appliances to exceed a prescribed efficiency threshold. These requirements are mandatory but fines for non-compliance are very low and therefore they are sometimes described as voluntary targets. Nonetheless, being named and shamed for non-compliance is likely to have severe consequences in the Japanese marketplace and hence is thought to be an adequate deterrent by Japanese regulators.

[60] Source: "Can Energy-Efficient Electrical Appliances be considered "Environmental Goods"?, OECD Trade and Environment, Working Paper No. 2006-04.

non-EU European countries have either implemented EU cold appliance energy-efficiency regulations for refrigerators and freezers or are likely to do so in the near future: Russia, Ukraine, Belarus, Turkey.

1.5.3.1 Australia and New Zealand

Like the majority of Europe, Australia[61] has had a national end-use energy efficiency program with a mandatory energy labelling of appliances, that between 1992 and 2000 delivered cumulative abatement of 5 Mt CO_2-e. Since this was considered a small contribution to the national stationary energy emissions calculated as 295 Mt CO_2-e pa in 2000 a change in perspective was decided. From 2000, Australian governments agreed to a programme of regulation policy matching world-best regulated efficiency requirements (but not exceeding them). Products cannot be sold unless they comply with these minimum levels, stipulated in Australian standards, which are called in law. Industry is a partner, publicly committed to bringing only complying product to market.

Australia has a small manufacturing base and imports many products from Europe, Asia and North America. As a rule Australia is a technology taker rather than developer of consumer products. The key to the policy of matching world best regulatory policies is allowing reasonable time for that technology to filter into our marketplace. It was considered unrealistic to demand Australian industry develop technologies in advance of the rest of the world; it is more realistic to expect locally based industry to match existing, proven technologies within a reasonable timeframe. The focus of policy measures debate therefore was shifted from disputes about technical feasibility issues to discussions about introduction dates. A key benefit of matching an existing technical level is avoiding divisive debates about what the standard level should be: Europe, Asia or North America has determined that for Australia in the last years. The national debate is focused on taking account of any special Australian circumstance to modify those pre-determined efficiency levels.

This specificity should be taken into account when the evolution of the Australian/New Zealand energy efficiency policy measures is considered.

a) Policy measures for cold appliances

Refrigerators and freezers (and their combinations) are regulated for energy labelling and for efficiency requirements in Australia. The requirements for energy labelling and efficiency are set out in AS/NZS 4474.2:2001. International standards specify the test methods but not the energy requirement limits, therefore, as previously explained, AS/NZS standards have two parts: Part 1 generally reflects an international standards (test method) while Part 2 specifies limits or labelling grades and are written to be suitable for referencing in regulations.

Products are classified into one of nine Groups, which are defined in Table 1.1 of AS/NZS 4474.1 standard:

- Group 1: Refrigerator without a low temperature compartment, automatic defrost
- Group 2: Refrigerator with or without an ice-making compartment, manual defrost
- Group 3: Refrigerator with a short or long term frozen food compartment, manual defrost
- Group 4: Refrigerator-freezer, fresh food compartment is automatic defrost, freezer manual defrost ("partial automatic defrost")

[61] Source: S. Holt, L. Harrington, Lessons learnt from Australia's standards & labelling program, ECEEE, 2003.

- Group 5B: Refrigerator-freezer, both compartments automatic defrost (frost free), bottom mounted freezer
- Group 5T: Refrigerator-freezer, both compartments automatic defrost (frost free), not side by side configuration or bottom mounted freezer (i.e. top mounted freezer)
- Group 5S: Refrigerator-freezer, both compartments automatic defrost (frost free), side by side configuration
- Group 6U: Separate vertical freezer, manual defrost
- Group 6C: Separate chest freezer, all defrost types
- Group 7: Separate vertical freezer, automatic defrost (frost free);

compartment in this context refers to compartment (with separate external door) or an internal sub-compartment.

A number of requirements must be met by refrigerators, freezers and refrigerator-freezers before being tested for energy consumption. These include:
- Volume: manufacturer declared values must be within defined tolerances of the measured compartment volumes;
- Pull down test: the unit is left off in an ambient temperature of 43°C with the doors open, the doors are then closed and the unit is switched on. The unit must reach certain internal temperatures within each compartment (as specified for its Group) after a period of 6 hours (including any compressor trips). This test is originally based on the US AHAM HRF-1 pull down test;
- Temperature Operation Test: the unit must be able to maintain acceptable internal temperatures in each compartment (as specified for its Group) under external ambient temperatures of 10°C, 32°C and 43°C. This test is identical to the ISO Temperature Operation Test;
- Energy consumption: energy consumption is measured at specified internal compartment target temperatures (as specified for its Group) while operating at an ambient temperature of 32°C. During the energy consumption test, the freezer compartment does not contain test packages and any automatic defrost mechanism is allowed to operate. Energy consumption is measured over a whole number of defrost cycles and there are separate procedures for adaptive defrost systems (where time between defrosts exceeds 24 hours). There are no door openings in the test procedure. All tests are undertaken with a power supply at 240 Volts and 50 Hz.

b) The energy rating labelling scheme

Energy labelling for refrigerators and freezers was first implemented in Australia in the 1980s at State level and has since developed into a *de facto* national programme with a high level of co-ordination between State regulations.

The original label classified product efficiency using a star rating system ranging from 1 star (lowest efficiency) to 6 stars (highest efficiency) (Figure 6). The equations used to define the star ratings was expressed as linear functions of energy consumption against gross volume with the *y*-axis intercept passing through the origin.

The combined influence of the efficiency requirements enforced in 1999 and continuing evolution of the higher-efficiency end of the market had the effect of putting most products into the higher star ratings. Following a comprehensive review a new categorical label was designed and issued in 2000 (Figure 7). The new label closely resembles the old label in order to build on the brand recognition; however, it differs in the following key areas:
– a strip has been added to the bottom of the label stating the appliance rating under the old labelling scale

– the label design has been modified so as not to be mistaken for the old label but still clearly echoing the format of the old label
– the information given on the label has been slightly simplified and the most important information – the comparative star rating and the annual energy consumption – has been more heavily emphasised. People who require more information are invited to visit a specific web site created to support the label
– the same number of stars are used as previously (1–6) but half star ratings are also allowed, thereby effectively doubling the number of efficiency classes. The recasting of the star ratings was done in such a way as to ensure that the new label will continue to be viable for several more years before a new revision is required. Under the current system, the most efficient
– products are generally only 3 or 4 stars, although there are some products that rate nearly 5 stars already for some appliance types.
– the structure used to define the star ratings was modified to use the (adjusted) equivalent volume approach (reference energy consumption versus equivalent volume lines that do not pass through the origin have been defined and an efficiency index is calculated using a similar approach to that used in the EU energy labelling).

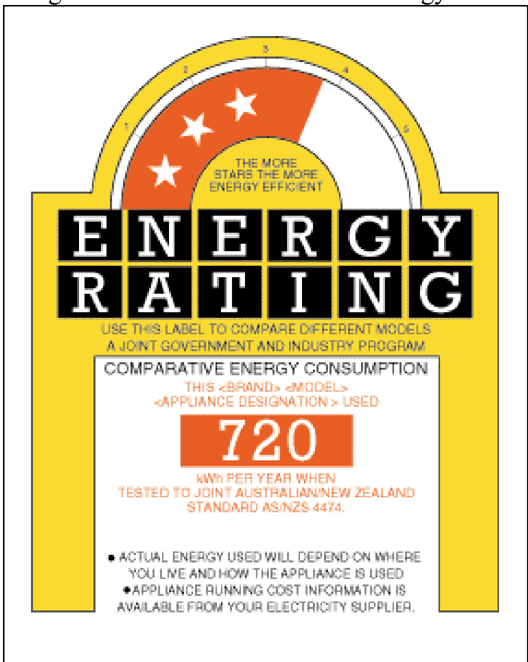


Figure 6: The former Australian energy label

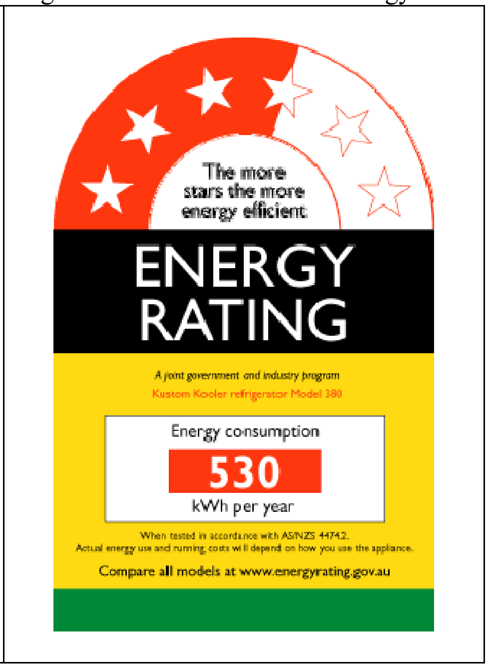


Figure 7: The new Australian energy label

The general form of the star rating algorithm for refrigerators and freezers is:

$$SRI = 1 + \left[\frac{\log_e \left(\frac{CEC}{BEC} \right)}{\log_e (1 - ERF)} \right]$$

where:
- SRI is the Star Rating Index (fractional star rating)
- CEC is the Comparative Energy Consumption (energy that appears on the energy label)
- ERF is the Energy Reduction Factor – reduction in CEC for each additional star
- BEC is the Base Energy Consumption – the equation for a product with an SRI of 1,0, calculated as:

$$BEC = C_f + \left(C_v \times V_{adj \cdot tot}\right)$$

where the (adjusted) equivalent volume is:

$$V_{adj \cdot tot} = \sum K_s \times compartment \cdot volume$$

and K_s is a volume adjustment factor depending on the compartment type:

Compartment type	Volume adjustment factor (K_s)
Cellar	0,7
Fresh food	1,0
Chill	1,1
Ice-making	1,2
Short term food storage	1,4
Freezer	1,6

Other factors by product group are shown in Table 1.24.

Table 1.24: Factors included in the Australian star-rating algorithm in 1999

Group	Description	Fixed allowance factor (C_f) (kWh/y)	Variable allowance factor (C_v) (kWh/y/l)	Energy reduction factor (ERF)
1	Refrigerator without a low temperature compartment, automatic defrost	368	0,892	0,14
2	Refrigerator with or without an ice-making compartment, manual defrost	300	0,728	0,20
3	Refrigerator with a short or long term frozen food compartment, manual defrost	330	0,800	0,20
4	Refrigerator-freezer, fresh food compartment is automatic defrost, freezer manual defrost ("partial automatic defrost")	424	1,020	0,23
5B	Refrigerator-freezer, both compartments automatic defrost (frost free), bottom mounted freezer	424	1,256	0,23
5T	Refrigerator-freezer, both compartments automatic defrost (frost free), not side by side configuration or bottom mounted freezer (i.e. top mounted freezer)	424	1,256	0,23
5S	Refrigerator-freezer, both compartments automatic defrost (frost free), side by side configuration	465	1,378	0,23
6C	Separate vertical freezer, manual defrost	248	0,670	0,17
6U	Separate chest freezer, all defrost types	439	0,641	0,20
7	Separate vertical freezer, automatic defrost (frost free)	439	1,020	0,20

The BEC defines the "1 star" line for particular products. An additional star is awarded when the CEC (Comparative Energy Consumption) of the model is reduced by a defined percentage from the BEC. Energy reductions per star vary from 14% to 23%, depending on the refrigerator Group. For example, if the energy reduction per star was 20% (as is the case for Groups 2, 3 6U and 7), then a

CEC that was 0,8 of the BEC or less would achieve 2 stars. Similar, a CEC of 0,64 (0,8 x 0,8) of the BEC or less would achieve 3 stars and so on.

To be eligible for the energy label a refrigerator has to meet a “temperature operation test” and a “pull down test” as defined in the Australian standard.

A review of the star rating labelling scheme is under preparation, and will be likely enforced starting March 2008 (see the following paragraph).

c) The energy efficiency requirements[62]

From 1 October 1999, refrigerators, freezers and refrigerator-freezers manufactured in or imported into Australia were subject to minimum energy performance requirements. More stringent requirements, which were broadly harmonised with US 2001 energy performance requirements, but have been adjusted to Australian test and mains-supply conditions, were introduced on 1 January 2005. The thresholds for both 1999 and 2005 are defined in AS/NZS 4474.2-2001. The main factors for both the 1999 and 2005 efficiency requirements are shown in Table 1.25.

The 1999 and 2005 efficiency requirement thresholds were a set of straight-line formulae expressed in terms of energy consumption against equivalent volume. The 1999 efficiency requirement levels were chosen as the threshold between 0 and 1 stars (of the star rating system) so that no appliances that pass the thresholds attain less than 1 star under the new label.

Table 1.25: Main factors used to calculate the cut-off value in Australia/New Zealand minimum efficiency requirement levels for 1999 and 2005

Requirement levels	1999		2005	
Refrigerator Group	Fixed allowance factor (K_f) (kWh/y)	Variable allowance factor (K_v) (kWh/y/L)	Fixed allowance factor (K_f) (kWh/y)	Variable allowance factor (K_v) (kWh/y/l)
1	368	0,892	278	0,335
2	300	0,728	289	0,290
3	330	0,800	283	0,344
4	424	1,020	277	0,330
5T	424	1,256	311	0,357
5B			411	0,357
5S	465	1,378	569	0,169
6C	248	0,670	190	0,483
6U	439	0,641	281	0,298
7	439	1,020	356	0,478

The formula to calculate the cut off value for an appliance is:

$$Threshold \cdot level = \left[k_f + \left(k_v \times V_{adj} tot\right)\right] \times k_a + Ad_{tot} + A_{wi} \quad \text{(eq. 8)}$$

[62] http://www.energyrating.gov.au/rf2.html.

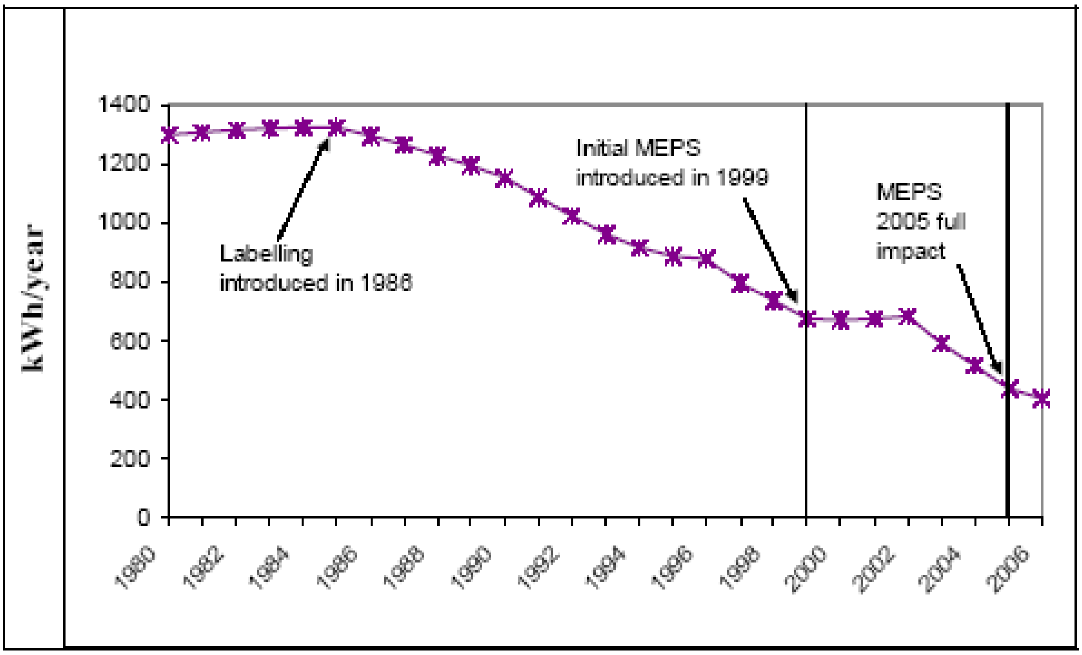
where:

- K_f = fixed allowance factor for its appliance group (kWh/y)
- K_v = Variable allowance factor (kWh/y/L)
- K_a = Adaptive defrost adjustment factor, set at 1,0 for 1999 and for non-adaptive defrost models in 2005 and 1,05 for adaptive defrost models for 2005.
- $V_{adj}tot$ = total adjusted volume (gross liters)
- Ad_{tot} = an allowance which is made where the external doors provided on an appliance differ from the regular arrangement for that appliance group. The door allowance can be positive or negative
- A_{wi} = an allowance of 120 kWh/year which applies where an appliance has a "through-the-door ice dispenser" i.e. it has an automatic ice-maker coupled with a device for delivery on demand of ice externally through a door. This allowance also applies if the through the door dispenser also dispenses chilled water.

The new minimum energy efficiency requirements for 2005 were developed and agreed by industry and government representatives during 2000, were introduced on 1 January 2005. Until 31 December 2004, regulatory authorities accepted testing of appliances to either 1999 requirements or 2005 requirements. All appliances within the scope of efficiency requirements, manufactured or imported for sale in Australia or in New Zealand on or after 1 January 2005, were required to meet the 2005 requirements. In addition, at the time of sale in Australia, such appliances are required to hold a valid registration, which indicates compliance with the relevant requirements.

Figure 1.8 shows the reduction in energy use in Australian refrigerators, since the mid-1980s.

Figure 1.8: Energy use of Australian refrigerators in 1980-2006



Energy labelling was introduced in 1986, and this resulted in a gradual steady reduction in unit energy consumption. When Australia developed a minimum energy efficiency requirements in 1989, annual energy consumption for refrigerators decreased nearly half compared to the mid-1980s. With the new requirements for refrigerators taking effect in 2006, it is expected that individual refrigerator energy consumption will fall by an additional 40% relative to the previous minimum requirement levels[63]. Refrigerators on the market in Australia in October 2005 with minimum energy efficiency requirement levels by Group are shown in Figure 1.9, freezers in Figure 1.10[64].

Figure 1.9: Refrigerators on the Australian market in October 2005 with minimum energy efficiency requirement levels by Group

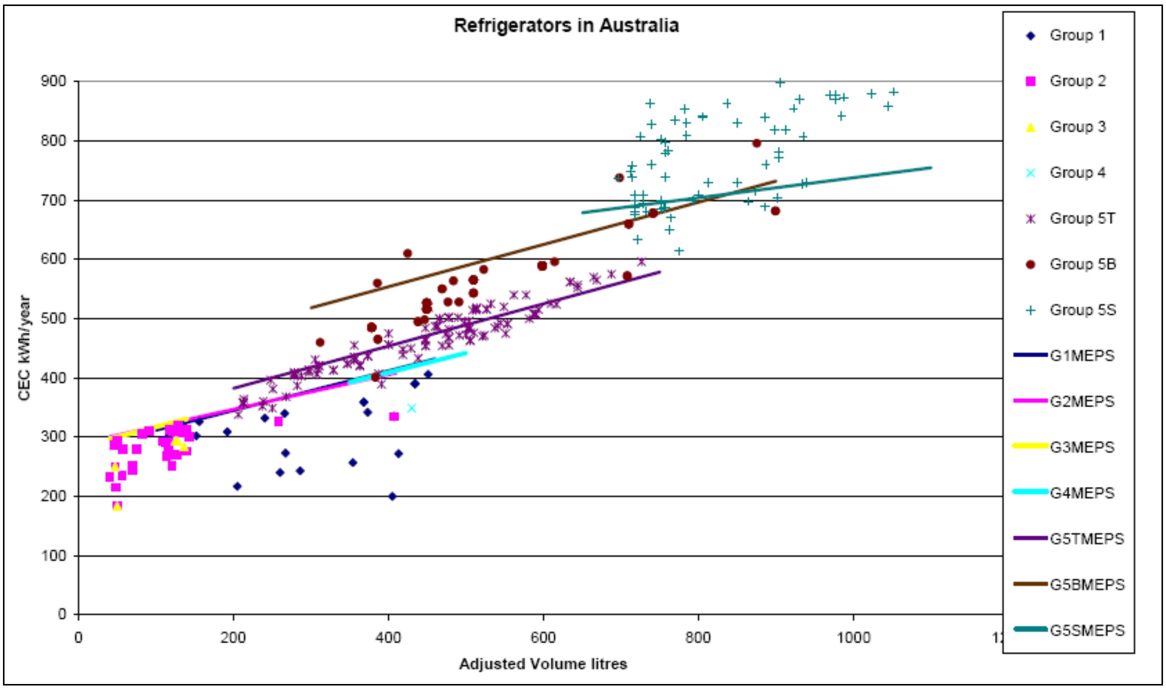
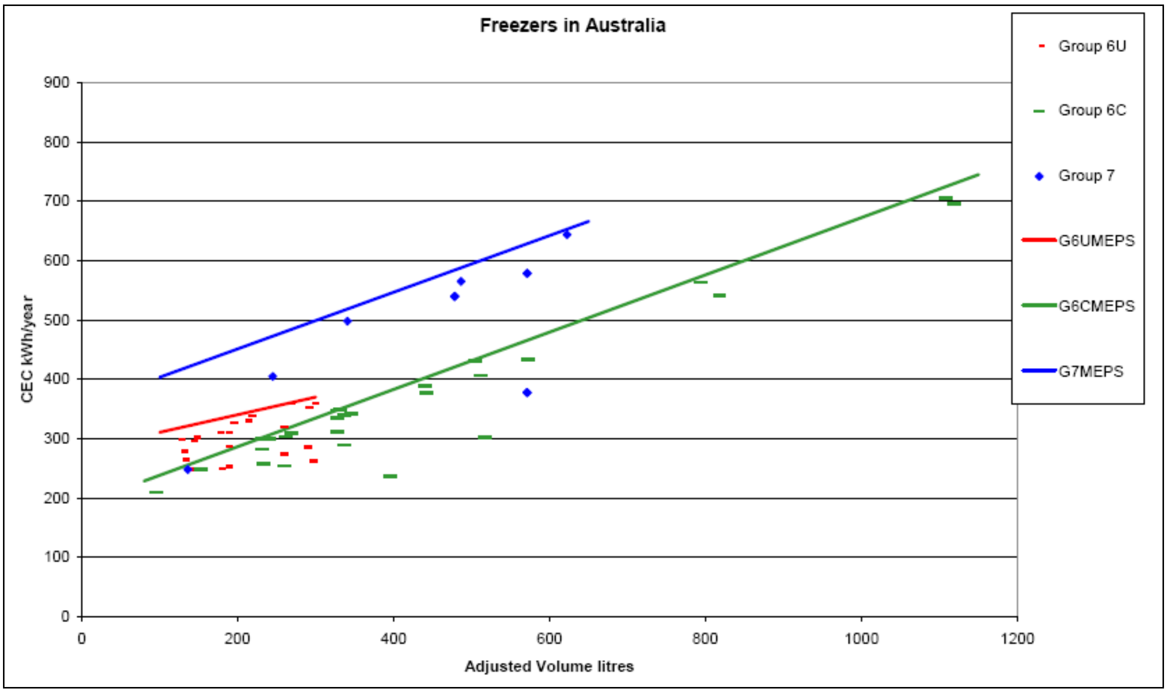


Figure 1.10: Freezers on the Australian market in October 2005 with minimum energy efficiency requirement levels by Group



63 Source: APEC, A Strategic Vision for International Cooperation on Energy Standards and Labeling.
64 Refrigerator Star Rating Algorithms in Australia and New Zealand, Discussion paper prepared for the Equipment Energy Efficiency Committee (formerly known as NAEEEC) by Energy Efficient Strategies, 4 January 2006, Report No 2006/01; downloadable from http://www.energyrating.gov.au/library/details200601-rf-algorithm.html .

Some products within some groups (mainly 5T, 5B and 5S) appear to lie above the relevant minimum efficiency requirement lines because they have one or more specified features for which they are permitted an energy allowance: these allowances are for adaptive defrost, additional doors and/or through the door icemakers. These allowances are not considered when determining star ratings.

d) The TESAW and the future Energy Star scheme

The Tower Energy Saver Award or TESAW[65] is an award system that Australian and State governments and the appliance industry have created in 2003, replacing the previous Galaxy Award system, to recognise the most energy efficient star rated products on the market. It applies to both electric and gas products that carry a star rating energy label. It is an award system that helps consumers quickly identify the most efficient products on the market. TESAW complements the mandatory labelling with an endorsement label. The TESAW label is about half the size of a normal electric energy label and is in the same colours.

Each year, the energy efficiency of all products on the market are reviewed. In consultation with industry, the Government sets energy efficiency criteria (usually the best star rating available) for TESAW awards for the coming year (each label specifies the year of the Award). From the start of the award period (November), manufacturers of existing products or new products that meet the set energy efficiency criteria will be eligible to apply for an award. Once an award is granted, the manufacturer is eligible to display the TESAW label on their products in retail stores. The award eligibility criteria for TESAW award to electric products are:

- the product must be registered and approved by the relevant regulatory authority for electric products.
- the product must be available for sale in Australia at the time of applying for the award or at some time during the calendar year of the award specified by the applicant. (Note, at the time of registration, all new energy labelling applications have to nominate an "on market" date - this date is used to trigger the appearance of the registration onto the public energy rating website, which also shows whether the product has received an award).
- the product must meet or exceed the performance requirements as set out in the performance criteria schedules. TESAW criteria for 2006 for cold appliances are presented in Table 1.26.

Table 1.26: TESAW criteria for cold appliances in 2006

Group	Description	Criteria
1	Refrigerator without a low temperature compartment, automatic defrost	≥ 6,0 stars wine storage cabinets ineligible
2	Refrigerator with or without an ice-making compartment, manual defrost	≥ 6,0 stars wine storage cabinets ineligible
3	Refrigerator with a short or long term frozen food compartment, manual defrost	≥ 4,0 stars
4	Refrigerator-freezer, fresh food compartment is automatic defrost, freezer manual defrost ("partial automatic defrost")	CEC ≤ 276 + 0,357 x Veq (kWh)
5B	Refrigerator-freezer, both compartments automatic defrost (frost free), bottom mounted freezer	CEC ≤ 276 + 0,357 x Veq (kWh)
5T	Refrigerator-freezer, both compartments automatic defrost (frost free), not side by side configuration or bottom mounted freezer (i.e. top mounted freezer)	CEC ≤ 276 + 0,357 x Veq (kWh)

65 http://www.energyrating.gov.au/tesaw-main.html.

Group	Description	Criteria
5S	Refrigerator-freezer, both compartments automatic defrost (frost free), side by side configuration	CEC ≤ 276 + 0,357 x Veq (kWh)
6C	Separate vertical freezer, manual defrost	≥ 3,5 stars
6U	Separate chest freezer, all defrost types	≥ 5,0 stars
7	Separate vertical freezer, automatic defrost (frost free)	≥ 5,0 stars

In 2005 detailed discussions and negotiations were held with the US Environmental Protection Agency and the US Department of Energy, resulted in an in-principle agreement that Australia and New Zealand could set local Energy Star criteria for products that were sold in the Australasian market (such as white goods, where the USA had their own domestic criteria), subject to detailed review by EPA and DOE on a product by product basis. This has been agreed on the basis that the energy star label would be available on products that are specifically for sale in Australia and New Zealand and would not appear on the US market. Possibly a version of the energy star that is unique to this region will be developed. On this basis, EEEC (Equipment Energy Efficiency Committee) decided to move towards the use of the Energy Star label as the primary endorsement label for appliances and equipment in Australia and to discontinue TESAW as an endorsement label.

A complete overview of the regulatory and endorsement framework in Australia and New Zealand is in preparation to facilitate further discussions. To allow a smooth transition from TESAW to Energy Star, EEEC has decided to continue the TESAW scheme for each product until suitable Energy Star criteria are finalised.

e) The policy measures for cold appliances in 2009

A discussion paper on new policy measures for refrigerators and freezers was prepared, setting out a new proposed energy labelling star rating algorithm (equation) for introduction in Australia and New Zealand standards during 2007 and also highlights the key issues for government and industry which need to be considered in the transition process to the new energy label and star ratings. The document sets out plans by the EEEC to introduce Energy Star as the primary high efficiency endorsement label for refrigerators in Australia and New Zealand. Draft eligibility criteria for the Energy Star for refrigerators and freezers are also proposed[66]. This paper documents the following issues and proposals:

- provides background on energy trends for refrigerators and freezers in Australia since labelling began in 1986
- documents the star rating equations introduced in 2000 and provides a rationale as to why these equations need to be revised and upgraded in the light of the minimum energy efficiency requirements in 2005
- lists issues that need to be considered in the development of a new star rating algorithm
- details a new star rating equation for refrigerators and freezers that is proposed for implementation in 2007
- presents a detailed discussion on the issue of adaptive defrost and whether or not a credit for this feature should be included in the star rating algorithm

[66] Refrigerator Star Rating Algorithms in Australia and New Zealand, Discussion paper prepared for the Equipment Energy Efficiency Committee (formerly known as NAEEEC) by Energy Efficient Strategies, 4 January 2006, Report No 2006/01; downloadable from http://www.energyrating.gov.au/library/details200601-rf-algorithm.html .

- provides an overview of the current endorsement labelling system (TESAW) and details the proposed transition to Energy Star as the primary endorsement system in Australia and New Zealand. Initial Energy Star criteria for refrigerators and freezers are also documented
- documents a range of labelling, implementation and transition issues that are still to be finalised prior to the introduction of the new star rating label and the transition from TESAW to Energy Star, possibly in 2007.

The discussed modification to the test methods were introduced in the new edition of AS/NZS 4474.1:2007 published in August 2007.

The new edition of AS/NZS 4474.2 is planned for publication in late 2007 to include the new MEPS and energy validity criteria as well as a new star rating algorithm for all refrigerators and freezers which is anticipated for implementation in 2009. The latest available information says that energy regulators have undertaken to analyse data on the impact of the changes of the test method introduced in AS/NZS 4474.1:2007 for a range of refrigerator types with a view to adjusting the minimum requirements levels where required for selected groups, this adjustment would be included in the new Part 2. An additional amendment to Part 2 was decided, to in effect add an energy allowance for any control system that reduces energy consumption for the purposes of the energy test. The allowance will be calculated as if the anti-sweat heater was on every hour of the day and then doubled to compensate for the refrigerator not having to overcome this heat load. This will encourage manufacturers to program the units to operate under the test conditions or accept the allowance being added to the test result if the anti-sweat heater does not operate at 32°C without door openings (as required in the standard). In addition, it is envisaged that the minimum energy efficiency requirements checking criteria used by government will be changed to make it clear that all the population of a model rather than just the mean of that population must have a lower energy test consumption than the set requirements; minimum requirement values in Part 2 will be adjusted to compensate for that tightening.

It is not at present clear if with the introduction of the new star rating labelling scheme also the Energy Star will substitute the TESAW.

1.5.3.2 Japan

Technically, Japan does not have minimum efficiency requirements. Rather, it has requirements for fleet-average energy efficiency levels for products, which manufacturers and importers must meet by a given (target) year - usually four to ten years after the target has been announced. Those companies not achieving the target, which determination is calculated on the weighted-average of their sales of different models, risk being singled out in public announcements, and possibly fined. Japan announced its first target average energy-efficiency requirements in 1979, for refrigerators, refrigerator-freezers, and household air conditioners.

In 1998 the country revised its Energy Conservation Law and in the following year issued new energy-efficiency targets for products delivered to the domestic market during the years starting 1 April 2003 (for televisions and video cassette recorders), 1 April 2004 (for refrigerators and freezers), 1 April 2005 (for fluorescent lamps, computers and computer disk drives), 1 October 2006 (for air conditioners and copying machines), and 1 April 2010 (for gasoline-fuelled passenger cars and motor trucks). These targets were set to the level of the most energy-efficient model in each product category on the market as of 1999 - hence the name “Top Runner”. In April 2003, the coverage of the programme was expanded to include stoves, gas cookers, gas or oil water systems, electric heated toilet seats, vending machines and transformers[67].

a) The Top Runner programme for cold appliances

The straight-line formulae that define the maximum permissible energy consumption as a function of equivalent volume are given in Table 27[68]. The Japanese standard JIS C9801:1999 is identical to ISO (and hence EN 153), except that it includes door openings in a controlled humidity environment. Both test procedures are conducted at 25 °C ambient temperature and both include loading of the freezer compartment with test packs. At present, the method of computing the equivalent volume is identical to that used in the EU. The differences in the Japanese standard JIS C9801 are likely to lead to a slight increase in the reported energy consumption compared to EN 153, estimated to be between 1-2% to 10% for average appliances, depending on the information source. Appliances using thermo-elements, or produced for industrial use, or absorption type are not covered by the Top Runner scheme.

Refrigerator-freezers are even more dominant in the Japanese market than in the EU, and among these no-frost models have the largest market share. Japanese efficiency requirements scheme applies much tougher levels for appliances using so-called ‘special technologies’ (VIPs and/or variable-speed compressors).

In 2010 the scheme will be revised according to already set specifications including the modification of the reference lines and the appliance classification (shown in Table 1.27 for comparison with the current criteria). In practice the same target will be applied to all natural convection appliances (without any distinction between refrigerators, refrigerator-freezers and freezers), while for the forced air circulation a new classification will be introduced based on appliance volume (below or grater that 300 litre) and number of doors (one door or two and more).

The supporting standard to measure the energy consumption will be the new edition of JIS 9801:2006 which has been modified, so that testing conditions more closely resembled actual use conditions, after the results of an extensive end-use monitoring survey on electricity demand in a group of 96 households and covering *inter-alia* 105 installed refrigerators or freezers, run starting July 2004 by JYURI (Jyukankyo Research Institute)[69]. The survey was entrusted by Central Research Institute of Electric Power Industry (CRIEPI) and was funded by Ministry of Economy, Trade and Industry (METI). The survey results on one side in the average annual energy consumption of cold appliances being 65% larger than the labelled value and on the other side in an evident improvement of 10% in the energy efficiency of refrigerators and freezers due to the Top-Runner despite an 18% increase in storage capacity (from 325 litre to 383 litre). The major differences between the actual and the standard energy consumption found in comparative tests could in fact be attributed to a control program embedded in the appliances which minimizes the operation of heaters under the standardised stable conditions (ambient temperature: 25°C, fresh food compartment: +5°C, freezer compartment: -18°C), while under real conditions the operation of heaters caused an increase in cooling load and leaded to increased electricity consumption.

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[67] Source: R. Steenblik, S. Vaughan, P. Waide, Can Energy-Efficient Electrical Appliances be considered “Environmental Goods”? OECD Trade and Environment, Working Paper No. 2006-04.

[68] Source: Developing the world’s best efficient appliances (Japan’s “Top Runner” Standard, Revised edition, October 2006, see www.eccj.or.jp/top_runner/index.html .

[69] T. Tsurusaki, Y. Iwafune, Y. Shibata, C. Murakoshi, H. Nakagami, Actual Energy Consumption of Top-Runner Refrigerators in Japan, Jyukankyo Research Institute, Inc., downloadable from: http://mail.mtprog.com/CD_Layout/Day_1_21.06.06/1400-1545/ID63_Tsurusaki_final.pdf .

Table 1.27: Japanese 'Top Runner' cold appliance energy efficiency requirements for 2004- 2009 and from 2010 onward

Categories 2004	Categories 2010	Type of appliance	Energy efficiency requirements: 2004-2009, under JIS C9801:1999[1]	Energy efficiency requirements: from 2010, under JIS C9801:2006[2]
Refrigerators				
a	A	natural convection air circulation	E = 0,427*Veq +178	E =0,844*Veq + 155
b		forced-air air circulation	E = 0,427*Veq +178	
	B	forced-air air circulation ≤ 300 litre		E = 0,774*Veq +220
	C	forced-air air circulation >300 litre, one door		E = 0,302*Veq +343
	D	forced-air air circulation >300 litre, 2 or more doors		E = 0,296*Veq +374
Refrigerator-freezers				
c	A	natural convection circulation	E = 0,433*Veq +320	E = 0,844*Veq +155
d		forced-air air circulation with special feature[3]	E = 0,507*Veq +147	
e		forced-air air circulation	E = 0,433*Veq +320	
	B	forced-air air circulation ≤ 300 litre		E = 0,774*Veq +220
	C	forced-air air circulation >300 litre, one door		E = 0,302*Veq +343
	D	forced-air air circulation >300 litre, 2 or more doors		E = 0,296*Veq +374
Freezers[4]				
a	A	natural convection air circulation	E = 0,281*Veq +353	E = 0,844*Veq +155
b		forced-air circulation	E = 0,281*Veq +353	
	B	forced-air circulation ≤ 300 litre		E = 0,774*Veq +220
	C	forced-air circulation >300 litre		E = 0,302*Veq +343

[1]JIS C9801:1999 is almost identical to ISO and EN 153 standard a part form door opening.
[2]JIS C 9801:2006 has been modified to take into consideration testing conditions more close to actual use conditions
[3]'Special features' are defined as vacuum insulated panels and/or variable-speed compressors.
[4]The Japanese efficiency requirements make no distinction between upright and chest freezers.
Veq = equivalent volume (litres). The equivalent volume is calculated:

- for refrigerators and refrigerator-freezers: by multiplying rated internal volume of freezing compartment by 2,15 for three-star type, 1,85 for two-star type, 1,55 for one-star type (these factors are increased from 2010 to respectively 2,20, 1,87, 1,54) and then by adding the result to the rated internal storage volume excluding the freezing compartment
- for freezers: by multiplying rated internal volume of freezing compartment by 2,15 for three-star type, 1,85 for two-star type, 1,55 for one-star type; these factors are increased from 2010 to respectively 2,20, 1,87, 1,54.

E = energy consumption in kWh/year
Until 2009 manufacturers/importers that manufacture/import less than 2 000 units (300 units for freezers) in total are exempted. However, the display obligations must be met regardless of the number of units shipped.

The new value of annual electricity consumption is labelled on products manufactured after 1st May 2006 and new energy efficiency requirements for refrigerators and freezers will be in place from 2010. In addition the correction factors for the frozen food storage and freezer compartments with 2 and 3 stars will be increased while for the one-star compartment will be slightly decreased.

b) The labelling schemes in Japan

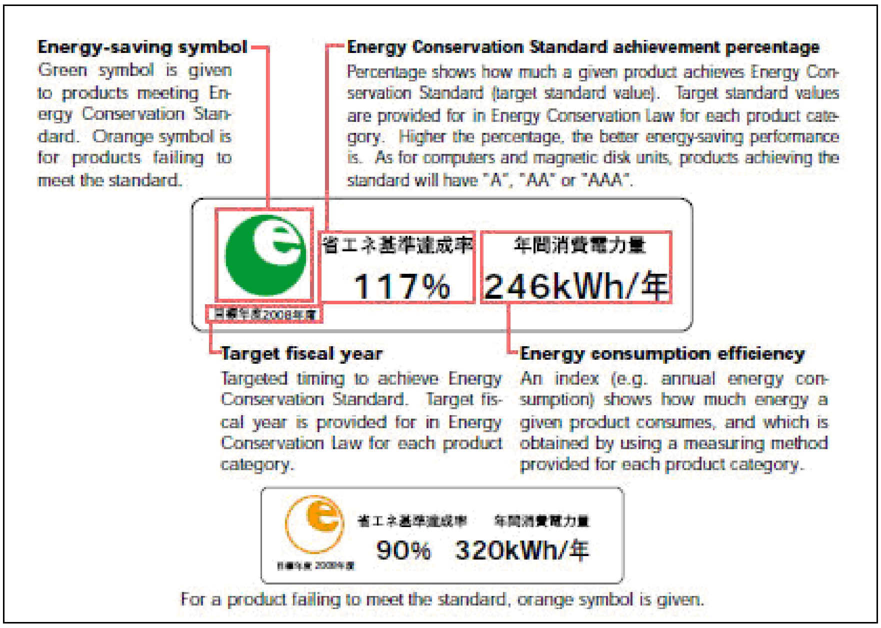
In the period 2000-2006 Japan developed three labelling systems, the "Energy-Saving Label" programme, the "Expected annual electricity bill" and the "Uniform Energy-Saving Label", often addressing the same product groups as shown in Table 1.28.

Table 1.28: Target products for the Japanese labelling schemes

Product	Energy-Saving Labeling Program	Expected annual electricity bill	Uniform Energy-Saving Label
Air conditioners	●	●	●
Electric refrigerators	●	●	●
Electric freezers	●	●	
Fluorescent lights	●	●	
Electric toilet seats	●	●	
TV sets	●	●	●
Computers	●		
Magnetic disk units	●		
Space heaters	●		
Gas cooking appliances	●	●(Fuel usage)	
Gas water heaters	●	●(Fuel usage)	
Oil water heaters	●	●(Fuel usage)	
Transformers	●		
Electric rice cookers	Due to be applied	●	
Microwave ovens	Due to be applied	●	
VCRs		●	
DVD recorders	Due to be applied	●	

The Energy-Saving Label scheme: Japan started developing its own "Energy Conservation Labelling Program" energy labelling system in August 2000. It is a **voluntary programme** using JIS standards as test methods and a label to indicate the compliance with the set criteria. This label is generally shown in product catalogues but not necessarily on actual products. During the initial phase, the program targeted five product categories: air conditioners, fluorescent lights, TV sets, electric refrigerators and electric freezers, but in 2003, five additional products were added (space heaters, gas cooking appliances, gas water heaters, oil water heaters, and electric toilet seats), additional products (computers, magnetic disk units and transformers) followed later. In January 2005, the labelling program covered 13 products. The information shown on the label (Figure 1.11) are the Top Runner target year, achievement rate relative to Top Runner target and annual energy consumption. The Minister of Economy, Trade and Industry sets the criteria to evaluate each product.

Figure 1.11: Energy-Saving Label in Japan



The Uniform Energy-Saving Label for retailer: efficient machinery and equipment had so far been promoted with the labelling program. However, taking into consideration the importance of retailers' role as an interface to consumers, obligation of retailers to make efforts for information provision was included in the revised Law Concerning the Rational Use of Energy that went into effect in April 2006. Under this new scheme retailers provide information of products displayed at their shops through the use of an "Uniform Energy-Saving Label" which presents multistage rating, expected electricity bill and other information. The multistage rating uses 5-star-mark to represent a relative position of a given product in the market with respect to energy-saving performance. Since October 2006, "Uniform Energy-Saving Label" (Figure 1.12) has been applied to air conditioners, refrigerators and TV sets. The information already included in the Energy-Saving Label and the expected annual electricity bill are required to be displayed on the product body or nearby.

Figure 1.12: The Uniform Energy-Saving Label in Japan

Expected annual electricity bill: is the expected annual energy consumption or the annual fuel usage for gas oil equipment.

1.5.3.3 USA (and Canada)

The US has both mandatory and voluntary policy measures for household appliances.

During the mid-1970s, several individual states in the United States had begun promulgating their own energy efficiency requirements. With the passage of the National Energy Policy and Conservation Act of 1978, Federal law in this area was given precedence over state laws - unless the Federal government determines that no efficiency requirements are warranted for a particular product, in which case states are then free to establish local requirements. The National Appliance Energy Conservation Act (NAECA) was signed into law in 1987 giving the US Department of Energy (DoE) the power to set federal standards for maximum energy consumption on household appliances. DoE currently imposes minimum efficiency requirements for 25 products including 15 used in the residential sector and manages the two US labelling schemes, the Energy Guide and the ENERGY STAR.

Since 2004, ten states (Arizona, California, Connecticut, Massachusetts, Maryland, New Jersey, New York, Oregon, Rhode Island, and Washington) have established new energy-saving requirements covering between 5 and 30 products, most through new state legislation. In August 2005, Congress took its cue from the states and made 15 of these state standards federal law through the "Energy Policy Act" of 2005. The new law includes two major energy efficiency provisions: it sets (1) manufacturer and consumer tax incentives for advanced energy-savings technologies and practices and (2) minimum energy efficiency requirements for 16 products, including household appliances and directs DoE to set requirements for several other products. The law also sets other provisions including the revision of the long lasting appliances labelling scheme.

Canada and Mexico adopted efficiency requirements identical or very similar to those set by the US DoE.

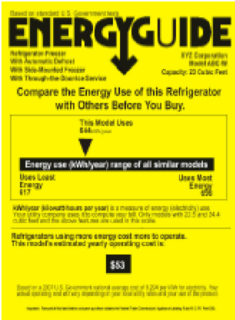
a) US Energy efficiency labelling programmes

The US has two primary federally funded labelling programmes for consumer products and appliances: "Energy Guide" and "ENERGY STAR". A comparison of the two schemes is presented in Table 1.29[70]

In 1994, the FTC revised the label so that energy use or efficiency (as opposed to operating cost) appears as the primary descriptor on the label.9 The revised labels continued to display cost information (for most products), but the cost figures were moved to the bottom half of the label. As part of the 1994 review of the Rule, the Commission conducted consumer research and made certain format changes to the Energy Guide label as a result. These changes enhanced the appearance of the range and bar graph on the label in an effort to reduce consumer confusion. In 2000, the Commission issued an exemption allowing manufacturers to include the ''Energy Star'' logo on the Energy Guide label for covered appliances.

[70] Source: Ecos Consulting,, Policy Recommendations for Improving Energy-Efficiency Labeling in the United States, Report prepared for: National Commission on Energy Policy, October 2004.

Table 1.29: comparison of the Energy Guide and the Energy Star labelling schemes

	EnergyGuide	ENERGY STAR
Logo/Label		
Program type	Mandatory	Voluntary
Label type	Comparison (Continuous) – label compares the energy use of a given model to other similar models by providing a range (with a low-end and a high-end) of energy use of similar models	Endorsement – label indicates that product meets certain levels of performance.
Year Started	1980	1992
Responsible federal agency	FTC (labeling) and DOE (testing)	EPA and DOE[5]
Underlying legislation	Energy Policy and Conservation Act, 1975; National Energy Conservation Policy Act, 1979; FTC Appliance Labeling Rule, 1980	Voluntary government/industry partnership
Products covered	▪ Refrigerators ▪ Freezers ▪ Dishwashers ▪ Clothes washers ▪ Room air conditioners ▪ Water heaters ▪ Furnaces ▪ Boilers ▪ Central air conditions ▪ Heat pumps ▪ Pool heaters *Other products (e.g., lighting) are required to display energy-efficiency information directly on their product labels/packaging.	Products in more than 40 categories: ▪ Appliances (Clothes Washers, Dehumidifiers, Dishwashers, Refrigerators, Room Air Conditioners) ▪ Heating & Cooling (Air-source Heat Pumps, Boilers, Central AC, Ceiling Fans, Dehumidifiers, Furnaces, Geothermal Heat Pumps, Home Sealing (Insulation), Light Commercial, Programmable Thermostats, Room AC, Ventilating Fans) ▪ Home Electronics (Cordless Phones, Combination Units, DVD Products, Home Audio, Set-top Boxes, Televisions, VCRs) ▪ Lighting (Compact Fluorescent Lamps, Residential Light Fixtures, Ceiling Fans, Exit Signs, Traffic Signals) ▪ Office Equipment (Computers, Printers, Copiers, Faxes, Mailing Machines)

Note: the Energy Star logo has been modified in 2005.

No systematic federal evaluation of the Energy Guide program or the efficacy of the current label design has been undertaken in the last 20 years. Small-scale studies and anecdotal evidence, as well as better results in other countries (in terms of consumer awareness, market impacts, and energy savings) suggest that improvements could be made to the Energy Guide program. Two recommendations for the revision of the Energy Guide were made in 2004[71]:

– revise the current Energy Guide label format to increase clarity and usefulness, employing the categorical rankings that have been proven so effective internationally
– extend the Energy Guide label's coverage to a wider range of products.

[71] Source: Ecos Consulting,, Policy Recommendations for Improving Energy-Efficiency Labeling in the United States, Report prepared for: National Commission on Energy Policy, October 2004.

The mentioned Energy Policy Act of 2005 directs FTC to review the effectiveness of its current Energy Guide label in assisting consumers in making purchasing decisions and improving energy efficiency and to make appropriate changes to the labelling rules (including categorical labelling) that would improve the effectiveness of consumer product labels. Currently FTC is preparing to conduct consumer research, the results of which will be used to propose amendments to the Energy Guide label. The regulatory review of the "Appliance Labeling Rule" had been scheduled for 2008.[72]

The Energy Guide label on **cold appliances** indicate how much electricity in kilowatt-hours (kWh) a particular model uses in one year plus a comparative range for the different product types. The program covers refrigerators or refrigerators-freezers with a cabinet designed for the refrigerated storage of food at temperatures above 0°C (32 °F), and having a source of refrigeration requiring single phase, AC electric energy input only. An electric refrigerator may include a compartment for the freezing and storage of food at temperatures below 0°C, but does not provide a separate low temperature compartment designed for the freezing and storage of food at temperatures below -13,3°C (8°F). An "all-refrigerator" may include a compartment ≤ 14,2 litre (0,50 cu. ft.) capacity for the freezing and storage of ice.

End January 2006 the new ranges for refrigerators, refrigerator-freezers, and freezers were published on the Federal Register[73]. As consequence, after May 1, 2006, manufacturers of these products calculated the operating cost figures at the bottom of labels for the products using the 2005 cost for electricity (9,06 USD cents per kilowatt-hour).

a.2) The ENERGY STAR

Energy Star, introduced in 1992, is a voluntary labelling program operated jointly by the Environmental Protection Agency (EPA) and Department of Energy (DOE). It is designed to reduce greenhouse gas emissions by identifying and promoting energy-efficient products. The program functions as a voluntary partnership between government and various businesses, including manufacturers and various trade allies like retailers, installers, utilities, and energy service companies. The programme logo has been updated in 2005 (Figure 1.13). Labelled products receive preferential treatment in federal and state procurement processes and in various utility-funded incentive and marketing programs.

Figure 1.13: New US Energy Star logo

[72] See: Federal Register / Vol. 70, No. 211 / Wednesday, November 2, 2005 / Proposed Rules.
[73] See: Federal Register / Vol. 71, No. 20 / Tuesday, January 31, 2006 / Rules and Regulations.

The Energy Star criteria for residential refrigerators and freezers are based on the federal NAECA appliance requirements. On 1st January 2003, the criteria for cold appliances (Table 1.30) expanded to include all sizes and configurations of refrigerators and freezers:

- all refrigerators and freezers 220 litre (7,75 cu. ft.) or greater in volume must be at least 10% above the minimum federal standard to qualify for Energy Star;
- all refrigerators and freezers less than 220 litre (7,75 cu. ft.) in volume and 91,4 cm (36 inches) or less in height had to be at least 20% above the minimum federal requirements to qualify for Energy Star.

This expansion allowed the qualification of the previously ineligible products in the following categories: chest freezers, upright freezers, manual defrost freezers and refrigerators, partial automatic defrost refrigerators, single door refrigerators, and compact refrigerators and/or freezers. On 1st January 2004, the criteria for refrigerators changed to require all full-size models to be at least 15% above the minimum federal requirements to qualify for Energy Star. The criteria for full-sized freezers and compact refrigerators and freezers did not change at this time. New criteria, effective from 29th April 2008, were finalised in August 2007[74] (Table 1.30): all refrigerators and refrigerator-freezers with 220 litre (7,75 cu. ft.) or greater volume must be 20% more efficient than required by the minimum federal requirements; the criteria for freezers and for full-sized freezers and compact refrigerators and freezers did not change.

The Energy Star criteria do not apply to commercial models or refrigerators and refrigerator-freezers with total refrigerated volume exceeding 1 104 litre (39 cubic feet) or freezers with total refrigerated volume exceeding 850 litre (30 cubic feet). The models energy consumption is self-declared by the manufacturers according to DoE's standard defined in 10 CFR 430, Subpart B, Appendix A1 for refrigerators and in 10 CFR 430, Subpart B, Appendix B1 for freezers.

Residential refrigerator manufacturers must self-test their equipment according to DoE's test procedure defined in 10 CFR 430, Subpart B, Appendix A1. Residential freezer manufacturers must self-test their equipment according to DoE's test procedure defined in 10 CFR 430, Subpart B, Appendix B1. But, when determining energy performance for purposes of Energy Star certification, the following principles of interpretation should be applied to the existing DoE test procedures:

- the energy test procedure simulates typical room conditions (approximately 21°C or 70ºF) with door openings, by testing at 32,3°C (90°F) without door openings;
- except for operating characteristics that are affected by ambient temperature (for example, compressor percent run time), the unit, when tested under the DoE test procedure, shall operate equivalent to the unit in typical room conditions;
- energy consuming components that operate in typical room conditions (including as a result of door openings, or in response to humidity levels), and that are not exempted by this standard, shall operate in an equivalent manner during energy testing under the DoE test procedure, or be accounted for by all calculations as provided for in the standard;
- examples:
    - (i) energy saving features that are designed to operate when there are no door openings for long periods of time shall not be functional during the energy test;
    - (ii) the defrost heater should not either function or turn off differently during the energy test than it would when in typical room conditions;
    - (ii) electric heaters that would normally operate at typical room conditions with door openings should also operate during the energy test;

[74] See: ENERGY STAR Program Requirements for Residential Refrigerators and/or Freezers, Partner Commitments, Final Version, 03 August.2007, downloadable at: http://www.energystar.org

- (iv) energy used during adaptive defrost shall continue to be tested and adjusted per the calculation provided for in this standard.

A manufacturer has one year after signing the Partnership Agreement to ensure that the Energy Star label appears directly on at least one Energy Star qualified refrigerator and/or freezer model.

Table 1.30: US Energy Star criteria for cold appliances in 2003, from 1st January 2004 and from 29th April 2008

Category no.	Category description	Energy use in 2008 (kWh/year)	Energy Star criteria 2003	Energy Star criteria 2004	Energy Star criteria 2008
1	Refrigerators and refrigerator-freezers with manual defrost	≤ 0,249 × Veq* + 198,72	10% less than the federal maximum energy consumption	15% less than the federal maximum energy consumption	20% less than the federal maximum energy consumption
2	Refrigerator-freezer – partial automatic defrost				
3	Refrigerator-freezers – automatic defrost with top-mounted freezer without through-the-door ice service	≤ 0,277 × Veq + 220,80			
4	Refrigerator-freezers – automatic defrost with side-mounted freezer without through-the-door ice service	≤ 0,138 × Veq + 406,00			
5	Refrigerator-freezers – automatic defrost with bottom-mounted freezer without through-the-door ice service	≤ 0,130 × Veq + 367,20			
6	Refrigerator-freezers – automatic defrost with top-mounted freezer with through-the-door ice service	≤ 0,288 × Veq + 284,80			
7	Refrigerator-freezers – automatic defrost with side-mounted freezer with through-the-door ice service	≤ 0,286× Veq + 324,80			
8	Upright freezers with manual defrost	≤ 0,240 × Veq + 232,47		10% less than the federal max. energy consumption	
9	Upright freezers with automatic defrost	≤ 0,395 × Veq + 293,49			
10	Chest freezers and all other freezers except compact freezers	≤ 0,314 × Veq + 129,33			
11	Compact refrigerators and refrigerator-freezers with manual defrost	≤ 0,302 × Veq + 239,20	20% less than the federal maximum energy consumption		
12	Compact refrigerator-freezer – partial automatic defrost	≤ 0,198 × Veq + 318,40			
13	Compact refrigerator-freezers – automatic defrost with top-mounted freezer and compact refrigerators – automatic defrost	≤ 0,358 × Veq + 284,00			
14	Compact refrigerator-freezers – automatic defrost with side-mounted freezer	≤ 0,214 × Veq + 400,80			
15	Compact refrigerator-freezers – automatic defrost with bottom-mounted freezer	≤ 0,370 × Veq + 293,60			
16	Compact upright freezers with manual defrost	≤ 0,276 × Veq + 200,64			
17	Compact upright freezers with automatic defrost	≤ 0,322 × Veq + 312,80			
18	Compact chest freezers	≤ 0,295 × Veq + 121,60			

*Veq = (adjusted) equivalent volume (in litres) and is given by:
- Refrigerators equivalent volume = Fresh Volume + (1,63 x Freezer Volume)
- Freezers equivalent volume = 1,73 x Freezer Volume

b) The energy efficiency requirements

From 1 July 2001 the USA (and Canada) applied the minimum energy efficiency requirements, replacing those in place since 1993, described in Table 1.31 for 18 cold appliance categories.

Table 1.31: US (and Canada) cold appliance energy efficiency requirements entering into force from 1 July 2001

Category no.	Category description	Requirements[1] (kWh/year)	
		Gradient	Intercept
1	Refrigerators and refrigerator-freezers with manual defrost	0,311	248,4
2	Refrigerator-freezer – partial automatic defrost	0,311	248,4
3	Refrigerator-freezers – automatic defrost with top-mounted freezer without through-the-door ice service	0,346	276,0
4	Refrigerator-freezers – automatic defrost with side-mounted freezer without through-the-door ice service	0,173	507,5
5	Refrigerator-freezers – automatic defrost with bottom-mounted freezer without through-the-door ice service	0,162	459,0
6	Refrigerator-freezers – automatic defrost with top-mounted freezer with through-the-door ice service	0,360	356,0
7	Refrigerator-freezers – automatic defrost with side-mounted freezer with through-the-door ice service	0,357	406,0
8 (a)	Upright freezers with manual defrost	0,267	258,3
9 (a)	Upright freezers with automatic defrost	0,439	326,1
10 (a)	Chest freezers and all other freezers except compact freezers	0,349	143,7
11 (b)	Compact refrigerators and refrigerator-freezers with manual defrost	0,378	299,0
12 (b)	Compact refrigerator-freezer – partial automatic defrost	0,247	398,0
13 (b)	Compact refrigerator-freezers – automatic defrost with top-mounted freezer and compact refrigerators – automatic defrost	0,448	355,0
14 (b)	Compact refrigerator-freezers – automatic defrost with side-mounted freezer	0,268	501,0
15 (b)	Compact refrigerator-freezers – automatic defrost with bottom-mounted freezer	0,463	367,0
16 (b)	Compact upright freezers with manual defrost	0,345	250,8
17 (b)	Compact upright freezers with automatic defrost	0,403	391,0
18 (b)	Compact chest freezers	0,369	152,0

Note: for Canada, US categories 8-10 (a) are covered under freezers categories 16-18; and (b) compact products in US categories 11-15 are not separately defined.

A different cold appliance product categorisation to that applied in the EU is used, where distinctions between cold appliance types are made according to:

- the method of defrosting, be it automatic (not specifically no-frost), partially automatic or manual
- the position of the freezer in a refrigerator-freezer, be it top-mounted, side-mounted or bottom-mounted
- the presence or absence of a through-the-door ice service for refrigerator-freezers

- the size of the appliance, where "compact" appliances are defined as those of less than 220 litre (7,75 cu. ft.) volume and less than 91,4 cm (36 inches) height

The efficiency requirements do not apply to refrigerators and refrigerator-freezers with total refrigerated volume exceeding 1 104 litre (39 cubic feet) or freezers with total refrigerated volume exceeding 850 litre (30 cubic feet).

The requirement levels are expressed in terms of straight-line formulae that define the maximum permissible energy consumption as a function of (adjusted) equivalent volume. The maximum permissible energy consumption, E_{max}, is defined by the straight-line equation:

$$E_{\max} = V_{eq} \times gradient + \text{intercept} \qquad \text{(eq. 9)}$$

where *Veq* is the (adjusted) equivalent volume given by:

$$V_{eq} = \sum_{c=1}^{c=n} V_c \times K_c \qquad \text{(eq.10)}$$

as summed over all "*n*" compartment of the appliance, where:

V_c = the gross volume of a given type of compartment in the appliance
K_c = the temperature weighting coefficient for that type of compartment or:

- 1,0 for a refrigerator without a freezing compartment
- 1,44 for the freezer compartment in a single-door refrigerator
- 1,63 for the freezer compartment in a refrigerator-freezer
- 1,73 for freezers

and is equal to $(32{,}22-T_c)/32{,}22$, where T_c is the compartment design temperature in °C.

Energy and volume are measured according to the US Department of Energy Code of Federal Regulations (CFR Part 430 Subpart B Appendices A1 and B1, which draws in parts of the AHAM HRF-1-1979 test procedure). Under the US standard cold appliances are tested at an ambient temperature of 32,22 °C, and the internal compartment design temperatures also differ from those defined in ISO/EN 153. A freezer compartment should operate at –17,8 °C (0 °F) for a chest or upright freezer but at –15 °C (5 °F) for a refrigerator-freezer. A fresh-food compartment in a pure refrigerator should be tested at 3,3 °C (38 °F).

In Canada, the test method is CAN/CSA-C300-00. It is essentially harmonized with US standard CFR Part 430. The measurements are carried out at an ambient temperature is 32,3°C (90°F) with the doors closed and with the following target internal temperatures: 3,3°C (38°F) in the fresh food compartment of a refrigerator; ≤ 7,22°C (45°F) in the fresh food compartment of a refrigerator-freezer; -9,4°C (15°F) in the freezer compartment for a refrigerator (category 1); -15,0°C (5°F) in the freezer compartment for a refrigerator-freezer (categories 2 to 7); -17,8°C (0°F) for a separate freezer.

The energy consumption of the U.S. refrigerators significantly reduced since the early 1970s to the latest federal minimum efficiency requirements, from 1.825 kWh/year in 1973 to 476 kWh/year. During this time, the average real price has fallen by more than 50%, from more than USD 1,200 to less than USD 500 and at the same time, the average refrigerator (adjusted) equivalent volume has remained almost stable around 566 litre (20 cu.ft) after an initial raise from 510 (18 cu.ft) between 1973 and 1978, only in 2001 another increase to 623 litres (22 cu.ft) took place.

A new round of minimum energy efficiency requirements for cold appliances is forecast for 1st January 2010 by the Energy Policy Act of 2005, where the new thresholds will be those set in the CEC (California Energy Commission), almost identical to the 2004 Energy Star criteria (energy consumption about 15% less than the 2001 federal limits).

c) The tax incentives for manufacturers

The Energy Policy Act of 2005 offers incentives that promote the use of more efficient appliances. This legislation is expected to increase the market penetration of products meeting and exceeding the act's Energy Star criteria. The new legislation provides credits to the manufacturer for very efficient refrigerators, washing machines and dishwashers. The incentives are for products sold in 2006 and 2007, relative to *additional* sales by each manufacturer above the average of the previous three years (Table 1.32). This type of policy has the distinct advantage of minimizing the problem of free riders that would have purchased the new model in any case; and thus is more effective than such policies as rebate or reduction in value added taxes, which allow and pay for free riders.

For cold appliances there are three efficiency tiers, which are based on the 2001 federal minimum efficiency requirement levels:

1. 75 USD credit for each unit using 15-19,9% less energy than the 2001 minimum
2. 125 USD credit for each unit using 20-24,9% less energy
3. 175 USD credit for each unit using 25% or more less energy.

In addition, the first 15% incentive only applies to units sold in 2006, and baseline sales are multiplied by 110% before determining the number of units that earn an incentive. All the appliance credits only apply to products produced in the USA, which could affect the foreign production plans of US manufacturers and also means that imported products are not eligible. There is also a total cap per manufacturer of 75 million USD, a figure some larger manufacturers may reach but the smaller manufacturers will not.

With the federal tax credits, it is likely that manufacturers will reduce the prices of complying refrigerators. In addition, since incentives end in 2007, local programmes should consider not only promote eligible products to consumers but also to consider incentives in 2008 and beyond for cold appliances that save 25% or more. Product availability and sales at this level could influence the level of the new federal efficiency requirements level to be prepared by DoE by 2010.

d) The 2006 Appliance Efficiency Regulations for California

The 2006 Appliance Efficiency Regulations, (California Code of Regulations, Title 20, Sections 1601 through 1608) dated December 2006, were adopted by the California Energy Commission on Oct 11, 2006, and approved by the California Office of Administrative Law on Dec 14, 2006.

The Appliance Efficiency Regulations replace all previous versions of the regulations[75] and include standards for both federally regulated appliances and non-federally-regulated appliances. Twenty-one categories of appliances are included in the scope of these regulations, including freezers with total refrigerated volume between 850 litre (30 ft^3) and 1 104 litre (39 ft^3), wine chillers that are consumer products and a series of commercial products. For the other household cold appliances the federal requirements apply.

[75]Downloadable at: http://www.energy.ca.gov/appliances/2006regulations/index.html .

Table 1.32: Summary of the Energy Efficiency Tax incentives in Energy Policy Act of 2005 (source ACEEE)

Summary of Energy Efficiency Tax Incentives in Energy Policy Act of 2005

Product	Eligibility Level	Units	Amount of Incentive	Years Covered	Notes
Existing homes and other non-business applications					$500 per taxpayer cap for existing home credits
Central air conditioners (split systems)	15	SEER	$300 if meets SEER & EER	2006 & 2007	For list of qualified products, go to the Consortium for Energy
	12.5	EER			Efficiency Product Directory-
Central air conditioners (package systems)	14	SEER	$300 if meets SEER & EER	2006 & 2007	www.ceehvacdirectory.org/continue.html
	12	EER			Look for "Residential Tier 2" Air Conditioners
Heat Pumps (air cooled)	15	SEER	$300 if meets SEER, EER & HSPF	2006 & 2007	See CEE list (link noted above) for products that meet 15 SEER
	13	EER			and 9 HSPF. There is no way to identify equipment that meets 13
	9.0	HSPF			EER without contacting manufacturer/distributor (or contractor).
Group-source heat pumps					All Energy Star labeled Geothermal Heat Pumps qualify for credit
Closed loop	14.1/3.3	EER/COP	$300	2006 & 2007	System must also provide water heating.
Open loop	16.2/3.6	EER/COP	$300	2006 & 2007	System must also provide water heating.
Direct expansion (DX)	15/3.5	EER/COP	$300	2006 & 2007	System must also provide water heating.
Water heaters (non-business applications)					See GAMA Web site for list of qualifying products:
Electric	2.0	EF	$300	2006 & 2007	www.gamanet.org/gama/inforesources.nsf/vContentEntries/Produ
Gas and oil	0.8	EF	$300		ct+Directories?OpenDocument
Gas and oil furnaces and boilers					See GAMA Web site (link above) for list of qualifying products.
High combustion efficiency equipment	95%	AFUE	$150	2006 & 2007	Can earn either one or both incentive with the same unit.
High electric efficiency equipment	Meets CEE spec		$50	2006 & 2007	CEE spec requires electricity use to be <=2% of site use.
Envelope improvements to existing homes					
Insulation, exterior doors, duct sealing and infiltration reduction	Meet 2000/2003 IECC + supplements		10% up to $500	2006 & 2007	Includes duct sealing and infiltration reduction. All Energy Star windows and doors qualify for credits.
Windows and skylights	Same as above		10% up to $200	2006 & 2007	Credits cover cost of components only, and do not include
Pigmented metal roofs	Meet Energy Star spec		10% up to $500	2006 & 2007	costs of onsite prep, assembly or installation.
Appliances					All appliance incentives go to manufacturer, not consumer;
Refrigerators					manufacturers are expected to reduce prices accordingly.
Save 15-19.9% relative to federal standard	Look to left		$75	2006	
Save 20-24.9% relative to federal standard	Look to left		$125	2006 & 2007	
Save 25% or more relative to federal standard	Look to left		$175	2006 & 2007	
Clothes washers	1.72 MEF, 8.0 WF		$100	2006 & 2007	This is the 2007 Energy Star specification.
Dishwashers	2007 Energy Star		TBD -- based on final Energy Star	2006 & 2007	Incentive likely to be around $30.

Table 1.32: Summary of the Energy Efficiency Tax incentives in Energy Policy Act of 2005 (continued)

Summary of Energy Efficiency Tax Incentives in Energy Policy Act of 2005

Product	Eligibility Level	Units	Amount of Incentive	Years Covered	Notes
New homes					Incentives go to the builder, not the homebuyer.
Site-built or manufactured homes	50%	savings	$2,000	2006 & 2007	Savings relative to 2004 IECC.
Manufactured homes	30%	savings	$1,000	2006 & 2007	Savings relative to 2004 IECC.
	or meets Energy Star			2006 & 2007	
Commercial buildings					Max. is $0.60/sq.ft. per system or $1.80/sq.ft. for whole bldg.
Whole building	50%	savings	Deduction of $1.80/sq.ft.	2006 & 2007	Savings relative to ASHRAE 90.1-2001.
Lighting, HVAC or envelope	50%	savings	Deduction of $0.60/sq.ft. per system	2006 & 2007	Savings relative to ASHRAE 90.1-2001.
Lighting savings of at least 25%	25-50%	savings	Sliding scale: $.30/sq.ft. for 25% svgs	Unclear	Term of this provision depends on Treasury rulemaking.
Fuel cells and microturbines					
Fuel cells (business or individual credit)	30%	efficiency	30% up to $1000/kW	2006 & 2007	Systems >=0.5 kW for business credit. No size floor or efficiency requirements for individual credit.
Microturbines (only business credit)	26%	efficiency	10% up to $200/kW	2006 & 2007	Systems < 2000 kW.
Passenger vehicles	Complicated formula -- see http://aceee.org/press/0508hybridtaxcr.htm				
Heavy-duty vehicles	Complicated formula -- a description of the credit will be put on www.aceee.org shortly.				

Key: AC= air conditioner; AFUE= annual fuel utilization efficiency; ASHRAE = American Society of Heating, Refrigerating & Air-Conditioning Engineers; CEE = Consortium for Energy Efficiency
COP= coefficient of performance; EER= energy efficiency ratio; EF= energy factor; HP= heat pump; HSPF= heating season performance factor; IECC= International Energy Conservation Code
kW= kilowatt; MEF= modified energy factor; SEER= seasonal energy efficiency ratio; WF= water factor.

The standard for the measurement of the energy consumption of wine chillers is a modification of the same standard already used for refrigerators, refrigerator-freezers and freezers, with a nominal temperature of 12,8°C. The efficiency requirements for freezers with volume exceeding 850 litre (30 ft^3) and wine chillers designed and sold for household use, in force from 1st March 2003 are presented in Table 1.33.

Table 1.33. Californian cold appliance energy efficiency requirements entering into force from 1 March 2003

Category no.	Category description	Requirements[1] (kWh/year)	
		Gradient	Intercept
1	Wine chillers with manual defrost	13,7	267
2	Wine chillers with automatic defrost	17,4	344
3	Upright freezers with manual defrost	7,55	258,3
4	Upright freezers with automatic defrost	12,43	326,1
5	Chest freezers	9,88	143,7

[1] Volume is in ft^3

The requirement levels are expressed in terms of straight-line formulae that define the maximum permissible energy consumption as a function of (adjusted) equivalent volume. The maximum permissible energy consumption, E_{max}, is defined by the previous straight-line eq. 9. For wine coolers the volume in eq. 9 is the appliance volume, while for freezer is the equivalent volume, calculated according to eq. 10 with a factor 1,73.

1.5.3.4 India

In 2002, the Indian government passed a landmark Energy Conservation Bill creating the Bureau of Energy Efficiency (BEE), a department of the Ministry of Power (MOP), and directing it to collaborate with the Bureau of Indian Standards (BIS) in energy efficiency requirements and labelling development. The BEE-MOP has developed a scheme for energy efficiency labelling of equipment[76]. This scheme will come into force from the date of its announcement in the media and the Bureau of Energy Efficiency's web site (www.bee-india.nic.in) and on www.energymanagertraining.com and will remain in force until a notification is issued by the Central Government. The scheme has been developed in collaboration with all the stakeholders, and aims at providing information on energy performance so that consumers can make informed decisions while purchasing appliances.

Participation in the scheme is voluntary and currently applicable for Frost-Free (No-Frost) Refrigerators and Tubular Fluorescent Lamps. The labelling of other equipment and appliances would be introduced in a phased manner. A committee will be set up by the Bureau to oversee implementation of the scheme. The committee will be chaired by Director General, Bureau of Energy Efficiency and consisting of representatives from Ministry of Power, Bureau of Indian Standards, Consumer Associations, Manufacturers Association, and Test laboratories.
The test procedures, schedule of tests, rating plan, sampling plan, qualification requirements, label design, label fee and the manner of display of label have been specified for each equipment.

Manufacturers of equipment, importers and persons-in-trade (users of the label) can participate in the scheme by registering with the Bureau (and paying 100 Rs). A separate application will be made by the user of label for labelling of each equipment/model, accompanied by non-refundable

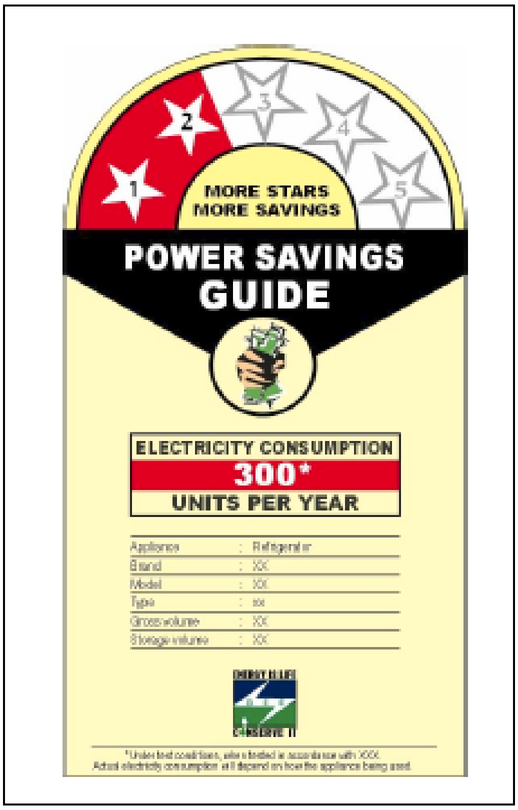
[76]Source: Bureau of Energy Efficiency Ministry of Power, Govt. of India, "Energy Efficiency Labels, Details of Scheme for Energy Efficiency Labeling, May 2006, downloadable from:
http://www.bee-india.nic.in/sidelinks/Announcement/Label-launch/National_Energy_Labeling_Programme_2006.pdf

registration charges of 1.000 Rupees. A labelling fee (Rs 10/refrigerator and Rs. 0,05/tubular fluorescent lamp) will be given by the manufacturer in advance to the Bureau of Energy Efficiency for the displaying of the label on each refrigerator units. The agreement will be valid for a period of 3 years or until notification. In case the application is renewed e a fee of 500 Rupees will be paid.

The user of label will print and affix the labels for the particular equipment and will maintain the list of labelled equipment and provide a statement of labelled equipment, their star rating level and the number of such labelled equipment produced, with serial numbers, wherever applicable, every six months. A list of labelled equipment (and information on the label) will be maintained by the Bureau and made available to the public through publications and its web site. The user is solely responsible for ensuring the accuracy of the information displayed on the label or any public claim for label level and quality of equipment and to use the label only for such equipment/models for which the agreement has been entered with the Bureau.

The Bureau would prepare a poster/brochure informing the consumers as to how to read/interpret the label and select equipment for purchase. The user of the label would distribute a copy of the poster/brochure along with their technical brochure to the buyer and would also display the poster/brochure at the point of purchase. The Bureau will appoint an independent agency to evaluate the program impact and process of implementation on a periodic basis. The scope of evaluation will include the impact on sales, energy consumption, cost, consumer purchasing behaviour, manufacturing, national energy use and the environment. The scheme will be reviewed periodically to determine the need for revision or amendment or termination of the scheme. An example of a printed energy label for a refrigerating appliances is shown in Figure 1.14.

Figure 1.14: An example of the Indian energy label for a refrigerating appliances



The label will mention the following information:

1. Appliance: Refrigerator
2. Energy Consumption per year (CEC)
3. Model Name/Number, Year of Manufacturing
4. Brand
5. Type
6. Gross Volume
7. Storage Volume

The equations and procedures for calculating values of Projected Annual Energy Consumption (PAEC) & Comparative Energy Consumption (CEC) and the Star Rating which appear on the energy label are:

- the CEC is the nominal energy consumption of a model of refrigerating appliance, based on its PAECav; for determining the CEC of a model, three separate units must be tested for energy consumption. The number of tests per unit should be sufficient to enable a valid Et to be determined for that unit;

- PAEC = Et x (365/1000) (in kWh/year), where:

  Et = tested energy consumption, in Wh per 24 hours, rounded to the nearest whole number. After testing three or more separate units, the separate values of PAEC (the estimated energy used by a single unit during one year, calculated from Tested Energy Consumption Et) shall be averaged and referred to as $PAEC_{av}$. The CEC for a model must not be less than the $PAEC_{av}$ for the three (or more) units that are tested;.

- the Star Rating Bands for a particular model is:

$SRB_{nf} = k_{nf} \times V_{adj\_tot\_nf} + c_{nf}$, where:

k_{nf} = Constant Multiplier (kWh/litre/lear)
$V_{adj\_tot\_nf}$ = Total Adjusted Storage Volume for No Frost (litre)
c_{nf} = Constant Fixed Allowance (kWh/year);

Vadj_tot_nf = Fresh Food Storage Volume + 1,62 x Freezer Storage Volume, where:

1,62 = (Test room Temperature – Freezer Temperature)/(Test room Temperature – Fresh Food Temperature) and:

- Fresh Food Chamber Target Temperature = +3 °C
- Freezer Chamber Target Temperature = -15 °C.

Unless otherwise stated, number shall be rounded and recorded to five significant figures. The values of PAEC, $PAEC_{av}$, CEC, and Star Rating Band shall be rounded of (< 0,5 to lower whole number and ≥ 0,5 to higher whole number) to the nearest whole number.

Star Rating: the number of stars displayed on the energy label. The available stars are between a minimum of 1 and a maximum of 5, with one star interval. The star rating is calculated from the Star Rating Band as presented in Table 1.34.

The CEC of the model is compared with the various Star Rating Bands and the star rating chosen for the model will be based on the above comparison:

Lower Limit of SRB < CEC ≤ Upper Limit of SRB.

Table 1.34: Coefficients for the calculation of the Star Rating Band in India for the period 2006-2014

Star Rating Band	from 1 June 2006 to 31 December 2008		from 1 January 2009 to 31 December 2011		from 1 January 2012 to 31 December 2014	
	k_{nf}	c_{nf}	k_{nf}	c_{nf}	k_{nf}	c_{nf}
1 star	0,8716	759	0,5578	486	0,4463	389
2 stars	0,6973	607	0,4463	389	0,3570	311
3 stars	0,5578	486	0,3570	311	0,2856	249
4 stars	0,4463	389	0,2856	249	0,2285	199
5 stars	0,3570	311	0,2285	199	0,1828	159

1.5.3.5 China

a) Appliance energy efficiency programmes

In 1980, there was little home appliance manufacturing in China: the total output of household refrigerators in that year was less than 50 000 units. By 2004, China's output of colour televisions, room air-conditioners, refrigerators, and clothes washers had each reached 73,3 million, 66,5 million, 30,3 million, and 23,5 million units, respectively. In early 1980s, it was rare to find major electric appliance in any Chinese households. By 2004, penetration levels have reached to 96% for clothes washers, 90% for refrigerators, and 70% for room air-conditioners, respectively, for 100 urban households.

In 1989, the former State Bureau of Technical Supervision (SBTS) issued the first set of standards related to energy efficiency. They included energy efficiency requirements for eight types of products: refrigerators, room air conditioners, clothes washers, television sets, automatic rice cookers, radio receivers, electric fans, and electric irons.

Since then, China has significantly expanded its efficiency requirement program, both covering more product categories and raising the stringency of the performance levels. At present, the Administration of Quality Supervision, Inspection, and Quarantine (AQSIQ) has succeeded SBTS as the requirements setting agency in China, with the China National Institute of Standardization (CNIS) providing much of the technical analyses in the development process.

In 2004 (Table 1.35) China had minimum efficiency requirements for refrigerators and freezers, room air conditioners (windows and split types), TVs, fans, rice cookers, radios and audio receivers, fluorescent lamp ballasts, clothes washers, motors and irons. Requirements for external power supplies were under development. The first fuel efficiency requirements were enacted the same year.

Table 35: Summary of minimum efficiency requirements in China

	1989	1990	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Domestic refrigerators/freezers		◆				◆				◆			
Room air conditioners		◆					◆					◆	
Clothes washers		◆								◆			
Electric irons		◆											
Automatic rice cookers		◆											
Televisions		◆											◆
Radio receivers and recorders		◆											
Electric fans		◆											
Fluorescent lamp ballasts							◆					○	
Small electric motors								◆					
Compact Fluorescent lamps										◆			
Linear Fluorescent lamps										◆			
Instantaneous Gas Water Heaters												○	
External power supplies												○	
Commercial packaged AC												◆	

◆ Implemented
○ Revision or development

The stringency of the requirements has also been raised: for example, the requirements for room air-conditioners has been raised in 2005 from a coefficient of performance (COP) of 2,2 to 2,6 in the most popular category (4 500 Watt and below); a further rise is due in 2009 as well[77].

China is one of relatively few countries that have both an endorsement label and an information label. In March 2005 a categorical energy information label was launched, aimed at assisting consumers with their purchasing decisions. The label classifies appliances into five efficiency categories, with level one being the most efficient, and level five set at the minimum efficiency requirements level. At the moment, the information label is only applied to refrigerators and room air-conditioners, and is likely to be extended to other appliances in the future. In addition, China Standard Certification Centre (CSC) runs since 1999 a voluntary endorsement label, granted to products that are certified to meet both quality assurance and energy performance specifications.

[77] Jiang Lin, LBNL - Environmental Energy Technologies Division, Mitigating Carbon Emissions: the Potential of Improving Efficiency of Household Appliances in China, July 2006.

China's standards are mostly harmonised with ISO/IEC procedures.

a.1) Efficiency requirements for cold appliances

China represents the largest refrigerator market in the world[78]. From 1980 to 1995, residential power use rose from 3% to 12% of total electricity consumption, growing at an annual rate of 16,3%. This growth was driven by an explosive increase in household appliance use, as household income was rising. Within the residential sector, it is estimated that refrigerators alone, found in 70% of urban households in 1999, accounted for approximately half of all residential electricity consumption. In 1992, there were a total of 39 million refrigerators in service, an increase from only 4 million in 1985 representing 38% average annual growth. Future sales are projected to stabilize around 33 million units per year from 2020 onward.

From 1989-1995, work was conducted (the China Refrigerator project was a bilateral cooperation project between the US EPA and China State Environmental Protection Administration) in the areas of CFC substitutes research, energy efficient design options, prototype development, safety testing, and field-testing. Prior to the China Refrigerator Project, Chinese refrigerators were significantly less energy efficient than those produced in the European Union, United States, or Japan (e.g., the average refrigerator in China consumed up to 2,5kWh/year per litre of volume compared to 1,5kWh/year in Europe). Domestic research demonstrated that the energy consumption by refrigerators in China could be reduced by as much as 40%. However, there were many barriers for the widespread commercialization of energy efficient refrigerators in China.

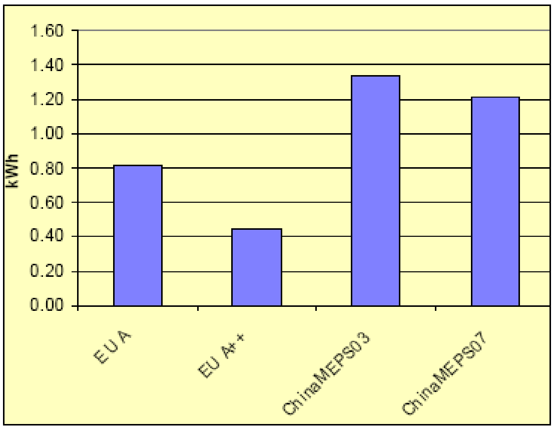
Since 1989, the minimum energy efficiency requirements for household refrigerators and freezers has been updated twice. The current requirements has been in force since 2003, and another more stringent level will become effective in 2007. The maximum consumption reference lines in 1999, as well as the appliance categories, and the formula for the calculation of the equivalent volume are very similar to those set in the EU directive 94/2/EC, with the exception of the upright and chest freezers reference lines and the addition of two categories: chest and upright frozen food coolers.

Table 1.36[79,80] presents the cold appliance categories and coefficients to calculate the threshold lines in 2003 along with the comparison of the prescribed maximum daily consumption values as well as the European labelling scheme for refrigerators with a total volume of 220 litre, which is the most popular refrigerator type in China today. The common size for refrigerators in US is about 550 litre, and those for Europe and Japan are between 300 and 400 litre. Since China and EU both use the ISO standards for refrigerators, the EU label value is presented here as a comparison. 2003 minimum requirements are in GB12021.2-2003, test method in standard GB/T 8059.2-1995 (equivalent to ISO 8187). This revision includes 10-15% energy savings relative to the 1999 efficiency levels, with an additional 10% savings scheduled to take effect in 2007.

Table 1.36: Cold appliance categories and coefficients to calculate the minimum efficiency requirements in 2003

Categories	M	N	Maximum daily energy use comparison (for a 220

[78] Source: UN Department of Economic and Social Affairs Division for Sustainable Development, Case Studies of Market Transformation: Energy Efficiency and Renewable Energy, United Nations, New York, 2005.
[79] Jiang Lin, LBNL - Environmental Energy Technologies Division, Mitigating Carbon Emissions: the Potential of Improving Efficiency of Household Appliances in China, July 2006.
[80] Source: GEF-UNDP, Case Study of the China Energy Efficient Refrigerator Project, 2000.

			litre refrigerator)
Refrigerator, no star compartment	0,221	233	
Refrigerator, 1 star compartment	0,611	181	
Refrigerator, 2 star compartment	0,428	233	
Refrigerator, 3 star compartment	0,624	223	
Refrigerator-freezer	0,697	272	
Frozen food cooler	0,530	190	
Food freezer	0,657	205	

The average refrigerator energy index has improved from 0,794 in 1999 to 0,572 as of June 2005 (means that on average, refrigerators used 57% of the energy allowed by the minimum requirements level), for a gain of 28%. Production of super-efficient refrigerators (those at least 60% more efficient than the minimum energy efficiency requirements) has increased from 400 units in 1999 to 3,3 million during the 12 months ending in June 2005.

There are currently 256 models of domestically manufactured energy efficient refrigerators on the market, which meet the energy efficiency requirement of Grade 1 of the national labelling scheme (the same level as the EU energy efficiency class A).

a.2) Mandatory information label for energy efficiency

The draft plan for management of the labelling program was completed at the end of 2003[81]. Regulations to create the energy efficiency label were approved in 13 August 2004 and took effect on 1 March 2005. Refrigerators are the first product to use the label (Figure 1.15), which will then be applied to other products as well, thus expanding the scope of its impact.

[81] Source: UN Department of Economic and Social Affairs Division for Sustainable Development, Case Studies of Market Transformation: Energy Efficiency and Renewable Energy, United Nations, New York, 2005.

Figure 1.15: China's information label for refrigerators

η≤ 55%	1
55%<η≤65%	2
65%<η≤80%	3
80%<η≤ 90%	4
90%<η≤ 100%	5

This label is similar to the EU energy label, but with a number instead of letter scale and divided into 5 levels. Energy use thresholds for each label category is expressed as a percentage of the maximum energy consumption of the efficiency requirements, which is the maximum threshold for Grade 5.

a.3) Voluntary endorsement label for energy efficiency

The State Economic and Trade Commission (SETC) and the China State Bureau of Quality and Technical Supervision (CSBTS) together established the China Certification Centre for Energy Conservation Product (CECP) to promote advanced energy conservation technology and the wide use of high efficiency products on October 1998. The first batch of energy efficient products were certified on April, 1999 and the first energy product certified on September, 1999. Products under this certification program now include 41 types of consumer appliances, including refrigerators and freezers, lightings products and office equipment, as well as selected industrial equipment.

Figure 1.16: Voluntary endorsement label for energy efficiency in China

The criteria used for the associated endorsement label (Figure 16) were developed in parallel with the efficiency requirements, allowing any manufacturer to apply for efficiency certification and labelling if a model consumed 75% or less energy than the minimum requirements. The vast majority of Chinese product manufacturers have voluntarily decided to use the label since it can enhance the attractiveness of their products in the Chinese consumer marketplace.

b) Other policies

b.1) CFCs Restrictions

China joined the Vienna *Convention for the Protection of the Ozone Layer* in September 1989 and the London Amendment to the *Montreal Protocol on Substances that Deplete the Ozone Layer* in June 1991. The Montreal protocol asked the developing countries, including China, to phase-out CFCs by 2010. In January 1993, the Chinese Government formally committed to implement the revised *Guideline to National Phase-out Scheme on Substances that Delete the Ozone Layer*, which sets out the phase-out for each sector and confirmed that the appliance industry in China would realise the complete substitution of CFCs in newly produced refrigerators by the end of 2006.

From January 1, 2007 the *Announcement on Stopping Production, Sale, Import and Export of Household Appliances and Relevant Accessory that Use CFCs as Refrigerant and Blowing Agent* will be formally implemented, signed and released by China's national general Environmental protection Bureau, the National Development and Reform Commission and General Administration of Custom.

The announcement mainly targets household appliances and accessory including household refrigerators, coolers below 500 litre, household ice-cream makers, hot-cold water dispensers, rice cookers, electric water heaters, and others to be produced/imported by China. Material such as CFC11, CFC12 and CFC113, mostly used as refrigerants or blowing agents for household appliances and as cleaning/degreasing agents for the manufacture of home appliances will be banned.

The mandates are not expected to cause too much of negative impact on the industry in China since the CFC-alternative technologies are quite mature and it is believed that only few Chinese appliance manufacturers still make use of CFCs.

b.2) Appliance noise limits

In 2005[82], a new appliance noise regulation "*Noise Limit Value for Household and Similar Electrical Appliances* went into effect in China on 1st August. Appliance manufacturers are required to mark the noise value on the product label or instruction booklet. Products that exceed the noise limits will not be allowed on the market. In addition, China intends to compulsorily withdrawn products that are already on the market. The Chinese government may start checking products on the market in the next several months.

The first phase impacts refrigerators, freezers, air conditioners, clothes washers, microwave ovens, kitchen ventilation hoods and fans. For washing machines the noise limits are: wash 62 dBA, spin cycle 72 dB(A); microwave oven noise limits: 68 dBA. For refrigerators and freezers, the limits depend to the appliance type and volume as presented in Table 1.37.

Table 1.37: Noise limits for refrigerators and freezers in China in 2005.

Volume	Direct-cooled refrigerators	Air-cooled refrigerators	Chest freezers
(litre)	(dBA)	(dBA)	(dBA)
≤ 250	45	47	47
> 250	48	52	55

The new noise legislation has three aims: (i) standardise the market and provide consumers with guidance; (ii) control imports of appliances that do not meet noise regulations, specifically imported low-end products and second-hand appliances that could not previously be rejected for noise problems due to a lack of a standard ; and (iii) increase the technical level of Chinese appliances by causing appliance makers to address relevant technical issues.

China has had ongoing appliance noise issues for years, but they were never addressed because of the lack of noise standard. The new standard, designated *China National Standard GB4214.1*, was issued jointly by the China Quality Surveillance Examination Quarantine Bureau and the National Standardisation Management Committee.

1.5.3.6 Brazil

Brazil has developed voluntary efficiency requirements and two types of energy label: one is a comparative energy label, mandatory for some products and voluntary for others and grades the efficiency of appliances from A to G as in the EU, the other is a voluntary endorsement energy label. Labels are currently in place for room air conditioners, freezers, refrigerators and refrigerator-freezers, ballasts, clothes-washers and lamps. The Brazilian government also recently passed legislation allowing the imposition of mandatory efficiency requirements for a broad range of equipment and these are currently under development.

The Brazilian energy labelling program or PBE (*Programa Brasileiro de Etiquetagem*) started to address household appliances in mid '80s, as shown in Table 1.38.

The Brazilian Energy Conservation Program, PROCEL, is managed by Eletrobras, the Brazilian government holding of the power sector. PROCEL has granted the "*Stamp Procel de Economia de*

[82] V. Han, China Implements Appliance Noise Standard, Appliance, October 2005, p.18

Energia" annually, since 1993 (Figure 1.17). It is awarded to the electric equipment that is the most energy efficient in its category in the given year. Its duel purpose is to stimulate the national manufacture of more efficient products and guide the consumer to purchase the most efficient appliance.

Table 1.38: Brazilian INMETRO PBE, summary as per beginning 2004

	Product	Working Group Initiation Date	Specific Regulation	Standard-Type	Type of Label	Endorsement Label
1	Refrigerators	Nov-84	RESP-01	ISO	comparison	yes
2	Combined Refrigerators	Nov-84	RESP-01	ISO	comparison	yes
3	Vertical Freezers	Nov-84	RESP-01	ISO	comparison	yes
4	Horizontal Freezers	Nov-84	RESP-01	ISO	comparison	yes
5	Water Coolers	Mar-01			comparison	
6	Commercial Freezers	Mar-01			comparison	
7	Commercial Refrigerators	Aug-03	RESP-01	ISO	comparison	
8	Electric Instant Showers-Chuveiros	May-92	RESP-02	NBR/IEC	comparison	
9	Electric faucets *(torneiras)*	May-92	RESP-02	NBR/IEC	comparison	
10	Instant Water Heaters (Passagem)	May-92	RESP-02	NBR/IEC	comparison	
11	Storage Water Heaters	Dec-03		NBR/IEC	comparison	
12	Hybrid Storage Water Heaters	Dec-03		NBR/IEC	comparison	
13	Hidro. Heaters	May-92	RESP-02	NBR/IEC	comparison	
14	Intelligent Instant Water Heater -Chuvei	Sep-98			comparison	
15	Room Air Conditioner (domestic)	Oct-00	RESP-03	NBR	comparison	yes
16	Split Air Conditioner	Jun-00	RESP-03		comparison	
17	Electric Motors - Tri-Phase	Aug-92	RESP-04	NBR	approval	yes
18	Electric Motors - one phase	Sep-98			approval	
19	Centrifugal Pumps	Jul-01				
20	Washing Machine	Jul-95	RESP-05	IEC	comparison	
21	Centrifugas Machine	Aug-04			comparison	
22	Dryer				comparison	
23	Dishwasher				comparison	
24	Flat panel solar collectors - bathroom	Mar-96	RESP-06	NBR/ASTM	comparison	yes
25	Flat panel solar collectors - pool	Mar-96	RESP-06	NBR/ASTM	comparison	yes
26	Termicos Reservatorio	Oct-00	RESP-06	NBR/ISO/IEC	approval	yes
27	Acoplados Coletores	Oct-00	RESP-06	ISO	comparison	yes
28	Installation Project	Mar-00			approval	
29	Installation Approved				approval	
30	Compact Fluorescent Lamps	May-99	PROCEL 01	NBR	approval	yes
31	Incandescent Lamps	Sep-99	RESP-07	NBR	comparison	
32	Decorative Incandescent Lamps	Jan-02	RESP-07		comparison	
33	Dicroicas Lamps	Jan-02	RESP-07		comparison	
34	Flourescent Tube Lamps				comparison	
35	Sodium Vapor Lamps				comparison	
36	Electromagnetic Reactors	Apr-00	RESP-11		approval	
37	Electrical Reactors	Apr-00			approval	
38	Magnetic p/Sodium Reactors	Apr-00	RESP-10		approval	
39	Public Lighting fixtures w/components					
40	Fixtures and components					
41	Residential Gas Stoves	Apr-01	RESP-08	NBR	comparison	
42	Residential Gas Furnace	Apr-01	RESP-08	NBR	comparison	
43	Heaters - Passagem	Apr-01	RESP-09		comparison	
44	Storage Heaters	Apr-01	RESP-09		comparison	
45	Transformers	Aug-04				
46	Vehicle Emissions	Mar-81	IBAMA	NBR	approval	
47	Vehicle Consumption	Mar-81				
48	Microwaves	Aug-01	RESP-12		comparison	
49	Electrics Stoves				comparison	
50	Electric Ovens				comparison	
51	Photovoltaic Panels	Dec-02	RESP-13	ISO	comparison	
52	Photovoltaic Storage Devices	Dec-02	RESP-13	NBR	approval	
53	Inversores CC/CA	Dec-02	RESP-13	IEC	approval	
54	Load Controlers	Dec-02	RESP-13	IEC	approval	
55	Photovoltaic Energy Systems	Dec-02	RESP-13		approval	
56	Wind Energy Systems	Jul-03	RESP-13	ISO	approval	
57	Solar Exhaust	Dec-03	RESP-13	ISO	approval	
58	Televisions		RESP-13		stand-by	
59	Monitors		RESP-13		stand-by	
60	Ventilator *de teto*		RESP-13		comparison	
61	Industrial Ventilators					
62	Tire Compresors - Pneumaticos					

products with labels (25)
products that already have working groups initiated (22)
proposed labels/programs (15)

Figure 1.17: The PROCEL Stamp Procel de Economia de Energia for appliances

a) Energy labelling for cold appliances

The PBE scheme for cold appliances was launched in 1997 and is mandatory since August 2006. It contains an efficiency rating - from A to G (Figure 1.18) - along with energy consumption and cold appliance temperature information as described in the Regulation ETIQUETAGEM RESP/001-REF of 27 February 2003[83]. The reference standards are ISO 7371:1995 *Household refrigerating appliances – Refrigerators with or without low-temperature compartment – Characteristics and test methods*, ISO 8187:1991 *Household refrigerating appliances – Refrigerator-freezers – Characteristics and test methods*, ISO 8561:1995 *Household refrigerating appliances – Refrigerators, refrigerator-freezers, frozen food storage cabinets and food freezers cooled by internal forced air circulation – Characteristics and test methods* and ISO 5155:1995 *Household refrigerating appliances – Frozen food storage cabinets and food freezers – Characteristics and test methods*, i.e. the same standards used for the EU energy labelling.

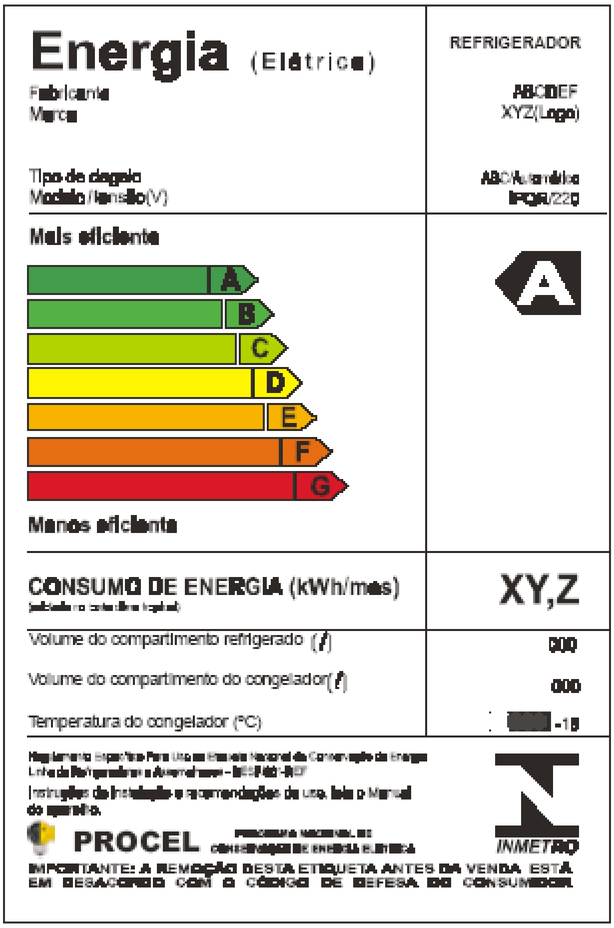
The program is conducted by PROCEL (*Programa Nacional de Conservacao de Energia Electrica*), the national energy efficiency program and the government agency INMETRO (*Instituto Nacional de Metrologia, Normalizacao e Qualidade Industrial*) which is responsible for verifying the manufacturers data.

Cold appliances are divided into six Categories:

- Category 1: Refrigerators (all refrigerators and refrigerators with a low temperature compartment with 1 and 2 stars, as covered by the standard ISO 7371)
- Category 2: Refrigerator-freezers (as covered by standard ISO 8187)
- Category 3: Refrigerator-freezers, frost-free (as covered by standard ISO 8561)
- Category 4: Upright freezers (as covered by standard ISO 5155)
- Category 5: Upright freezers frost free (as covered by standard ISO 8561)
- Category 6: Chest freezers (as covered by standard ISO 5155).

[83] Source: Regulamento Específico Para Uso da Etiqueta Nacional de Conservação de Energia – Ence, Linha de Refrigeradores e Assemelhados (Congeladores, Combinados e Conservadores), RESP/001-REF of 27 February 2003.

Figure 1.18: PBE label for cold appliances in Brazil



The energy consumption of any given appliance is compared to the reference energy consumption of the same category of appliance with an identical equivalent volume (*volume ajustado*) in order to calculate its Energy efficiency Index "*Ie*" and from it the relevant energy efficiency class.

The appliance energy efficiency index is calculated as Ie = C/Cp where:

$$C_p = a \times V_{eq} + b$$

and

$$V_{eq} = Vr + \sum_{c=1}^{c=n} f \times Vc$$, where:

Vr = volume of the refrigerator compartment
Vc = volume of the freezer compartment
f = factor depending on the temperature of each compartment as:

- 1,41 for one-star compartments
- 1,63 for two-star compartments
- 1,85 for three-star compartments

for frost-free models a multiplying factor of 1,2 should be used for *Vr* and *Vc*.

Values for a and b depend on the appliance Category, as shown in Table 1.39, while the minimum efficiency index value for the seven energy efficiency classes are:

- Class A: 0,869
- Class B: 0,949
- Class C: 1,020
- Class D: 1,097
- Class E: 1,179
- Class F: 1,267
- Class G: 1,362

Table 1.39: Consumption baselines for cold appliances

Category	Description	a	b
1	Refrigerators and refrigerators with a low temperature compartment with 1 and 2 stars	0,0346	19,117
2	Refrigerator-freezers	0,0916	17,083
3	Refrigerator-freezers, frost-free	0,1059	7,4862
4	Category 4: Upright freezers	0,0211	39,228
5	Upright freezers frost free	0,0178	58,712
6	Chest freezers	0,0758	13,095

Class A models can also bear the PROCEL endorsement label (Figure 17).

1.5.3.7 Other countries

The **Korean** government set both minimum efficiency requirements and a more stringent "target energy performance requirements". The former establishes the bottom (a rating of 5) of Korea's mandatory comparative energy labels, and the latter value (a rating of 1) the top. When minimum efficiency requirements are revised upwards (typically every three to five years) also the targets are.

Russia first implemented minimum efficiency requirements in 1983 and between then and 1991 introduced regulations for room and other types of air conditioners, audio signal amplifiers, computers, dishwashers, refrigerators, refrigerator-freezers, freezers, graphical input devices, monitors, printers, ranges & ovens, TVs and electric water heaters. Most of these policies have not been updated and hence have since become largely obsolete; however, in 2001 Russia passed a general law allowing the issuing of efficiency requirements and labels for a large range of appliance types.

Other countries: a summary and description of mandatory and voluntary policy measures for cold appliances worldwide can be also found at:

- Energy Labelling and Standards Programs Throughout the World, NAEEEC Report 2004/04[84];
- CLASP (Collaborative Labeling and Appliance Standards Programme)[85];
- APEC (Asia-Pacific Economic Cooperation) energy standards information system (ESIS)[86].

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[84] See document L. Harrington, Energy Efficient Strategies, Australia, "Energy Labelling and Standards Programs Throughout the World", NAEEEC Report 2004/04. Downloadable from www.energyrating.gov.au/library /publications2004.html .

[85] See: www.clasponline.org/main.php .

1.5.3.8 Seal-of-approval and other voluntary environmental labels worldwide

A part from the EU eco-label award scheme, seal-of-approval labels[87] are voluntary and selective, and are awarded only to products that meet relatively strict environmental requirements, including requirements related to energy performance. Many of these labels are administered by governments and are closely co-ordinated with their corresponding mandatory energy labelling programmes. Examples include the China "Great Wall" energy certification label, India "Ecomark" scheme, Korea "Energy Boy" label, Singapore "Green Labelling Scheme", Chinese Taipei "Greenmark", and the USA "ENERGY STAR" programme. In addition there are several voluntary labelling schemes administered by non-profit organisations, such as Japan "Eco Mark" scheme, Korea "Energy winner", the USA "Green Seal" and Thailand "Green Labelling Scheme". Canada third-party multi-criteria "Environmental ChoiceM Programme" is owned by the Federal Government and licensed to a "for profit" organisation to administer. In Australia and Thailand, associations of gas and electric utilities sponsor their own voluntary energy-labelling schemes.

1.5.4 The RoHS and the WEEE directives in Europe and worldwide

In the past five years, the EU has developed and adopted major electric and electronic equipment directives, which member states will begin to implement during 2007. The WEEE and the RoHS directives require electric/electronic equipments manufacturers to offer free disposal of consumers' used equipment and also to prohibit the export of hazardous waste to developing countries for disposal. The rules affect a list of 10 product categories including household appliances, toys, computers and many more. Meanwhile, the just approved REACH regulation on chemical safety will introduce requirements for importers of products and for information flow in the supply chain (the description of the REACH regulation is out of the scope of the present study).

The United Nations Environment Programme estimates that the world's population discards 20 to 50 million tons of electrical and electronic waste each year and predicts the amount will increase by 3% to 5% each year. Much of that waste ends up in China.

1.5.4.1 The RoHS and WEEE directives provisions

Directives on Waste Electrical and Electronic Equipment (WEEE), 2002/96/EC, aims to prevent WEEE arising, to encourage reuse, recycling and recovery of WEEE and to improve the environmental performance of all operators involved in the lifecycle of electrical and electronic equipment, especially those dealing with waste management. The directive sets requirements relating to criteria for the collection, treatment, recycling and recovery of WEEE and makes producers responsible for financing most of these activities. Retailers/distributors also have responsibilities in terms of the take-back of WEEE and the provision of certain information[88].

The main requirements and obligations were scheduled to become mandatory from 13 August 2005 onwards and some specific actions, e.g. producer registration and reporting of data on equipment

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[86] See: www.apec-esis.org/home.php .
[87] Source: R. Steenblik, S. Vaughan, P. Waide, Can Energy-Efficient Electrical Appliances be considered "Environmental Goods"? OECD Trade and Environment, Working Paper No. 2006-04.
[88] Source: EC, DG-JRC, Institute for Prospective Technological Studies, "Implementation of the Waste Electric and Electronic Equipment Directive in the EU", EUR 22231 EN, 2006.

placed on the market, were scheduled to be started from January 2005 onwards. However, many EU Member States have encountered major practical difficulties in meeting the directive's legal deadline of 13 August 2005 for implementation of their obligations on producers and retailers. Before the WEEE Directive came into force several European countries (e.g. Belgium, the Netherlands, Sweden and Denmark as well as Norway and Switzerland) defined national regulations and organised management schemes for WEEE. These systems respond sometimes to very different national situations and philosophies. Some of these countries will have to adapt their national laws when implementing the WEEE Directive. Other countries that have not developed any management systems are developing new ones in order to comply with the Directive.

The key aims of the WEEE Directive are:
- reduce WEEE disposal to landfill;
- provide for a free producer take-back scheme for consumers of end-of-life equipment from 13 August 2005;
- improve product design with a view to both preventing WEEE and to increasing its recoverability, reusability and/or recyclability;
- achieve targets for recovery, reuse and recycling of different classes of WEEE;
- provide for the establishment of collection facilities and separate collection systems of WEEE from private households;
- provide for the establishment and financing of systems for the recovery and treatment of WEEE, by producers including provisions for placing financial guarantees on new products placed on the market.

The WEEE directive covers a list of 10 product categories:

1. Large household appliances (refrigerators, washing machines, stoves)
2. Small household appliances (vacuum cleaners, toasters, hair dryers)
3. Information and telecommunications equipment (computers and peripherals, cell phones, calculators)
4. Consumer equipment (radios, TVs, stereos)
5. Lighting (fluorescent lamps, sodium lamps)
6. Electrical and electronic tools (drills, saws, sewing machines)
7. Toys, leisure, and sports equipment (electric trains, video games)
8. Medical devices (ventilators, cardiology and radiology equipment)
9. Monitoring instruments (smoke detectors, thermostats, control panels)
10. Automatic dispensers (appliances that deliver hot drinks etc).

Producers are responsible for the costs of picking up waste electrical and electronic equipment from collection facilities and for refurbishing waste products for reuse or for recycling and recovery. For "historical" products (i.e., those put on the market before August 13, 2005), the costs of waste management are to be shared by all producers in existence at the time those costs are incurred. These producers may impose a separate "visible fee" (one that is explicitly designated) to cover these costs for eight years (ten years for large household appliances). End users other than households may be made partly or totally responsible for financing the management of historical products. For new products (i.e., those put on the market after August 13, 2005), producers have "individual responsibility." That is, they must pay the cost of managing their own products. They can do this through programs set up by individual companies or through participation in collective schemes. No visible fees are permitted to fund the management of waste from new electrical and electronic products. When producers put a new product on the market, they must provide a financial "guarantee" that waste management of the product will be paid for. Producers can make good on this guarantee by participating in a producer responsibility organization (PRO), paying recycling insurance, or setting up a special bank account for this purpose.

Every "new" product must bear a label that verifies that it was put on the market after August 13, 2005, verifies that it will be separately collected, and bears the name of the producer according to an EU standard. Producers must provide information to consumers on the collection systems available and on the environmental and health impacts of hazardous substances contained in waste electrical and electronic products. Producers must also provide information to facilitate the environmentally sound reuse, recycling, and treatment of waste electrical and electronic products. Such information includes the identity of components and materials and the location of dangerous substances inside a product.

Member States must establish a register of producers and collect annual information on the amounts of electrical and electronic equipment that are put on the market, collected, reused, recycled, and recovered. They must transmit this information to the EU Commission every two years according to an established a standard format for the reporting. The first set of information will cover the years 2005 and 2006. Member States must establish inspection and monitoring systems and impose effective penalties for lack of compliance. The recovery and recycling targets to be met by EU Member States (excluding those who have received derogation[89]) at 31 December 2006 is outlined in Table 1.40. It should be noted that for medical equipment the target will be established by the end of 2008.

[89] Greece, Ireland and Slovenia had a 12-month extension, Cyprus, Czech Republic, Estonia, Hungary, Malta, Latvia, Lithuania, Poland and Slovakia has a 24-month extension.

Table 1.40: Targets for recovery and reuse/recycling, by weight at 31 December 2006

Product category	Recovery target (%)	Recycling target (%)
Large household appliances	80	75
Small household appliances	70	50
Information and telecoms	75	65
Consumer equipment	75	65
Lighting	70	50
Tools	70	50
Toys, Leisure, Sports	70	50
Medical Equipment	n.a.	n.a.
Monitoring instruments	70	50
Dispensers	80	75

There are two clear generic categories of national organisation, the “national collective system” (monopoly) and the competitive “clearing house system”. National legislators as well as producers have different views on the preferred system: some support the laws of the competitive market while others see the benefits of managing risk collectively. There are advantages and disadvantages with both systems. National collective schemes properly managed are considered by many stakeholders as providing the simplest and most effective route to collecting and recycling WEEE. Additionally, collective systems as run in the Netherlands, Belgium and Sweden are “tried and tested” and represent the only approach that has so far been shown to work in practice. The clearing house model, on the other hand, lacks experience and data to make good analyses and comparisons with existing collective schemes. Before the WEEE Directive came into force several European countries (e.g. Belgium, the Netherlands, Sweden and Denmark as well as Norway and Switzerland) defined national regulations and organised management schemes for WEEE. In Figures 1.19-1.20 the costs and the recycling rates of the existing systems in Belgium, Netherlands, Norway, Sweden and Switzerland are compared[90].

[90] Source: M. Dempsey , The WEEE Directive: The UK Experience, APSWG, 2006.

Figure 1.19: Economic costs of existing disposal systems for electric and electronic equipment

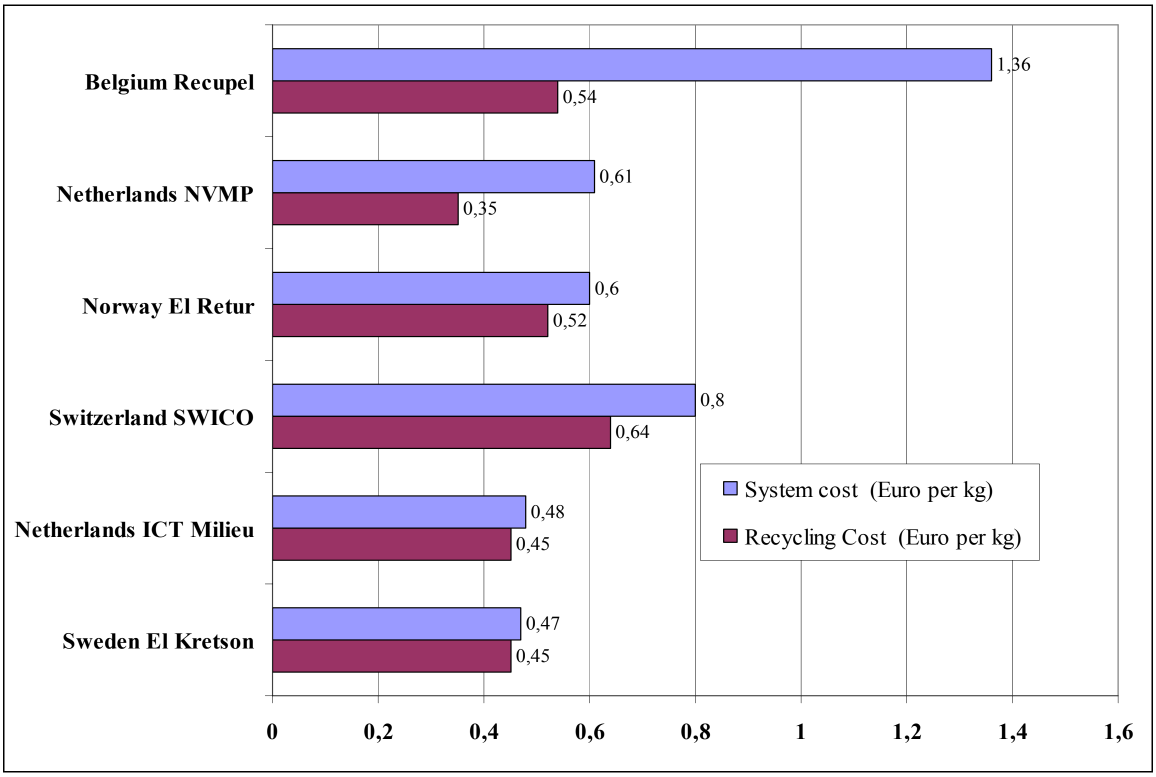
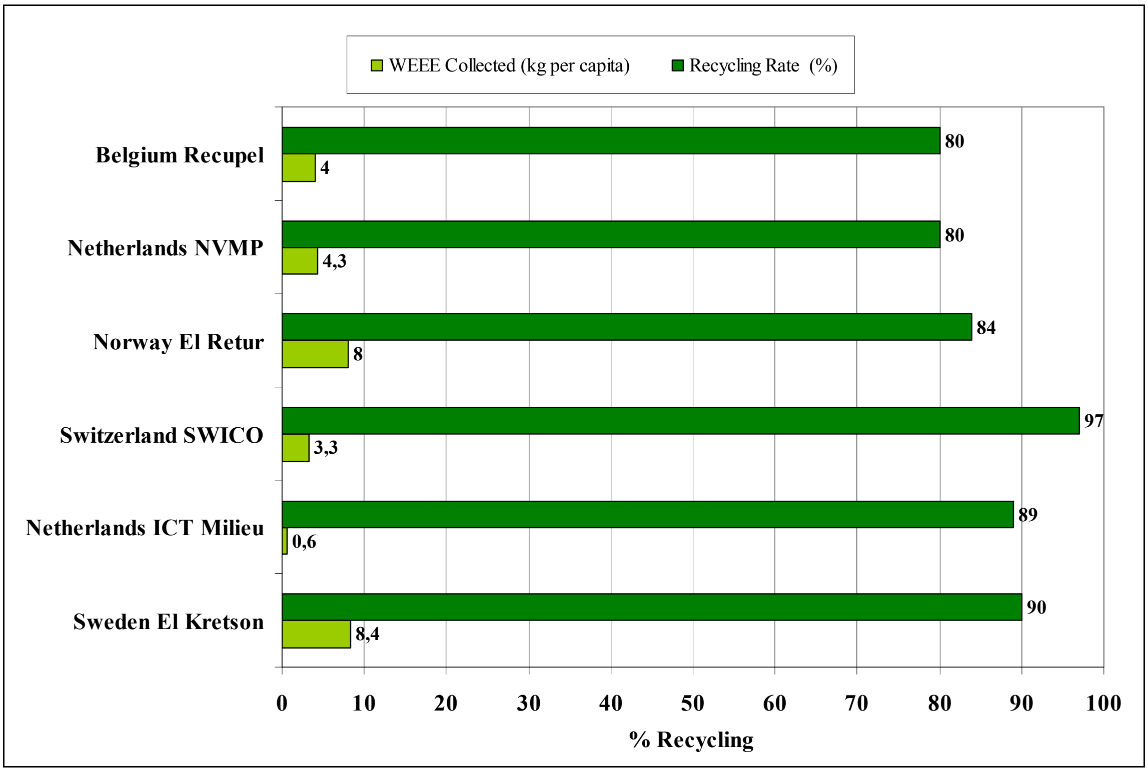


Figure 20: Recycling rates of existing disposal systems for electric and electronic equipment



These systems respond sometimes to very different national situations and philosophies. Some of these countries will have to adapt their national laws when implementing the WEEE Directive. Other countries that have not developed any management systems are developing new ones in order to comply with the Directive. The clearing house model is the preferred industry route where the market is large and the potential cost savings are substantial. For smaller markets, including those countries with existing schemes, the benefits of market mechanisms are not big enough to outweigh the greater simplicity of structure and financing of collective models.

The development of legislation and compliance structures for the WEEE directive is an ongoing process in all EU countries. The final national legislative and operational situation was defined by the end of 2006 but its effectiveness will remain unclear for a considerable period of time. The interaction and overlap with other areas of legislation, e.g. hazardous waste regulations, transfrontier shipment regulations, health and safety related marking etc., may have delayed the process of transposition and development of national legislation. In addition, where countries experience significant cross-border trade and imports, the efforts devoted to coordinate the implementation of the legislation between neighbouring countries and the tendency to resist first-mover disadvantage, have caused further delay.

While legislators in Member States have spent considerable time studying the legal and operational approach in those countries with established WEEE schemes, all have indicated the importance of building systems that meet local specifics of culture, geography and industry, and that take into account existing practices of waste collection.

Cooperation between Member States is already taking place. In the WEEE technical committee, discussions are on-going regarding whether details provided by producers for registers can be harmonised (i.e. the same type of information for all registers). Work is also being done at the European level on financial guarantees and how they will work. The quality of recycling facilities will be another area for cooperation. Recycling may be concentrated at a few facilities for the whole EU.

The Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive (2002/95/EC) affects manufacturers, sellers, distributors and recyclers of electrical and electronic equipment containing lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls or polybrominated diphenyl ethers. The RoHS directive covers the same scope as the WEEE Directive except for medical devices and monitoring and control instruments. It also applies to electric light bulbs and light fittings in households. It aims to protect human health and the environment by restricting the use of certain hazardous substances in new equipment and to complement the WEEE Directive.

From 1 July 2006, producers of new electrical and electronic equipment must demonstrate that their products do not contain more than the maximum permitted levels of:

- lead, including lead/tin solder,
- mercury,
- cadmium,
- hexavalent chromium,
- polybrominated biphenyls (PBBs) or
- polybrominated diphenyl ethers (PBDEs).

These substances must be replaced by other substances. Certain applications are exempt from the requirements of the directive, including mercury in certain types of fluorescent lamps, lead in the glass of cathode ray tubes, electronic components and fluorescent tubes, lead in electronic ceramic parts, lead in certain types of solder and hexavalent chromium as an anti-corrosion treatment of the carbon steel cooling system in absorption refrigerators. The exemptions will be reviewed every four years.

1.5.4.2 The WEEE directive implementation worldwide, a comparison

The exact nature of national WEEE legislation, in terms of elements such as the scope of products covered and the range of instruments used, varies from country to country. For example, the political culture in some countries or regions might mean that extensive market intervention is regarded as a viable and desirable policy alternative whereas legislation in other areas might be more heavily influenced by a value system that promotes deregulation. The EU, China, and to a lesser extent Japan might be characterised by the former, while Australia, Canada and the US prefer to develop initiatives at a state or regional level, on a voluntary basis where possible, and to avoid legislative solutions, considered to have a lower impact upon economic competitiveness.

Australia[91]: Activity in Australia remains voluntary. The main electrical and electronic industry associations are developing voluntary product stewardship initiatives. The Australian, State and Territory Governments are working with industry to develop product stewardship schemes for televisions and computers, primarily because of the CRT, which contains large quantities of lead. Once schemes have been developed for these products, these may serve as models for a broader range of products. With the support of major television manufacturers, state environment ministers in Australia are considering a plan to impose an 18,75 USD recycling fee on the sale of new TVs. The collected funds would be used to develop and operate a nationwide recycling scheme.

Canada[92,93]: at the national level, the Canadian Council of Ministers of the Environment (CCME) adopted landmark national stewardship principles for electronics products in June 2004. The principles are intended to provide a framework to help develop and deliver WEEE programmes in each Canadian province and territory and also to ensure harmonisation of key elements that are necessary for balancing environmental and economic considerations. In October 2004 Alberta started its WEEE management scheme, the first regulated electronics recycling programme in the country. The initial phase includes computer monitors, laptops and notebook computers, CPUs (including keyboards, cables, speakers), printers and televisions, and more products may be added later. Since 1st February 2005 retailers have applied a visible fee to those products, ranging from C$5 for laptops/electronic notebooks to C$45 for televisions. Under the Ontario Waste Diversion Act of 2002, the government of the province of Ontario has recently requested the development of a waste diversion program for WEEE materials, including refrigerators. Although the process for WEEE recovery and required recovery rates have yet to be established, it also requires manufacturers to take responsibility for diversion of WEEE. A study was completed mid-2005 including recommendations on the adequacy of a year-long timeline for developing the program with a launch possible in 2007.

China[94]: the State Development and Reform Commission (SDRC) drafted the “Management Regulations on the Recycling of Used Household Electronic Products and Electronic Products” in 2004 using the Chinese translation of the EU 2002/96/EC directive as a key reference document.

[91] Source: US DoE, TECHNICAL REPORT: Analysis of Amended Energy Conservation Standards for Residential Refrigerator-Freezers, October 2005.
[92] Source: EC, DG-JRC, Institute for Prospective Technological Studies, “Implementation of the Waste Electric and Electronic Equipment Directive in the EU”, EUR 22231 EN, 2006.
[93] Source: US DoE, TECHNICAL REPORT: Analysis of Amended Energy Conservation Standards for Residential Refrigerator-Freezers, October 2005.
[94] Source: EC, DG-JRC, Institute for Prospective Technological Studies, “Implementation of the Waste Electric and Electronic Equipment Directive in the EU”, EUR 22231 EN, 2006.

The State Council issued the so called "China WEEE" in late 2005. Its objective was to regulate the recycling and treatment of waste and used household electrical and electronic appliances and promoting resource recycling and reuse, environmental protection and human health. China WEEE would initially cover the following product categories: televisions, washing machines, refrigerators, air conditioners and computers. The Regulations focuses on household products and computer related and only covers product disposal. Household appliance producers are responsible for: adopting product design favourable to recycling and reuse, selecting non-hazardous and non-toxic materials and substances, and materials favourable to recycling and reuse, and providing major components and other information in the instruction manual. They must also undertake their own treatment of waste and used household appliances or entrust this treatment to qualified treatment enterprises and provide the provincial authorities with information on the categories, quantities, sales volumes and export volumes of the household appliances they produce. Issues of financing and producer responsibility remain poorly defined and the recycling system is largely unorganised. In 2004, China's State Development Reform Commission announced that Zhejiang province and the city of Qingdao would be the first two locations in the country to set up recycling systems for scrap electronics. China's top state-owned electronics manufacturers Haier and Hisense are located in Qingdao, while Zhejiang is an affluent province that is thought to have a high diffusion of electronics. Large enterprises and volunteer environmentalists are also involved in the recycling of electrical and electronic wastes, mainly mobile phones with their batteries and other accessories. Meanwhile, the country's largest electrical and electronic waste disposal plant using non-polluting processes - the Citiraya Environment Industry - is already under construction in Wuxi of Jiangsu Province, at a cost of 65 million USD. When the first phase of the project is completed, it will have the capacity to dispose of 30.000 tons of electrical and electronic wastes annually. This capacity will eventually be raised to 60.000 tons per year.

Japan[95]: the Japanese Home Appliance Recycling Law, enacted in 1998 and fully enforceable in 2001, requires industry to establish a recovery and recycling system for used products. The law allows for financing through end-user fees and the collection of used products by municipalities and retailers. The law initially covered 4 products (televisions, air conditioners, refrigerators, and washing machines) as obligatory items, but was extended to electronic products such as personal computers and copiers on a voluntary basis. The recycling goals contained in the law are lower than those of the WEEE directive and they do not escalate over time. Japanese legislation tends to follow EU legislation (thereby ensuring conformity and enabling exports to Europe), but whereas the EU uses environmental legislation, Japan often uses advanced technical specifications to achieve the same objective. Manufacturers are obligated to finance the recycling of their own products and every time they sell a new product, they must take back from the consumer either a similar used product or some other product that they sold in the past. The level of fees in Japan tends to be slightly higher than those in the EU. However, Japan's law does impose specific obligations on individual producers, which have individual responsibility for their own products. The end-of-life fee financing system, while effective in meeting the law's recycling goals, has proven to be very expensive for individual consumers (18-24 Euro for TVs, 30-38 Euro for refrigerators and 16-22 Euro for washing machines) and for the system as a whole, since the law provides few incentives to pursue a more efficient model.
Japanese government estimates that the four product categories targeted by the law account for 80% by weight of all discarded electrical and electronic equipment.

[95] Source: EC, DG-JRC, Institute for Prospective Technological Studies, "Implementation of the Waste Electric and Electronic Equipment Directive in the EU", EUR 22231 EN, 2006.

New Zealand[96]: *The New Zealand Waste Strategy* sets out the proposed long-term approach to reducing waste, improving recycling and reuse of waste materials, and better management of residual waste. Released in 2002 in partnership with Local Government New Zealand, the strategy sets the overarching strategic direction of solid, liquid, gaseous and hazardous wastes in New Zealand. The Waste Strategy signalled the Ministry for the Environment's preference for product stewardship solutions for the country's waste problems. For some wastes, a product stewardship regime can be an extremely effective solution. The volume or toxicity of certain wastes can be cut significantly by steps taken throughout the product's life cycle, from manufacture through to disposal. The New Zealand approach to product stewardship is set out in the discussion document *Product Stewardship and Water Efficiency Labelling* released last year. It outlines product stewardship options to deal with wastes that are particularly hard to manage or dispose of, such as electronic waste, end-of-life vehicles, used oil. The preferred option is voluntary agreements by industry, with legislation as a backstop only if required. The discussion document can be found on the Ministry for the Environment's website[97], where a summary of the submissions on it are also available[98].

USA[99]: WEEE management varies from state to state within the USA and is focused on electronic wastes such as CRT. At the national level the EPA is active in shaping WEEE management. Under its Resource Conservation Challenge the EPA work with retailers and manufacturers of electronic products, as well as with government agencies, to reduce the environmental impacts of the production, use and disposal of electronic products. Goals include increasing the national recycling rate to 35%. One of the main issues facing the US is the challenge of establishing effective governance structures to deal with the waste electronics issue due to the specific political structure of the country. At present, there are not waste disposal or recycling requirements for refrigerator-freezers and other white goods. Some manufacturers indicated that they believe similar requirements as in the Ontario Waste Diversion Act of 2002 could be extended to all of Canada and, in the future, potentially to the U.S. This could cause manufacturers to alter product re-designs to facilitate product recycling. At this point in time, DoE is not familiar with any similar legislation in the United States, but acknowledges that the Ontario legislation could have an impact on refrigerator-freezer design because of the tight integration of the U.S. and Canadian white goods markets.

1.5.4.3 The RoHS directive implementation worldwide, a comparison

The major implementations of RoHS[100] to date have been the EU, China, Japan and California and Korea. There are numerous aspects of RoHS that can be legislated differently leading to non-harmonization. Main aspects include:

- Scope
- The Restricted Substances
- Restriction or disclosure only.
- Maximum Concentration Values (allowable limits)
- The level at which the restriction is applied (Component or Homogeneous material

[96] Helen Bolton, Ministry for the Environment, NZ

[97] http://www.mfe.govt.nz/publications/waste/product-stewardship-water-labelling-jul05/.

[98] http://www.mfe.govt.nz/publications/waste/product-stewardship-water-labelling-aug06/.

[99] Source: US DoE, TECHNICAL REPORT: Analysis of Amended Energy Conservation Standards for Residential Refrigerator-Freezers, October 2005.

[100] Source: Roland Sommer, Newsletter No. 9, November 2006, RoHS and WEEE Specialists International. The newsletter and the www.electronicssouth.com RoHS and WEEE website are made possible by an initiative and funding from New Zealand Trade and Enterprise

- Exemptions

Scope: the EU RoHS provided a list of 10 categories listed in the WEEE Directive plus a number of exclusions, listed in both the WEEE Directive and the RoHS Directive. This was a comprehensive approach but led to a number of “grey areas” that have caused much confusion and uncertainty not only in industry.

China has produced a 35 page, detailed list of products split into 11 broad categories. They have described the list as fully comprehensive, however at the end of each category is the catch-all “other”. The notable exclusion from the China scope is the major category of white goods such as washing machines, clothes dryers, refrigerators etc. The motivation for this is still unclear. They have included medical devices, which are out of scope of EU RoHS until 2012, and as a result have created a very difficult situation for many medical device manufacturers.

Japan has 7 categories that do not directly relate to either the EU or China categories, although the equipment would all be covered by the EU categories in some manner.

Korea has 10 products but intend to implement the EU's scope in the long term. They are beginning with only 10 items: TVs, refrigerators, air conditioners, laundry machines, personal computers, audio devices, cellular phones, printers, copy machines, fax machines.

California covered electronic devices with a LCD, CRT or Plasma screen of greater than 4 inches measured diagonally. However they are proposing adopting EU ROHS in its entirety in 2010.

Restricted Substances: the EU Restricted lead, cadmium, mercury, hexavalent chromium, PBB (polybrominated biphenyls) and PBDE (polybrominated diphenyl ethers). All other countries have followed, except California who has a pre-existing legislation that effectively performs the same function. The net effect is that banned substances are consistent across all implementations.

Restriction or Disclosure only: the EU and California physically restrict the substances in the products. China, Japan and Korea are disclosure only. “Disclosure only” means that companies still have to collect all the material composition data on their components, but instead of designing out non compliant components they have to declare, usually in the users manual, where any of the restricted substances are. This is generally being used as a soft introduction for industry, with China certainly intending to physically restrict the substances in the future. So, there is a pretty even split between the two approaches, with the EU and California enacting physical restrictions and China, Japan and Korea following the “disclosure only” approach.

Maximum Concentration Values (allowable limits): the EU set a limit of 0,1% for all substances except Cadmium which is set at 0,01%. This has been universally adopted, but with a couple of improvements. The major use of hexavalent chromium is in corrosion protection passivation (chromating) on metals. The way the limits are applied in the EU (weight/weight) makes it impossible to accurately measure the amount of hexavalent chromium. China bans all intentionally added hexavalent chromium in metal treatment, which very nicely gets around the issue and meets the original aim of the ban, which was to prohibit the chromate treatment.
The other issue was with small parts, which again are practically impossible to test. China improved on the EU RoHS by introducing a category for components smaller than 4 mm^3. Components of this size and smaller, under certain conditions, will be considered one homogeneous material and will be tested as a whole. Subsequent to this the EU *Enforcement Authorities Informal Network* announced similar measures, no doubt for very pragmatic reasons. So, apart from the issue of hexavalent

chromium in chromate conversion coatings, the “Maximum Concentration Values” are consistent across all legislations.

Component or Homogeneous material (the level at which the restriction is applied): the EU applies the prohibitions at the homogeneous level, but found difficulties to define “homogeneous material” which, in simple terms, is any material that cannot be mechanically disjointed into sub- materials by unscrewing, cutting, grinding or abrasive actions. The rest of the world has followed this verbatim. The Chinese translation to English comes back with the same phraseology and examples. The original definition has now been tempered by the limitations of testing technology, with the emergence of the Chinese category of components of $4mm^3$ or less under certain conditions.

Exemptions: only the EU and California so far have enacted an actual restriction of the substances, with California adopting the EU exemptions. California is planning to fast track exemptions locally, to overcome the lengthy process that the EU exemptions need to follow. China is also expected to follow suit. They previously had a category of materials called EIP-D which was the list of EU exemptions; this has been withdrawn but is expected to be reintroduced when China go ahead with phase 2, which involves the actual restriction of the substances rather than just disclosure. Interestingly this country will continue to require disclosure of any substance above the limit irrespective of whether it is in an exempt application or not.

There are some aspects of RoHS which are not harmonizing well at a global level such as scope, but the fundamentals such as the banned substances, the limits applied and how they are applied are harmonized. Whether to start with a straight ban or to take a phased approach appears to be very much a country by country decision.

1.6 ANNEX 1: SOUND, NOISE AND HOUSEHOLD APPLIANCES

Sound power: is the amount of energy per unit time that radiates from a source in the form of an acoustic wave. The unit of measurement is the Watt, like the electric power. This distribution of sound power over the area of the propagating wave is designated as **sound intensity** and is measured in W/m^2 (Watts per square meter). Sound power cannot be measured directly. It is possible to measure intensity, but the instruments are relatively expensive and must be used carefully. Under most conditions of sound radiation, sound intensity is proportional to the **sound pressure**.

Sound power level: indicated with SWL or L_w is a measure of the sound power in comparison to a specified reference level. Since in the case of sound, the amount of power is very small, the reference selected for comparison is the picoWatt (10^{-12} Watt), which is the lowest sound persons of excellent hearing can discern. Sound power levels are connected to the sound source and **independent of distance** and are measured in decibel (dB). The sound power level is defined as :

$L_w = 10 \log (W / W_0)$, where W_0 = reference power

Sound pressure: the instantaneous difference between the actual pressure produced by a sound wave and the average or barometric pressure at a given point in space. It is measured in Pa.

Sound pressure level: Sound Pressure Level (SPL or L_p) is 20 times the logarithm, to the base 10, of the ratio of the pressure of the sound measured to the reference pressure, which is 20 mN/m^2. In equation form, sound pressure level is expressed as:

$SPL (dB) = 20 \log p/p_0$

Although a decibel scale is actually a means for comparing two sounds, a decibel scale of sound level by can be defined by comparing sounds to a reference sound with a pressure level of :

$p_0 = 2 \times 10^{-5} (N/m^2)$

assigned to a sound pressure level of 0 dB. SPL quantifies in decibels the intensity of given sound sources. It **varies substantially with distance** from source, and also diminish as a result of intervening obstacles and barriers, air absorption, wind and other factors.

There is a significant advantage to using decibel notation rather than the wide range of pressure (or power): a change in sound pressure by a factor of 10 corresponds to a change in sound pressure level of 20 dB:

- $p = 40\ \mu Pa$: $L_p = 20 \log (40/20) = 6$ dB
- $p = 400\ \mu Pa$: $L_p = 20 \log (400/20) = 26$ dB

Sound pressure can be measured more easily, so sound measuring instruments are built to measure the sound pressure level in dB.

Correlation between sound power and sound pressure: the sound power is proportional to the square of sound pressure and $10 \log p^2 = 20 \log p$.

Correlation between sound power level and sound pressure level: doubling the sound pressure level increases the sound power level by 3 decibels (dB) as described in the first row of Table 1.41.

Table 1.41: Correlation between sound power level and sound pressure level

Increase magnitude (times)	**Increase in sound power level** (dB)	**Increase in sound pressure level** (dB)
2	3	6
3	4,8	9,6
4	6	12
5	7	14
10	10	20
15	11,8	23,6
20	13	26

A-Weighted sound level: a measure of sound level designed to reflect the acuity of the human ear, which does not respond equally to all frequencies. The ear is less efficient at low and high frequencies than at medium or speech-range frequencies. Therefore, to describe a sound containing a wide range of frequencies in a manner representative of the ear's response, it is necessary to reduce the effects of the low and high frequencies with respect to the medium frequencies. The resultant sound level is said to be A-weighted, and the units are dB(A). **The A-weighted sound level is also called the "noise level".**

The A-weighted sound level L_A is widely used to state acoustical design goals as a single number, but its usefulness is limited because it gives no information on spectrum content. A-weighted comparisons are best used with sounds that sound alike but differ in level. They should not be used to compare sounds with distinctly different spectral characteristics; that is, two sounds at the same sound level but with different spectral content are likely to be judged differently by the listener in terms of acceptability as a background sound. One of the sounds might be completely acceptable, while the other could be objectionable because its spectrum shape was rumble like, hissing, or tonal in character. A-weighted sound levels correlate well with human judgments of relative loudness, but give no information on spectral balance. Thus, they do not necessarily correlate well with the annoyance caused by the noise.

Therefore, many different-sounding spectra can have the same numeric rating, but have quite different subjective qualities

Comparing decibel A, B and C:

Relative response (dB)	Frequency (Hz)								
	31,5	63	125	250	500	1000	2000	4000	8000
dB(A)	-39,4	-26,2	-16,1	-8,6	-3,2	0	1,2	1	-1,1
dB(B)	-17	-9	-4	-1	0	0	0	-1	-3
dB(C)	-3	-0,8	-0,2	0	0	0	-0,2	-0,8	-3

If the frequency weighting employed (A, B or C) is not indicated, the A-weighting is implied.

The noise chart below gives an idea of average decibel levels for everyday sounds:

- Painful:

- 150 dB = rock music peak
- 140 dB = firearms, air raid siren, jet engine
- 130 dB = jackhammer
- 120 dB = jet plane take-off, amplified rock music, car stereo, band practice

- Extremely loud:
  - 110 dB = rock music, model airplane
  - 106 dB = timpani and bass drum rolls
  - 100 dB = snowmobile, chain saw, pneumatic drill
  - 90 dB = lawnmower, shop tools, truck traffic, subway
- Very loud:
  - 80 dB = alarm clock, busy street
  - 70 dB = busy traffic, vacuum cleaner
  - 60 dB = conversation
- Moderate:
  - 50 dB = moderate rainfall, quite office
  - 40 dB = quiet room, bedroom
- Faint:
  - 30 dB = whisper, quiet library
  - 20 dB = very quiet room
  - 10 dB = calm

1.7 ANNEX 2: ABSORPTION REFRIGERATORS: PRODUCTION AND MARKET

1.7.1 The absorption cycles

In 1922 two Swedish students, Carl Munters and Baltzar von Platen invented absorption technology. There are two main intermittent-cycle absorption systems and continuous-type absorption systems[101], the former is not commercially available today. The absorption system offers a cooling technology with some major advantages for certain applications:

- The cooling circuit can be operated by alternative energy sources, such as kerosene, fuel gas or electrical heat. Therefore the system is often used in Recreational Vehicles (RV), marine applications or elsewhere when there is lack of, or non-reliable, electrical infrastructure.
- The absorption refrigeration system is free from any moving mechanical parts. The system is therefore practically noise free and therefore often used in hotels or small apartments.
- Due to the lack of moving mechanical parts the adsorption system is reliable and has a long lifetime. For this reason absorption refrigeration has come to use for medical applications.

This type of refrigerating system is quite simple. The piping is welded steel because the pressures on the generating cycle are quite high. The refrigerating ability is quite good. Kerosene flame heated absorption refrigerators are popular in areas where electric power is not available. Other means of firing the burner can be propane or natural gas. Many Recreational Vehicles (RV) unit refrigerators use a combination of propane fired burners and add a small 12 volt fan assembly to improve cooling within the evaporator section of the refrigerator (ice box).

The absorption refrigeration system: the continuous-cycle absorption cooling unit is operated by the application of a limited amount of heat. This heat is furnished by gas, electricity or kerosene. No moving parts are employed. The operation of the refrigerating mechanism is based on Dalton's Law. A cooling unit uses ammonia as the coolant, and it uses water, ammonia and hydrogen gas to create a continuous cycle for the ammonia. The system has five main parts (Figure 21):

- Generator - generates ammonia gas
- Separator - separates ammonia gas from water
- Condenser - where hot ammonia gas is cooled and condensed to create liquid ammonia
- Evaporator - where liquid ammonia evaporates to create cold temperatures inside the refrigerator
- Absorber - absorbs the ammonia gas in water.

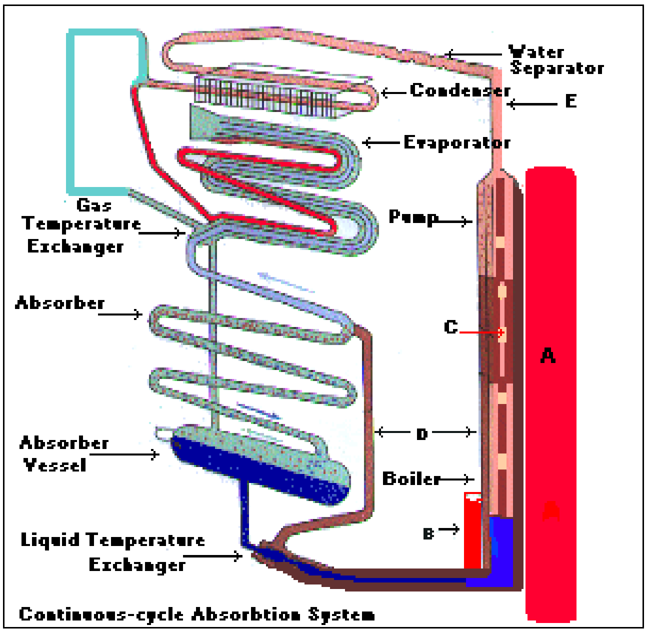
The cycle works like this:

- heat is applied to the generator. The heat comes from burning something like gas, propane or kerosene in a burner fitted underneath the central tube (A) in Figure 1.21, or from an electric resistance inserted in the pocket (B) ;
- in the generator there is a solution of ammonia and water. The heat raises the temperature of the solution to the boiling point of the ammonia; ammonia gas and weak ammonia solution pass through C, the solution goes through the tube (D), while the ammonia gas flows through the vapour pipe (E)
- the boiling solution flows from (E) to the separator. In the separator, the water vapour separates from the ammonia gas;

[101] Source: Howstuffworks, downloadable at: http://www howstuffworks.com

- the ammonia gas flows upward to the condenser. The condenser is composed of metal coils and fins that allow the ammonia gas to dissipate its heat and condense into a liquid;
- the liquid ammonia makes its way to the evaporator, where it mixes with hydrogen gas (which decreases the ammonia water pressure) and evaporates, producing cold temperatures inside the refrigerator;
- the ammonia and hydrogen gases flow to the absorber. Here, the water that has collected in the separator is mixed with the ammonia and hydrogen gases;
- the ammonia forms a solution with the water and releases the hydrogen gas, which flows back to the evaporator. The strong ammonia solution flows toward the generator to repeat the cycle.

Figure 1.21: Continuos-type absorption system



This cycle operates continuously as long as the boiler is heated. A thermostat which controls the heat source regulates the temperature of the refrigerated space.

This refrigeration system is widely used in hotels and recreational vehicles. Service is usually quite simple. The burner and stack must be kept clean. The refrigerator should be carefully leveled before being placed in operation and care should be taken to leave enough space for air circulation and heat removal especially in built-in models. Most appliances require also electrical devices such as fans, so both gas and electricity must be supplied. Except for the thermostatic controls and (in some cases) fans, there are no moving parts.

1.7.2 The absorption refrigerators production in Europe

China and Turkey produce and exports electrical absorption refrigerators in Europe. In the EU, absorption refrigerators are produced in Germany, Hungary, The Netherlands and Italy, by SMEs and larger companies: Dometic and Sibir (owned by Dometic, which in turn is owned by the private equity company BC Partners) are the main European manufactures of absorption refrigerators; Dometic employees about 1 500 people in its 3 production sites.

Asia is an important source of basic components for European manufacturers, although, the bulkiness of some finished products eliminates any cost advantage in making them in Asia for

European markets. Most of the components that are assembled into final products in European factories are designed in Europe and sourced in Asia. This will increase in future, but final products can be bulky and costly to transport, while material prices are not much lower than they are in Europe. Future decisions on production in low cost countries, like China, will be likely based on a product by product basis.

1.7.3 *The absorption refrigerators market*

The worldwide market for absorption refrigeration is shared between North America, accounting for 50% of sales followed closely by Western Europe with 45%. It is also expected that within 10 years an RV market will emerge in Eastern Europe and Asia. China is an expanding market. Thousands of hotels are being built in China at the moment for a number of events coming up, such as the Olympic Games in Beijing and the World Exhibition in Shanghai, and this is creating a surge in demand.

The annual European market[102] for absorption refrigerators is estimated in 700 000-800 000 units. About 300 000 units (mainly gas appliances) are absorbed by various types of recreation vehicles and boats and the rest by various environments:

- miniBars for hotels and cruise liners (where no noise is required)
- refrigerators (miniCool) for compact living spaces, offices and rooms outside the kitchen
- wine cellars (no vibration from the compressor on/off could "compromise" wine maturation)
- large refrigerators for areas with unreliable power supply
- portable and stationary refrigeration systems for medical applications (see Annex 3).

About 250 000 units are sold to hotels, other 125 000 to other professional uses such as medical applications and about 10-20 000 units are estimated for household use.

Common volumes for recreation vehicles are 60, 100, 120 and 180 litre, with an energy consumption in the range 2,4-3,2 kWh/24h. Common volumes for hotel and household refrigerators are 30, 40, 60 and 80 litre, where the energy consumption is in the range 0,6-1,2 kWh/24h.

Larger appliances for recreational vehicles can be equipped with a small 3-star freezer. For the other appliances a simple ice box is possible.

1.8 ANNEX 3: OTHER TYPES OF REFRIGERATORS FOR PUBLIC USE: VACCINE REFRIGERATION TECHNOLOGIES

Since three out of the four key suppliers for WHO pre-qualified refrigerators and freezers for vaccine storage are European: Dometic (Luxemburg), Vestfrost (Denmark), Sibir International AB (Sweden) a brief description of this niche product market and its specific problems has been considered an interesting addendum to the EuP – cold appliance study.

In an attempt to better understand the current public-sector market and future potential of vaccine refrigeration technologies, PATH[103] interviewed refrigerator manufacturers, policymakers,

[102] Most of the information of this paragraph come from a personal communication from Dometic.
[103] Path Interview Findings, Vaccine Cold Chain Refrigeration Technologies: Assessment of the Public-Sector Market August 2005, downloadable from: http://www.technet21.org/ColdChainMarketStudyFindings.doc .

purchasers, immunization programs, and other key influencers to gather data. Specifically, PATH wanted to learn more about the current size of the public-sector market, the key suppliers and key buyers, how purchasing decisions are made, and which trends could affect the market for refrigeration technologies in the future. Thirteen interviews were conducted. A summary of key findings is reported.

There are two main types of refrigerators for vaccines: compression and absorption. Compression refrigerators have an electric compressor and are either powered from the grid (AC current) or by solar energy (DC current). The solar refrigerator runs on a battery charged by photovoltaic cells which convert sunlight to electricity. If the supply of electricity is available, but not continuous, ice-lined refrigerators are used to maintain vaccine storage temperature for up to five days. Absorption refrigerators have a heating unit in the back. There are three types of absorption refrigerators: kerosene (paraffin), gas, and electric (the electric element is different than a compressor).

The "Product Information Sheets" (PIS) have been produced by the WHO Department of Vaccines and Biologicals in collaboration with the UNICEF Supply Division on a regular basis since 1979. The PIS provide general information on the choice of equipment, together with specific technical and purchasing data for individual selected items. In order to be included in the PIS, each item of equipment must be independently tested in accordance with standard test procedures and found to meet established specifications for performance. This testing can be a time-consuming and resource-intensive process for the manufacturer. The 2000 edition of the PIS, which is the most recently published edition in hard copy (although updates have been posted on the internet site), lists a total of 37 refrigerators and freezers. They are divided into three categories: compression (15 approved products), absorption (13 approved products), and solar (9 approved products). In 2006, the new Performance, Quality and Safety prequalification system (PQS) replaced PIS. The new system incorporates technical specifications, standardized test procedures and post-marketing monitoring. A key difference in approach between the PQS and the PIS system is a greatly increased emphasis on user feedback and field testing.

There are four key manufacturers in this market, which account for the majority of approved refrigerators and freezers for vaccine storage in the WHO PIS: Dometic (formerly Electrolux Luxembourg, 14 total products in the PIS), Vestfrost (Denmark, 7 total products in the PIS), Sibir International AB (Sweden, 4 products in the PIS), and Zero Appliances (South Africa, 3 products in the PIS). Dometic owns part of Sibir. The solar category is not dominated by a single player.

Competition is within the product category: compression, absorption, or solar. Only one of these key players, Dometic, has items listed in all three product categories in the PIS. Some companies have a stronghold in different world regions. Companies conduct direct marketing to local Ministries of Health (MoHs) and local UNICEF offices and spend time out in the field with technicians to educate people about their products.

The public-sector market for the vaccine refrigerators accounts for less than 1% of total refrigerator sales. Sales of such equipments are not a significant portion of total sales for most suppliers and generally account for less than 10% of a company's total sales. According to UNICEF, approximately 200.000 vaccine refrigerators are in use in immunization programs in the developing world. Total UNICEF expenditures from 1997 to 2003 on refrigerators and freezers were 77 million USD: 32% of products supplied are absorption refrigerators fuelled by kerosene and about 10% are solar. Sales of kerosene-only refrigerators totalled 9.772 units from 1997 to 2003 and 3.043 solar refrigerators in the same period

UNICEF is the major public-sector buyer of vaccine refrigerators and freezers, accounting for 85% of public-sector sales. The remaining 15 percent of public-sector sales come directly from country MOHs, and other donors. These other buyers do not always buy products included in the PIS. MOHs, for example, are less strict and are more open to buying other domestically manufactured products not listed in the PIS. Other donor countries may only donate the products supplied by their local manufacturers.

South American countries, in particular, are not major users/buyers of products listed in the PIS. Instead, they source their vaccine refrigerators from domestic sources, often using refrigerators that are intended for home (kitchen) use. This trend may be expanding to other world regions as well. Interest in solar refrigerators may also be growing in South America. Although some of these domestic refrigerators may not be of the same quality as the products listed in PIS, the ultimate effect of buying domestic refrigerators (not listed in the PIS) may be to drive down prices of PIS equipment.

Given the limited market opportunity, the process involved in qualifying a product for inclusion in the PIS, and the fact that public-sector purchases are erratic and difficult to predict, the industry probably will not see the entry of many new players unless there are new incentives provided by the public sector. This also reduces technical innovation, given the expense of research and development and the small size of the market.

Buying behaviour is often a purchase of habit. Decisions are made based on company and device reputation; national program managers' insights; and on-the-ground, in-country, or neighbouring-country experiences. Although in general most buyers are relatively price sensitive, price is not always the driving factor (Japan, for example, is considered one of the least price sensitive buyers.) Instead, reliable field experience is often a more important factor. National program manager meetings are an important source of information for many people.

There are a number of potential developments that could affect the market of such equipments in the future. For example, new vaccines could be developed so that they are less temperature sensitive, thereby reducing the need for the cold chain. Yet demand for cold chain equipment could also increase: tetravalent and pentavalent vaccines, may result in required expansion due to increased volume needs; furthermore, based on recent evidence that freezing of vaccine is a common problem in the cold chain, there could be an increasing demand for refrigerators that reduce the risk of inadvertent vaccine freezing.

Increased availability of energy could reduce the need for absorption refrigerators. And since kerosene refrigerators are difficult to control, there is a trend toward LPG refrigerators in situations where absorption refrigerators are used. There is also a likelihood of a decreasing need for icemakers, given WHO is moving towards the use of water packs instead of frozen ice packs for vaccine transport, and because polio campaigns are declining. Finally, CFC refrigerators were phased out by 2006, and thus, existing CFC refrigerators will eventually need to be replaced. In the area of solar technology, a new approach is being developed, the Solar Chill. If the Solar Chill technology is proven, there will be an alternative to battery-operated solar refrigerators. The Solar Chill project aims to help deliver vaccines and refrigeration to regions of the world without electricity or with inadequate electrical supply. Solar Chill is developing a versatile refrigeration technology that is environmentally sound, battery free, technologically reliable, affordable, and multi-source powered. Solar Chill prototypes are currently being field-tested in Senegal, Indonesia, and Cuba. Once the field tests are deemed to be reliable, the Solar Chill technology will be freely made available to the world and will be in the public domain. The project is supported by the United Nations Environmental Programme, Greenpeace, UNICEF and PATH.

Manufacturers also gave feedback on a variety of technical issues, especially with regard to solar refrigerators. Specifications for solar refrigerator power systems should be tighter. For example, requirements for the number of sunlight hours and autonomous days (days without sunlight) should be specified as should the battery quality. Some say that batteries are the weak link in the solar refrigerator system. Battery quality and availability for solar refrigerators is a big issue, and there are batteries of varying quality out in the field. Furthermore, batteries heavily influence the price of a system. Storage temperature ranges could also be extended.

There does not seem to be a uniform replacement plan for equipment for the vaccine cold chain. Instead, purchase decisions are based on financing cycles and available resources. The main drivers of purchases of cold chain equipment are upcoming large immunization campaigns; availability of emergency funding (which will sometimes be used for cold chain equipment); and availability of post-conflict funds, which also are sometimes used for periodic replacement of cold chain equipment.

2 Task 2: Economic and market analysis

2.1 GENERIC ECONOMIC DATA

2.1.1 Production and import export of cold appliances in Europe

The production of cold appliances for the household appliance industry and market in the EU27 and more in general in Europe is estimated through the data collected in Task 1 and described in detail in the document "A Portrait of the Household Appliance Industry and Market in Europe" [104]. According to the available data (**Errore. L'origine riferimento non è stata trovata.**), about 23,3 million units were produced in EU27 in 2005, of which 18 million refrigerators and refrigerator-freezers and 5,3 million freezers (for some countries freezers are included in the refrigerators figures). However, since data relevant to some producing countries are missing this number is likely 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 in not known.

When Turkish production is added to the EU27 figures, the total production rises to about 33 million cold appliances.

Table 2.1Production of refrigerators and freezers in Europe in 2005 (10^3 units)

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

[104] See www.ecocold-domestic.org - study output/draft document/task 1 section

Country	**Refrigerators**	**Freezers**	**Total**
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

*refrigerators and freezers

Note: in bold 2005 information from a US specialised magazine.

The import/export information are provided by Eurostat. Unfortunately only a part of these data are available and so it is no possible to properly evaluate the apparent market at European level. In particular the data on the "Combined refrigerators-freezers, with separate external doors" (according to the Eurostat/NACE classification) and on the freezers are missing.

Tables 2.2 and 2.3 show the data provided by EUROSTAT

Table 2.2 Importation of domestic refrigerators in Europe in 2005 (units)

Country	Combined refrigerators-freezers , with separate external doors	Household-type refrigerators (including compression-type electrical absorption) (excluding built-in)	Compression-type built-in refrigerators
AT	:	156.224	89.257
BE	:	446.037	105.337
DE	:	1.240.325	465.156
DK	:	214.905	30.644
GR	:	365.867	5.044
ES	:	1.090.738	20.388
FI	:	146.782	11.615
FR	:	1.781.040	168.067
IE	:	121.943	34.981
IT	:	1.213.215	14.005
LU	:	10.121	6.767
NL	:	544.716	228.360
SE	:	235.063	48.238
UK	:	2.300.189	178.066
PT	:	152.340	4.624
CY	:	27.109	1.273

Country	Combined refrigerators-freezers , with separate external doors	Household-type refrigerators (including compression-type electrical absorption) (excluding built-in)	Compression-type built-in refrigerators
CZ	:	373.819	10.288
EE	:	20.321	2.979
SI	:	58.467	2.274
SK	:	67.421	1.909
HU	:	128.494	9.109
MT	:	7.397	630
LV	:	43.222	2.006
LT	:	21.781	2.579
PL	:	168.009	23.332
EU25 *	**:**	**7.527.507**	**296.568**

*The row "EU25" shows the **net intra EU import values** and not the sum of the units imported by each country

Table 2.3 Exportation of domestic refrigerators in Europe in 2005 (units)

Country	Combined refrigerators-freezers , with separate external doors	Household-type refrigerators (including compression-type electrical absorption) (excluding built-in)	Compression-type built-in refrigerators
AT	:	15.993	21.719
BE	:	208.835	6.197
DE	:	623.282	461.657
DK	:	86.563	7.417
GR	:	167.492	10.782
ES	:	264.628	4.291
FI	:	54.89	2.161
FR	:	108.704	5.386
IE	:	10.225	1.190
IT	:	2.257.766	484.327
LU	:	19.552	90
NL	:	299.519	54.016
SE	:	495.693	18.613
UK	:	452.494	1.002.065
PT	:	23.340	35

Country	Combined refrigerators-freezers , with separate external doors	Household-type refrigerators (including compression-type electrical absorption) (excluding built-in)	Compression-type built-in refrigerators
CY	:	27	20
CZ	:	44.7901	385
EE	:	1.684	112
SI	:	292.818	136.559
SK	:	4.918	149
HU	:	718.439	2.083
MT	:	17	0
LV	:	6.028	9
LT	:	29.572	6.366
PL	:	695.046	23.675
EU25 *	**:**	**3.243.919**	**137.732**

*Also in this case the row "EU25" shows the **net intra EU import values** and not the sum of the units imported by each country

2.2 TASK 2: MARKET AND STOCK DATA

2.2.1 Market data: Sales analysis

2.2.1.1 Content of this paragraph

This paragraph illustrates the sales data of the cold appliances for the years 2002 and 2004. The data have been provided by the German firm GfK. The regional coverage is rather good for the western EU countries but it is partial for the Eastern Countries. For these last countries the data concern only 4 countries for the year 2002 and 8 for the year 2004 for the refrigerators and no countries for the year 2002 for freezers.

The following table shows the Western and Eastern countries taken into account by this data set:

	Refrigerators		Freezers	
Country	2002	2004	2002	2004
Austria (AT)	X	X	X	X
Belgium (BE)	X	X	X	X
Germany (DE)	X	X	X	X
Denmark (DK)	X	X	X	X
Spain (ES)	X	X	X	X
Finland (FI)	X	X	X	X
France (FR)	X	X	X	X
UK (GB)	X	X	X	X

	Refrigerators		Freezers	
Country	2002	2004	2002	2004
Greece (GR)	X	X	X	X
Italy (IT)	X	X	X	X
The Netherlands (NE)	X	X	X	X
Portugal (PT)	X	X	X	X
Sweden (SE)	X	X	X	X
Czech Republic (CZ)	X	X		X
Estonia (EE)		X		X
Hungary (HU)	X	X		X
Lithuania (LT)		X		X
Latvia (LV)		X		X
Poland (PL)	X	X		X
Slovenia (SI)		X		X
Slovakia (SK)	X	X		X

The sales data are broken down by energy efficiency classes, volume and star categories (this last only for the refrigerators) and, per each of these sales partition, the 2002/2004 data are compared and discussed.

2.2.1.2 The sales break down by energy efficiency classes

a. Refrigerators

Table 2.4 and 2.5 as well Figures 2.1 and 2.2 that follow, show the refrigerators sales repartition by energy efficiency classes for the years 2002 and 2004.

The first four columns of Table 2. 4 (units) and Table 2.5 (percentages) compare the 2002 sales with those of 2004. For the Eastern countries, only the four nations taken into account in the 2002 data are compared. The fifth columns of tables 1 & 2 carries out the 2004 sales data of all the 8 countries considered by GfK. Overall the 2004 western plus eastern sales (8 countries) exceed the 14 millions. The increment of the 2004 sales with respect those of 2002 (4 countries) is around the 9 % (8,7 %) of which the 7,7 % is attributable to the western countries and at least the 17,5 % to the eastern ones. This remarkable increment shows, if confirmed for these last years and in the future, that this market is very rapidly renewing. .

For what concerns the data break down by energy efficiency classes (figures 2.1 and 2.2), the sales show in both the eastern and western markets a strong penetration of the A class (very strong for the eastern countries), the apparition of the A+ class (and for the w. countries also of the A++ class), the decreasing of the B class and the disappearance of the other low efficiency classes. This trend seems to be consolidated (as also confirmed in the next chapter 2.3 of the market trends) and should bring to the phase out of even the class B (that in two years has lost the 19 % of the market) in few years.

Finally figures 2.3 and 2.4 provide the percentage variation of the 2004 sales with respect those of the year 2002 by EU western and eastern countries and by EE classes. To easy the analysis the EE classes have been grouped in three categories: A++ & A+, A and B & C. These figures clearly show the dynamic of the market for each EU country: the longer histogram, the faster the market transformation of a country. Overall, with the exception of Greece, all classes A (A++, A+ and A) are increasing and classes B&C are decreasing. In the Netherlands even the class A has started decreasing.

Table 2.4 Refrigerators sales for the years 2002 – 2004 (units)

	TOTAL WEST		TOTAL East (cz hu pl sk)		TOTAL East
	January 2002 - December 2002	January 2004 - December 2004	January 2002 - December 2002	January 2004 - December 2004	January 2004 - December 2004
<Grand Total>	11.541.989	12.431.120	1.315.482	1.546.201	1.857.210
A ++	5.552	20.811	0	25	25
A +	125.509	724.853	282	41.140	56.297
A	4.651.801	6.865.883	345.144	932.093	1.138.703
B	4.455.311	3.730.621	761.130	494.211	559.360
C	1.695.030	798.017	193.774	70.694	81.535
D	106.789	40.800	1.692	787	1.002
E	18.626	5.330	357	93	93
F	10.350	1.902	286	1	1
G	13.719	5.973	18	0	1
UNKNOWN	459.304	236.929	12.799	7.157	20.192

Table 2.5 Refrigerators sales for the years 2002 – 2004 (%)

	West EU(***)	East EU (*)	West EU(***)	East EU (*)	East EU (**)
	2002		2004		2004 *
A ++	0,05	0,00	0,17	0,00	0,00
A +	1,09	0,02	5,83	2,66	3,03
A	40,30	26,24	55,23	60,28	61,31
B	38,60	57,86	30,01	31,96	30,12
C	14,69	14,73	6,42	4,57	4,39
D	0,93	0,13	0,33	0,05	0,05
UNKNOWN	4,35	1,02	2,01	0,47	1,09
Total	100,00	100,00	100,00	100,00	100,00

Figure 2.1 Refrigerators sales by energy efficiency classes in Western Europe

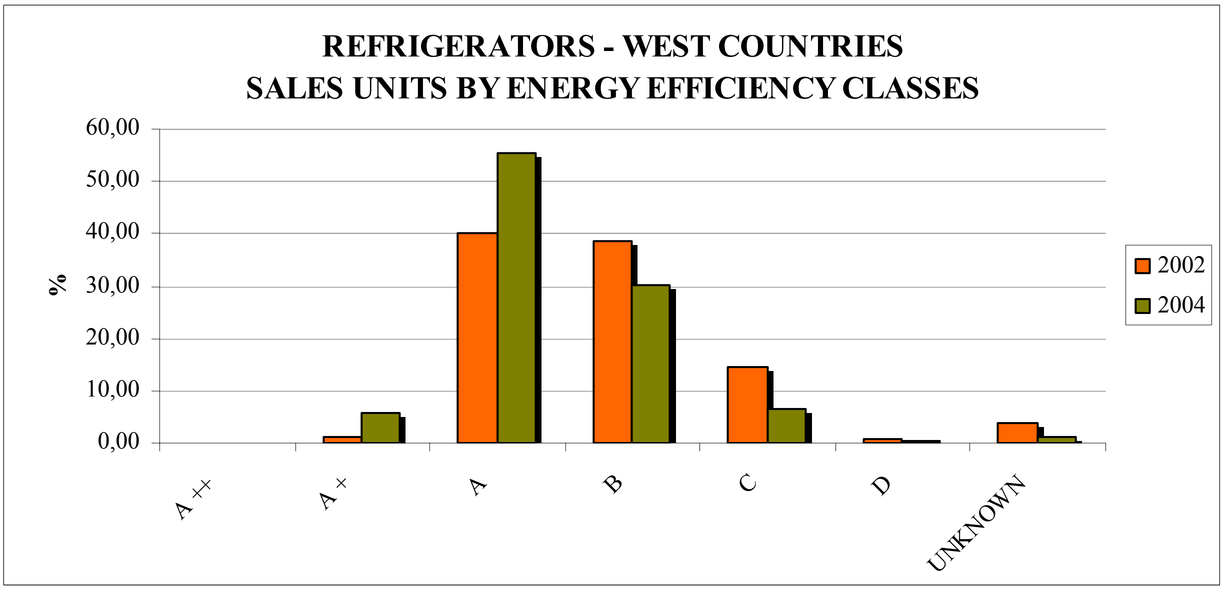


Figure 2.2 Refrigerators sales by energy efficiency classes in Eastern Europe (4 countries)

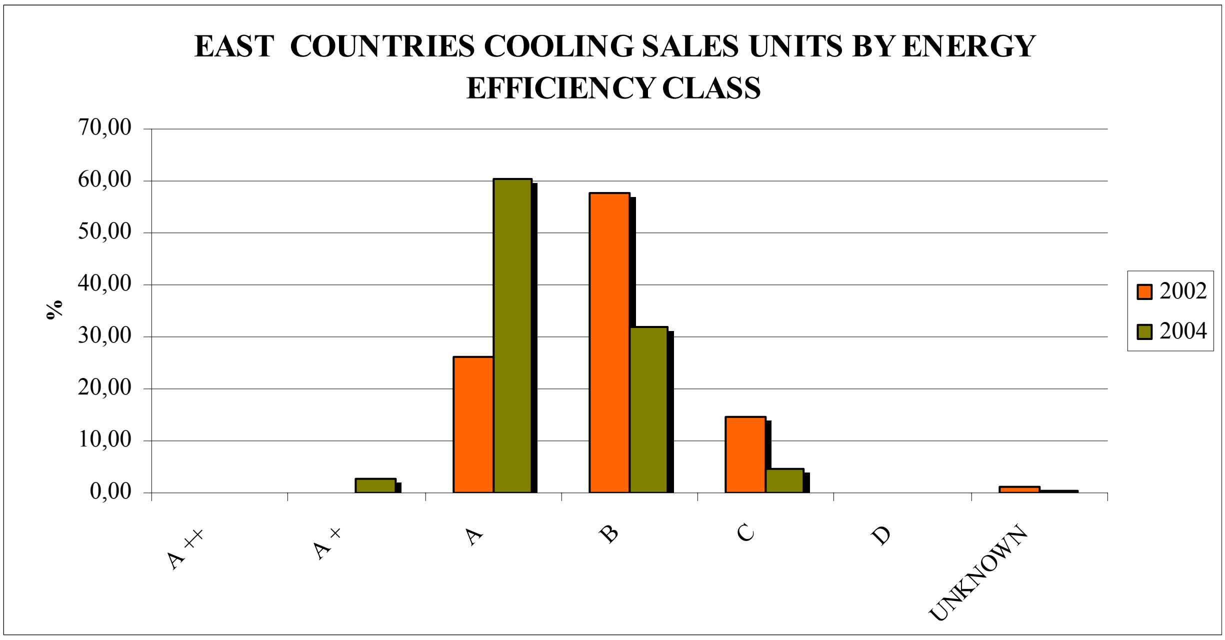


Figure 2.3 Refrigerators West EU- Sales Variation of the major EE classes in the years 2002 - 2004

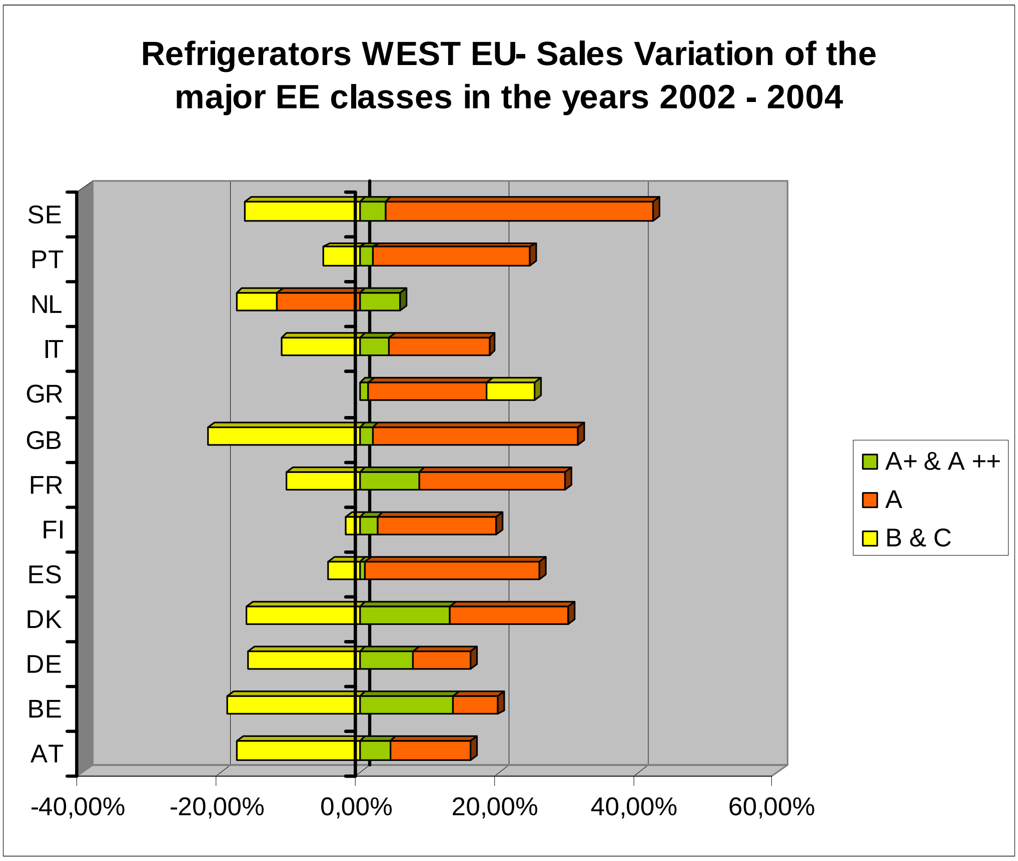
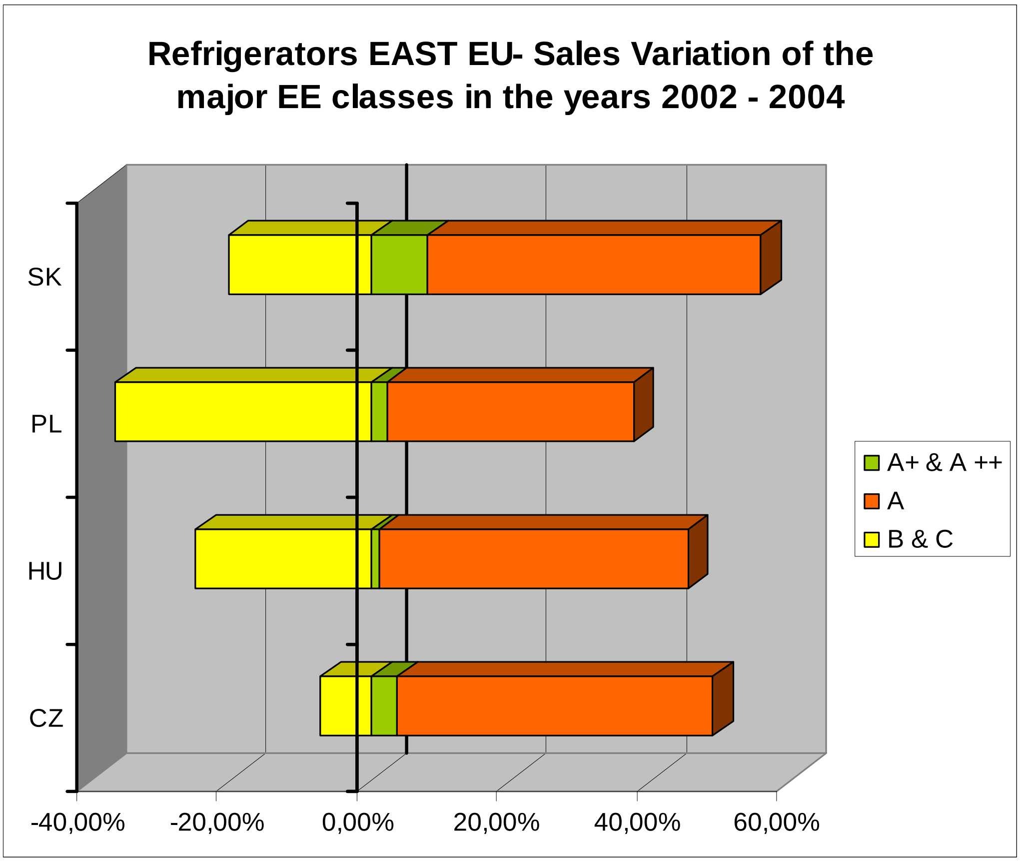


Figure 2.4 Refrigerators East EU- Sales Variation of the major EE classes in the years 2002 - 2004



b. Freezers

The following tables 2.6 (units) and 2.7 (percentage) and figures 2.5 and 2.6, show that the 2004 western and eastern sales (8 countries) exceed the 4 millions of units. In this case it is no possible to know the sales variation between these two years because the 2002 eastern countries data are missing.

Also for the freezers, and at least for the western countries, it is possible to observe the penetration of the high efficiency classes (especially the class A+) to the detriment of the other classes, but, in this case, the dynamic is less marked than in the refrigerators one. The B and C classes still represent the half of the market (45 % in 2004) and seem to decrease rather slowly.

Finally figure 2.7 provides the percentage variation, by the EU western countries and by EE classes, of the 2004 sales with respect those of the year 2002. The lower dynamic of the freezers market is again confirmed and the EU countries behave in a rather different way: in 4 countries out of 13 the decreasing of the lower EE classes is not yet started and the Italian data are controversial (the A class decreases and the B&C classes increase). Nevertheless the penetration of the A+ and A++ classes is greater than in the refrigerators case.

Table 2.6 Freezers sales for the years 2002 – 2004 (units)

	TOTAL WEST		TOTAL East
	January 2002 - December 2002	January 2004 - December 2004	January 2004 - December 2004
<Grand Total>	3.687.536	3.992.194	178.485
A ++	10.380	38.868	27
A +	67.977	394.515	10.869
A	1.099.347	1.392.590	21.495
B	1.062.780	1.048.746	64.152
C	826.865	766.549	46.630
D	231.020	179.529	31.086
E	207.871	62.742	2.383
F	37.305	14.777	548
G	27.122	11.215	30
UNKNOWN	116.869	82.664	1.266

Table 2.7 Freezers sales for the years 2002 – 2004 (percentage)

	West EU		East EU (**)
	2002	2004	2004
A ++	0,28	0,97	0,01
A +	1,84	9,88	6,09
A	29,81	34,88	12,04
B	28,82	26,27	35,94
C	22,42	19,20	26,13
D	6,26	4,50	17,42
E	5,64	1,57	1,34
F	1,01	0,37	0,31
G	0,74	0,28	0,02
UNKNOWN	3,17	2,07	0,71
Total	**100,00**	**100,00**	**100,00**

Figure 2.5 Freezers sales by energy efficiency classes in Western Europe

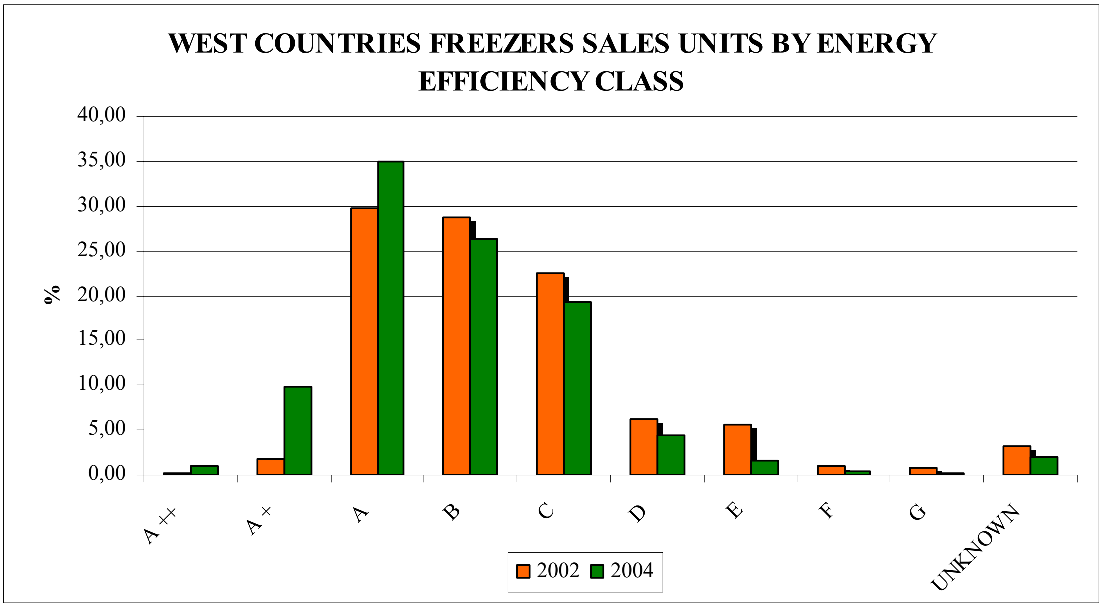


Figure 2.6 Freezers sales by energy efficiency classes in Eastern Europe (8 countries)

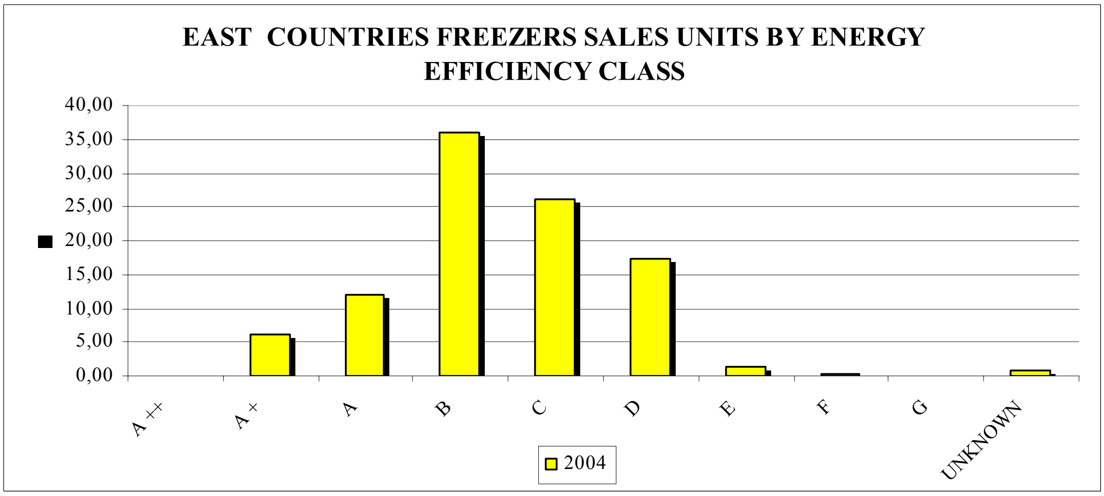
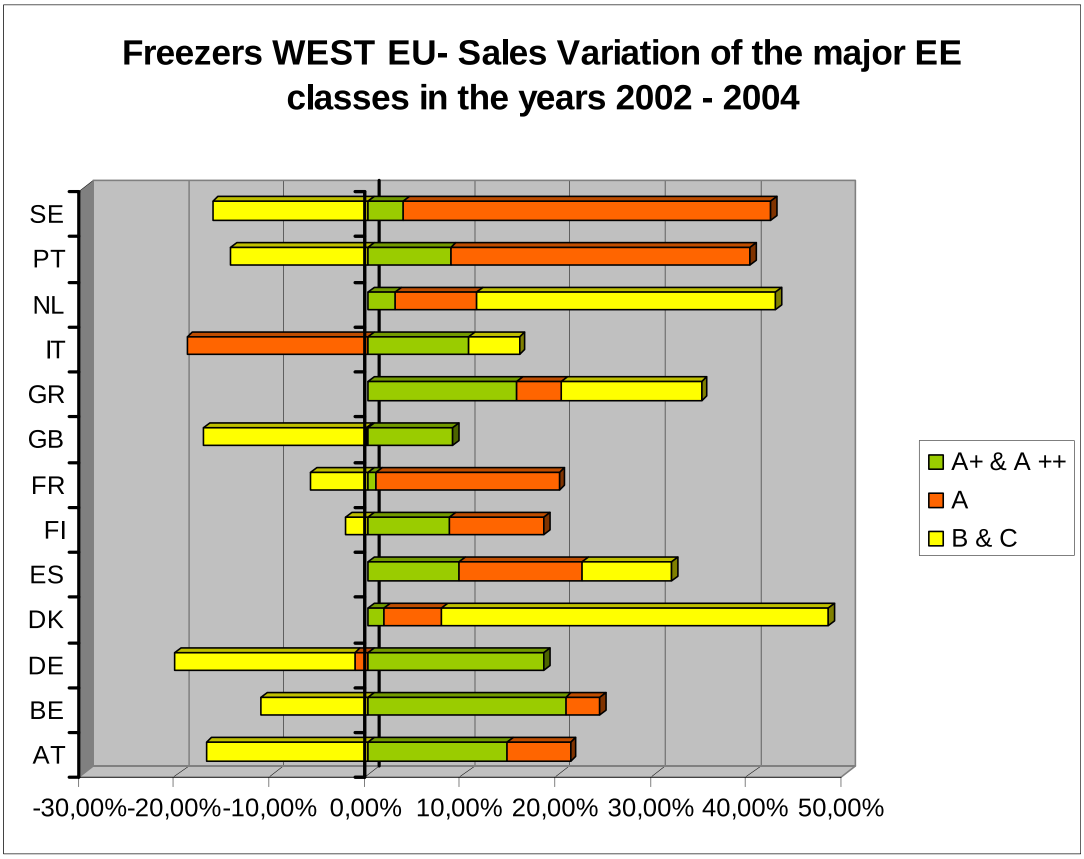


Figure 2.7 Freezers West EU- Sales Variation of the major EE classes in the years 2002 - 2004



2.2.1.3 The sales break down by litres categories

a. Refrigerators

Table 2.8 and figures 2.8 and 2.9 compare the 2002 sales per litres category with those of 2004. For the Eastern countries, only the four nations taken into account in the 2002 data are compared. The fifth columns of table 2.5 shows the 2004 sales data of all the 8 countries considered by GfK. GfK breaks down the refrigerators sales in 16 litres categories[105], but, for readability sake, we have reclassified these data in 7 broader categories. Nevertheless, to better understand where the market goes and which the producers policy is, it is worth zooming out the two main broad categories where the majority of the sales are concentrated (i.e. from 121 to 250 litres and from 251 to 400 litres) by using the more detailed GfK data. Looking at Figures 2.10 and 2.11[106], it is thus possible to see that:

- within the first category, the sales seem to concentrate on the edges of the interval (121-160 and 200-300 litres) with a remarkable market dynamic (especially in Western Europe): the smaller refrigerators seem to shift from the 120 litres category to the next one (161-180 litres) and the medium one from the 200 litres category to that of 251-300 litres.

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[105] The GfK categories are: >750 LTR; 651 - 750 LTR; 551 - 650 LTR; 450-500 LTR; 500-550 LTR; 401-450 LTR; 161-180 LTR; 181-200 LTR; 351-400 LTR; <120 LTR; 231-250 LTR; 141-160 LTR; 121-140 LTR; 201-230 LTR; 301-350 LTR; 251-300 LTR

[106] The percentages here refer to the total appliances sold

- the trend of the sales within the second category seem to indicate, in Western Europe, a shift toward bigger refrigerators (351-400 litres) and in Eastern Europe, the concentration on the 301-350 litres category

By using the GfK data it is finally possible to roughly figure out the average size of the refrigerators sold in these two years by assigning to each litres category its median value (to the first and last categories we have arbitrary assigned the value of respectively 80 and 800 litres) and weighting these estimates by the corresponding sales. The final results of this estimation is that in the Western countries the average refrigerators size is passed from the 237 litres of 2002 to the 244 litres of 2004 and in the Eastern countries from 236 to 241 litres. Overall it seems that the average size of the refrigerators is increasing in all Europe and that the differences between West and East are very small or even negligible (see also paragraph 2.3.2, figure 2.60).

Table 2.8 Refrigerators sales by litres classes for the years 2002 – 2004 (in percentage and totals in units)

	West EU	East EU (*)	West EU	East EU (*)	East EU (**)
	2002		2004		2004
<120 LTR	3,60	3,03	5,84	4,91	4,64
121-250 LTR	51,00	56,25	45,88	48,91	47,04
251-400 LTR	36,47	38,13	39,75	43,95	45,85
401-500 LTR	1,90	0,34	2,54	0,64	0,65
501-750 LTR	1,58	0,28	2,54	0,37	0,42
>750 LTR	0,06	0,00	0,01	0,01	0,01
UNKNOWN	5,39	1,96	3,42	1,20	1,40
Total	100,00	100,00	100,00	100,00	100,00
Absolute value	**11.541.989**	**1.315.482**	**12.431.957**	**1.546.201**	**1.857.210**

Figure 2.8 West EU: refrigerators sales by litres classes for the years 2002 – 2004

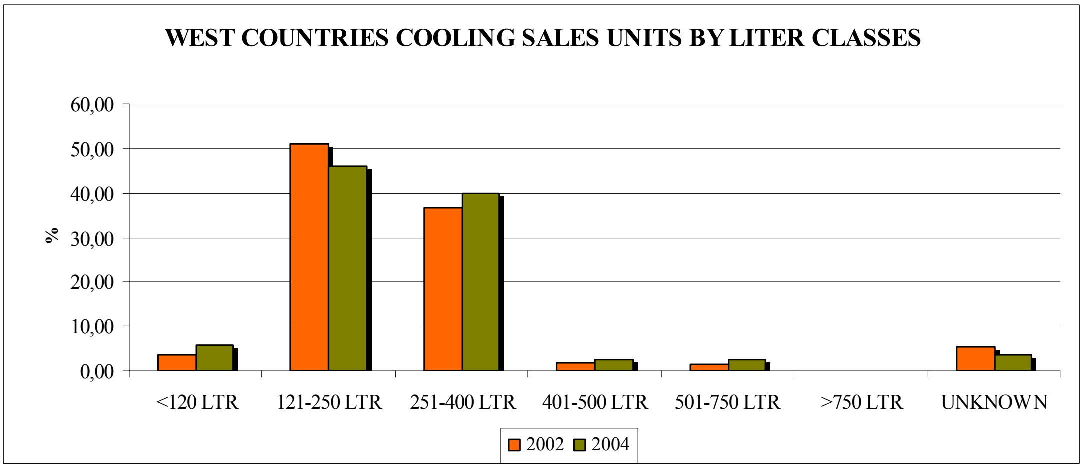


Figure 2.9 East EU: refrigerators sales by litres classes for the years 2002 – 2004

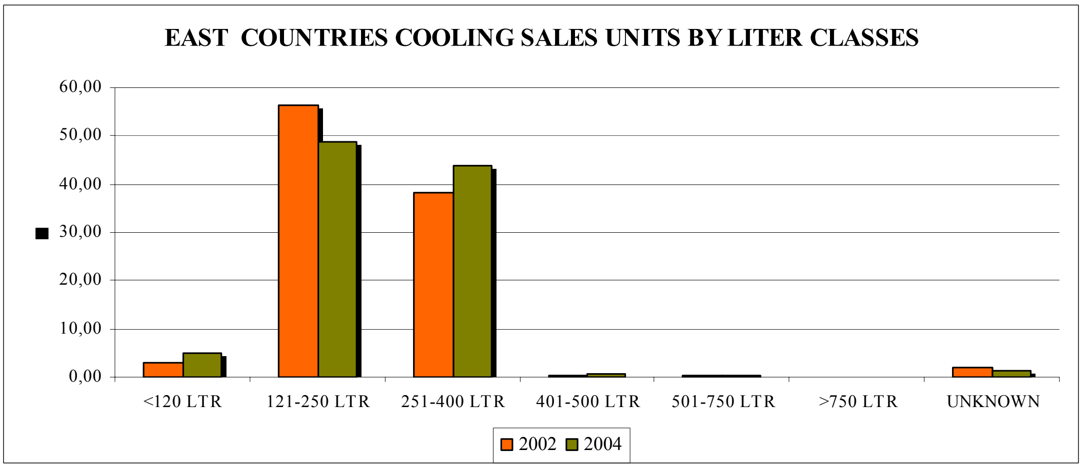


Figure 2.10 West EU: refrigerators sales by litres classes for the years 2002 – 2004 (Detail)

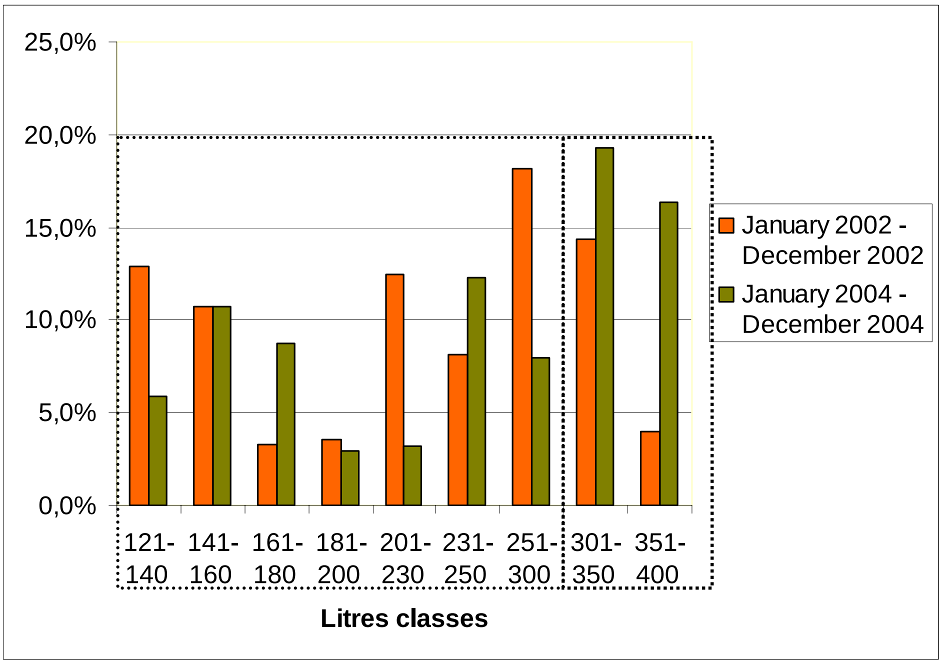
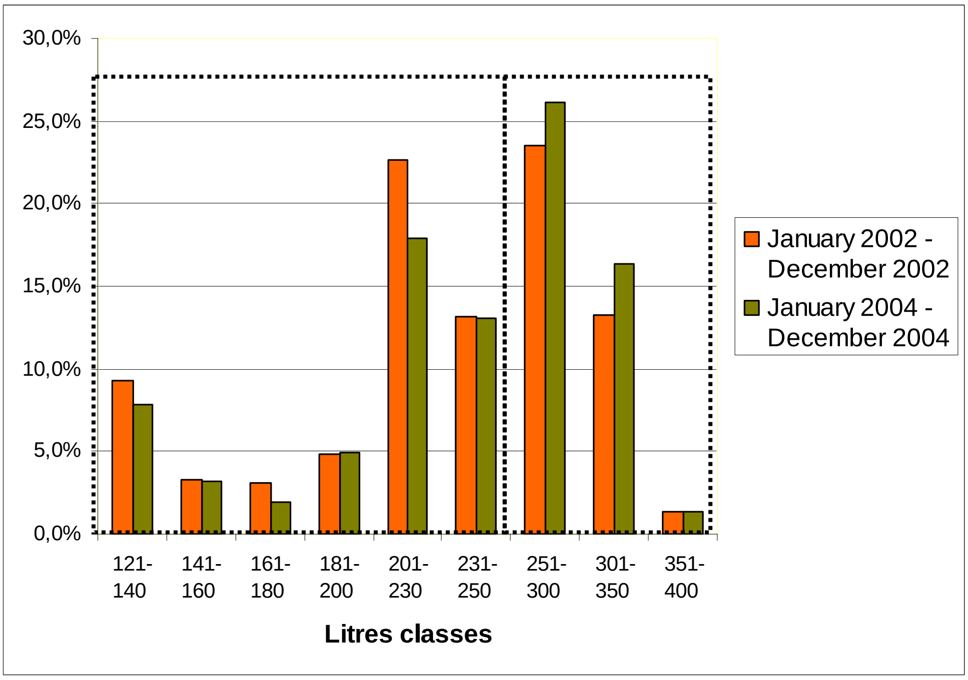


Figure 2.11 East EU: refrigerators sales by litres classes for the years 2002 – 2004 (Detail)



b. Freezers

As in the case of the refrigerators, also here table 2.9 and figures 2.12 and 2.13, compare the 2002 sales per litres category with those of 2004. For the Eastern countries only the 2004 are provided. The sales data have been classified, at first glance, in 6 broad categories to have a first, immediate, view on their distribution (see Figures 2.12 and 2.13). Also in this case we have two big categories where the sales are concentrated: from 81 to 180 litres and from 181 to 300 litres. To better understand the market dynamics, it is again worth zooming out these two categories obtaining the histograms shown in figures 2.14 and 2.15[107]. Looking at these figures, it is thus possible to argue that:

- within the first category, in both the East and West Europe, the sales seem to concentrate on the left edge of the interval and in particular on the smaller appliances. In Western Europe the market dynamic seem to indicate a slow shift toward the 121-160 litres class (and also the 160-180 litres category seem to increase a little).
- within the second category the sales are concentrated in the 201-250 litres category in Western Europe, and in the bigger 251-300 litres category in eastern Europe (where account for the 20 % of the total freezers sales)

[107] The percentages here refer to the total appliances sold

Table 2.9 Freezers sales by litres classes for the years 2002 – 2004 (in percentage and totals in units)

	West EU		East EU
	2002	2004	2004(*)
<80 LTR	7,92	7,08	4,62
81-180 LTR	49,76	48,64	31,69
181-300 LTR	34,70	37,16	52,37
301-400 LTR	3,45	3,75	5,53
401-500 LTR	1,34	1,25	4,10
>500 LTR	0,46	0,38	0,29
UNKNOWN	2,37	1,74	1,40
Total	100,00	100,00	100,00
Absolute value	**3.687.536**	**3.992.194**	**204.764**

Figure 2.12 West EU: freezers sales by litres classes for the years 2002 – 2004

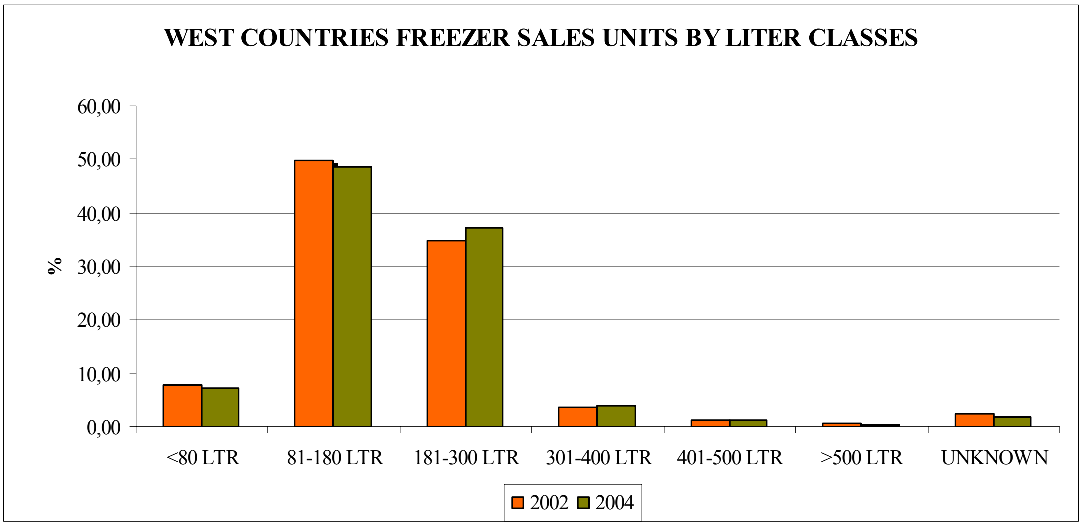


Figure 2.13 East EU: Freezers sales by litres classes for the years 2002 – 2004

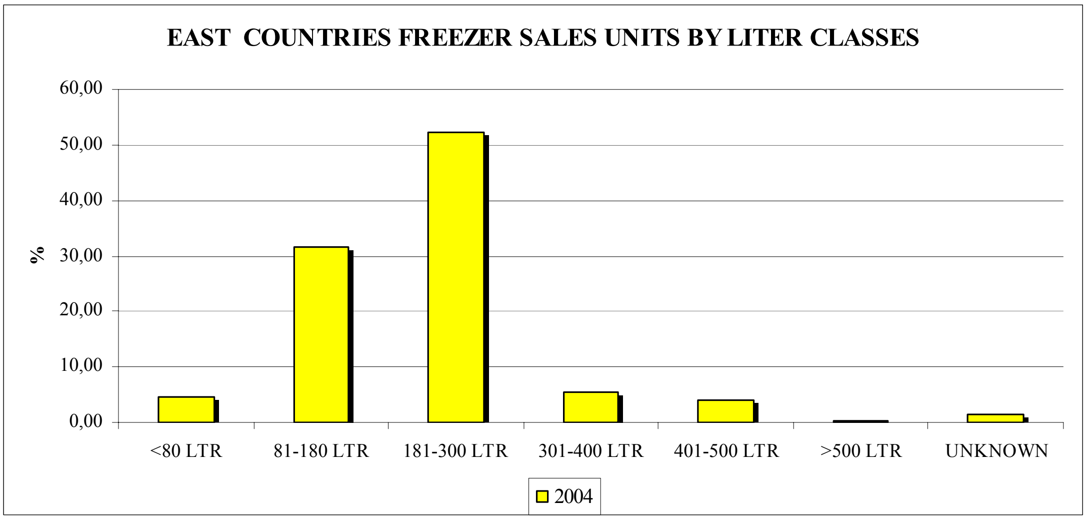


Figure 2.14 West EU: freezers sales by litres classes for the years 2002 – 2004 (Detail)

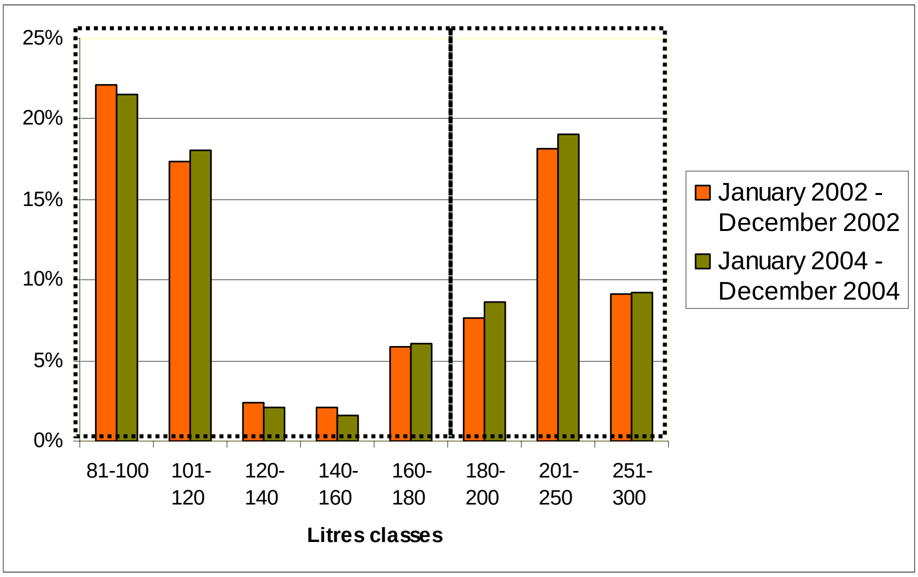
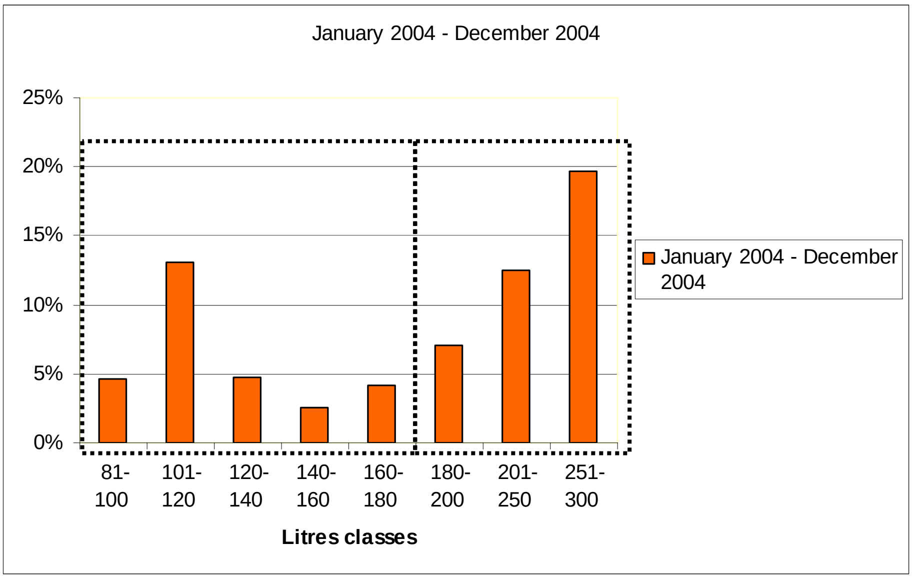


Figure 2.15 East EU: freezers sales by litres classes for the years 2002 – 2004 (Detail)



2.2.1.4 The sales break down by Star categories

Table 2. 10 and figures 2.16 and 2.17 provide the sales break down by the star categories. As usually, table 1.10 shows the comparison between the 2002 and 2004 sales in percentage and in absolute values and, for the Eastern countries, only the four nations taken into account in the 2002 data are compared. The fifth column of table 2.10 shows the 2004 sales data of all the 8 countries considered by GfK.

The data show the well known and almost stabilized market situation where the 4 star refrigerators dominate the sales in both parts of Europe. In Western Europe is worth noting the presence of the 20 % of 0 star refrigerators, mostly owned by families that generally also have a separated freezer.

Table 2.10 Refrigerators sales by Star classes for the years 2002 – 2004 (in percentage and totals in units)

	West EU	East EU (*)	West EU	East EU (*)	East EU (**)
	2002		2004		2004 *
WITHOUT FREEZER	21,19	5,94	21,54	5,16	5,68
1 STAR	2,39	0,84	2,34	2,95	2,67
2 STARS	4,43	6,72	3,44	3,52	3,22
3 STARS	1,16	3,68	0,59	2,02	2,31
4 STARS	70,45	82,80	72,06	86,12	83,59
Others/Unknowns	0,38	0,02	0,03	0,24	2,54
Total	100,00	100,00	100,00	100,00	100,00
Absolute value	**11.541.989**	**1.315.482**	**12.431.120**	**1.546.201**	**1.857.210**

Figure 2.16 West EU: refrigerators sales by litres classes for the years 2002 – 2004

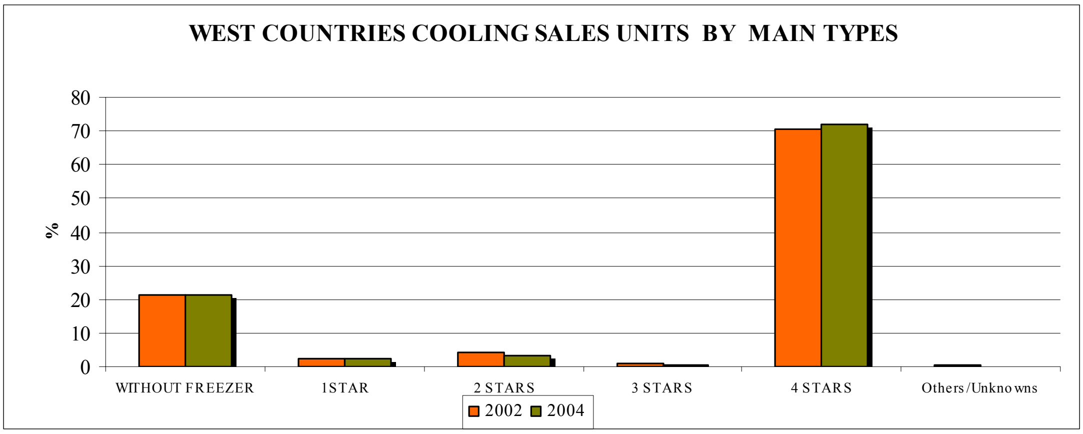
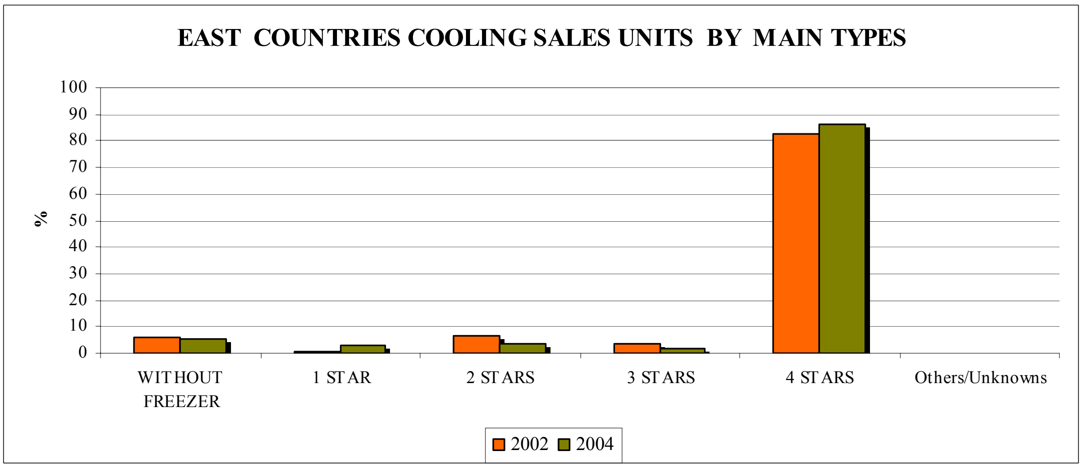


Figure 2.17 East EU: refrigerators sales by litres classes for the years 2002 – 2004



2.2.2 Market data: Price analysis

The following analysis of the cold appliances prices is developed in three steps:

- the 2002-2004 (weighted) average EU prices comparison of the main EE categories (from A++, where available, to C);
- the global prices trend of the whole refrigerators and freezers compartments from 1996 to 2004;
- and finally a by country overview on the 2004 price difference between the EE categories (min, max and average).

All the prices are expressed in value 2004[108] and, as usual, the data source is the German firm GfK.

[108] The prices have been rescaled to 2004 by using the "Harmonised Indices of Consumers Prices" figures provided by Eurostat

2.2.2.1 2002-2004 EU prices comparison

Refrigerators

Tables 2.11 and 2.12 as well figures 2.18 and 2.19 provide the price comparison between the years 2002 and 2004. As usual, for the Eastern countries, only the four nations taken into account in the 2002 data are compared. Overall the average refrigerators prices decline (5 % in Western Europe and 14 % in Eastern Europe) but in Western Europe the A++ and A+ prices have notably increased with respect the 2002 of respectively the 14 % and 17 %. It is moreover worth noting here the substantial difference of price between the Western and Eastern prices (41 % for the refrigerators!). This difference is probably the result of a particular price policy carried out by the manufacturers in the new accession countries. Figure 2.20 shows, for instance, the West/East price comparison among the cold and wet appliances.

It is worth adding that, to better analyse this price difference, we should compare the prices per litre but, unfortunately, we don't have the data on the sales per litres *and* per energy efficiency category and so we can't carry out this more precise comparison. In any case the figures 2.10 and 2.11 of paragraph 2.2.1.3 (page 17) show that there are not a substantial difference for what concerns the average size of the refrigerators between the EU 15 and the EU 10 countries.

Finally figure 2.21 shows the prices trend by some western EU countries of the entire refrigerators compartment from the year 1996 up to the year 2004. It is interesting to see here that at the beginning, till the year 2002, the prices trend were rather different among the EU countries: in some the prices steadily decreased in other increased as in Italy, UK and, partially, Spain. After the 2002 all the prices decline confirming the data carried out in tables 2.11-2.12 and figures 2.18 and 2.19. The initial price increasing of the above mentioned countries is probably the consequence of the deep market transformation occurred during the years 90' in that nations.

Table 1. 2.11 Refrigerators prices comparison by EE categories for the years 2002 – 2004

	West EU		East E. 4	
	2002	2004	2002	2004
Weighted Average	481	457	360	316
A ++	444	516		627
A +	439	534	695	420
A	538	496	394	342
B	450	392	358	273
C	411	358	308	224

Table 1. 2.12 Refrigerators prices comparison by EE categories, % variation 2004 /2002

	% 2004/2002	
	West EU	East EU
Weighted Average	-5,2%	-13,8%
A ++	14,0%	100,0%
A +	17,7%	-65,5%
A	-8,4%	-15,4%
B	-14,8%	-31,2%
C	-14,8%	-37,2%

Figure 2.18 West EU: Refrigerators prices comparison by EE categories for the years 2002 – 2004

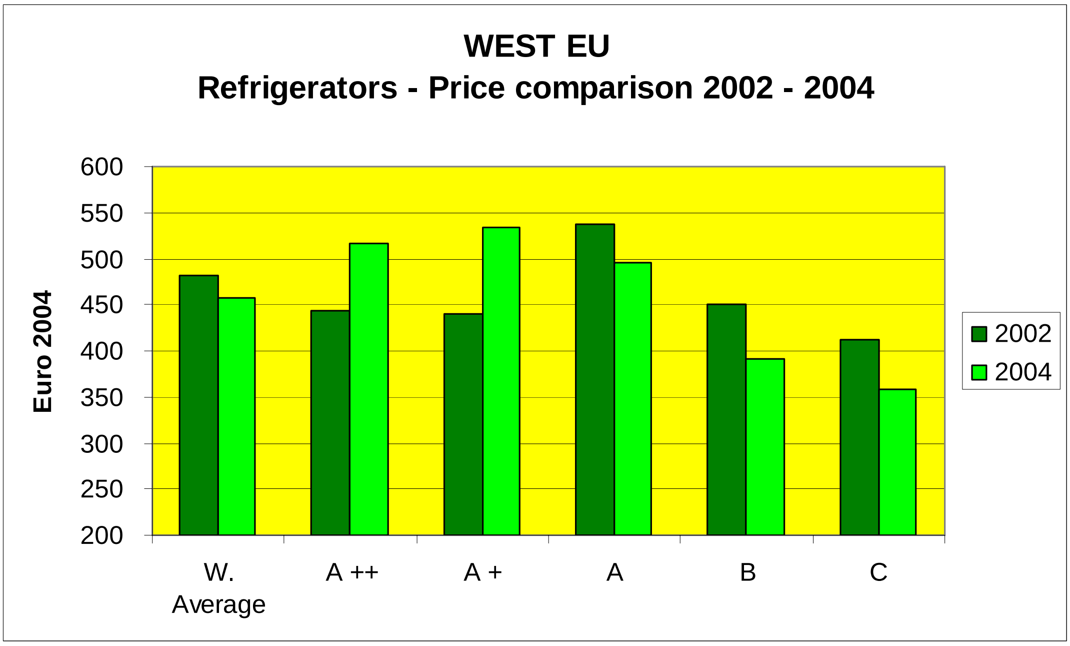


Figure 2.19 East EU: Refrigerators prices comparison by EE categories for the years 2002 – 2004

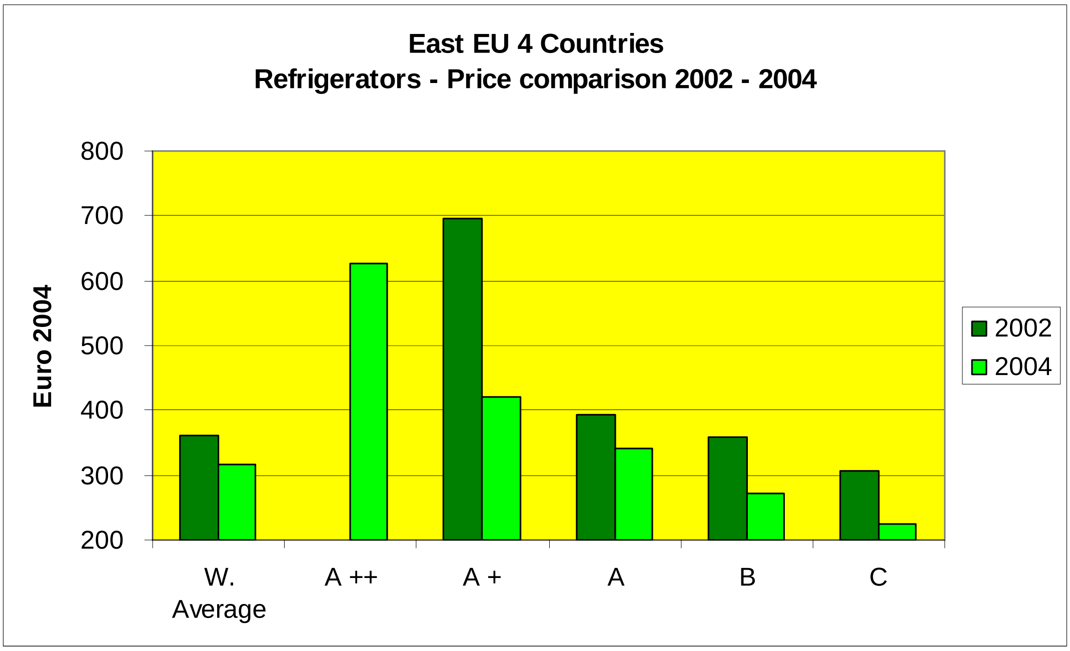


Figure 2.20 Prices West-East comparison for the cold and wet appliances.

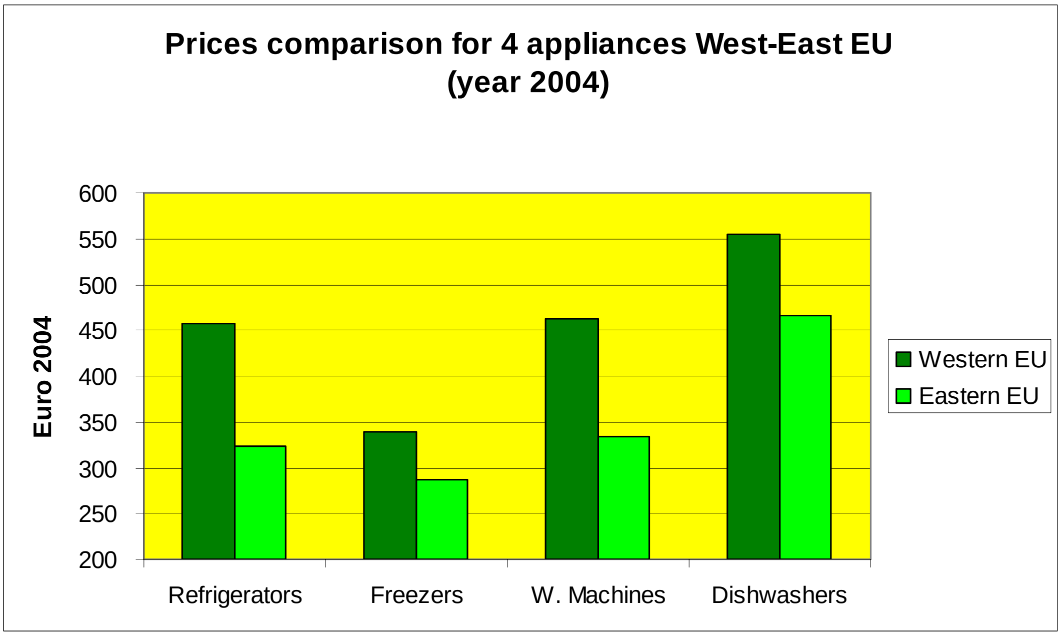
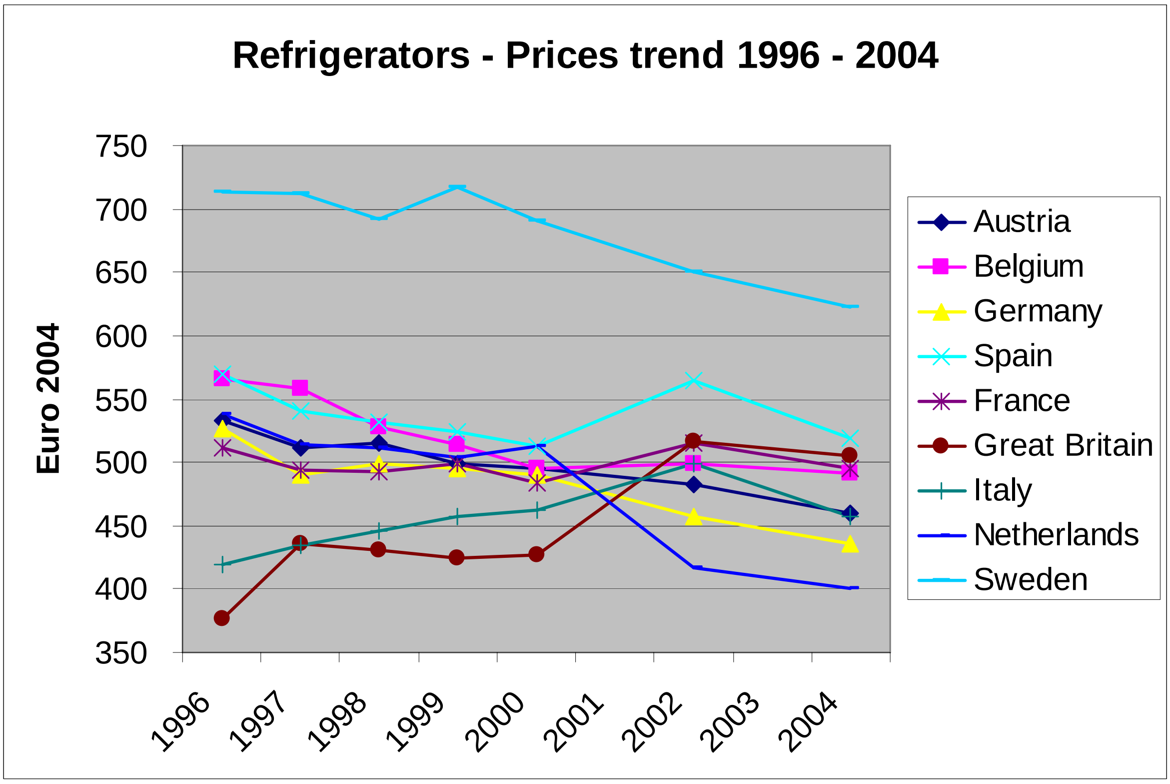


Figure 2.21 EU western countries: 1996 – 2004 prices trends for refrigerators.



Freezers

Tables 2.13 and 2.14 as well figures 2.22 and 2.23 provide the price comparison between the years 2002 and 2004 for the freezers compartment. As usual, for the Eastern countries, only the 2004 data are available. The freezer prices decline considerably in all the considered EE categories (with the exception of the A+ category). It is worth noting that, in both West and East EU countries, the prices difference among the EE categories seems to be linearly scaled up. Finally, also in this case there is a substantial difference of price between the Western and Eastern prices.

Table 2.13 Freezers prices comparison by EE categories for the years 2002 – 2004; absolute values

	West EU		East EU
	2002	2004	2004
W. Average	376	339	288
A ++	717	556	425
A +	460	458	373
A	437	368	330
B	368	311	284
C	295	253	243

Table 2.14 Freezers prices comparison by EE categories for the years 2002 – 2004; % variation

	West EU
	% 2004/2002
W. Average	-10,7%
A ++	-28,9%
A +	-0,5%
A	-19,0%
B	-18,4%
C	-16,7%

Figure 2.22 East EU: Freezers prices comparison by EE categories for the years 2002 – 2004

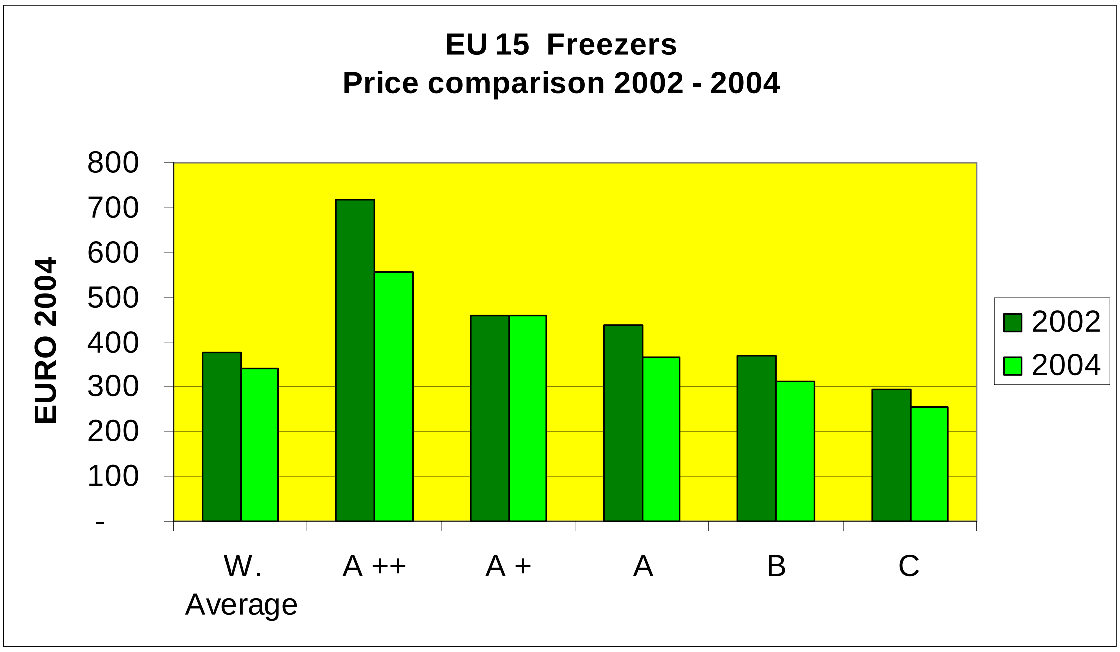
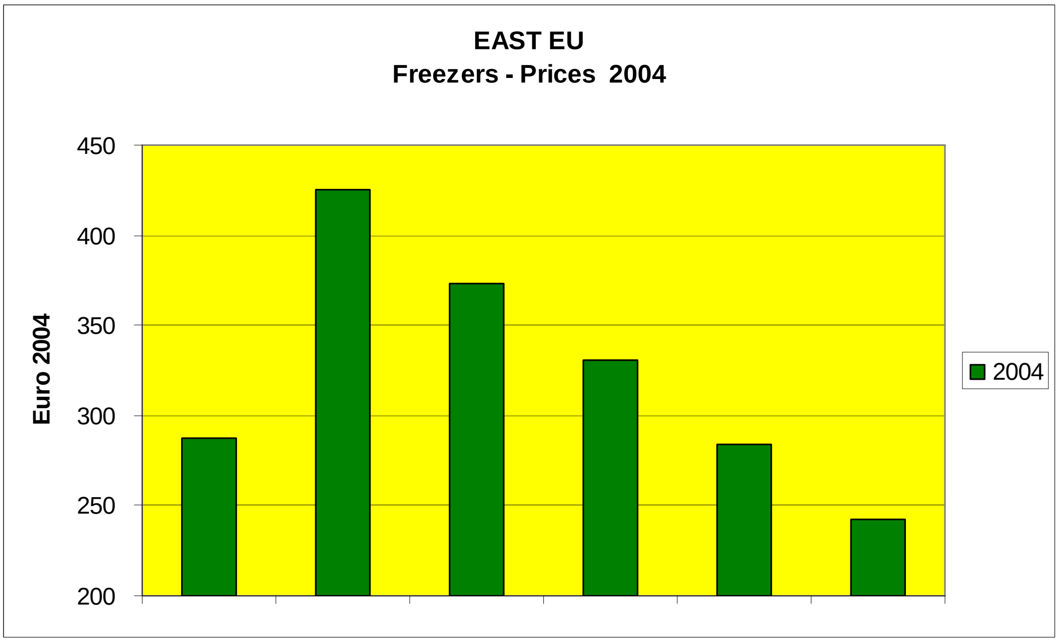


Figure 2.23 East EU: Freezers prices by EE categories for the year 2004

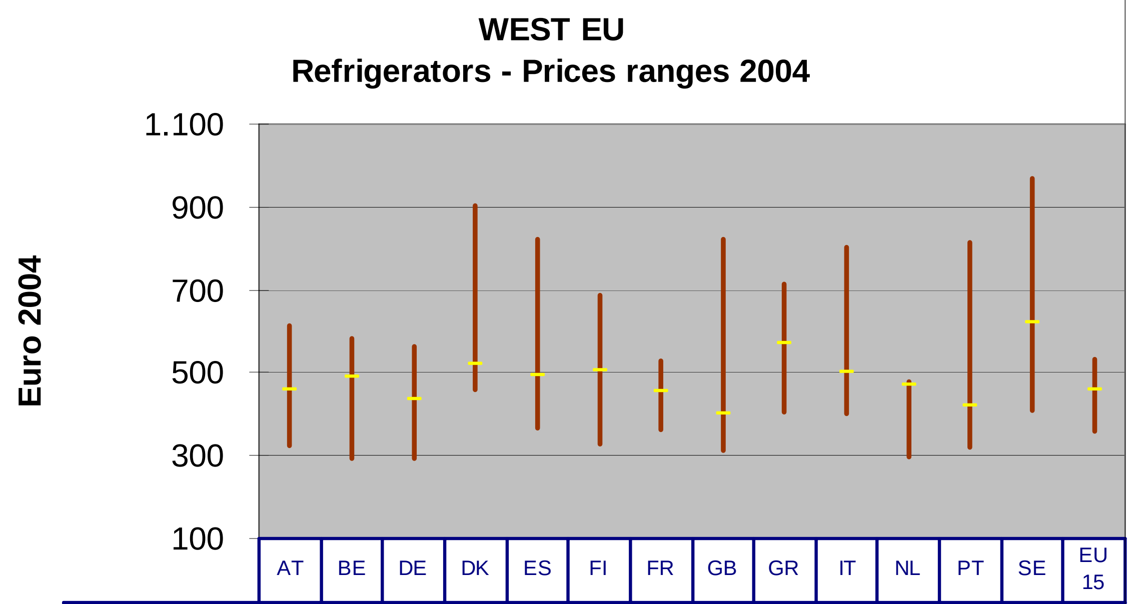


2.2.2.2 2004 EU prices analysis

Refrigerators

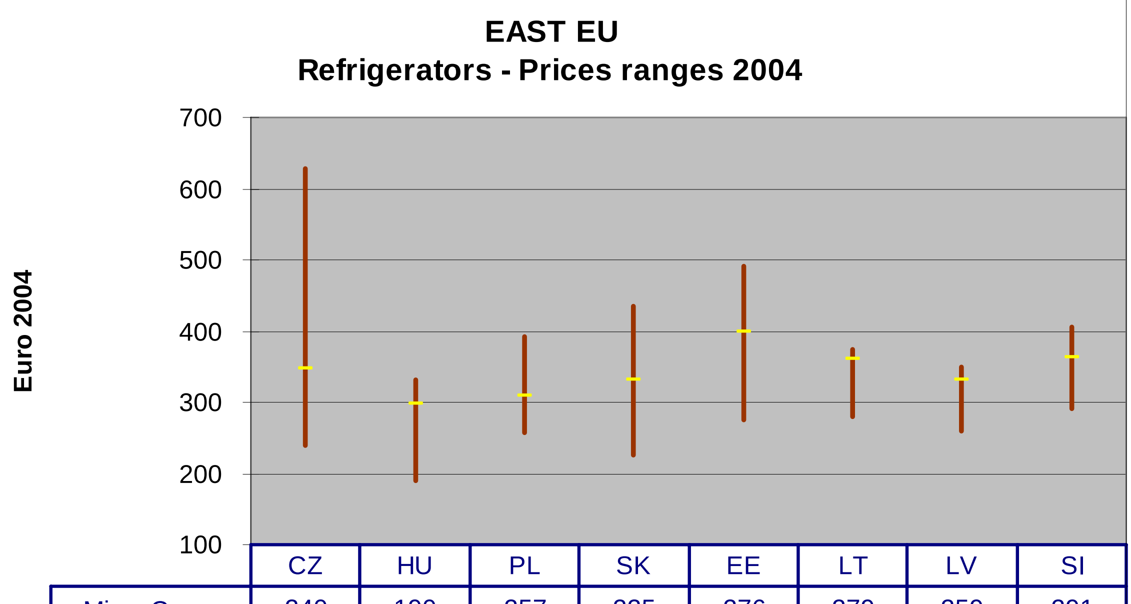
Figures 2.24 and 2.25 show the prices interval of the appliances sold in the West and East EU markets ranked by the highest and the lowest EE classes. The horizontal mark in between the vertical bars indicates the average refrigerators price. As the table below the graph indicates, in general the average price coincide or is very close to the A class appliances. At first glance the closer id this mark to the top of the bars, the fastest is the corresponding market transformation speed. In figure 2.25 the maximum for the Czech Republic corresponds to the A++ class while in all the other cases to the A+ or A classes.

Figure 2.24 EU western countries: 2004 prices ranges for refrigerators.



	AT	BE	DE	DK	ES	FI	FR	GB	GR	IT	NL	PT	SE	EU 15
Min = C	324	292	295	459	365	327	364	313	404	403	299	322	407	358
Max = A++ or A+	613	581	563	905	823	688	527	822	713	801	480	813	968	534
W. Average	460	491	436	519	495	505	457	401	573	502	470	421	622	457
Class A	484	513	443	518	620	562	504	447	704	565	477	534	637	496

Figure 2.25 EU eastern countries: 2004 prices ranges for refrigerators.

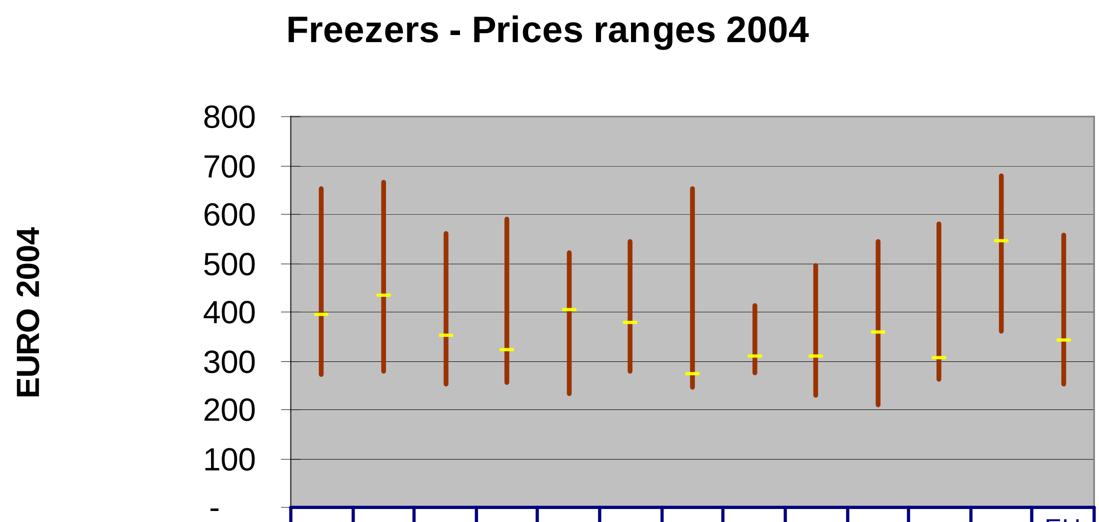


	CZ	HU	PL	SK	EE	LT	LV	SI
Min = C	240	190	257	225	276	279	259	291
Max = A+ or A	627	330	391	435	492	374	349	405
W. Average	347	298	308	332	399	361	331	363
Class A	377	330	327	354	413	364	349	405

Freezers

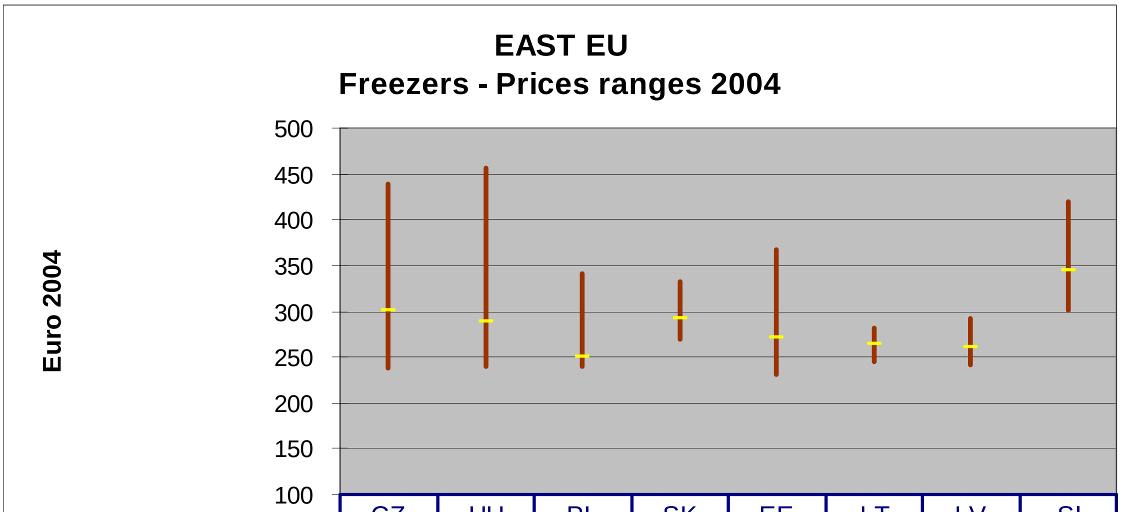
As in the refrigerators case, also here the prices interval of the appliances sold in the West and East EU markets, ranked by the highest and the lowest EE classes, are provided by figures 2.26 and 2.27. The horizontal mark in between the vertical bars indicates the average freezer price. For freezers the average price doesn't coincide, apart from few countries, with the A class price and, in some cases, is considerably lower. Overall the graphs confirm the impression, already provided by the sales analysis of this compartment, of a market that's transforming rather slowly (actually, the majority of the average prices are closer to the lower edge of the vertical bars, indicating a concentration of the EE classes around the A/B categories).

Figure 2.26 EU western countries: 2004 prices ranges for freezers.



	AT	BE	DE	ES	FI	FR	GB	GR	IT	NL	PT	SE	EU 15
Min = C	272	278	254	257	232	278	246	277	231	210	262	359	253
Max = A++ or A+	652	664	561	589	521	543	653	414	495	544	582	679	556
W. Average	395	434	351	323	404	378	271	308	309	357	306	543	339
A class	402	461	338	552	518	453	282	411	379	335	391	659	368

Figure 2.27 EU eastern countries: 2004 prices ranges for freezers.



	CZ	HU	PL	SK	EE	LT	LV	SI
Min = C or B	238	240	240	270	231	245	241	300
Max = A++, A+ or A	440	457	341	332	368	281	293	419
W. Average	301	289	251	292	271	263	260	344
A class	310	310	341	305	350	281	293	419

2.2.3 Stock data

2.2.3.1 Description of the Stock Model

A "stock model" is defined as a mathematical representation of one or more characteristics of the products in use ("the stock") in a specified time period, as a function of the age of these products.[109] The model uses a bottom-up approach to energy consumption based on the number households and the energy average consumption by household appliance.

In order to build up the "stock model" it needs:

- A set of sales (actual or estimated through market evaluation) and the so called "Remain" that is the share of devices sold in the year j that are working in the year k;

$$Stock\ (j,k) = Sales\ (j) \times Remain\ (j,k)$$

- Or a Household succession and the related "ownership" that is the market share.

$$Stock\ (k) = Households\ (k) \times Ownership\ (k)$$

As the "ownership" does not exist for all the years it should be estimated through a not linear interpolation, as linearity enhances the miscalculation (the difference between the actual value and

[109] Rainer Stamminger " Energy consumption of domestic appliances in European households CECED

the estimation). More realistic is to adopt the Gompertz function, where the growth speed is always proportional to the real event, but the scale decreases exponentially according to the time.

The formula is:

$$Y = A \exp(-\exp(-B(X-C)))$$

The asymptotic value depends on the starting point, which is different from a simple logistics model where, independently from N(0), the "entire group" tend to the M value (highest value of the function). The function is estimated through a non linear regression. Its parameters, B, C are estimated through the minimum square Gauss- Newton method.

After having estimated the Stock (k) is possible to estimate the sales through the following formula:

$$ESTsales\ (k) = Stock\ (k) - \sum_{i=i0}^{k-1} ESTsales\ (i) * \mathrm{Re}\ main\ (i,k)$$

where the "remain" is a probabilistic function like this:

$$Remain\ (i,k) = Prob(\ Sales\ (i) \in Stock\ (k)) \Rightarrow P_n(x) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{x} e^{\frac{(x-\mu)^2}{2\sigma}} dx$$

In the above formula μ is the average appliances lifetime[110] and σ the lifetime standard deviation.

The "Remain" function (j,k) provides the share of appliances sold in the year j that are still working in the year k. For calculating "remain" (j,k) we assume the appliances average lifetime as a normal distribution with average and standard deviation known .

Finally, to calculate the annual energy consumption of an appliance stock over a range of future years, the following the formula is used:

$$ENERGY(k) = \sum_{k=1950}^{2005} \sum_{j=1950}^{k} Sales(j) * \mathrm{Re}\,main(j,k) * EnergyAverageConsumption(j)$$

Where:

- *Energy(k)* is the estimated Total Energy Consumption of appliances in year k;
- *Sales (j)* is the number of appliances sold in year j;
- *Remain (j, k)* is the probability that the appliances sold in year j are still remaining in the stock in year k;
- *Energy Average Consumption (j)* is the unitary average energy consumption of the appliances sold in year j.

---

[110] The average lifetime is the duration when 50 % of the devices sold in a given year are no longer in the stock

2.2.3.2 Stock model results for Refrigerators in EU15

The input parameters that are required for the period 1950-2005 are:

- the *unitary energy average consumption* of the product in the year of built or import (kWh /app. year) [111];
- the *number households* in EU15 ;
- the *ownership rate*

The unitary energy consumption data used by the models are shown in the following table 2.15

Table 2.15 Unitary Energy Average Consumption of Refrigerators in EU 15(kWh/app year)

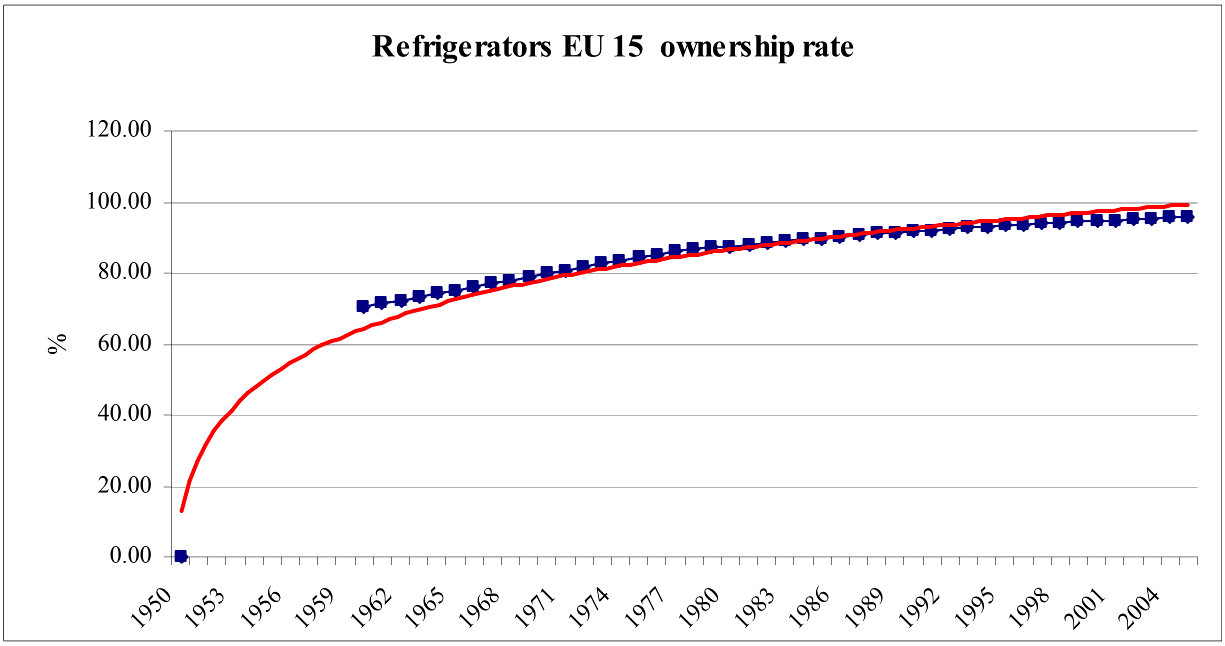
Year	Energy Average Consumption (kWh/year)
1950-1979	839
1980-1984	586
1985-1990	526
1990-1994	482
1995	425
1996	437
1997	432
1998	411
1999	382
2000	363
2001	334
2002	328
2003	317
2004	308
2005	292

The number of households in EU15 has been calculated summing up the data of each relevant country.

The ownership rate is estimated assuming:

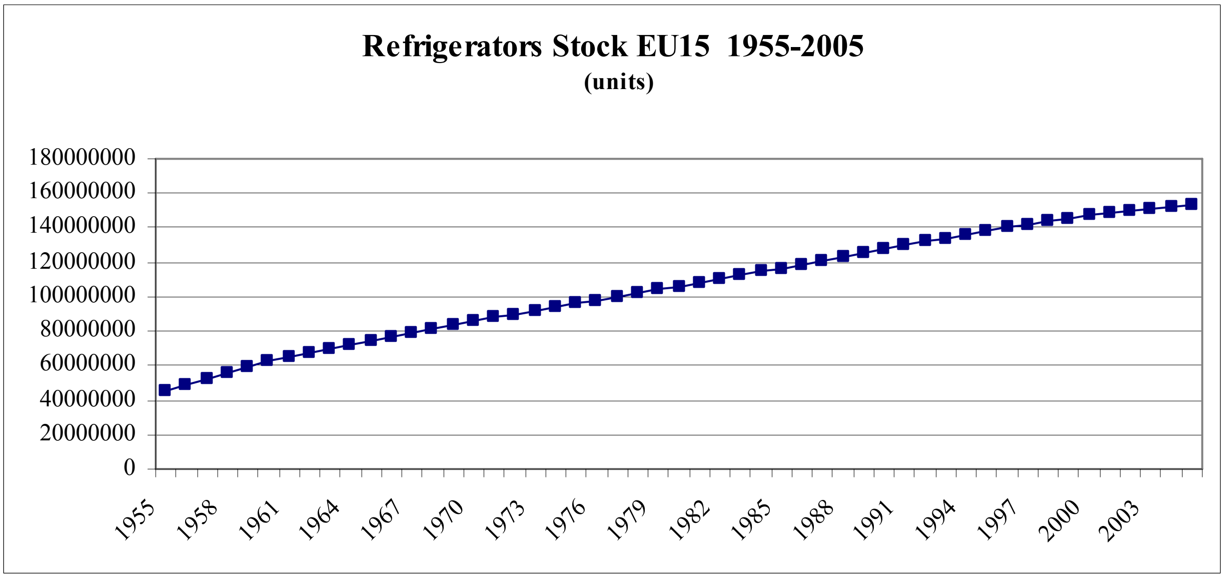
1. before year 1950 there were no refrigerators ;
2. the growth is depicted through a linear logistic function. The refrigerators market is totally saturated and is supposed to go beyond the 100%[112]

[111] Source: CECED databases and stock model [ref 6]



From the above data it has been estimated the refrigerators stock trend for the years 1950 – 2005 (figure 2.28).

Figure 2.28 Refrigerators stock trend for EU 15 (1955 – 2005)

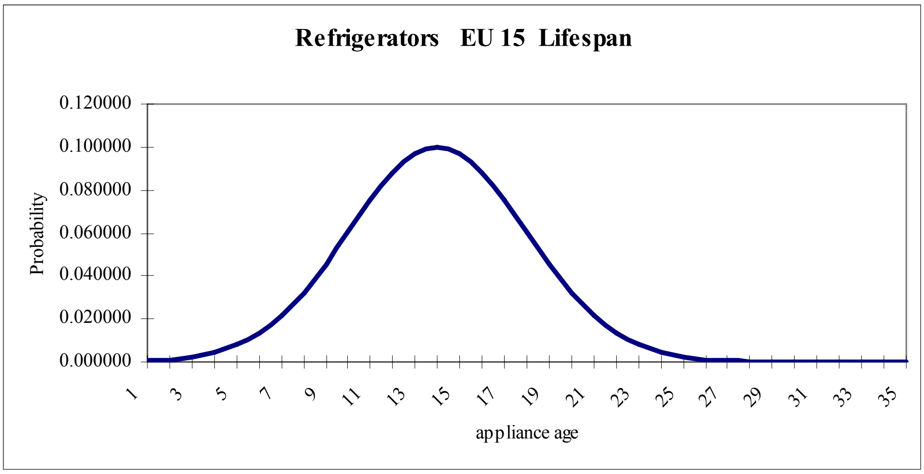


After estimation of the stock, the sales have been thus calculated through the following formula.

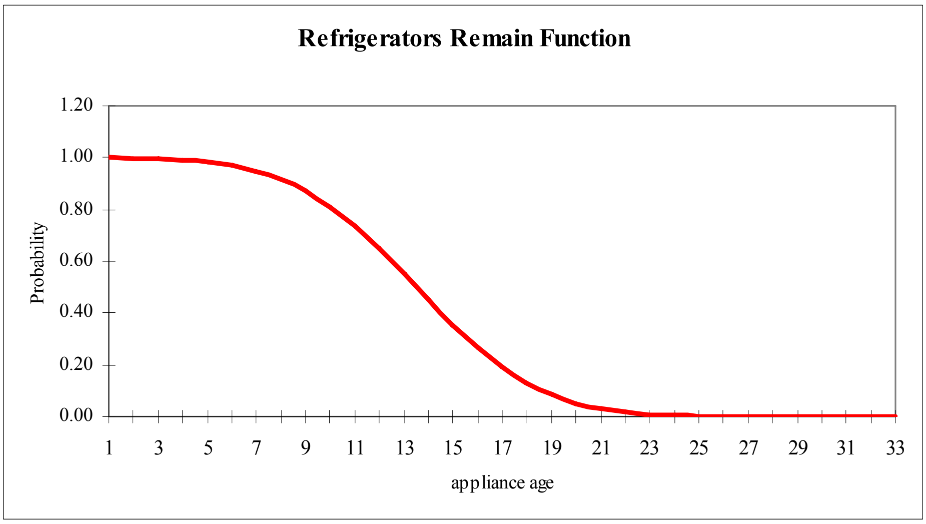
[112] Actually many household own more than one refrigerator due to the phenomenon of the second holiday houses, but not all these refrigerators work at the same time during the year.

(1) $$ESTsales(k) = Stock(k) - \sum_{i=i0}^{k-1} ESTsales(i) * \mathrm{Re}\,main(i,k)$$

The Remain (i,k) function has been calculated assuming that the probability of life average is distributed as a normal function with average and standard deviation known (14 years and 4 years)[113].



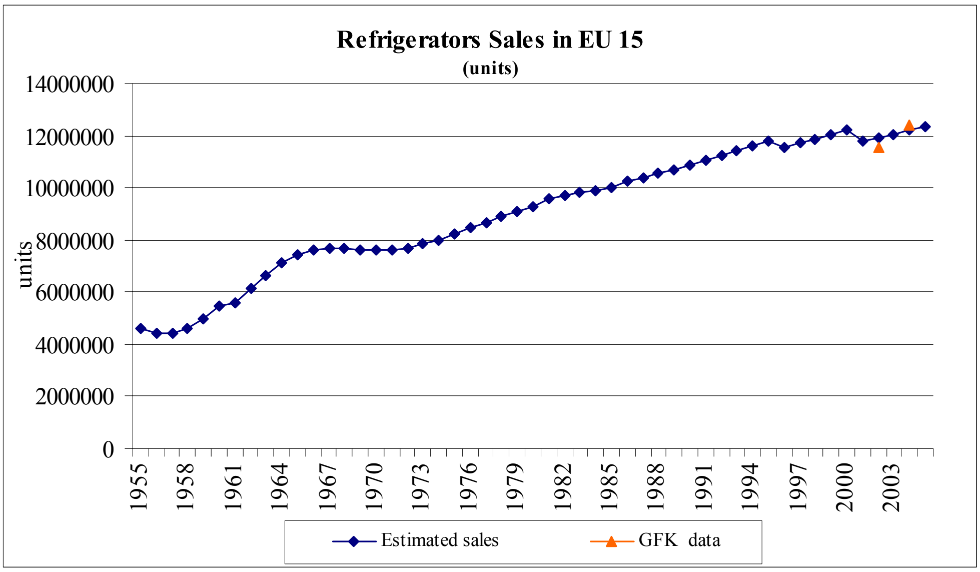
The trend of the function *Remain (j, k)*, that is the probability that the appliances sold in year j and are still remaining in the stock in year k, is shown in the following graph:



The estimated sales are shown in the figure 2.29 and the results are compared with the actual sales data of the years 2002 and 2004 (the orange triangle, GfK).

Figure 2.29 Refrigerators sales trend for EU 15 (1955 – 2005)

[113] Actually the lifetime data has been used to calibrate the sales function with the 2002/2004 data provided by GfK. and a life time of 14 year ± 4 is the period that best fits with these figures.



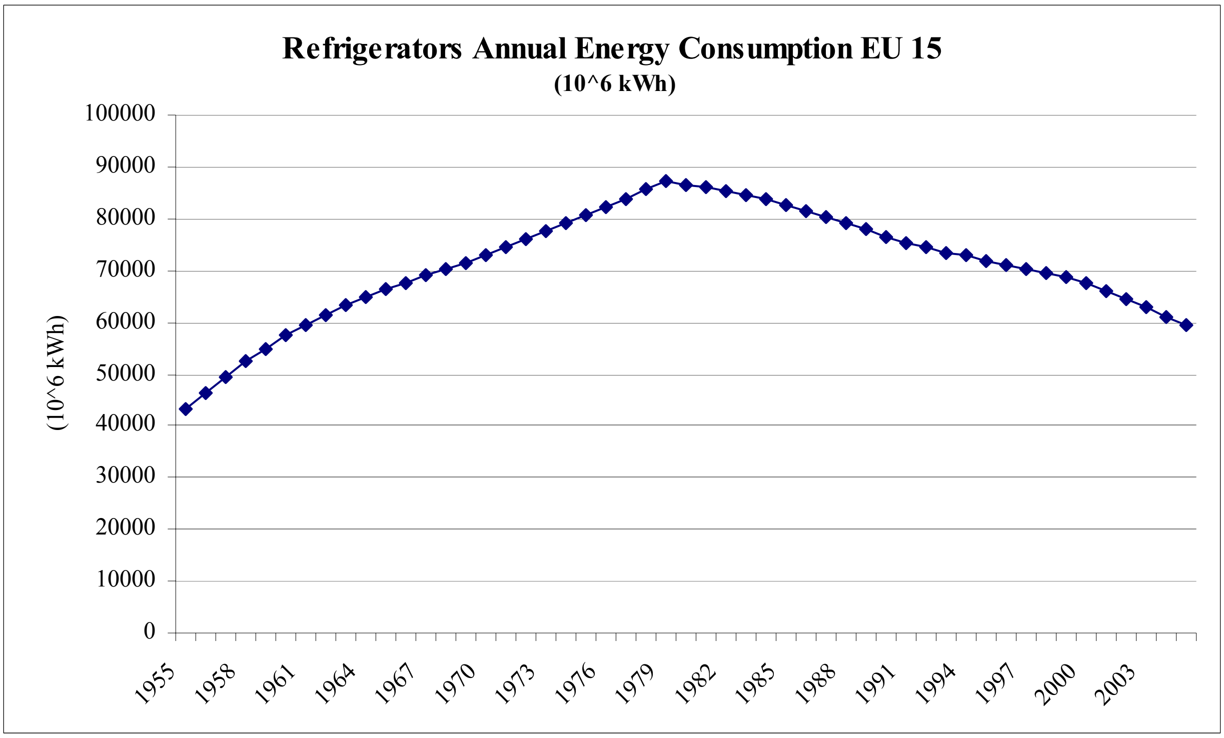
The proximity between sales estimated with the "stock model" and the actual of the GfK database is good (see note 113).

Finally the formula

$$ENERGY(k) = \sum_{k=1950}^{2005} \sum_{j=1950}^{k} Sales(j) * \mathrm{Re}\,main(j,k) * EnergyAverageConsumption(j)$$

has been used to calculate the total energy consumption of the refrigerators stock for the years 1955 – 2005 as shown in figure 2.30.

Figure 2.30 Refrigerators total stock energy consumption trend for EU 15 (1955 – 2005)



It is interesting to note that the energy consumption in 2005 is equal to that of 1963, when, in accordance with the stock model outputs, the stock was 2,27 time smaller than the current one.

Figure 2.31 shows the unitary energy consumption trend of the refrigerator stock for the years 1955 – 2005 obtained by dividing the energy consumption data by the corresponding stock data. The EU 15 stock unitary consumption pass from the 839 kWh/app of 1955 to the 388 kWh/app of 2005 with an efficiency gain of the 54 %.

Figure 2.31 Refrigerators unitary stock energy consumption trend for EU 15 (1955 – 2005)

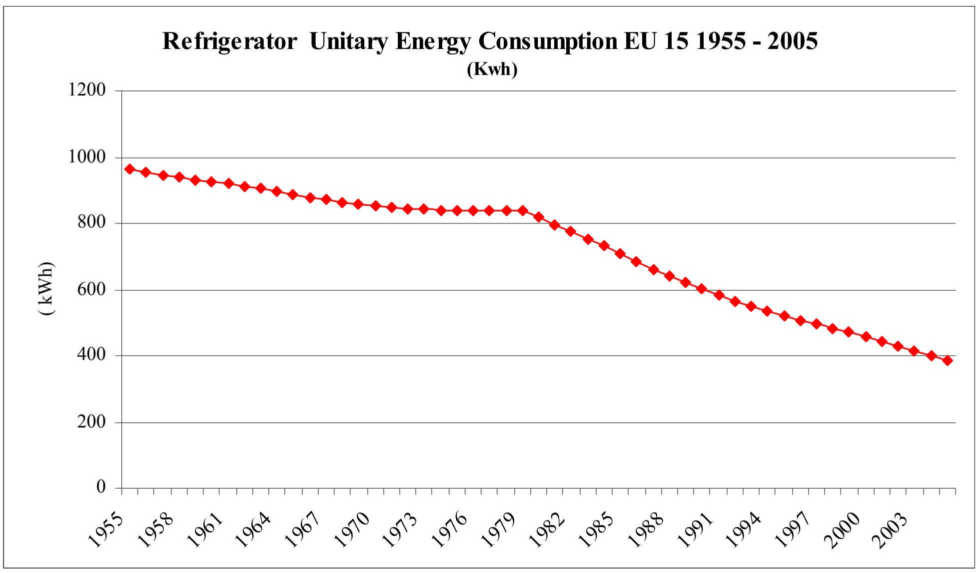


Table 2.16 shows the appliances stock and the corresponding total and unitary energy consumption as provided by the stock model. Table 1.14 shows the corresponding five-year variation rates.

Table 2.16 Main figures from the stock model; absolute values

Year	Refrigerators Sales	Total Stock Energy Consumption	Unitary Stock Energy Consumption
	Thousand	*GWh / year*	*kWh/year*
1990	8.838	76.561	600
1995	9.005	71.957	520
2000	9.405	67.489	458
2005	9.654	59.487	388

Table 2.17 Main figures from the stock model; five-years variation rates

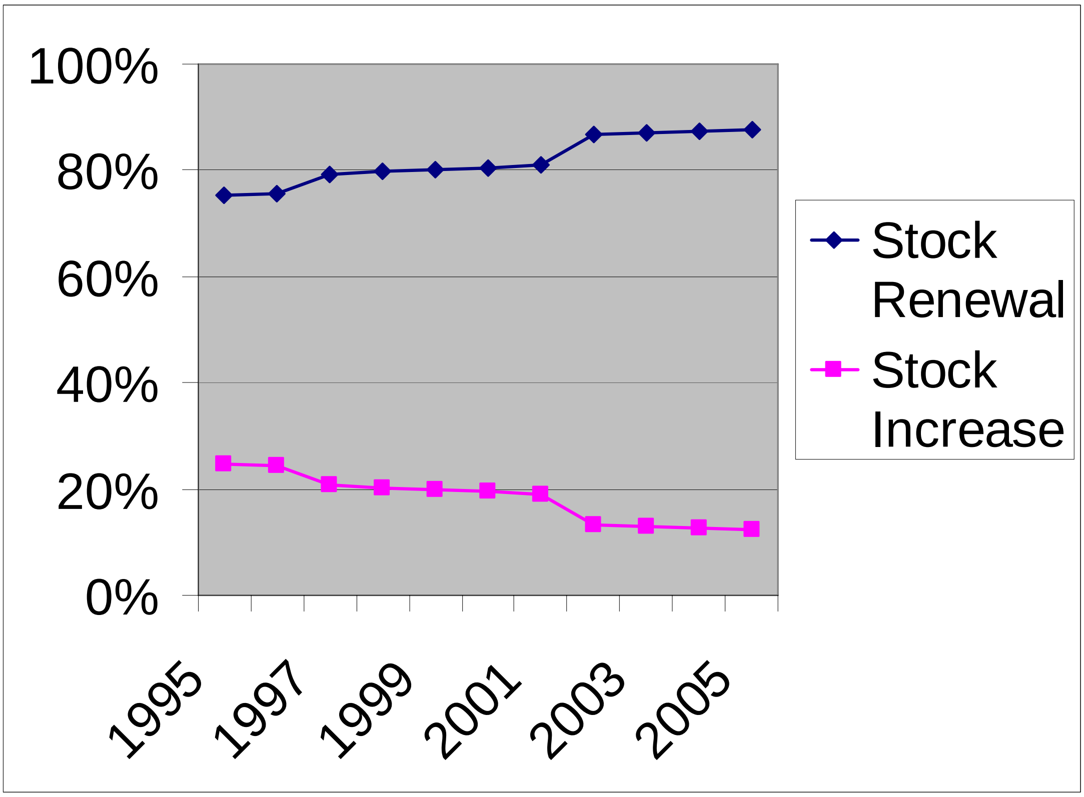
Year	Refrigerator Stock	Total Stock Energy Consumption	Unitary Stock Energy Consumption
	% variation	*% variation*	*% variation*
1990-1995	8.61	-6. 01	-13. 33
1995-2000	6.49	-6. 21	-11. 92
2000-2005	4.04	-11. 86	-15. 28

From the pattern of the variation rates it is possible to conclude that:

- the stock growth rate decreases, due to the saturation effect;
- the energy consumption decreases along the entire period (1990 – 2005) but with two different speeds: rather slowly between 1990 – 2000 and much faster in the last 5 years, due to the introduction of more efficient models;
- contribution factors to this reduction include replacement of old units with new ones, more aggressive energy regulations, and subsidies in some countries.

Finally, knowing the sales and stock trends it is possible to estimate the sales split between the net stock increase and the stock renewal. At the year 2005 only the 13 % of the sales (the total sales were more than 12 millions of appliances) contributes to the stock increase while the 87 % goes to the stock renewal. Figure 2.32 shows the sales split trend for the last 10 years. Being the stock totally saturated, in the future the portion of the sales that will go to the net stock increase will only depend to the household growth rate.

Figure 2.32 Sales split trend for the refrigerators



2.2.3.3 Stock model results for Freezers in EU15

The calculation procedure is obviously the same applied to the refrigerators. The required input parameters for the analysed period (1953-2005) are:

- the *energy average consumption* of the product or import in the year of built (kWh /year) [114];
- the *number households* in EU15 ;
- the *ownership rate*

The average unitary energy consumption data are then the following:

Table 1. 2.18 Unitary Energy Average Consumption of Freezers in EU 15 (kWh/app year)

Year	Energy Average Consumption (kWh/year)
1953-1979	911
1980-1984	711

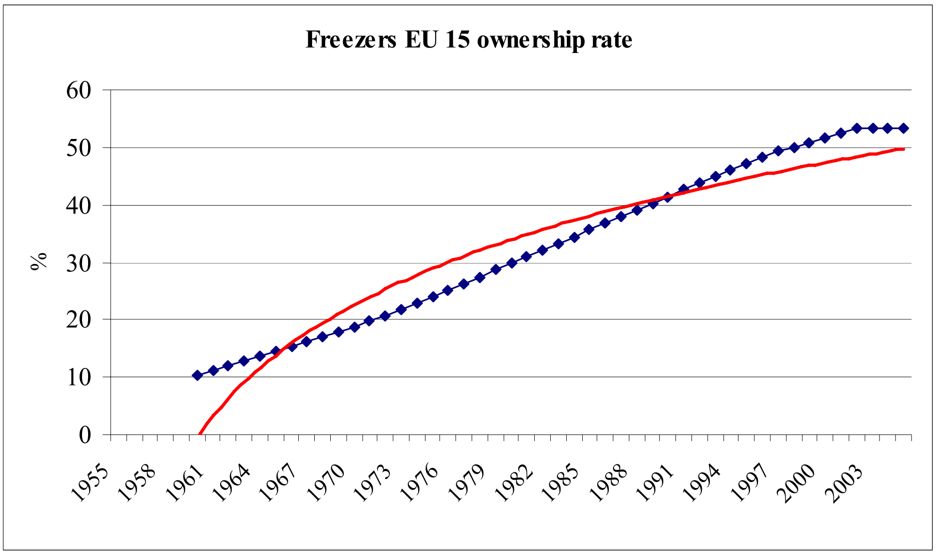
[114] Source: CECED databases and stock model [ref 6]

Year	Energy Average Consumption (kWh/year)
1985-1990	627
1990-1994	543
1995	427
1996	426
1997	417
1998	410
1999	378
2000	351
2001	321
2002	318
2003	314
2004	292
2005	279

The number households in EU15 has been calculated summing up the data of each relevant country

The ownership rate[115] is estimated, assuming that:

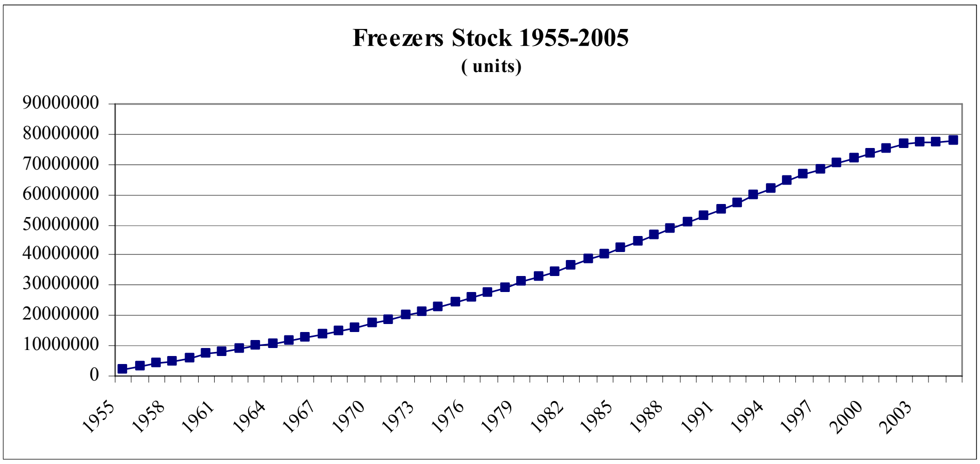
1. before year 1953 there were no freezers ;
2. the growth is depicted through a linear logistic function: the ownership rate increases steadily till the year 2000 up to the 50 % and then stop increasing. Indeed, also on the basis of the sales trend provided by GfK there are an increase of sales 300.000 of units in two years against an increase of 1 million of household in the same period), we estimate that the ownership rate will hardly go beyond this threshold in the future.



[115] ISIS estimations based on the Wuppertal Institute database

From the above data it has been estimated the freezers stock trend for the years 1950 – 2005 (figure 2.32).

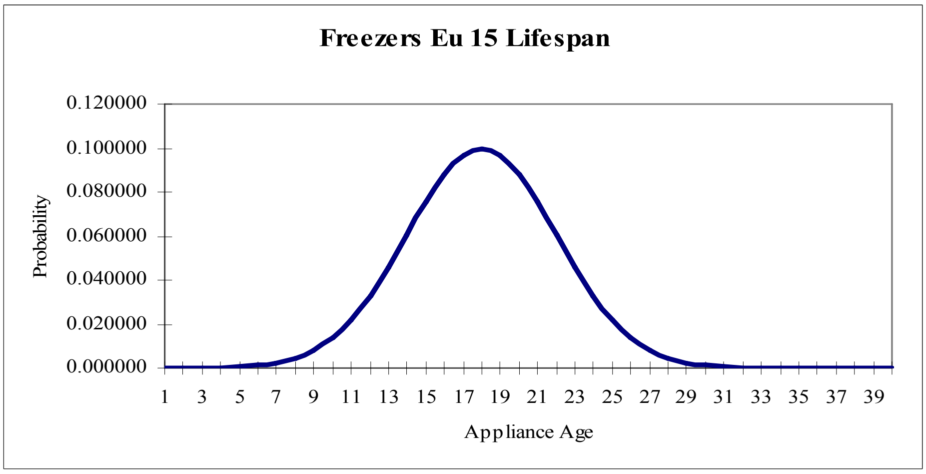
Figure 2.33 Freezer stock trend for EU 15 (1955 – 2005)



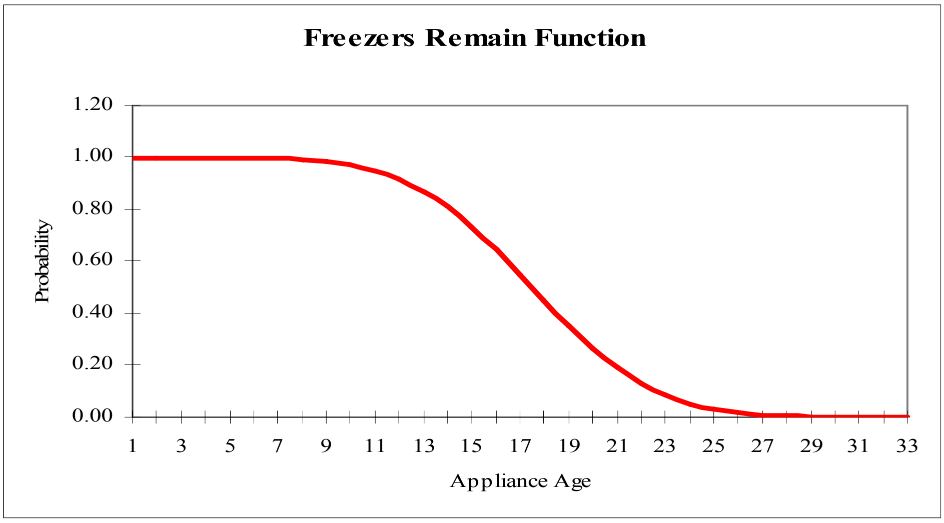
After estimation of the stock, the sales have been thus calculated through the following formula.

$$ESTsales(k) = Stock(k) - \sum_{i=i0}^{k-1} ESTsales(i) * Remain(i,k)$$

The Remain (i,k) function is calculated assuming that probability of life average is distributed as a normal function with average and standard deviation known (18 years and 4 years, see also note 113 at page 163).

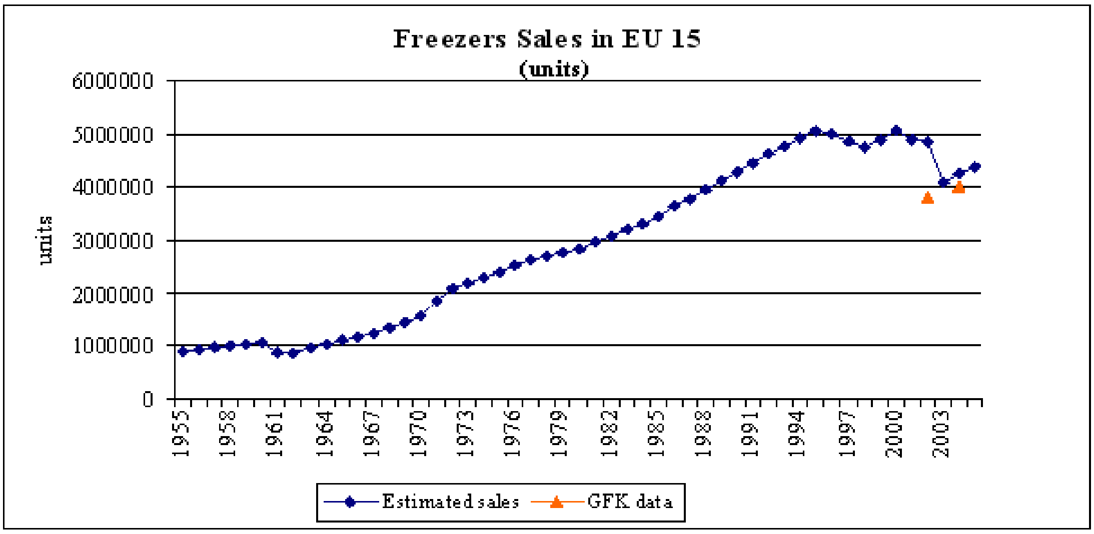


The trend of the function *Remain (j, k)*, that is the probability that the appliances sold in year j and are still remaining in the stock in year k, is shown in the following graph:



The estimated sales are shown in the figure 2.33 and the results are compared with the actual sales data of the years 2002 and 2004 (the orange triangle, GfK)

Figure 2.34 Freezers sales trend for EU 15 (1955 – 2005)



The proximity between sales estimated with the "stock model" and the actual of the GfK database is rather good.

Finally the formula

$$ENERGY(k) = \sum_{k=1950}^{2005} \sum_{j=1950}^{k} Sales(j) * \mathrm{Re}\,main(j,k) * EnergyAverageConsumption(j)$$

has been used to calculate the total energy consumption of the refrigerators stock for the years 1955 – 2005 as shown in figure 2.34:

Figure 2.35 Freezers stock total energy consumption trend for EU 15 (1955 – 2005)

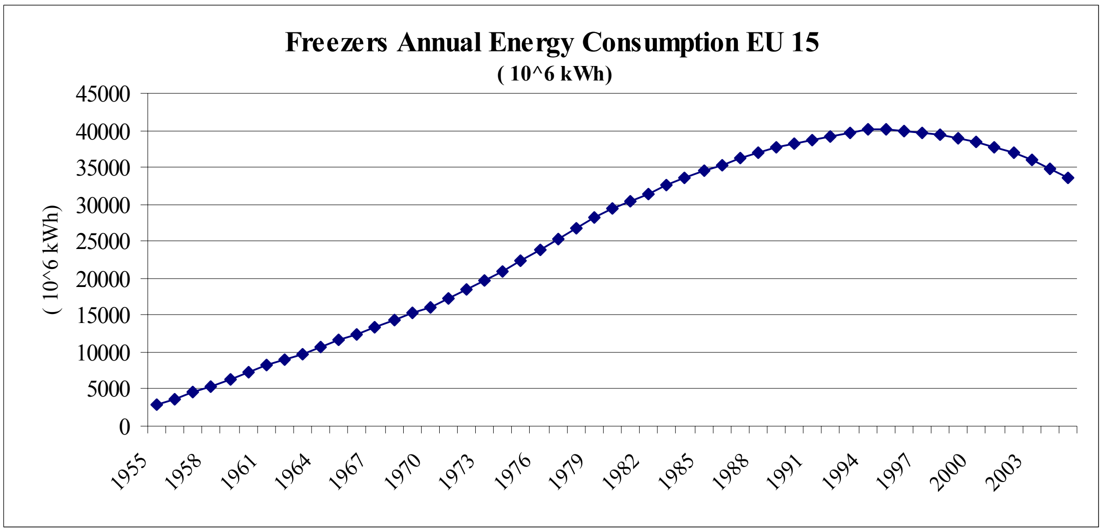


Figure 2.31 shows the unitary energy consumption trend of the refrigerator stock for the years 1955 – 2005 obtained by dividing the energy consumption data by the corresponding stock data. The EU 15 stock unitary consumption passes from the 1388 kWh/app of 1955 to the 432 kWh/app of 2005 with an efficiency gain of the 67 %.

Figure 2.36 Freezers stock unitary energy consumption trend for EU 15 (1955 – 2005)

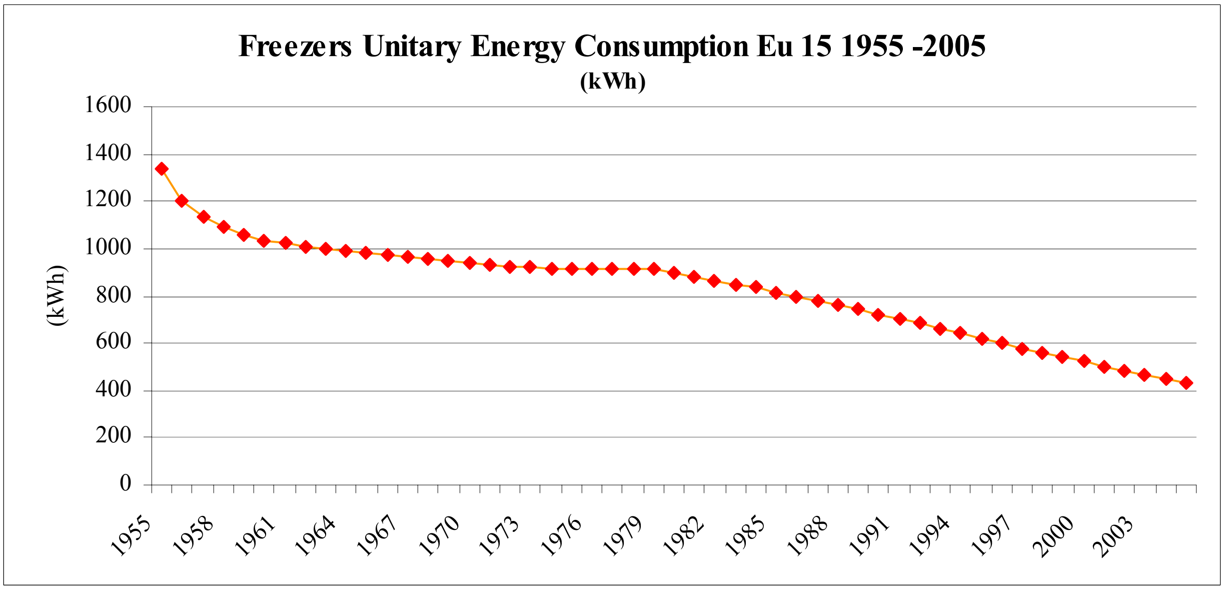


Table 2.19 shows the appliances stock and the corresponding total and unitary energy consumption as provided by the stock model. Table 2.20 shows the corresponding five-year variation rates.

Table 1. 2.19 Main figures from the stock model; absolute values

Year	Freezer Stock	Total Stock Energy Consumption	Unitary Stock Energy Consumption
	Thousand	*GWh / year*	*kWh/year*
1990	52.876	38.204	723
1995	64.388	40.018	622
2000	73.813	38.441	521
2005	77.930	33.631	432

Table 1. 2.20 Main figures from the stock model; five-years variation rates

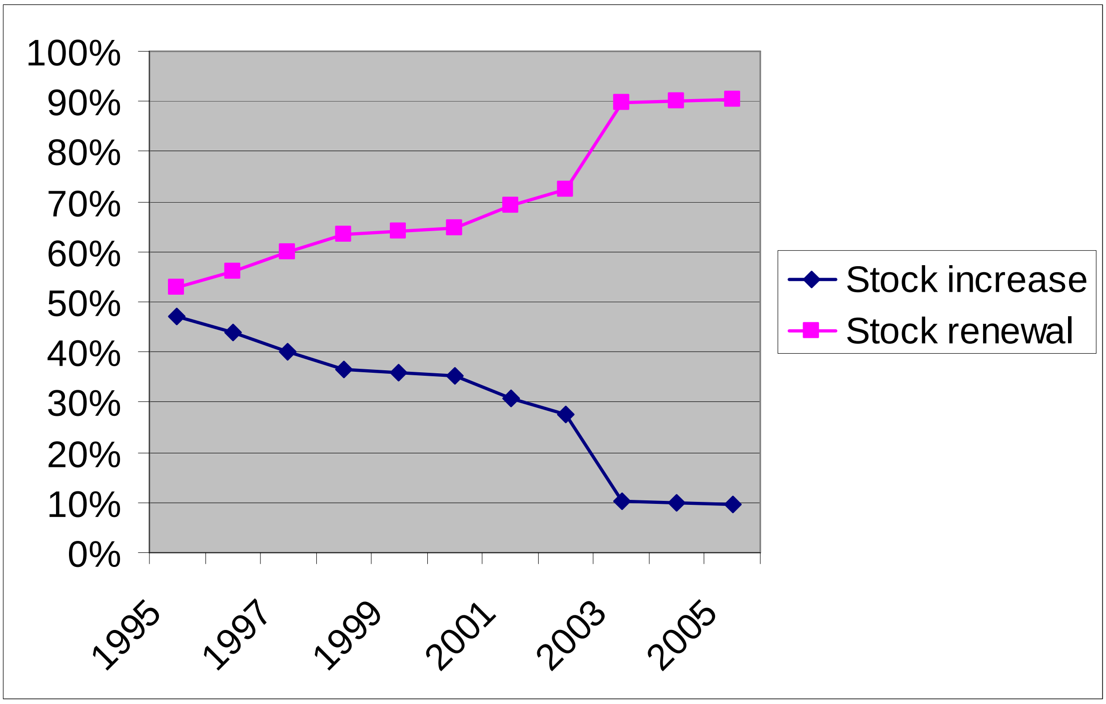
Year	Freezer Stock	Total Stock Energy Consumption	Unitary Stock Energy Consumption
	% variation	*% variation*	*% variation*
1990-1995	21.77	4.75	-13.97
1995-2000	14.64	-3.94	-16.24
2000-2005	5.58	-12.51	-17.08

From the pattern of the variation rates it is possible to conclude that:

- the stock growth rate decreases, even if the market is not yet "technically" saturated (but, as already outlined, we are probably close to the economic saturation);
- the energy consumption increases till the year 1995 and then start decreasing due to the introduction of more efficient models;

Finally, also for the freezers, knowing the sales and stock trends it is possible to estimate, even if with less accuracy than in the refrigerators case, the sales split between the net stock increase and the stock renewal. Having fixed the upper limit of 50 % for the ownership rate, starting from the year 2000, the portion of the sales that goes to the stock renewal increases rapidly and passes from the 53 % of 1995 to the 90 % of 2005 as it is shown in figure 2.37:

Figure 2.37 Sales split trend for the freezers



2.2.3.4 Stock model results for Refrigerators and Freezers in EU10

The data for the New Accession Countries are less reliable than those for EU 15, especially for what concerns the ownership rates of the Freezers and the share of the sales by energy efficiency classes. Here we refer to the data provided by the database of the Wuppertal Institute stock model and to the sales figures provided by GfK for the years 2002 and 2004. On the basis of these sources the main reference input data for the EU 10 stock model are:

Table 2.21 Refrigerators EU 10: ownership rates and sales energy average consumption for the years 1995, 2000, 2005

	Ownership rate	Stock- thousand	Sales energy consumption (kWh/year
1995	93 %	25.111	425
2000	95%	26.763	363
2005	97%	28.220	292

Table 2.22 Freezers EU 10: ownership rates and sales energy average consumption for the years 1995, 2000, 2005

	Ownership rate	Stock- thousand	Sales energy consumption (kWh/year
1995	7,8 %	2.123	427
2000	9,6%	2.697	351
2005	10,1%	3.198	279

It is worth noting here that the figure on the ownership rate of the refrigerators is rather reliable. Actually, also during the socialist period, the majority households of the eastern countries were equipped with a (simple) refrigerator and so, also in accordance with the data gathered by the SACHA projects[116], it is possible to affirm that the penetration rate of this appliances was around the 90 % already from the years 70'/80'. For the freezers the situation is different and the data are less reliable. From the assessment carried out within the SACHA project during the second half of the years 90' and taking into consideration the more recent figures on the yearly sales provided by GfK, it is possible to assume that the penetration rate of these appliances was very low at the beginning of the years 90' (around the 5-6 %) and that it is slowly but steadily increasing.

On the basis of these input, the stock models outputs are.

Table 2.23 Refrigerators EU 10: yearly sales, total stock energy consumption and unitary stock energy consumption for the years 1995, 2000, 2005

	Yearly sales Thousand	Total Stock energy consumption GWh/year	Unitary Stock energy consumption kWh-appliance/year
1995	869	13.804	550
2000	1.712	12.832	479
2005	1.833	11.580	410

[116] The SACHA 1 and SACHA 2 projects (SAVE programme, years 1995-1998) evaluated the refrigerators and washing machines state of art in 7 Eastern countries.

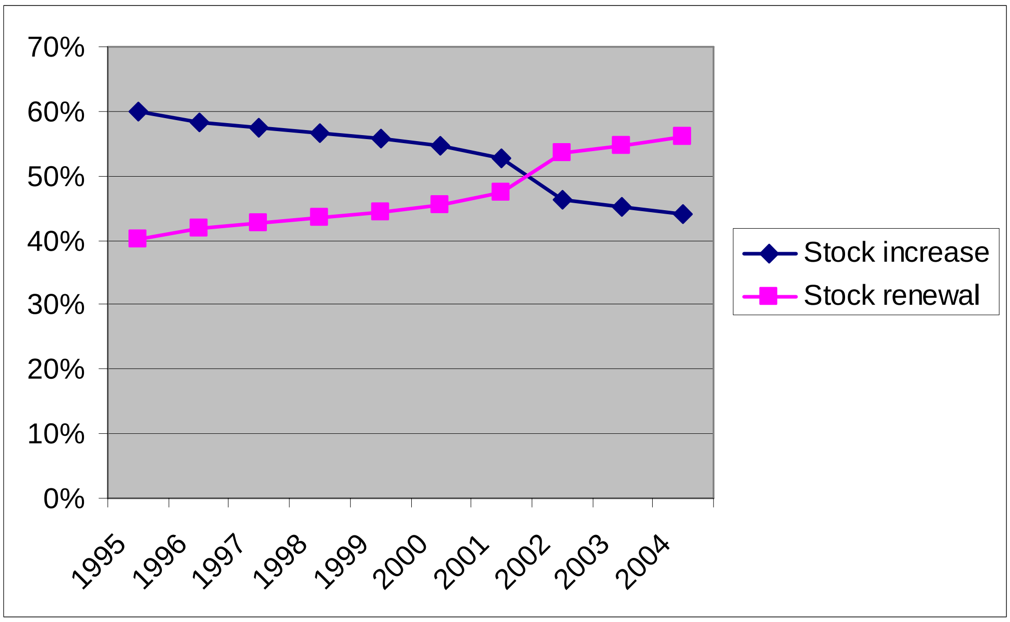
Table 2.24 Freezers EU 10: yearly sales, total stock energy consumption and unitary stock energy consumption for the years 1995, 2000, 2005

	Yearly sales Thousand	Total Stock energy consumption GWh/year	Unitary Stock energy consumption kWh-appliance/year
1995	190	1.297	611
2000	216	1.369	508
2005	230	1.332	417

The energy consumption data for the EU 10 countries confirm the trend already observed for EU 15, especially for the refrigerators. For freezers the inversion of the energy consumption trend happens by the year 2000 while, for EU 15, it is anticipated. The figures on stock unitary consumption are comparable (a little big higher those of EU 10 for the refrigerators, see page 38 and very similar those concerning the freezers, see page 43) and thus the energy efficiency potential are of the same order of magnitude for both side of Europe. On the other hand, the freezers stock energy consumption of the EU 10 countries should still steadily increase due the low current ownership rate for these appliances (the future energy consumption scenarios are carried out in task 7).

For what concerns the sales split by stock increase and stock renewal, the refrigerators show a trend very similar to the EU 15 countries (respectively 16 % and 84 % at 2005) while the behaviour of the freezers is, as expected rather different. Actually in this last case the stock increase is still strong and takes in approximately the 50 % total sales as shown by figure 2.38

Figure 2.38: Sales split for refrigerators in the EU 10 countries



2.2.3.5 Stock model results for Refrigerators and Freezers in EU25

Summing up the results obtained from the stock model for EU 15 and EU 10 we obtain the figures shown in tables 2-25 and 2-26. There are no more to add here to the analysis carried out for the two separated cases. Practically all the 183 millions of households in the EU 25 posses at least one refrigerator (of which the majority a fridge freezer of class A) and approximately the 44 % possess a freezer. The overall final energy consumption to keep fresh or frozen the food exceed the 100 TWh that have to be provided by power plants having an overall installed capacity of 30 GW (assuming a primary/final energy coefficient of 2,5).

Table 2.25 Refrigerators EU 25: Stock, total stock energy consumption and unitary stock energy consumption for the years 1995, 2000, 2005

	Refrigerator Stock	Total Stock energy consumption	Unitary Stock energy consumption
	Thousand	*GWh/year*	*kWh-appliance/year*
1995	163.579	85.761	524
2000	174.221	80.321	461
2005	181.637	71.067	391

Table 2.26 Freezers EU 25: Stock, total stock energy consumption and unitary stock energy consumption for the years 1995, 2000, 2005

	Freezer Stock	Total Stock energy consumption	Unitary Stock energy consumption
	Thousand	*GWh/year*	*kWh-appliance/year*
1995	66.511	41.315	621
2000	76.510	39.810	520
2005	81.128	34.963	431

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2. Christopher Riedy (2003). *Vintage Stock Modelling of Domestic Appliances: Dealing With Uncertainties* . Institute for Sustainable Futures, University of Technology, Sydney (Australia)
3. Pernille Schiellerup. (1995) *DECADE : Domestic Energy and Carbon Dioxide Emissions* .University of Oxford (UK)
4. Kevin Lane (2000) *Lower Carbon Future Appendix O: Modelling approach* Environmental Change Institute , Oxford (UK)
5. Market Transformation Programme *BNC08 Assumption underlying the energy projections for domestic cold appliances* www.mtprog.com
6. R. Stamminger, R. Kemna *Report on Energy Consumption of Domestic Appliances in European Household* CECED
7. Personal Communication Wuppertal Institute

2.3 Market trends

In this chapter possible market tendencies and trends on the refrigerator and freezer market will be pointed out. Furthermore the developments and opinions regarding these trends on the side of industry and on the side of consumers are analyzed.

On the manufacturer side the product database of all models of the last 10 years (chap.2.3.2), current product presentations (brochures, web presences) and the results of an opinion poll between the main manufacturers are analyzed (chap.2.3.3).

In order to estimate possible trends by the consumer point of view European consumer magazines (chap.2.3.4) and the results of the European consumer survey (chap.2.3.5) are analyzed.

2.3.1 General market 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. The EU household appliances market is described in detail concerning the topics sales, production and penetration of selected appliances in chap.2.4.1.

In Germany, for example, 99 % of all households possess a refrigerator (Figure 2.39). In some other European countries comparable data are noticed. The freezer market is lower and has decreased during the last decade, i.e. in Germany from 67 % in 1995 to 54 % in 2006, due to the increase use of combined refrigerator/freezer devices.

Saturation of the German market in % of the households											
	Houshold appliances										stock (in mio. units)
source: GfK	1980*	1985*	1990*	1995	2000	2002	2003	2004	2005	2006	2006
washing machine	88	90	92	94	93	93	94	94	95	**96**	**37,6**
laundry dryer	8	13	20	25	34	36	38	39	41	**44**	**17,3**
automatic dishwasher	21	27	35	40	52	57	57	58	59	**61**	**24,1**
cookers/oven	77	78	79	80	83	84	84	84	85	**85**	**33,4**
refrigerator	95	95	96	96	99	99	99	99	99	**99**	**39,0**
freezer	49	54	58	67	62	57	55	55	55	**54**	**21,4**
number of households (in millions)	25,0	26,4	28,2	36,9	38,1	38,7	38,9	39,1	39,2	**39,2**	**199,6**
	other household appliances										stock (in mio. units)
microwave oven	1	4	33	52	59	63	65	66	67	68	26,8
*until 1999 old Germany											

Figure 2.39: saturation of the German market (source: ZVEI[117])

[117] ZVEI (CENTRAL ASSOSIATION ELECTRO-TECHNOLOGY AND ELECTRONIC INDUSTRY REGISTERED ASSOSIATION / ZENTRALVERBAND ELEKTROTECHNIK UND ELEKTRONIKINDUSTRIE E.V.) (2006/7): Zahlenspiegel des deutschen Elektro-Hausgerätemarktes. Der Inlandsmarkt der Elektro-Hausgeräte-Industrie/ Verkäufe von

The market is characterized by a high level of substitution of old appliances. In the last year it was evaluated that 88 million refrigerators/ freezers were older than 10 years[118](Figure 2.40). Over 30 % of all refrigerators were older than 10 years in 2004.

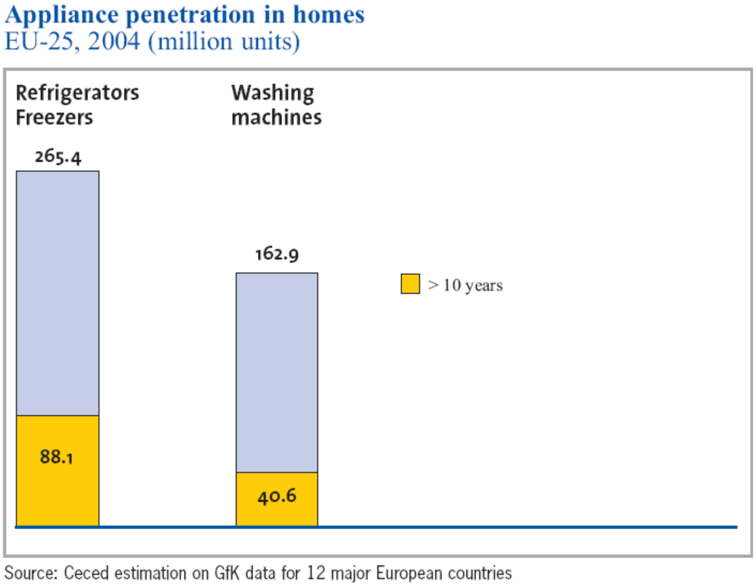

Figure 2.40: appliance penetration in homes EU-25, 2004 (source: CECED[119])

As new appliances are more energy efficient then older ones[120]., with educational advertising and informing of savings concerning resources and money the consumer should be persuaded to purchase an appliance of the new generation[121].

- Importance of information when buying an appliance

Refrigerators and freezers are appliances which operate irrespective of consumer usage, they are always on. This means that the energy consumption of the appliance is set by the manufacturer to a great extent. Hence the decision for buying an energy efficient appliance is an important factor when consumers want to save energy. To make this decision the consumer needs adequate information on energy consumption.

Elektro-Großgeräten/ Verkäufe von Elektro-Kleingeräten/ Marktsättigung. Online: http://www.zvei.de/index.php?id=585&no_cache=1&tx_ZVEIpubFachverbaende_pi1-[download]=681&type=98

118 EUROPEAN COMMISSION (2006/6): Newsletter °No.2: Sustainable Energy Europe 2005-2008 - New appliances, efficient and convenient. Online: http://www.sustenergy.org/UserFiles/File-/Newsletter_June_06_EN.pdf

119 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

120 APPLIANCE MAGAZINE (2006/12): Appliance Line - Europe's Action Plan. Online: http://www.appliancemagazine.com/applianceline/editorial.php?article=1642&zone=205&first=1

121 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

In Germany a survey[122, 123] assessed the sources of information consumers use when they plan to buy a new appliance. 70 % answered that they get counsel and advice from the sales assistant. 60 % collect information from advertisements or articles in newspapers or magazines, 50 % consult friends or acquaintances. Brochures and special interest magazines including journals containing test results are used for collecting information by 56 % and 46 %, respectively. Other sources used are the Internet, window displays as well as TV and radio (Figure 2.41).

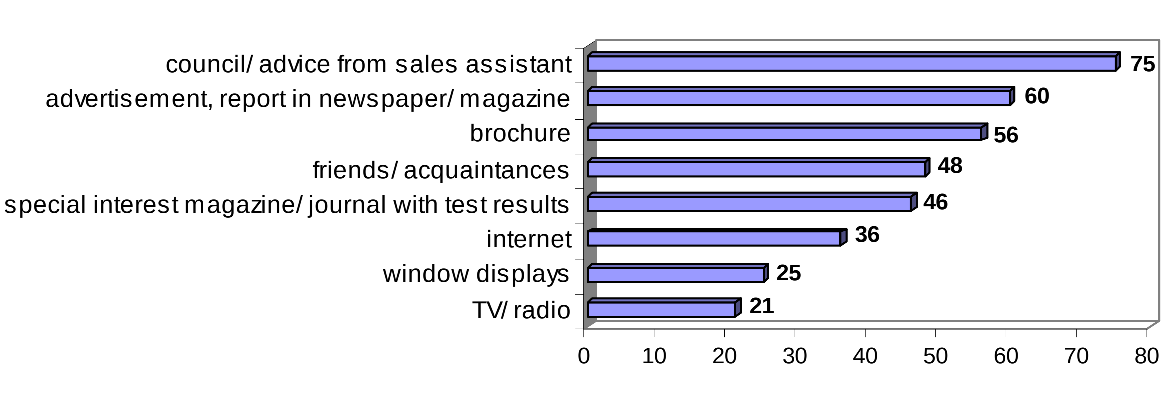

Figure 2.41: sources of information when buying an appliance (source: Forsa[124])

A survey[125] of 1000 German and 1000 Italian households showed that consumers most frequently buy an appliance in the first and often only store they go to. Those consumers who went to more than one store indicated that they then wanted a general idea, were looking at different models or were comparing prices (especially in Italy).

LEPTHIEN[126] (2000) found that 47 % of the questioned consumers (of 70 households) felt that they were unsatisfactorily advised in the store where they bought their appliance. 30 % of the consumers were satisfied with the counsel they received, 17 % felt they were advised decently. Only one of 100 questioned consumers sought advice from a consumer advice centre.

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[122] AGRICOLA A.-C. & AHRENS W. (2006): Energy Efficiency in Private Households: Information at the Point of Sale, In: BERTOLDI P., KISS B. & ATANASIU B. (eds.): Energy Efficiency in Domestic Appliances and Lighting – Proceedings of the 4th International Conference EEDAL '06 – Volume II

[123] FORSA GESELLSCHAFT FÜR SOZIALFORSCHUNG UND STATISTISCHE ANALYSEN MBH (2004): Evaluierung der Effizienz-kampagne der Initiative EnergieEffizienz / Abschlussbericht, Berlin 2004; http://www.stromeffizienz.de/fileadmin/InitiativeEnergieEffizienz/strom-effizienz/downloads-/sonstige_Downloads/Abschlussbericht_IEE.pdf [02/21/07]

[124] FORSA GESELLSCHAFT FÜR SOZIALFORSCHUNG UND STATISTISCHE ANALYSEN MBH (2004): Evaluierung der Effizienz-kampagne der Initiative EnergieEffizienz / Abschlussbericht, Berlin 2004; http://www.stromeffizienz.de/fileadmin/InitiativeEnergieEffizienz/strom-effizienz/downloads-/sonstige_Downloads/Abschlussbericht_IEE.pdf [02/21/07]

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

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

Relevance of criteria on the energy label

The energy label was implemented by the European Union to provide consumers with a neutral and standardised opportunity to compare different refrigerator/freezer/refrigerator-freezer models in terms of efficiency[127]. "Directive 94/2/EC of 21 January 1994 implementing Council Directive 92/75/EEC with regard to energy labelling of household electric refrigerators, freezers and their combinations" defines what the label has to look like, which information has to be given and which information may be included. Figure 2.42 shows the energy label for refrigerators, freezers and refrigerator-freezers.

Information given on the label is (from top to bottom):

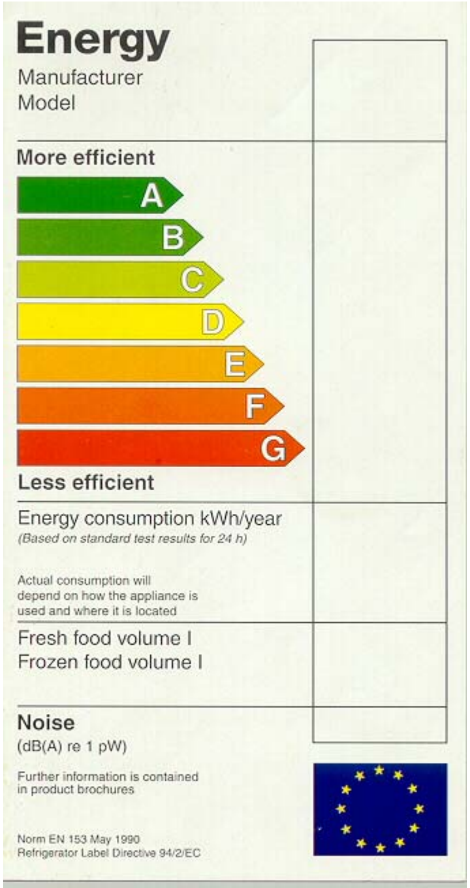


Figure 2.42: energy label for refrigerators, freezers and combinations (source: CECED)

- Name or trade mark of the manufacturer
- Identification number for the model
- The appropriate letter (A-G) for the energy efficiency class according to Annex V of Directive 94/2/EC
- In case the appliance model was given a 'Community Eco-label award' a copy of the award's mark may be added
- Energy consumption given in kWh/year
- Net volume of the refrigerator compartment/s which operate at temperatures above -6 °C given in litres
- Net volume of the freezer compartment/s with star rating which operate at temperatures below -6 °C given in litres
- Noise measured in accordance with Directive 86/594/EEC

Directive 2003/66/EC[128] includes the energy efficiency classes A+ and A++ for refrigerators, freezers and refrigerator-freezers. These classes are indicated on the label in the same place as class A. This Directive also includes – where applicable- the indication of the net volume of a chill compartment.

The Definition of the energy efficiency classes from A to G is based on the energy efficiency index, I. "I" is calculated by dividing the appliance's electricity consumption by the energy consumption for a model with the same adjusted volume originated from the energy consumption reference line and is given as percentage (Table 2.27). The energy

[127] CECED European Committee of Domestic Equipment manufacturers, Online: http://www.ceced.org-/IFEDE/easnet.dll/ExecReq/WPItem?eas:dat_im=010054 [02/21/07]

[128] COMMISSION DIRECTIVE 2003/66/EC of 3 July 2003 amending Directive 94/2/EC implementing Council Directive 92/75/EEC with regard to energy labelling of household electric refrigerators, freezers and their combinations, Online: http://www.ceced.org/ICECED/easnet.dll/ExecReq/Redirection?eas:oldfilename=/community/files/56/phphcvlec/Directive_2003-66-EC_Energy_Labelling_on_Refrigerators_Freezers_and_Combis.pdf [02/21/07]

consumption reference line defines an energy efficiency index of 100 % based on the average energy consumption as a function of adjusted volume of cold appliances on the EU market between 1990 and 1992[129].

Table 2.27: relative efficiency classes used in the EU energy label for cold appliances (source: Cold II[7])

Energy-efficiency index, I	Energy-efficiency class
I<30	A++
I<42	A+
I < 55	A
55 ≤ I < 75	B
75 ≤ I < 90	C
90 ≤ I < 100	D
100 ≤ I < 110	E
110 ≤ I < 125	F
125 ≤ I	G

A German survey[130] showed that the most important aspect when buying a refrigerator or refrigerator-freezer is the energy consumption of the appliance (62 %). 13 % of the questioned consumers answered that the energy consumption class which is indicated on the energy label is important information for their decision and 27 % indicated size and partitioning of the interior as important (Figure 2.43).

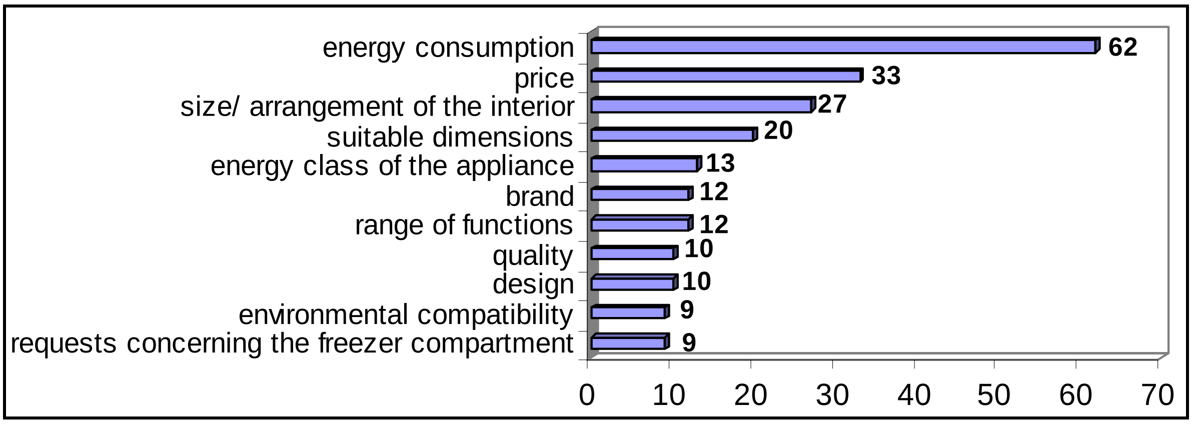


Figure 2.43: important aspects when buying a refrigerator (open question) (source: Forsa[9])

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

[130] FORSA GESELLSCHAFT FÜR SOZIALFORSCHUNG UND STATISTISCHE ANALYSEN MBH (2004): Evaluierung der Effizienz-kampagne der Initiative EnergieEffizienz / Abschlussbericht, Berlin 2004; http://www.stromeffizienz.de/fileadmin/InitiativeEnergieEffizienz/strom-effizienz/downloads-/sonstige_Downloads/Abschlussbericht_IEE.pdf [02/21/07]

The same study asked whether consumers have noticed the energy label on household appliances. 71 % answered they had already seen the label, especially men (74 % vs. 68 % for women) and employed (74 % vs. 65 % for unemployed). When asked where they had seen the label, most people indicated on washing machines (63 %), followed by refrigerators (54 %), clearly less frequently on freezers (19 %). Within this study it was also evaluated how established the energy consumption classes A-G are. 62 % of the consumers are familiar with the classes, compared to the first questioning in 2003 the awareness level accounted an increase of 10 %.

A different survey[131] in Germany from the year 2000 showed that 65 % of the questioned consumers did not know that there is an energy label for refrigerators and 15 % even indicated that there is no energy label for refrigerators.

2.3.2 Market trends as seen by the model offered

This analysis uses the database of all models of refrigerators and freezers offered in the European market as provided by CECED. Databases are available for all years from 1995 to 2005. It is worth mentioning, that during this period, the European Union has been enlarged from 15 countries to 25 countries, or from some 380 million inhabitants to 480 million inhabitants.

This increase in market size may explain - at least partly - the drastic increase in models as seen in these databases (Figure 2.44). According to this, the number of models has more than doubled. Another reason may be changes in the market itself, which is ruled by less, but bigger retailer chains, asking for more differentiation between the offers. But also changes in demography may have caused this increase as consumers are segmenting into more and higher differentiated interest groups.

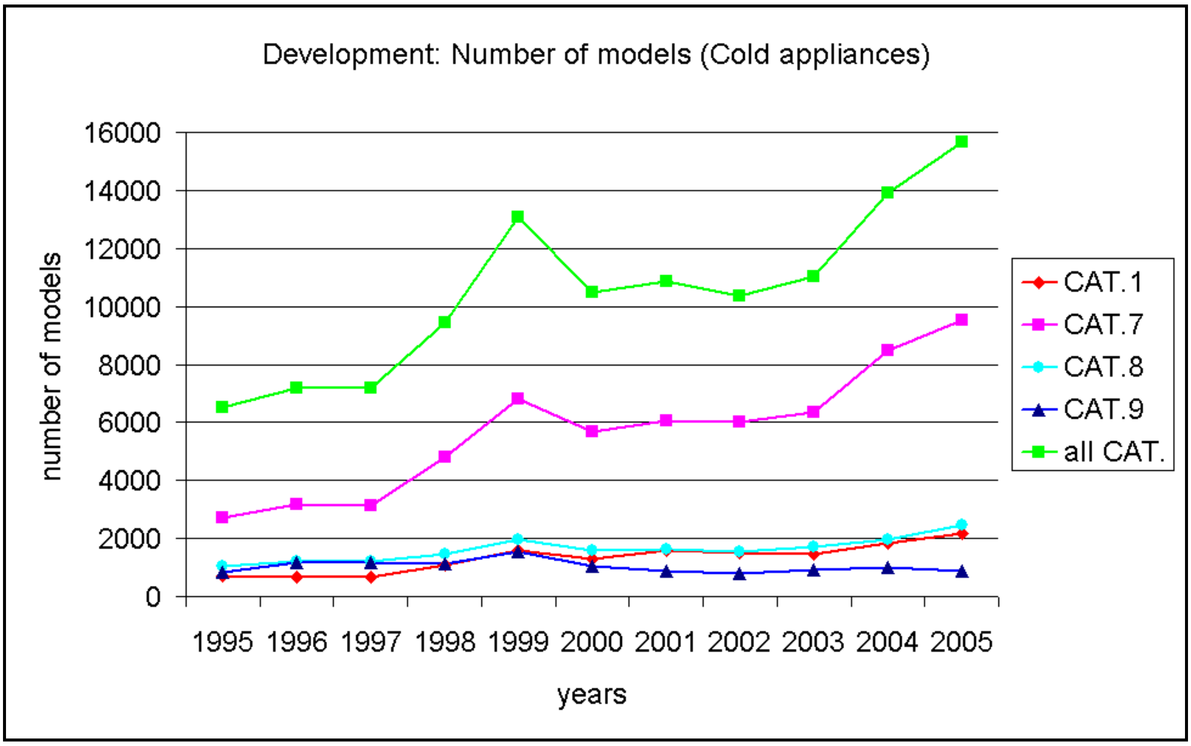


Figure 2.44: development of number of models of cold appliances in CECED databases

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

The kind of refrigerator and freezer models offered have also changed (Figure 2.45), leading to a concentration into just 4 of the 10 categories defined by the European Energy labelling directive. It is worth asking if this process is lead just by consumer requests or if the way as the energy label has defined the categories and the energy efficiency calculation, has also supported the concentration on those classes which allow the easiest realisation.

The analysis following will concentrate on those four classes of relevance.

A look at the storage capacity offered in the various categories (Figure 2.46) shows that there is only a moderate increase of about 10 % in the average of simple refrigerators (cat. 1) and upright freezers (cat. 8), but no change for refrigerator-freezers (cat. 7) and a slight decrease for chest freezers.

Also the climate class (Figure 2.28) for which the appliances are designed to be operated in has changed. Categories 1, 7 and 8 (Figure 2.47, Figure 2.48, Figure 2.49) show a drastic increase of the market offer in terms of the 'maximum climatic class' towards the sub-tropic and partly the tropic climate class. cat. 9 (Figure 2.50) shows this increase with some delay in time. This can hardly be explained by changes in the geographical extension of Europe or by the effect of global warming. And it is also questionable if about 70 % of the European market is really living in sub-tropical or even tropical areas. The effect gets clear, when analysing the multi attribution of climate classes (Figure 2.51). Over the years, the gadgets got assigned to more than one climate class. While in 1995 almost every product was designed and categorized just for one climate class, in 2005 each product has in average about 2,5 climate classes assigned to. Climate classes SN, N and ST are almost equally represented in the market offer.

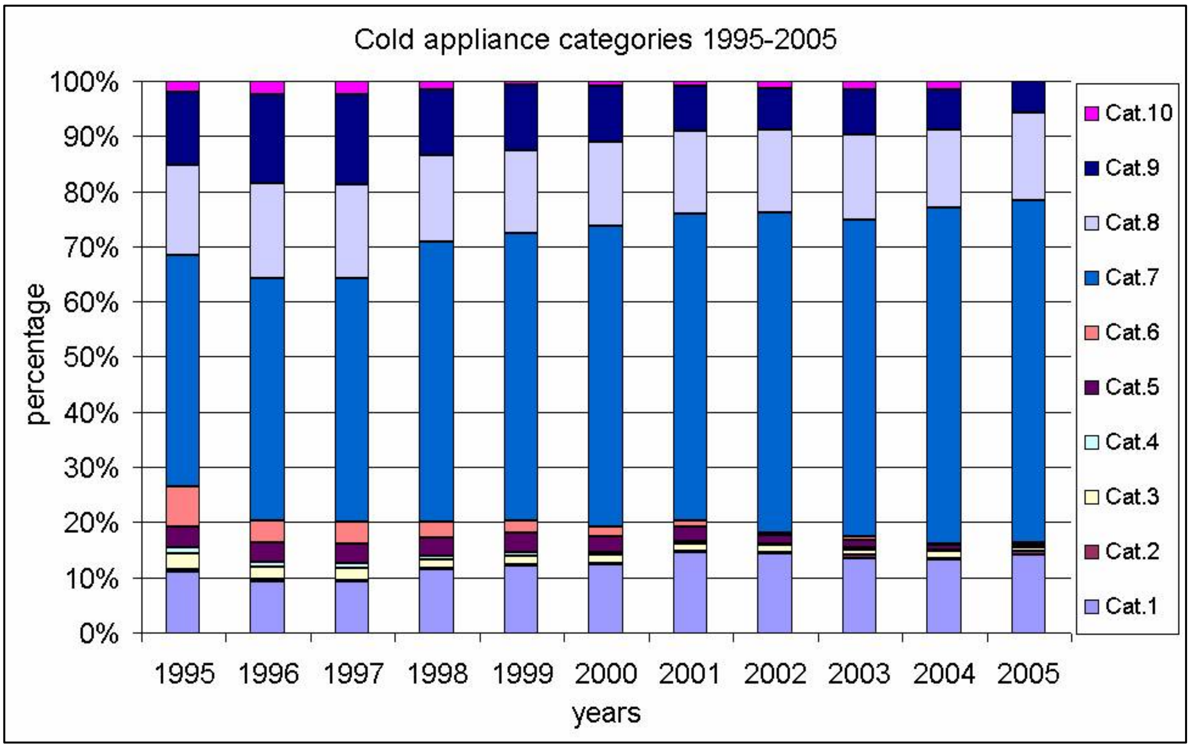


Figure 2.45: split of categories

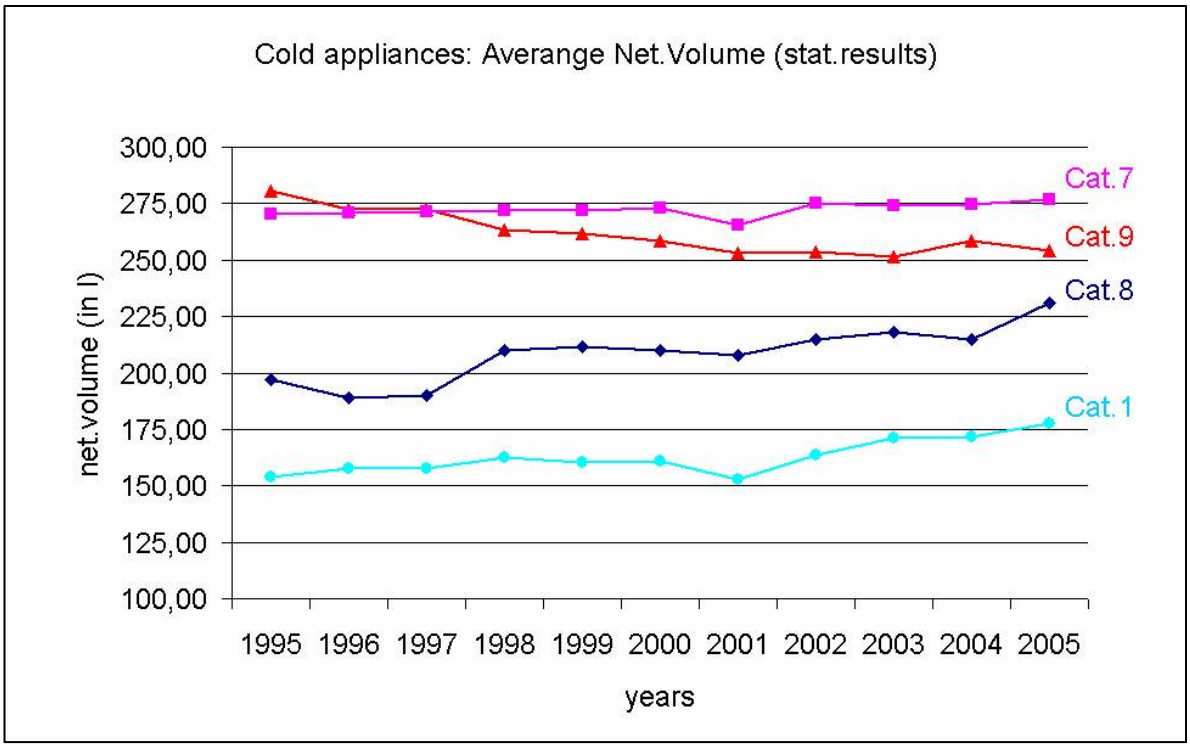


Figure 2.46: cool capacity development in terms of average net volume

Table 2.28: climate classes

climate class	temperature range
SN	10 – 32 °C
N	16 – 32 °C
ST (sub-tropical)	16[132] – 38 °C
T (tropical)	16[133] – 43 °C

[132] changed from 18 °C to 16 °C by EN ISO 15502:2006

[133] changed from 18 °C to 16 °C by EN ISO 15502:2006

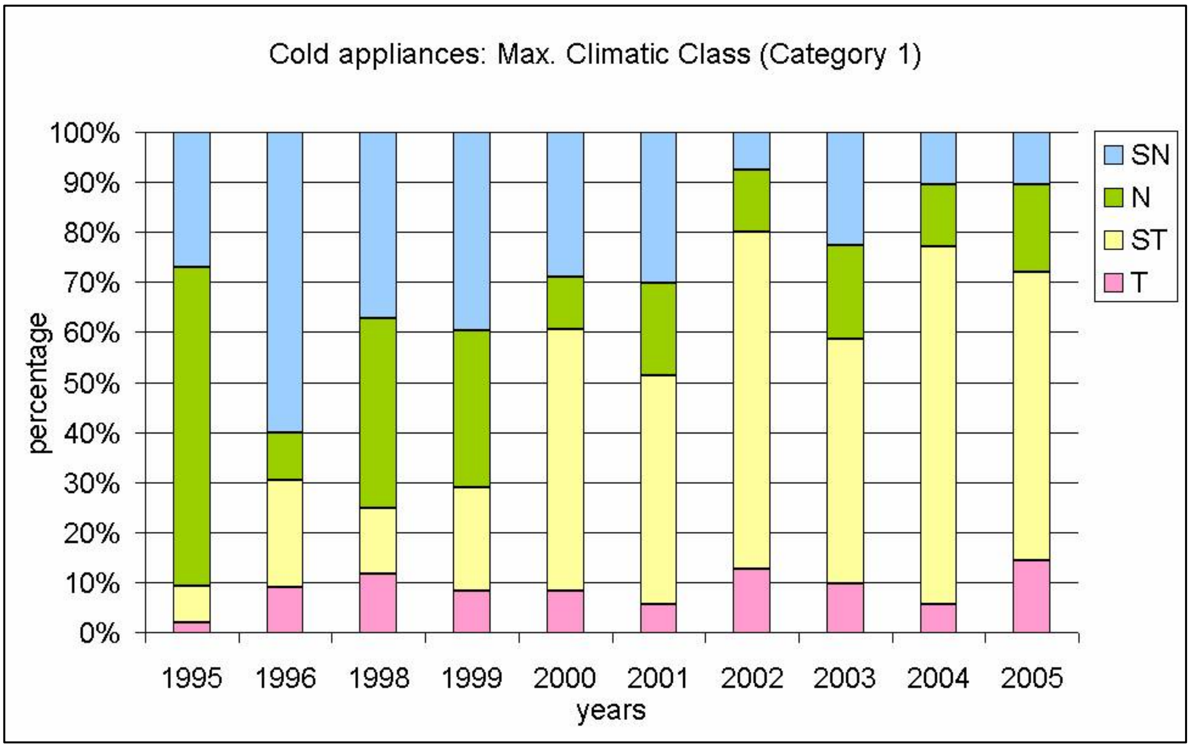


Figure 2.47: development of the climate class distribution for category 1

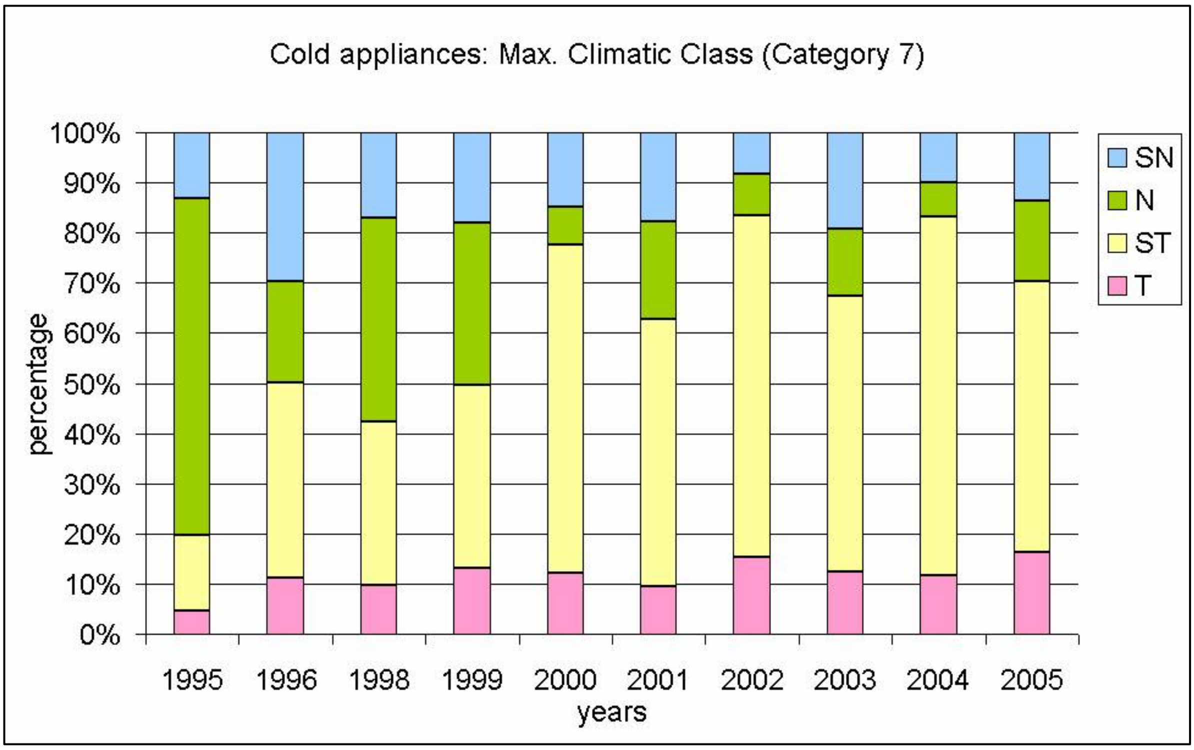


Figure 2.48: development of the climate class distribution for category 7

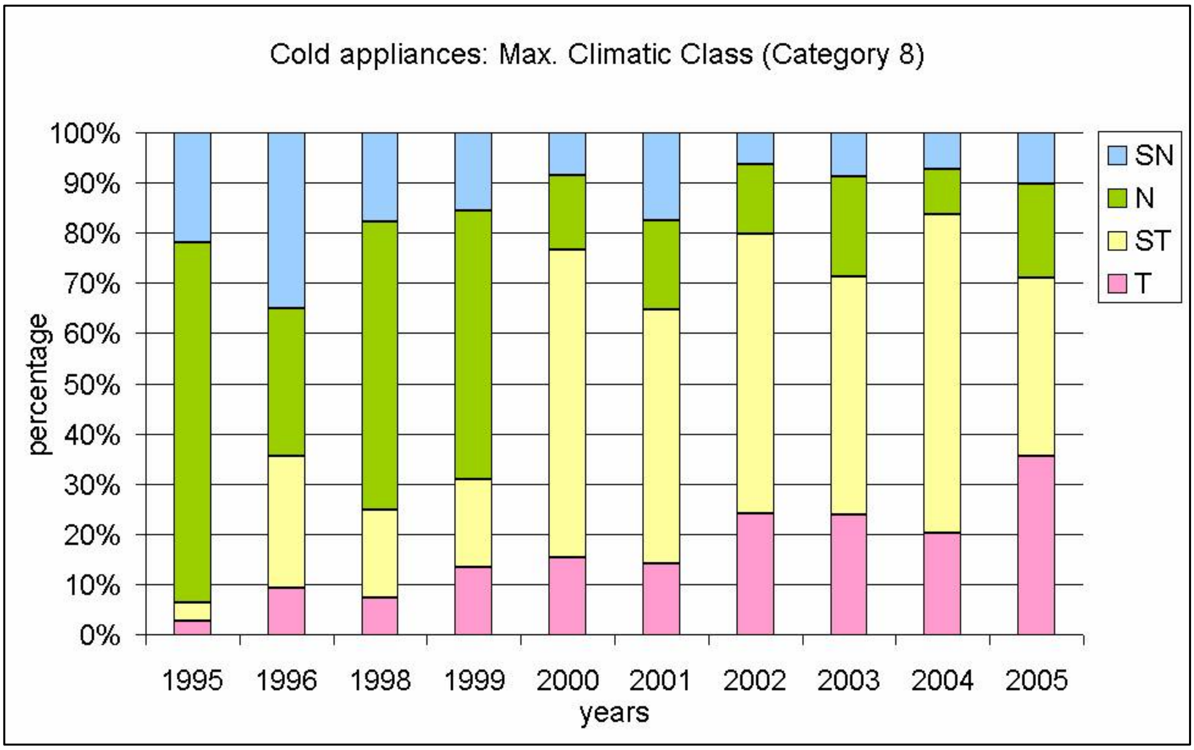


Figure 2.49: development of the climate class distribution for category 8

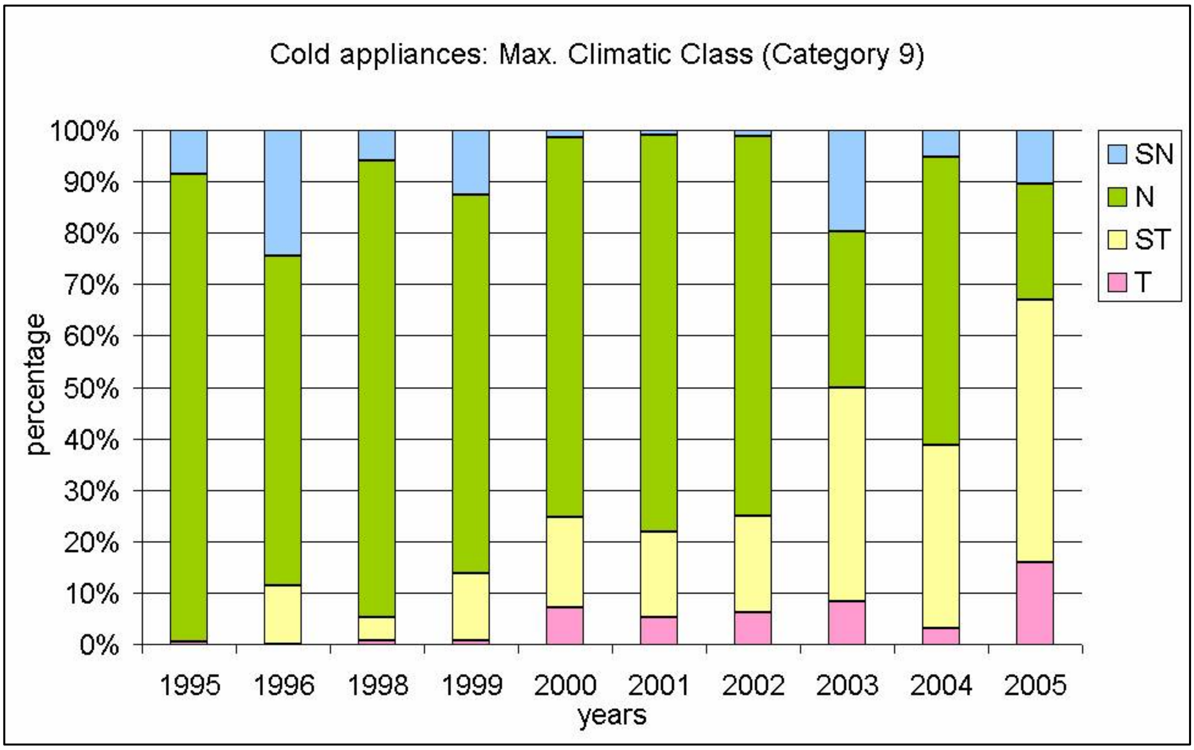


Figure 2.50: development of the climate class distribution for category 9

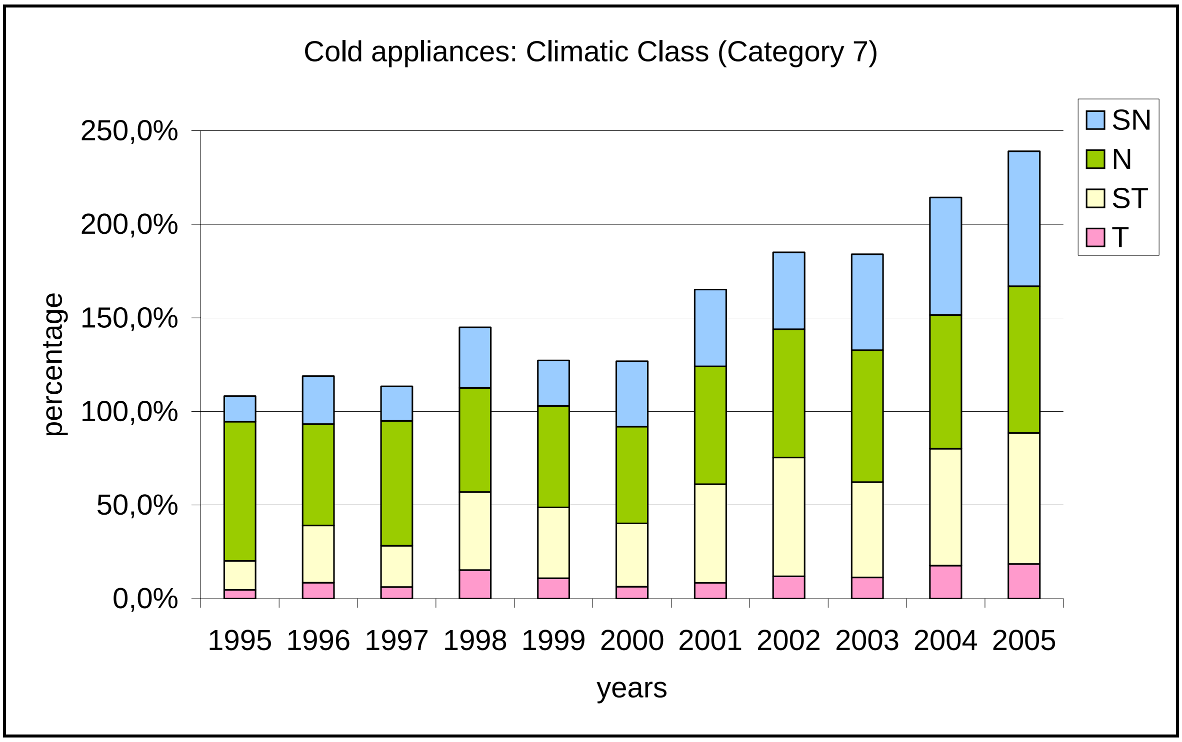


Figure 2.51: multiple climate class allocation (Cat. 7)

Looking at the development of the energy consumption in terms of the average annual energy (Figure 2.52) an almost continuous decrease can be observed for all relevant categories with total savings of between 32 and 39 % compared to the situation in 1995. This development is even more important, as in the same time the absolute net volume of the market offer has only increased about 10 % for the refrigerators and upright freezers, but is stable for refrigerator-freezers and decreasing for chest freezers, as shown before.

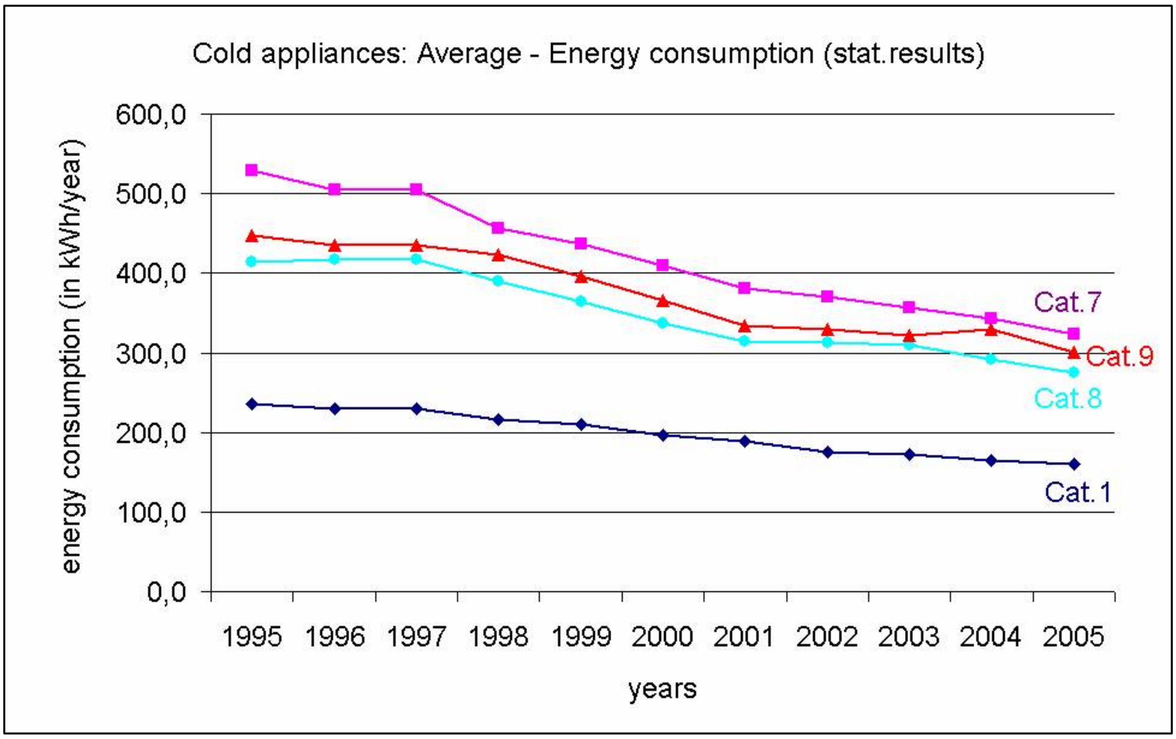


Figure 2.52: development of the annual energy consumption for four categories

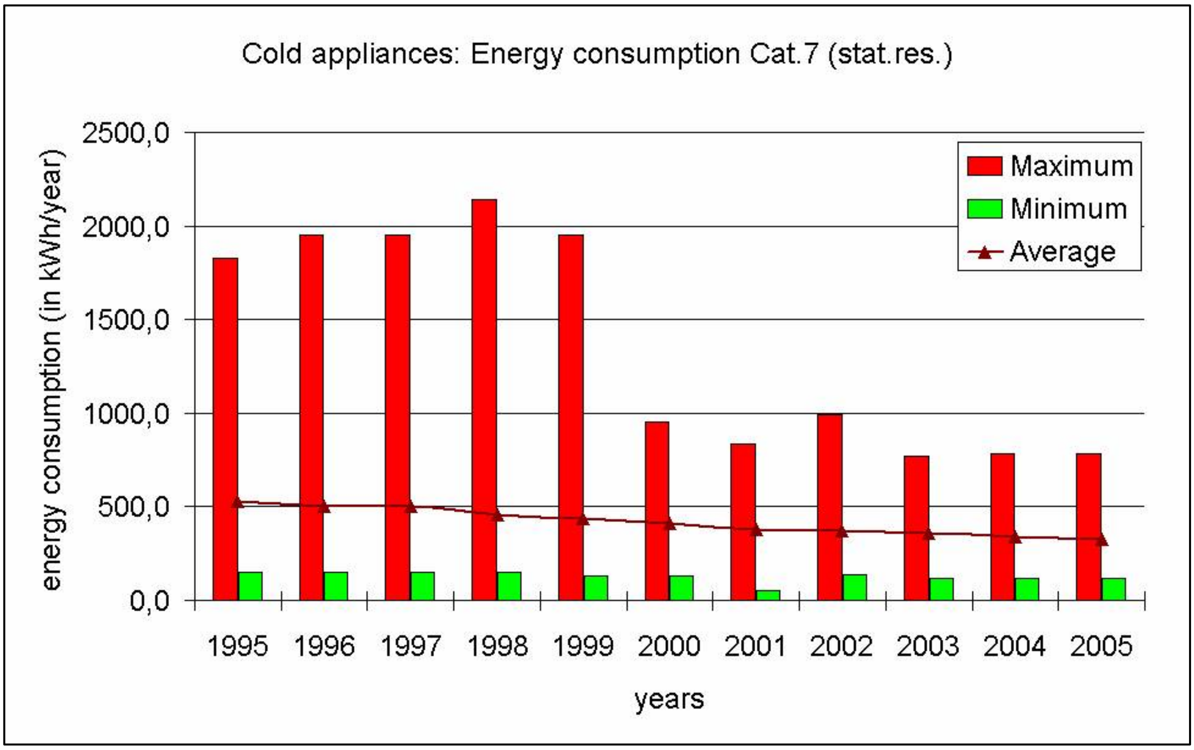


Figure 2.53: maximum, minimum and average annual energy consumption for refrigerator-freezers

This development is obviously not only due to a continuous optimisation of the models on the market, but also due to discarding the most inefficient models from the market (Figure 2.53), which can be seen in all categories. Consequently, the distribution of cold appliances regarding their classification under the energy label has changed (Figure 2.54). In 2005 about 80 % of all cold appliances were declared to be in class A or even better. The introduction of the new classes A+ and A++ in 2004 has obviously opened the market for a new differentiation. This is especially true for categories 1, 7 and 8 where A+ and A++ have gained up to 20 % of the models offered on the market (Figure 2.54, Figure 2.55, Figure 2.56). For refrigerators in 2005 (cat. 1 and 7), no models worse than class C can be found. For upright freezers just 3 % are still in class C and no models are class D or worse. Chest freezers (Figure 2.57) still have a significant amount of models remaining in class D and only some in class E.

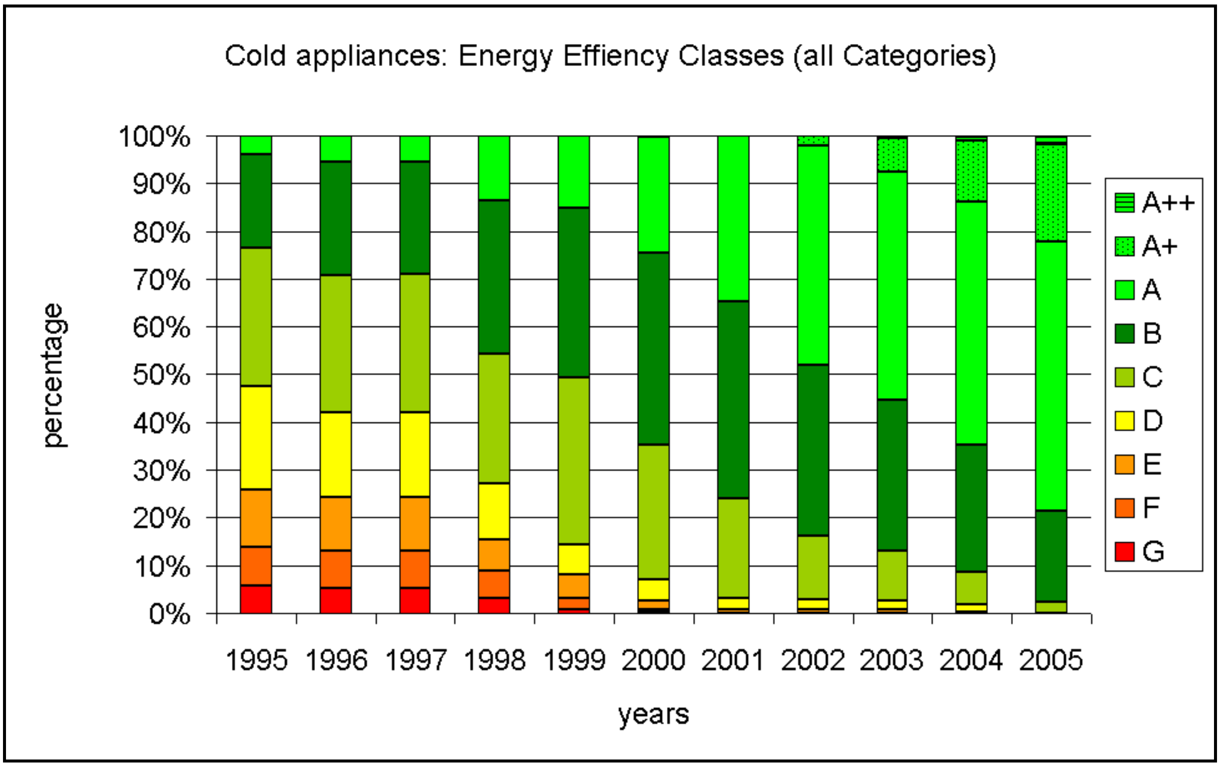


Figure 2.54: distribution of energy efficiency classes for all categories

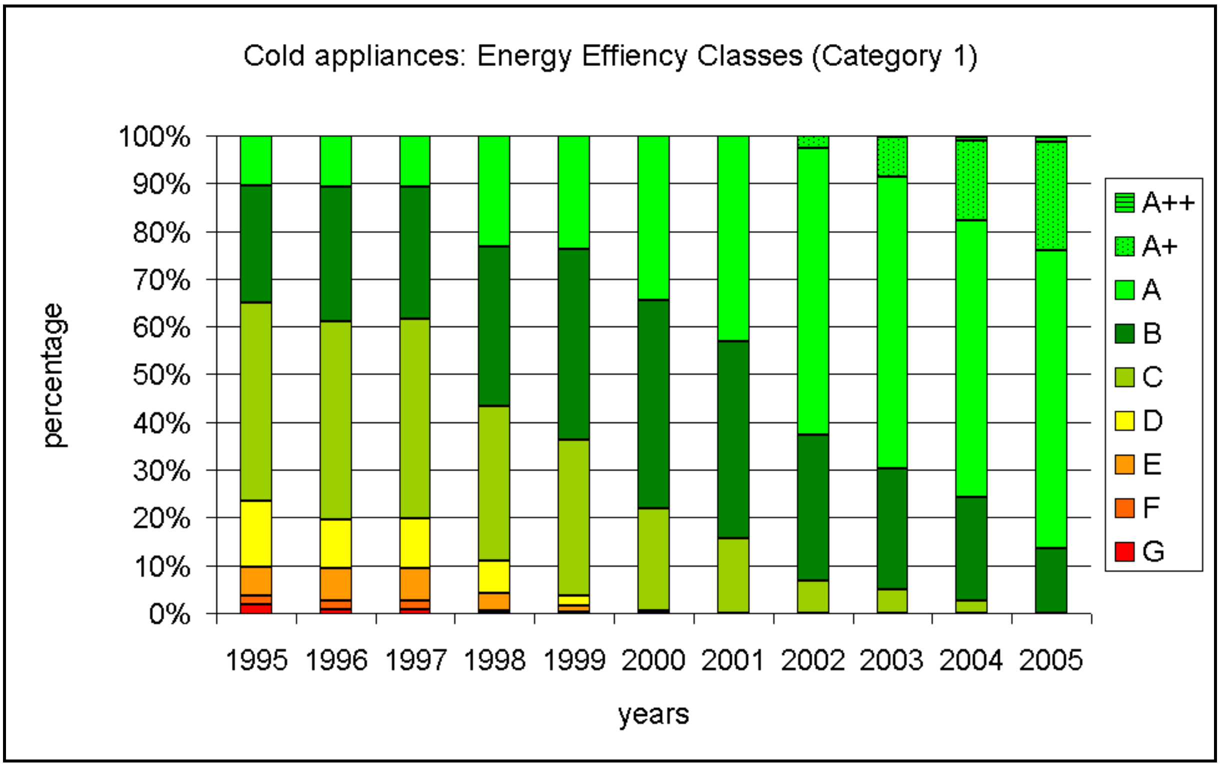


Figure 2.55: distribution of energy efficiency classes for category 1

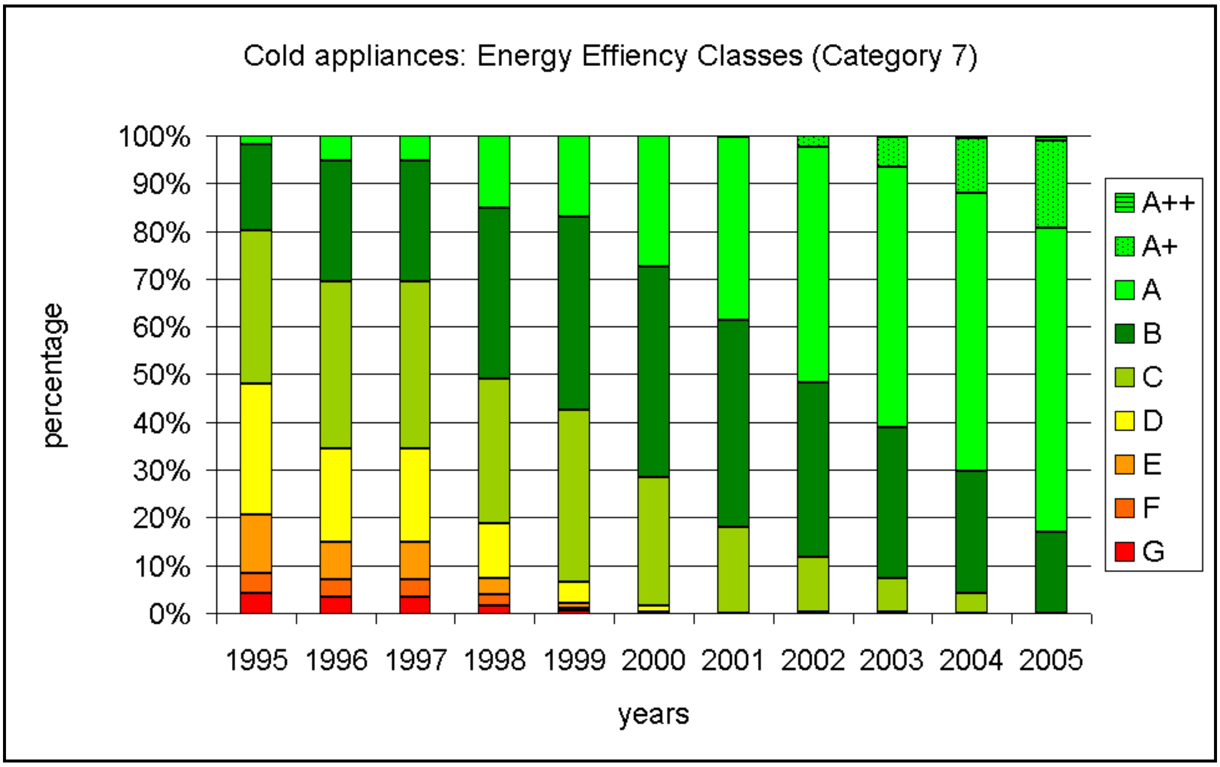


Figure 2.56: distribution of energy efficiency classes for category 7

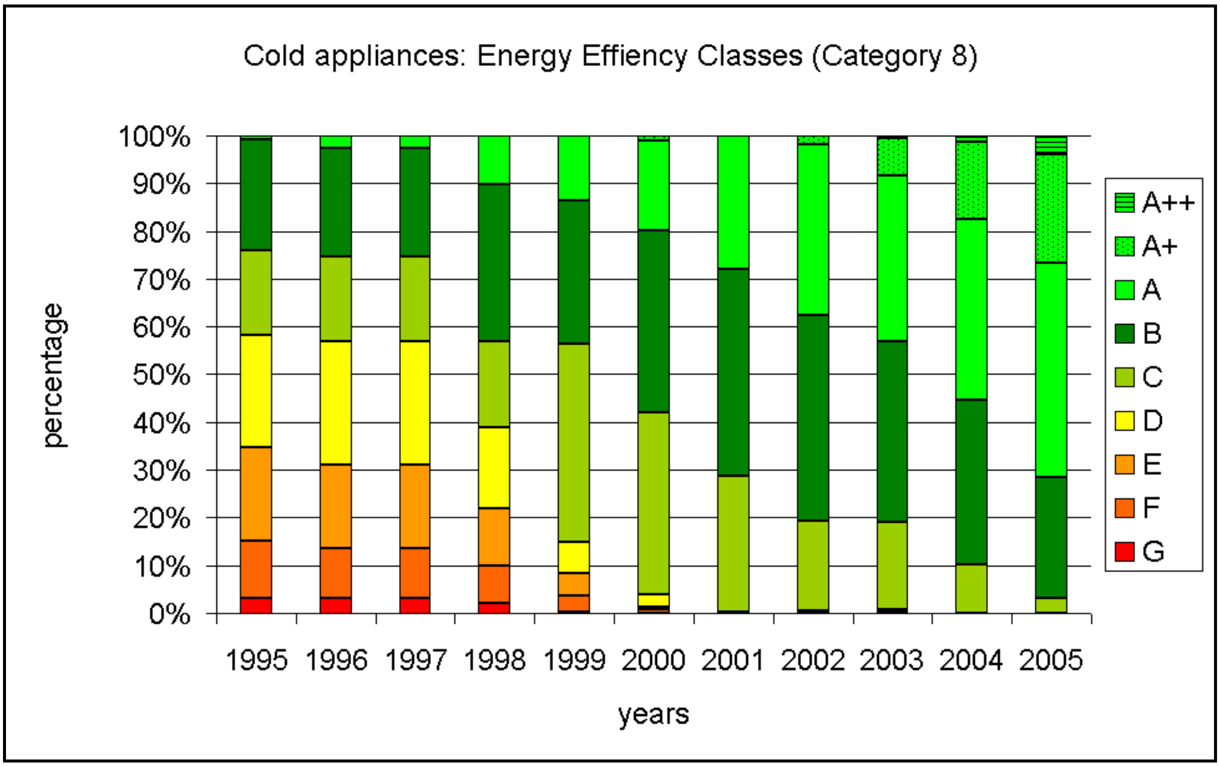


Figure 2.57: distribution of energy efficiency classes for category 8

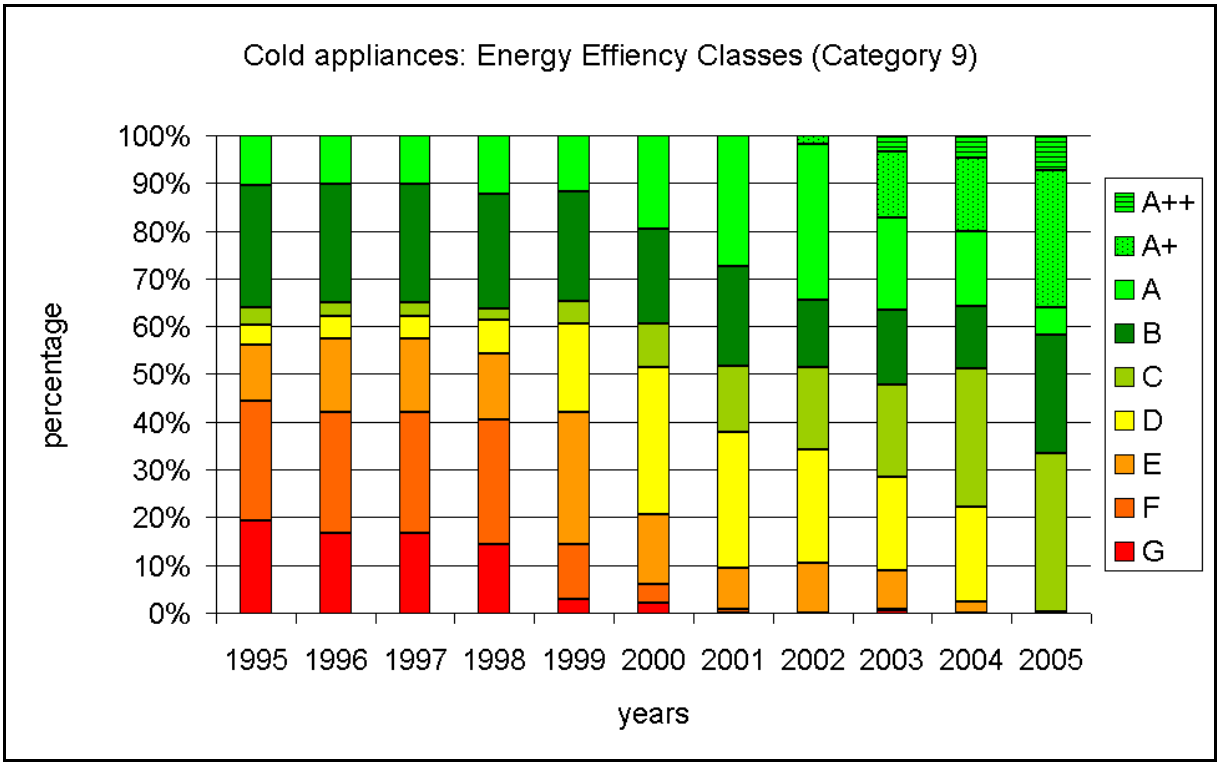


Figure 2.58: distribution of energy efficiency classes for category 9

Regarding the most important category (cat. 7 – refrigerator-freezers) a significant change in the design of appliances can be observed by the data contained in the database[134]: Most of these models are now designed to work with just one compressor and one thermostat (Figure 2.59, Figure 2.60).

[134] Relevant fields in the databases are not filled completely in all the years. The picture may therefore not be representative for all models on the market.

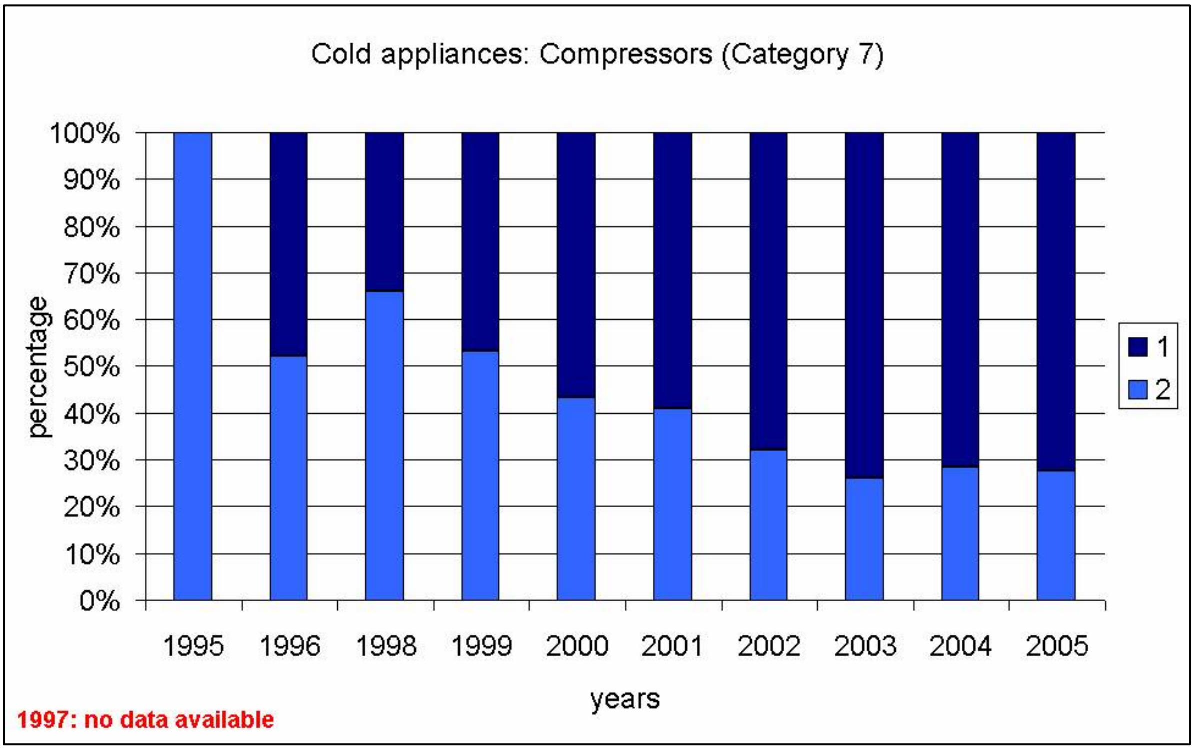


Figure 2.59: number of compressors used in models of category 7

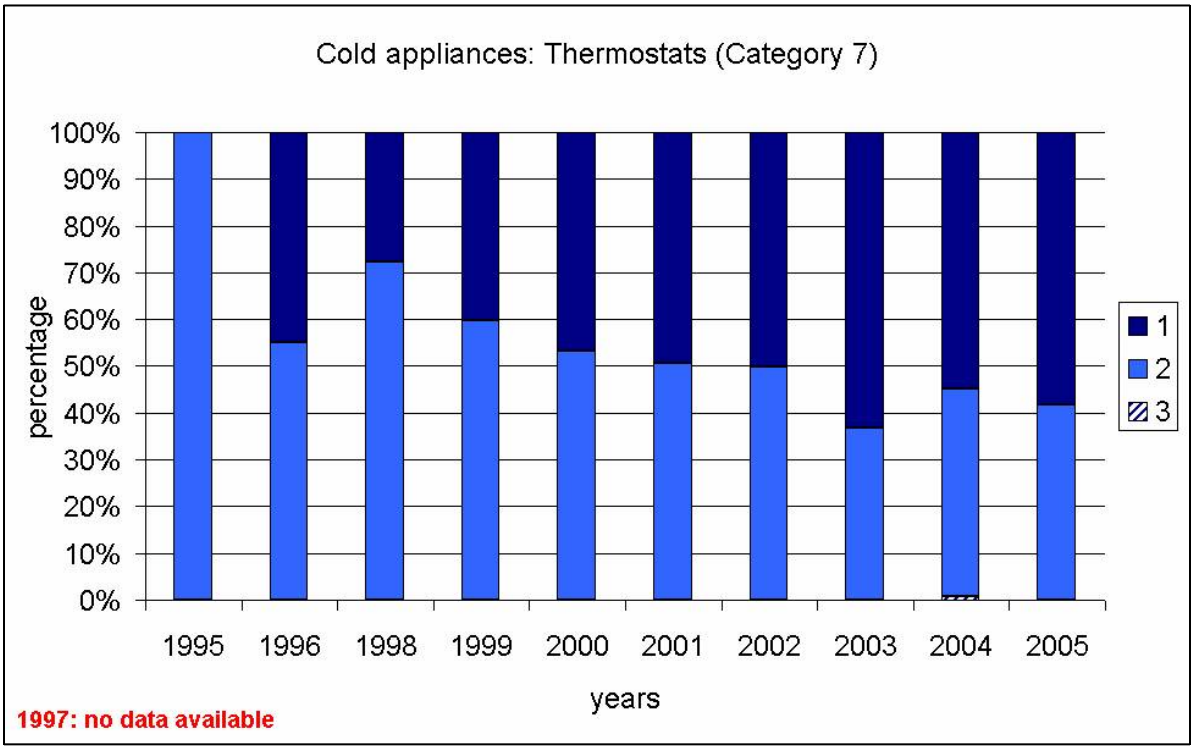


Figure 2.60: number of thermostats used in models of category 7

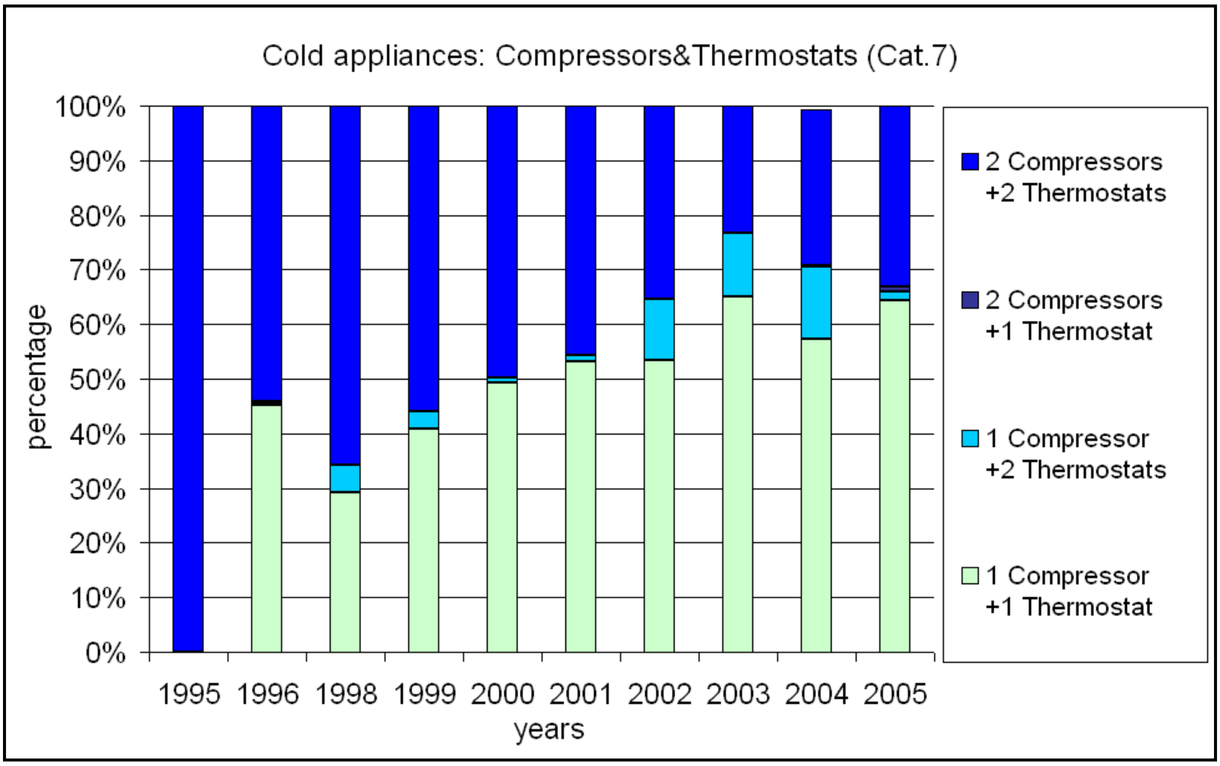


Figure 2.61: representation of combination of number of compressors and thermostats in category 7

In combining the information about the use of compressors and thermostats in category 7 appliances (Figure 2.61) it gets evident that about 60 % of those products do have just one compressor and one thermostat and are therefore limited in their adjustability to various ambient and consumer driven conditions. Solutions with just one compressor and two thermostats (using e.g. a valve to direct the cooling liquid) are found in less than 10 % of the models.

Freezing capacity has been constant over years for refrigerator-freezers and upright freezers and has reduced a little bit for chest freezers (Figure 2.62).

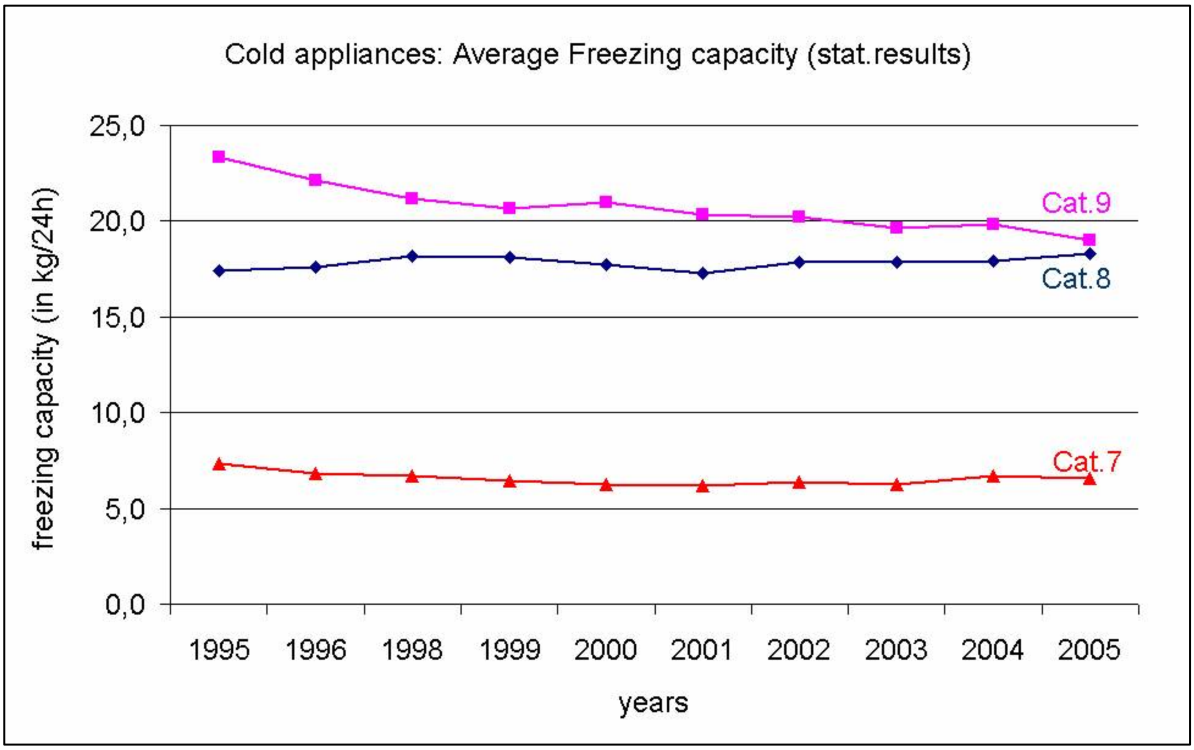


Figure 2.62: development of freezing capacity for categories 7, 8 and 9

Almost constant over time was the temperature rise time for those appliances offering a freezing function (Figure 2.63).

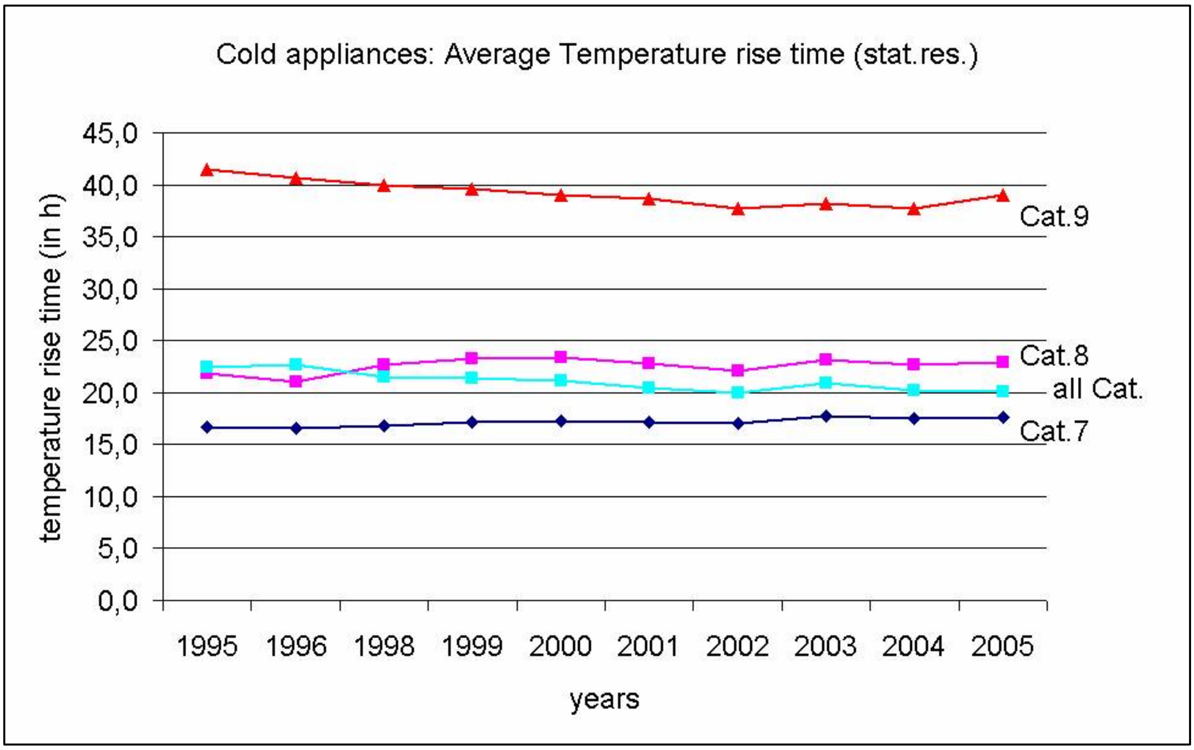


Figure 2.63 development of temperature rise time

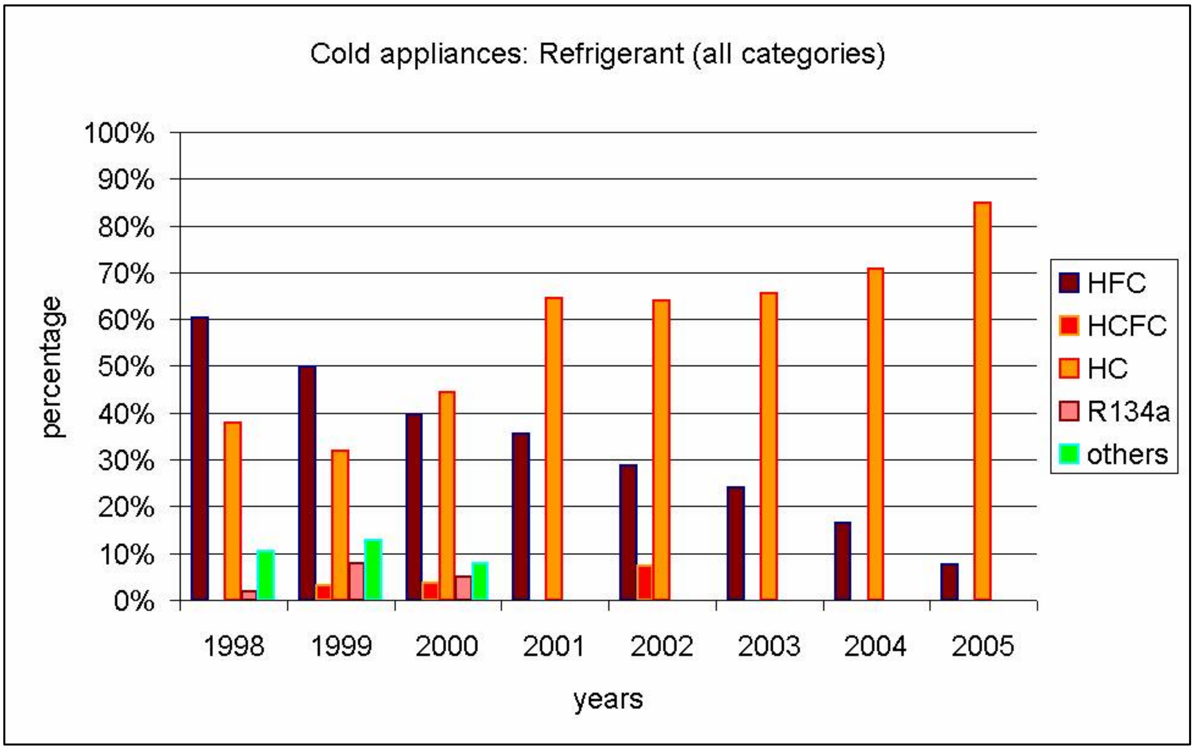


Figure 2.64: replacement of refrigerants

Beside all, the most important development regarding environmental impact of refrigerators and freezers over the period of observation was the almost complete change from chlorinated and halogenated refrigerants towards hydrocarbons (Figure 2.64). This move was almost completed in 2005.

In summary, following trends on the market for refrigerators and freezers can be identified by analysing the model databases:

- almost only 4 categories are left
- moderate increase (~10 %) of capacity of refrigerators – no change for freezers (upright slightly increased the volume, but chest it decreased) and no change for refrigerator-freezers
- drastic change in 'maximum climate' classes towards 'tropical' classes
- coverage of 2,5 climate classes in average by new appliances (cat .7)
- annual energy consumption' reduced between 32 and 39% between 1995 and 2005
- 80 % are in class A or better
- chest freezers are less represented in efficiency class A and better
- drastic increase of fridge-freezers with only one compressor and one thermostat
- small changes in freezing capacity and temperature rise time
- successful replacement of HFCs and HCFCs by hydrocarbons as refrigerant

2.3.3 Market trends as seen by the producer

- Product brochures analysis

Within the market trend analysis current product presentations of cold appliances (refrigerators and freezers) are researched in order to draw conclusions about possible trends.

In doing so primarily web presences and product brochures of the main leaders of the household appliance market in Europe[135] are analyzed under the aspect of which appliance options are emphasized, most frequently mentioned and are presented to the customer? It must be pointed out that the analyzed product presentations are based on the marketing strategies of the companies, which have the aim to reach a multitude of different types of consumers with different wishes and expectations. Nevertheless a set of options for each type of appliance is advertised by the manufacturers on a large or rather less scale. In this context new developments are presented too. Based on these researches general statements about trends of future appliance options are possible to be made.

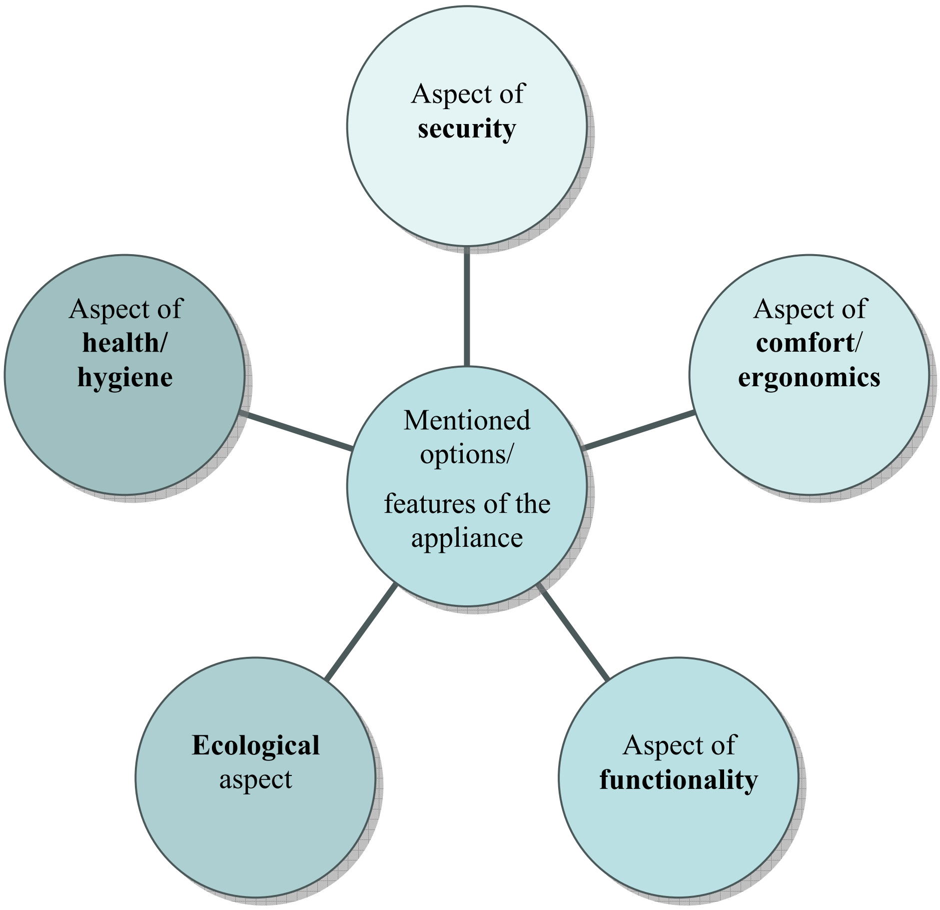


Figure 2.65: grouping criteria of the mentioned appliance options

Following attributes of cold appliances, emphasized by manufacturers, can be named:

[135] Countries: Germany, United Kingdom, Spain, Italy, France, Poland, Czech Republic, Finland

Table 2.29: results – cold appliances: mentioned appliance options/features

a. ecological aspect	- good evaluation in consumer magazines, environment competitions, WWF, etc.… - good evaluation by the energy label → energy consumption (A+ - A++)
b. aspect of functionality	- fresh keeping function/zones/storage (by 3x longer freshness of food, e.g. automatic humidity adjustment, dynamic cooling, conservation with vacuum,…) - "No- / Low-Frost" technology - very fast cooling down - very fast (super) freezing
c. aspect of comfort/ergonomics	- cool water and/or ice cube dispenser - easy opening of doors, baskets/shelves; easy loading,... - flexible, adjustable, clearly arranged baskets/shelves - bigger baskets/shelves - special shelves (e.g. for bottles, pizza, ice cubes,…) - clearly arranged display (e.g. storage- temperature information) - modern design (stainless steel, finger print free, graffiti design, modern colouring,…) - networking - low noise - holiday setting - integrated LCD-flat screen (TV)
d. aspect of health/hygiene	- hygienic filter (e.g. activated-carbon filter → anti-odour effect) - anti-bacterial surfaces - anti-bacteria-thermometer (Temperature control against growth of bacteria, germs,…)
e. aspect of security	- control options: against temperature rise, door close!, power fail, etc…) - modern displays, e.g. touch control LCD (easy, coherent control functions)

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 (Table 2.29).

Following the advertisements the storage of food will be a lot easier for the consumer because of flexible, adjustable and clearly arranged boxes and drawers and easy door opening. Not only bigger drawers but also special, specific food boxes/ shelves are advertised.

Further attributes which are highlighted by almost all producers are „no frost" and/or „low frost" options. These are presented to the consumer with emphasis on ease of work.

The aspect of hygiene plays an important role for cold appliances. This is warranted by e.g. antibacterial interior walls/surfaces of the appliance, hygienic filters, e.g. activated-carbon filters, which also support an anti-odour effect and anti-bacteria thermometer.

Prospective, improved security and more control of the cold appliances are given to the consumer with plain displays and various alarm systems.

Under the aspect of more comfortable design additional features like water and/or ice-cube dispensers or cooling of beer barrels are highly mentioned. Additionally a noble design and look, especially of freestanding appliances, shall establish these appliances as „attractive” in the household. By a lot of manufacturers accordingly modern design options, like stainless steel, finger print free, graffiti design; modern colouring, etc. are promoted in order to give the consumers the possibility to choose an appliance according to their life style. Additionally a reduced noise emission or integrated LCD-flat screens (for TV) should improve the quality of life of the consumer.

Another interesting aspect is, that with cold appliances, especially refrigerators/refrigerator freezers, the option of possible networking is increasingly offered in comparison with other household appliances.

- Manufacturers' Questionnaire

  a) *Refrigerators*

The objective of the market trend analysis is to make statements about the dominating present and future trends of the household appliance market. In addition to the analysis of current product brochures and web presences the appliance manufacturers were interviewed about their opinions on current and future wishes and preferences of their final customers. The results of the questionnaire are presented below.

Several appliance options of refrigerators were presented to a number of market leading appliance manufacturers. They had to give their estimation about the priority of these options for their final customers today and in the future via a ranking. For the estimation a scale was given from 1 point (low priority) to 10 points (high priority).

For refrigerators following appliance options/features were given:

- bigger capacity of loading
- lower energy consumption
- improved cooling adapted to the food (several cooling areas)
- improved possibilities of storage (bigger, removable storage baskets, shelves, bottle racks,…)
- improved cooling control (adjustment to loading, environment, etc…)
- higher comfort of the appliance (ice cubes- or water dispenser,...)
- new hygienic surfaces or effects
- easy or/and automatic defrosting
- network connectivity; communication between household appliances
- lower running costs
- lower price of the appliance

In conjunction with the trend analysis of refrigerators the opinions of nine manufacturers could be used. The highest priority for the customers today from the manufacturer's point of view is the option *lower energy consumption* with 8,6 points (Figure 2.66). This option will become more important in the next 5 years too, with a positive growth of 0,6 points (Table 2.32). All manufacturers show the highest agreement here which is shown by the lowest standard deviation of 1,17 (Table 2.31). But the largest increase is expected for the feature *network connectivity; communication between household appliances*, with a growth of 1,2 points of priority for the customers (Figure 2.66). The only decrease of importance shows the feature *lower price of the appliance* from a position of 7,2 points it will depreciate to 6,6 points (Figure 2.66; Table 2.32). The option *improved possibilities of storage* is evaluated by the manufacturers with a priority level of 7,0 for the consumers today (Table 1. 2.24). Here a high agreement of all manufacturers, derived from the lowest standard deviation, could be calculated again. A comparison of the evaluation of the manufactures on the option *new hygienic surfaces or effects with* the evaluation of the priority level for the customers shows discordance indicated by the highest standard deviation of 2,59 for today (Table 2.30: trends in refrigerators today – by manufacturers' point of view) and with 2,86 (Table 2.31) for the future. According to the opinion of the manufacturers this option only reaches a priority level of 4,2 (Figure 2.66) for their final customers today and they also see no important growing future trend (Δ = 0,6) (Table 2.32).

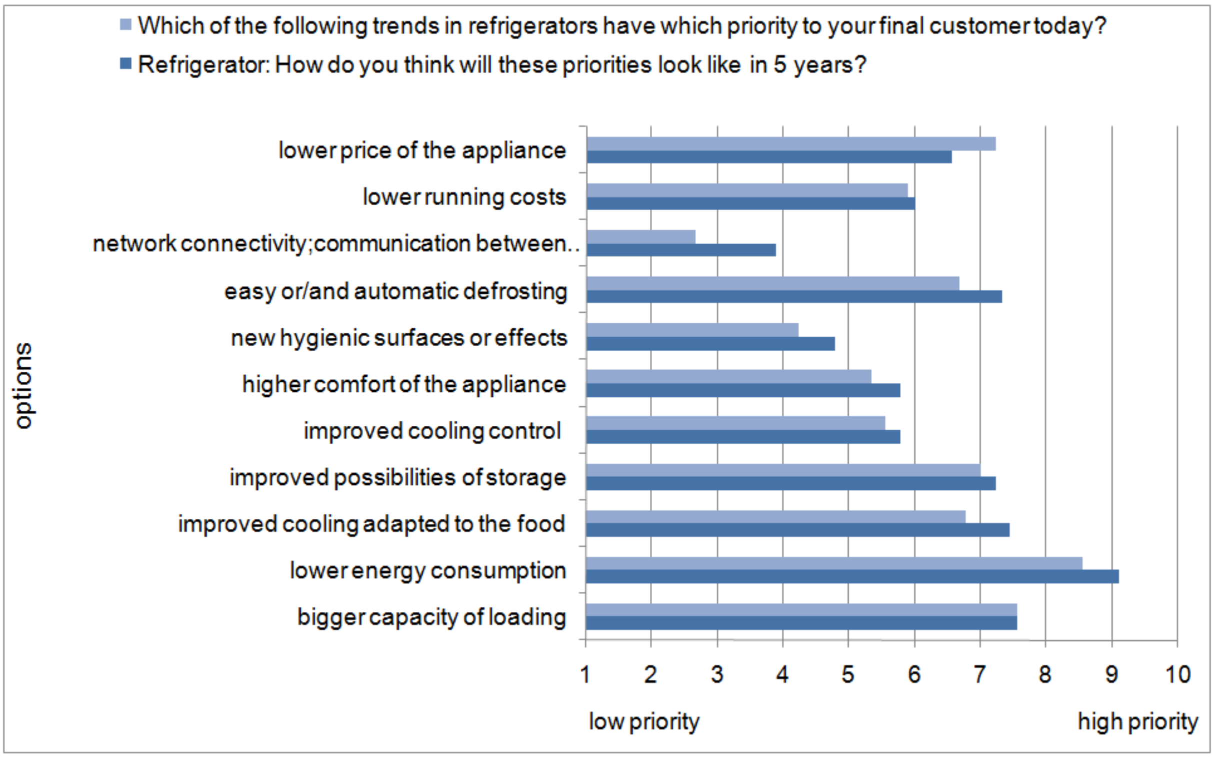


Figure 2.66: refrigerator: priority ranking (comparison: *today – future*) - manufacturer opinion

Table 2.30: trends in refrigerators today – by manufacturers' point of view

Which of the following trends in refrigerators have which priority to your final customer today: *1 (low priority), 2, 3,…, 10 (high priority)?* Descriptive statistic	N	Minimum	Maximum	Average	Standard deviation
network connectivity; communication between household appliances	9	1	6	2,7	1,87
new hygienic surfaces or effects	9	1	8	4,2	2,59
higher comfort of the appliance (ice cubes- or water dispenser,...)	9	3	7	5,3	1,50
improved cooling control (adjustment to loading, environment, etc…)	9	2	9	5,6	2,55
lower running costs	9	3	10	5,9	2,09
easy or/and automatic defrosting	9	2	9	6,7	2,18
improved cooling adapted to the food (several cooling areas)	9	3	10	6,8	1,92
improved possibilities of storage (bigger, removable storage baskets, shelves, bottle racks,…)	9	5	9	7,0	1,41
lower price of the appliance	9	2	10	7,2	2,39
bigger capacity of loading	9	3	10	7,6	2,35
lower energy consumption	9	5	10	8,6	1,67
Valid data (by list)	*9*				

Table 2.31: trends in refrigerators in 5years – by manufacturers' point of view

Refrigerator: How do you think will these priorities look like in 5 years? *1 (low priority), 2, 3,…, 10 (high priority)?* Descriptive statistic	N	Minimum	Maximum	Average	Standard deviation
network connectivity; communication between household appliances	9	1	8	3,9	2,76
new hygienic surfaces or effects	9	1	9	4,8	2,86
improved cooling control (adjustment to loading, environment, etc…)	9	2	9	5,8	2,77
higher comfort of the appliance (ice cubes- or water dispenser,...)	9	3	8	5,8	1,79
lower running costs	9	3	10	6,0	2,00
lower price of the appliance	9	2	10	6,6	2,74
improved possibilities of storage (bigger, removable storage baskets, shelves, bottle racks,…)	9	4	10	7,2	1,72
easy or/and automatic defrosting	9	2	10	7,3	2,29
improved cooling adapted to the food (several cooling areas)	9	5	10	7,4	1,67
bigger capacity of loading	9	3	10	7,6	2,30
lower energy consumption	9	7	10	9,1	1,17
Valid data (by list)	*9*				

Table 2.32: difference: trends in refrigerators *(future –today)* – by manufacturers' point of view

	Δ Rating Priority "Future - Today" Refrigerators
bigger capacity of loading	0,0
lower energy consumption	0,6
improved cooling adapted to the food (several cooling areas)	0,7
improved possibilities of storage (bigger, removable storage baskets, shelves, bottle racks,…)	0,2
improved cooling control (adjustment to loading, environment, etc…)	0,2
higher comfort of the appliance (ice cubes- or water dispenser,...)	0,4
new hygienic surfaces or effects	0,6
easy or/and automatic defrosting	0,7
network connectivity; communication between household appliances	1,2
lower running costs	0,1
lower price of the appliance	-0,7
Valid data (by list)	*9,0*

b) Freezers

Several appliance options of freezers were presented to a number of market leading appliance manufacturers. They had to give their estimation about the priority of these options for their final customers today and in the future via a ranking. For the estimation a scale was given from 1 point (low priority) to 10 points (high priority).

For freezers following appliance options/features were given:

- bigger capacity of loading
- improved possibilities of storage (bigger, removable storage baskets,...)
- lower energy consumption
- lower price of the appliance
- lower running costs
- new hygienic surfaces or effects
- very good cooling or freezing performance (e.g. short freezing time)
- easy or/and automatic defrosting
- improved cooling control (temperature control, acoustic/optical alarm, adjustment to loading, environment, etc…)
- network connectivity; communication between household appliances

In the analysis the answers of nine manufacturers are considered. With an average of 8,1 the manufacturers hold that *lower energy consumption* plays the highest priority for the final customers today, followed by *lower price of the appliance* (7,2) and *bigger capacity of loading* (7,1) (Figure 2.67). For the latter option the standard deviation shows the highest value (2,76) indicating that different opinions were given by the manufacturers (Table 2.33: trends in freezers today – by manufacturers' point of view. The *lower price of the appliance* will decrease in importance in the next 5 years most (-0,6). In a minor degree (-0,1) also the option *bigger capacity of loading* will decrease in priority. All remaining options will become more important in the future. With a growth of between 0,6-0,9 points *lower energy consumption, lower running costs, new hygienic surfaces or effects* and *easy or/and automatic defrosting* and in a smaller measure (0,2-0,4) *improved possibilities of storage*, *very good cooling or freezing performance* and *improved cooling control* (Table 2.35). The highest rise shows the feature *network connectivity; communication between household appliances.* Here the priority rises from a priority rank of 2,1 for the customers today to 3,7 in the future.

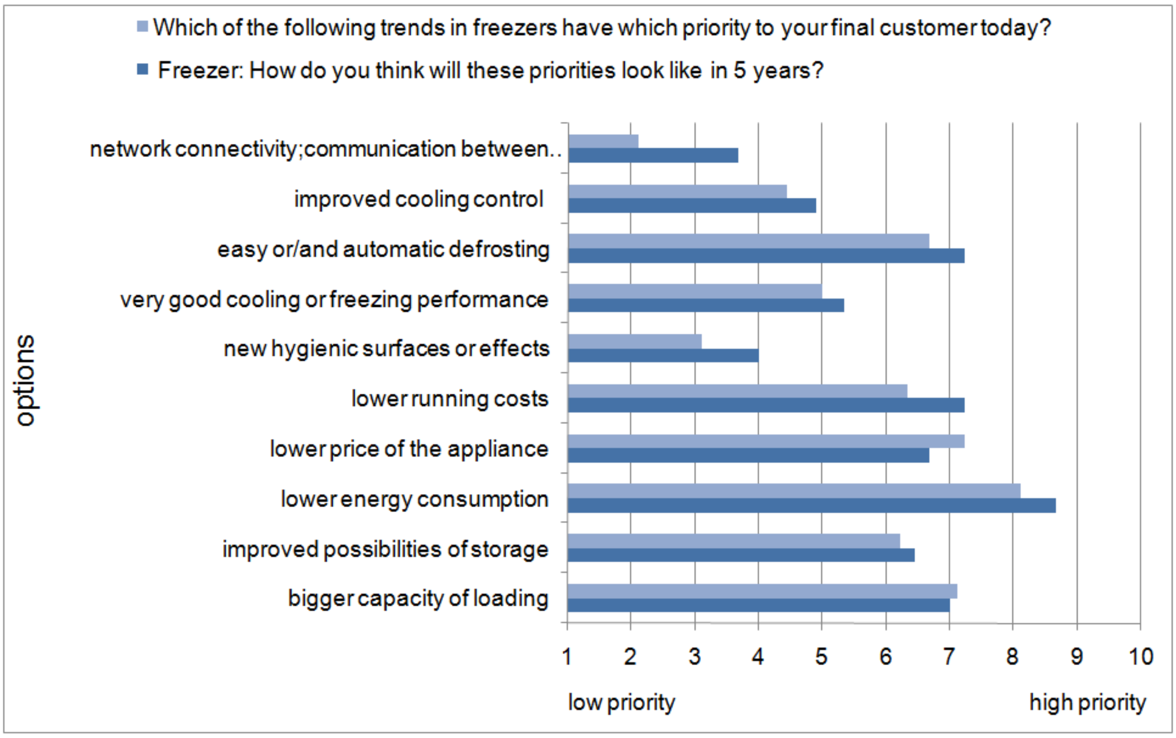


Figure 2.67 freezer: priority ranking *(comparison: today – future)* by manufacturer

Table 2.33: trends in freezers today – by manufacturers' point of view

Which of the following trends in freezers have which priority to your final customer today: *1 (low priority), 2, 3,…, 10 (high priority)?* Descriptive statistic	N	Minimum	Maximum	Average	Standard deviation
network connectivity; communication between household appliances	9	1	5	2,1	1,36
new hygienic surfaces or effects	9	1	6	3,1	1,76
improved cooling control (temperature control, acoustic/optical alarm, adjustment to loading, environment, etc…)	9	2	7	4,4	1,59
very good cooling or freezing performance (e.g. short freezing time)	9	3	8	5,0	1,73
improved possibilities of storage (bigger, removable storage baskets,...)	9	4	8	6,2	1,09
lower running costs	9	4	9	6,3	1,80
easy or/and automatic defrosting	9	3	10	6,7	2,50
bigger capacity of loading	9	3	10	7,1	2,76
lower price of the appliance	9	5	10	7,2	1,39
lower energy consumption	9	5	10	8,1	1,62
Valid data (by list)	9				

Table 2.34: trends in freezers in 5years – by manufacturers' point of view

Freezer: How do you think will these priorities look like in 5 years? *1 (low priority), 2, 3,…, 10 (high priority)?* Descriptive statistic	N	Minimum	Maximum	Average	Standard deviation
network connectivity; communication between household appliances	9	1	7	3,7	2,29
new hygienic surfaces or effects	9	1	8	4,0	2,12
improved cooling control (temperature control, acoustic/optical alarm, adjustment to loading, environment, etc…)	9	2	7	4,9	1,76
very good cooling or freezing performance (e.g. short freezing time)	9	3	8	5,3	1,73
improved possibilities of storage (bigger, removable storage baskets,...)	9	3	8	6,4	1,67
lower price of the appliance	9	5	10	6,7	1,58
bigger capacity of loading	9	3	10	7,0	2,83
lower running costs	9	3	10	7,2	2,17
easy or/and automatic defrosting	9	2	10	7,2	2,59
lower energy consumption	9	7	10	8,7	1,32
Valid data (by list)	*9*				

Table 2.35: difference: trends in freezer *(future – today)* – by manufacturers' point of view

	Δ Rating Priority "Future - Today" Freezer
bigger capacity of loading	-0,1
improved possibilities of storage (bigger, removable storage baskets,...)	0,2
lower energy consumption	0,6
lower price of the appliance	-0,6
lower running costs	0,9
new hygienic surfaces or effects	0,9
very good cooling or freezing performance (e.g. short freezing time)	0,3
easy or/and automatic defrosting	0,6
improved cooling control (temperature control, acoustic/optical alarm, adjustment to loading, environment, etc…)	0,4
network connectivity; communication between household appliances	1,6
Valid data (by list)	*9,0*

2.3.4 Market trends as seen by the consumer magazines

a) Refrigerators

Consumer magazines frequently test refrigerators for publication in their magazines. Via these magazines they have a broad audience by which they influence the consumer in his buying decision and therefore are one of the driving forces of the market. But they also get frequent feedback from their readers which they use to define what is tested and published and how the testing of products is done. It may therefore be assumed, that they reflect consumer expectations and market trends in their testing and publication work. In looking at and analysing these publications over the last five years a decent overview on consumer requirements and market trends can be achieved.

A systematic analysis of the criteria and functions tested and how they have changed over the last five years was performed using all publications as listed (Table 2.36).

Tested criteria and functions were collected for each country. If priorities of certain criteria were pointed out in the magazine, this was taken into account. The next step was to evaluate which criteria were tested in every publication in one country, whether priorities were shifted, which criteria were added and which were discarded through the years. Finally all countries were compared looking for similarities and differences. All criteria and functions were then sorted and listed by frequency of testing in all publications.

Table 2.36 magazines and publications which featured a test of refrigerators or refrigerator-freezers

	2001	2002	2003	2004	2005	2006
‚test' (Stiftung Warentest - D)	9/2001	8/2002	-	-	10/2005	-
Konsument (A)	-	-	1/2003	-	-	-
Which (UK)	9/2001	-	10/2003	3/2004	-	-
Consumentengids (NL)	-	4/2002	-	2/2004	-	1/2006
Compra maestra (E)	-	-	5/2003	-	6/2005	-
Pro Teste (P)	-	5/2002	5/2003	5/2004	-	-
Altroconsumo (I)	-	5/2002	5/2003	-	-	-
Que Choisir (F)	-	10/2002	-	10/2004	-	-
60 Millions de Consommateurs (F)	8/2001	-	-	-	-	-
Test-Achâts (B)	1/2001	1/2002 7-8/2002	1/2003 7-8/2003	1/2004	-	-
Kuluttaja (FI)	6/2001	4/2002	-	-	-	-
Råd & Rön (S)	-	1/2002 6/2002	4/2003	3/2004	-	-

	2001	2002	2003	2004	2005	2006
Tænk + Test (DK)	3/2001 8/2001	2/2002 5/2002	2/2003	2/2004	-	-
Forbruker-Rapporten (N)	-	8/2002	2/2003	1/2004	-	-

- Frequency of criteria/ functions tested on refrigerators and refrigerator-freezers in the observed countries during the past 5 years

Germany

"Stiftung Warentest" indicates testing priorities by giving the proportion of certain criteria from the final test score. A larger proportion/percentage indicates a higher priority of that characteristic.

The testing priorities have changed during the last five years.

Until 2002 first priority (45 %) lay on cooling performance including temperature stability, thermostat setting, room temperature range, temperature increase in case of failure and in 2001 freezing capacity. Second priority (30 %) lay on energy consumption. 15 % of the final test score is based on ease-of-use. In 2001 10% of the final score is based on a combined criterion including door sealing, storage rating and temperature indicator. In 2002 10 % is based on noise and door sealing combined.

In 2005 first priority (35 %) lay on energy consumption. 20 % each of the final score are based on cooling performance and freezing performance. Cooling performance includes temperature stability of the regular refrigerator compartment, temperature stability of the chill compartment and fast cooling. Freezing performance includes temperature stability, freezing capacity and temperature increase in case of failure. Ease-of-use makes up 15 % of the final score and accuracy of the temperature indicator and warning signal together make up 10 %.

Throughout all years information is given on price, volume of the refrigerator, energy consumption given as kWh/year, climate class, number of solid shelves and split shelves and whether the refrigerator has an electronic control panel.

Austria

"Konsument" indicates testing priorities by giving the proportion of certain criteria from the final test score. A larger proportion/percentage indicates a higher priority of that characteristic.

Refrigerators have only been tested once in the past five years.

First priority (80 %) lay on technical details such as energy consumption in 24 h, volume and storage surface area. 20 % of the final test score is based on ease-of-use including the user manual.

Other criteria indicated are, e.g. manufacturer warranty, super frost, chill compartment and antibacterial coating.

UK

"Which" indicates testing priorities by giving the proportion of certain criteria from the final test score. A larger proportion/percentage indicates a higher priority of that characteristic.

The percentages have changed throughout the years.

In 2001 25 % each of the final test score is based on temperature stability and temperature range, 15 % on ease-of-use, 10 % each on thermostat setting, ease of defrosting and noise. 5 % is based on temperature stability of the freezer compartment.

In 2003 25 % each of the final test score is based on temperature stability and temperature range also and 10 % each is based on ease-of-use, thermostat setting, and ease of defrosting, noise / vibration and freezing capacity.

In 2004 85 % of the final test score is based on temperature stability of the refrigerator compartment, freezer compartment, defrosting performance and noise/ vibration, 15 % is based on ease-of-use, storage flexibility and frost-free mechanism of refrigerator and freezer.

The Netherlands

"Consumentengids" indicates testing priorities by giving the proportion of certain criteria from the final test score. A larger proportion/percentage indicates a higher priority of that characteristic.

The percentages have changed throughout the years.

In 2002 14 % each of the final test score are based on temperature stability of refrigerator and freezer, thermostat setting and freezing capacity, 13 % is based on noise/ vibration, 9 % each on ease-of-use and temperature increase in case of failure. 7 % is based on the recommended thermostat setting and 6 % on ease of defrosting.

In 2004 25 % of the final test score is based on temperature stability of refrigerator and freezer combined, and 25% is based on thermostat setting. 10 % each are based on ease-of-use, cooling capacity, recommended thermostat setting and ease of defrosting, and 5 % each are based on noise/ vibration and user manual.

In 2006 15 % of the final test score is based on energy consumption, 10 % each on temperature stability of refrigerator and freezer, cooling capacity, freezing capacity, ease-of-use, recommended thermostat setting and temperature increase in case of failure. 5 % each of the final score is based on noise/ vibration, temperature indicator and ease of defrosting.

Throughout all years information is given on price, volume of refrigerator and freezer as well as climate class.

Spain

"Compra maestra" does not indicate testing priorities.

Following criteria have been tested throughout all observed years: thermostat setting, temperature stability of the freezer, temperature increase in case of failure, energy label, ease-of-use, ease of defrosting, annual running cost and noise. Since 2005 energy consumption, temperature stability of the refrigerator and defrosting performance are tested also.

Throughout all years information is given on price, dimensions, volume of refrigerator and freezer, number of compressors, super cool/frost and automatic defrosting.

Portugal

"Proteste" does not indicate testing priorities.

Following criteria have been tested throughout all observed years: thermostat setting of refrigerator and freezer, freezing capacity, ease-of-use, noise, annual running cost and recommended thermostat setting. Since 2003 energy consumption is tested also. Until 2002 temperature stability of the freezer and ease of defrosting were tested.

Throughout all years information is given on price, dimensions, volume of refrigerator and freezer and possibility to store bottles standing upright.

Italy

"Altroconsumo" does not indicate testing priorities.

Following criteria have been tested throughout all observed years: temperature stability of refrigerator and freezer, freezing capacity, temperature increase in case of failure, energy consumption and energy label, ease-of-use and ease of defrosting, noise and annual running cost.

Throughout all observed years information is given on price, dimensions, volume of refrigerator and freezer, ventilation and whether the refrigerator has an external control panel, super frost/ cool and rollers/ castor for easy moving.

France

France has two different consumer information magazines.

"Que Choisir" indicates testing priorities in 2004 only, but percentages are not given.

In 2002 only highest priority is indicated, this includes temperature stability of refrigerator and freezer, temperature increase in case of failure, freezing capacity and energy consumption.

In 2004 first priority lay on temperature stability of refrigerator and freezer, room temperature range and energy consumption, second priority lay on ease-of-use, noise, temperature increase in case of failure and storage surface area.

Throughout all years information is given on price, dimensions, volume of refrigerator and freezer, climate class, energy label and energy consumption given as kWh/year.

"60 Millions de Consommateurs" indicates testing priorities by giving the proportion of certain criteria from the final test score.

Refrigerators have only been tested once during the last five years.

25 % of the final test score is based on temperature stability and thermostat setting combined, and 25 % is based on freezing capacity. 20 % is based on energy consumption within 24 h, 10 % each are based on noise, ease-of-use and temperature increase in case of failure.

Information is given on price, dimensions, volume of refrigerator and freezer, energy label, refrigerant and climate class.

Belgium

"Test-Achats" does not indicate testing priorities.

Following criteria have been tested throughout all observed years: temperature stability, energy consumption and ease-of-use. In 83 % of all publications temperature stability of the freezer, freezing capacity, noise and temperature increase in case of failure have been tested.

Throughout all years information is given on price, dimensions and volume of the refrigerator.

Finland

"Kuluttaja" indicates testing priorities by giving the proportion of certain criteria from the final test score.

The priorities have changed throughout the years.

In 2001 35 % of the final test score is based on ease-of-use including cleaning and user manual as well as arrangement. Another 35 % is based on energy consumption given as kWh/year and energy label as well as noise, refrigerant and insulation material. 30 % of the final score is based on cooling performance including temperature stability, temperature range inside the refrigerator and room temperature range of refrigerator and freezer.

In 2002 35 % of the final test score is based on cooling performance and freezing capacity, another 35 % is based on ease-of-use including cleaning, defrosting, temperature setting, user manual and arrangement. 30 % of the final score is based on safety.

Throughout all observed years information is given on price, dimensions and volume of the refrigerator.

Sweden

"Råd & Rön" does not indicate testing priorities.

Following criteria have been tested throughout all observed years: energy consumption, energy label and noise. In 75 % of all observed publications refrigerator temperature range, freezing capacity and temperature increase in case of failure have been tested.

Throughout all years information is given on price, dimensions and volume of the refrigerator.

75 % of the publications give information on volume of the freezer, refrigerant, insulation material, number of solid racks, wine rack, adjustable door rack and an external control panel.

Denmark

"Test + Tænk" indicates testing priorities by giving the proportion of certain criteria from the final test score.

The percentages and priorities have changed throughout the years.

In March 2001 first priority (40 %) lay on energy consumption, energy label, refrigerant and insulation material. 30 % of the final test score is based on temperature stability of refrigerator and freezer, thermostat setting, room temperature range, freezing capacity and temperature increase in case of failure. Another 30 % is based on ease-of-use, cleaning, defrosting and arrangement.

In August 2001 ease-of-use, cleaning and user manual together make up 35 % of the final test score. Energy consumption, noise/ vibration, refrigerant and insulation material together make up 35 % also. 30 % of the final test score is based on thermostat setting, room temperature range and refrigerator temperature range.

In May 2002 thermostat setting, room temperature range and refrigerator temperature range, freezing capacity and temperature increase in case of failure together make up 30 % of the final test score. Ease-of-use, cleaning, defrosting and user manual also make up 30 %. 25 % of the final score is based on energy consumption, 15 % noise, refrigerant and insulation material.

In 2003 thermostat setting, room temperature range, refrigerator temperature range, freezing capacity and temperature increase in case of failure together make up 35 % of the final test score. Energy consumption, noise, refrigerant and insulation material also make up 35 %. 30 % of the final score is based on ease-of-use, cleaning, defrosting and user manual.

In 2004 44 % of the final test score is based on thermostat setting, room temperature range cooling capacity, freezing capacity and temperature increase in case of failure as well as number compressors and number thermostats. Ease-of-use, cleaning, defrosting and user manual make up 28 % of the final score. 16 % is based on refrigerant and insulation material and 12 % is based on energy consumption.

Throughout all observed years information is given on price, dimensions, volume of refrigerator and freezer and energy label.

Norway

"Forbruker-Rapporten" indicates testing priorities by giving the proportion of certain criteria from the final test score.

Percentages are only given until 2003.

In 2002 25 % of the final test score is based on energy consumption, 15 % on ease-of-use and arrangement combined, 10 % each is based on noise and user manual, 8 % refrigerator temperature range, freezing capacity and temperature increase in case of failure. Thermostat setting refrigerator, thermostat setting freezer and climate class each make up 2 % of the final score.

In 2003 first priority (20 %) lay on energy consumption. 15 % each of the final score are based on ease-of-use and arrangement combined, as well as refrigerator temperature range, 10 % each on noise, thermostat setting, room temperature range and user manual. 5 % each are based on ease of cleaning and defrosting as well as refrigerant.

Throughout all observed years information is given on price, volume of refrigerator and freezer, energy label and energy consumption given as kWh/year.

EU

Summary

The analysis of consumer magazines in the EU for refrigerators/ refrigerator freezers shows that one characteristic has been tested in every publication. This characteristic is the volume of the refrigerator. Tested or indicated in 97,6 % of all observed publications are cooling performance (global) and price. In most publications cooling performance consists of a variety of characteristics such as temperature stability, thermostat setting, temperature range and temperature increase in case of failure. Only in Portugal and France ("Que choisir") cooling performance is evaluated by just one characteristic (thermostat setting in Portugal and temperature stability in France).

Also tested or indicated with first priority are ease-of-use, noise, volume of the freezer, freezing performance (global), dimensions and freezing capacity.

Evaluated in 50 – 75 % of all observed publications are energy label, thermostat setting (refrigerator), energy consumption, ease of defrosting, temperature stability (refrigerator and freezer) and energy consumption given as kWh/year.

- Overview

The frequency of the tested criteria throughout the observed years and countries has been classified to four priority levels (PL) according to how often they have been evaluated.

For this purpose the frequency of a tested feature is given as percentage of all publications.

Priority level 1 (**PL 1**) for more than 75 %

Priority level 2 (**PL 2**) for 50 % - 75 %

Priority level 3 (**PL 3**) for 25 % - 50 %

Priority level 4 (**PL 4**) for less than 25 %

Following criteria can be ranked to the highest priority level. They are sorted by percentage, starting with the highest.

Table 2.37: refrigerator: ranking of criteria per priority level

PL 1	volume (refrigerator)	100,0 %
	cooling performance (global)	97,6 %
	price	97,6 %
	ease-of-use	92,7 %
	noise	90,2 %
	volume (freezer)	87,0 %
	freezing performance (global)	85,4 %
	dimensions	78,0 %
	freezing capacity	75,6 %
PL 2	energy label	68,3 %
	thermostat setting (refrigerator)	65,9 %
	energy consumption total	63,4 %
	ease of defrosting	61,0 %
	temperature stability (refrigerator)	58,5 %
	temperature stability (freezer)	51,2 %
	energy consumption given as kWh/year	51,2 %
PL 3	temperature increase in case of failure	46,3 %
	refrigerant	46,3 %
	ease of cleaning	43,9 %
	annual running cost	36,6 %
	user manual	34,1 %
	fridge temperature range	31,7 %
	temperature indicator	31,7 %
	super cool/ frost	31,7 %
	room temperature range (refrigerator)	29,3 %
	insulation material	29,3 %
	arrangement	26,8 %
	wine rack	26,8 %

PL 4	only the nine criteria with highest percentage of this priority level are mentioned	
	climate class	24,4 %
	number solid/ glass shelves	24,4 %
	split shelf	24,4 %
	adjustable door rack	24,4 %
	high temperature warning	24,4 %
	external control panel	19,5 %
	bottle grip	19,5 %
	number drawers (refrigerator)	19,5 %
	number compressors	19,5 %

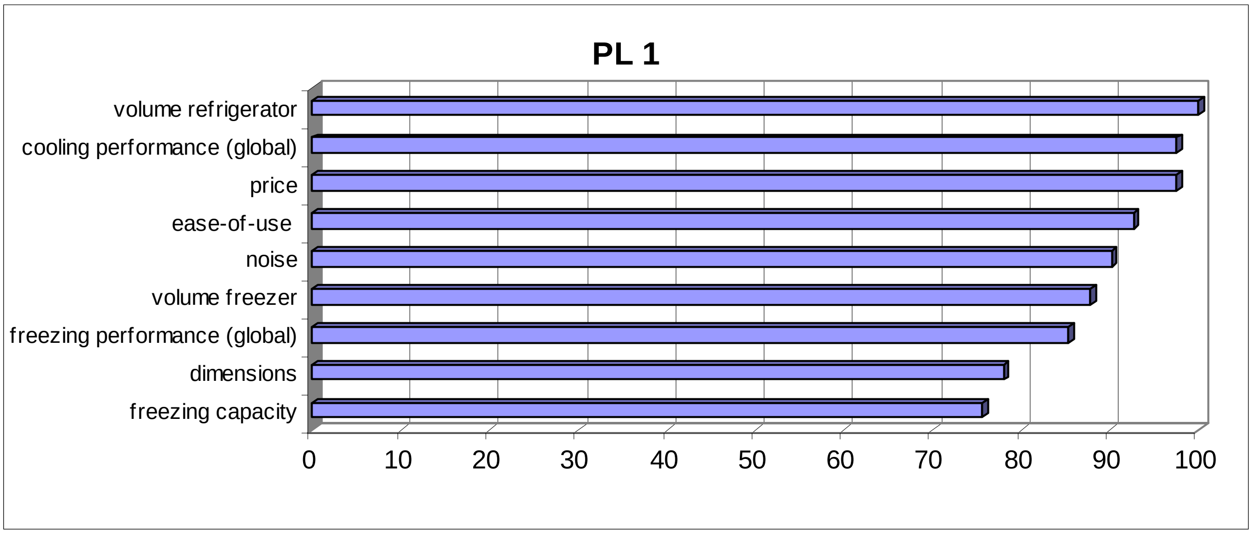


Figure 2.68: refrigerator: priority level 1: frequency of the tested criteria

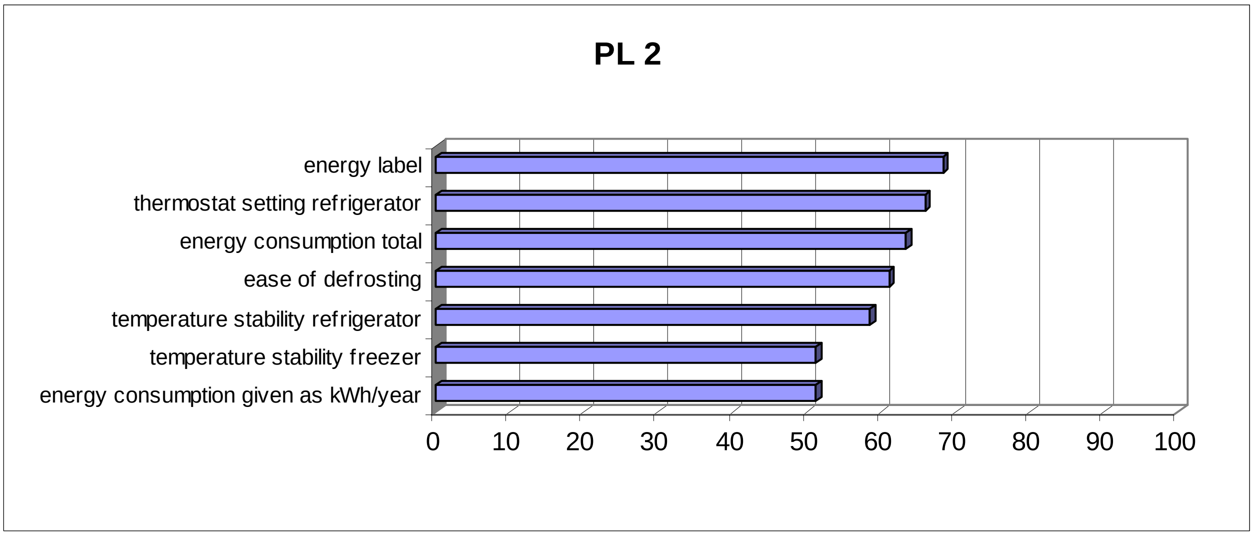


Figure 2.69: refrigerator: priority level 2: frequency of the tested criteria

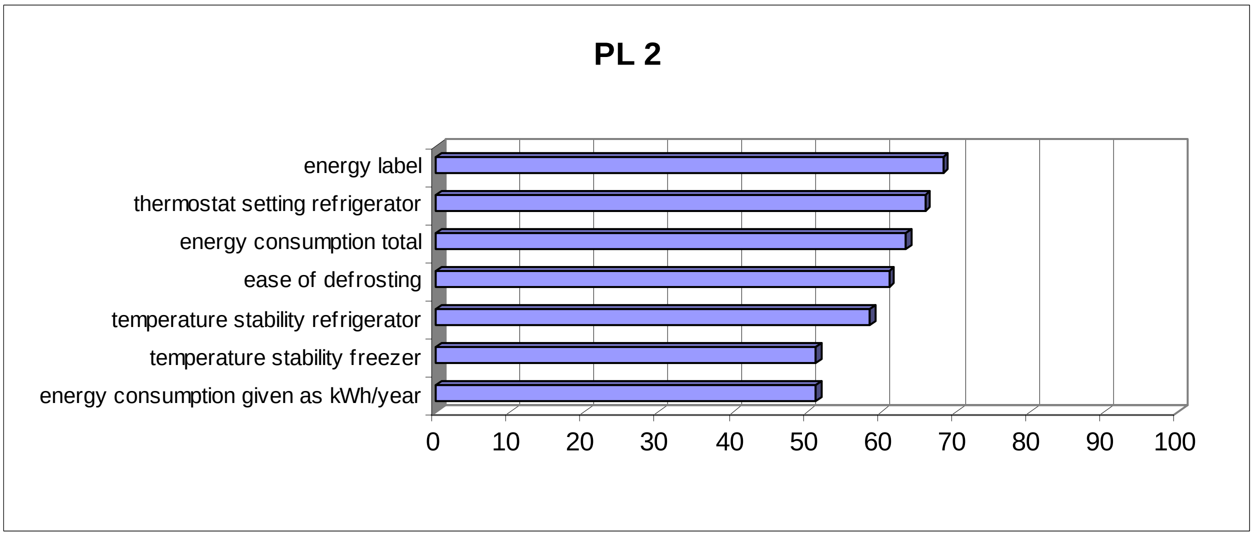


Figure 2.70: refrigerator: priority level 3: frequency of the tested criteria

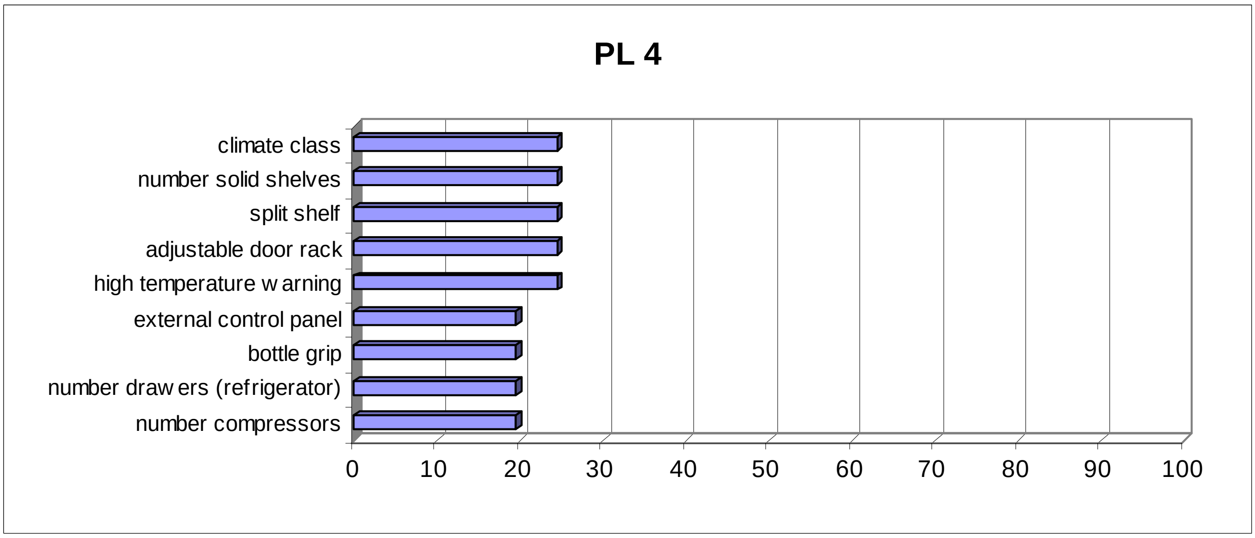


Figure 2.71: refrigerator: priority level 4: frequency of the tested criteria

b) Freezer

Consumer magazines frequently test freezers for publication in their magazines. Via these magazines they have a broad audience by which they influence the consumer in his buying decision and therefore are one of the driving forces of the market. But they also get frequent feedback from their readers which they use to define what is tested and published and how the testing of products is done. It may therefore be assumed, that they reflect consumer expectations and market trends in their testing and publication work. In looking at and analysing these publications over the last five years a decent overview on consumer requirements and market trends can be achieved.

A systematic analysis of the criteria and functions tested and how they have changed over the last five years was performed using all publications as listed (Table 2.38).

Tested criteria and functions were collected for each country. If priorities of certain criteria were pointed out in the magazine, this was taken into account. The next step was to evaluate which criteria were tested in every publication in one country, whether priorities were shifted, which criteria were added and which were discarded through the years. Finally all countries were compared looking for similarities and differences. All criteria and functions were then sorted and listed by frequency of testing in all publications.

Table 2.38: magazines and publications which featured a test of freezers

	2001	2002	2003	2004	2005	2006
‚test' (Stiftung Warentest - D)	-	-	-	11/2004	-	-
Konsument (A)	-	1/2002	-	-	-	-
Which (UK)	-	-	5/2003			7/2006
Consumentengids (NL)	-	-	5/2003	-	-	-
Compra maestra (E)	6/2001	-	-	-	-	-
Pro Teste (P)	6/2001	-	-	-	-	-
Altroconsumo (I)	11/2001	-	-	-	-	-
Que Choisir (F)	6/2001	-	-	-	-	-
60 Millions de Consommateurs (F)	-	-	-	11/2004	-	-
Test-Achâts (B)	11/2001	-	-	-	-	-
Råd & Rön (S)	-	-	2003	-	-	-
Tænk + Test (DK)	-	-	8/2003	-	-	-
Forbruker-Rapporten (N)	-	-	2003	-	-	-

- Frequency of criteria/ functions tested on freezers in the observed countries during the past 5 years

Germany

“Stiftung Warentest” indicates testing priorities by giving the proportion of certain criteria from the final test score. A larger proportion/percentage indicates a higher priority of that characteristic.

Freezers have only been tested once during the past five years.

First priority lay on freezing performance (45 %) including freezing capacity, temperature stability, fast freezing/ super frost and temperature increase in case of failure. Second priority lay on energy consumption (30 %), third on ease-of-use (15 %). 10 % of the final score is based on accuracy of the temperature indicator and warning signal.

Price, running cost for fifteen years, volume, dimensions, climate class, number of compartments and cooling batteries as well as existence of warnings in case of high temperature, power loss and open door are indicated.

Austria

“Konsument” indicates testing priorities by giving the proportion of certain criteria from the final test score. A larger proportion/percentage indicates a higher priority of that characteristic.

Freezers have only been tested once in the past five years.

First priority (80 %) lay on technical characteristics such as freezing capacity, temperature increase in case of failure, energy consumption, volume and storage surface area. Second priority (20 %) lay on ease-of-use, ease of cleaning, defrosting, opening the door, temperature setting and user manual.

Information is given on price, running cost for ten years, energy label, power rating, super frost, number of compartments, cooling batteries, ice cube trays, warning signals for high temperature, freezing control light, defrosting accessories and ethical appraisal of the manufacturer.

UK

“Which” indicates testing priorities by giving the proportion of certain criteria from the final test score. A larger proportion/percentage indicates a higher priority of that characteristic.

The percentages have changed throughout the years.

In 2003 20 % each of the final test score is based on temperature stability and freezing capacity, 15 % each on annual running cost and temperature increase in case on failure, 10 % each on thermostat setting and noise, 5 % each on ease-of-use and ease of defrosting.

In 2006 40 % of the final test score is based on temperature stability and freezing capacity combined, 20 % on ease-of-use, ease of defrosting and defrosting performance combined, 15 % each on annual running cost and temperature increase in case of failure, 10 % on noise.

In both years information is given on price, volume, dimensions, storage flexibility, energy label, room temperature range, acoustical warning in case of high temperature and whether the freezer is frost-free.

The Netherlands

“Consumentengids” indicates testing priorities by giving the proportion of certain criteria from the final test score. A larger proportion/percentage indicates a higher priority of that characteristic.

Freezers have only been tested once in the past five years.

20 % each of the final test score is based on temperature stability and freezing capacity, 15 % each on energy consumption and temperature increase in case on failure, 10 % each on thermostat setting and noise, 5 % each on ease-of-use and ease of defrosting.

Price, volume, dimensions, energy label, climate class, temperature indicator, numbers of compartments, cooling batteries and ice cube trays as well as a warning signal in case of high temperature are indicated.

Spain

"Compra maestra" does not indicate testing priorities. Freezers have only been tested once in the past five years.

Tested were freezing capacity, thermostat setting, temperature stability, temperature increase in case of failure, energy consumption, ease-of-use, ease of defrosting and noise.

Price, annual running cost, dimensions and volume as well as existence of temperature indicator, super frost, roller/ castor (easy moving) and internal light were indicated.

Portugal

"Proteste" does not indicate testing priorities. Freezers have only been tested once in the past five years.

Tested were freezing capacity, thermostat setting, temperature stability, energy label, ease-of-use, ease of defrosting, noise and recommended thermostat setting.

Price, annual running cost, dimensions, volume, number of drawers and refrigerant as well as existence of super frost, super frost control lamp, lid, roller/ castor (easy moving), internal light and high temperature warning were indicated.

Italy

"Altroconsumo" does not indicate testing priorities. Freezers have only been tested once in the past five years.

Tested were freezing capacity, thermostat setting, temperature stability, temperature increase in case of failure, energy consumption, ease-of-use, ease of defrosting and noise.

Price, annual running cost, dimensions, volume, number of racks and height of chest with open top as well as existence of super frost, roller/ castor (easy moving), defrosting accessories, thermometer and acoustic signal in case of high temperature were indicated.

France

France has two different consumer information magazines.

"Que Choisir" indicates testing priorities but without giving percentages. Freezers have only been tested once in the past five years.

First priority lay on freezing capacity, temperature stability, temperature increase in case of failure and energy consumption. Second priority lay on ease-of-use, noise and acoustical warning in case of high temperature.

Price, safety (electricity), energy label, dimensions, volume, climate class, refrigerant and numbers of compartments, cooling batteries and ice cube trays as well as existence of temperature indicator, super frost, super frost control lamp and roller/ castor (easy moving) are indicated.

“60 Millions de Consommateurs” indicates testing priorities by giving the proportion of certain criteria from the final test score.

Freezers have only been tested once during the last five years.

First priority lay on freezing capacity (30 %), second (25 %) on energy consumption given as kWh/year. 22,5 % of the final test score is based on temperature stability and accuracy of the temperature indicator combined and 12,5 % is based on temperature increase in case of failure and acoustic signal in case of high temperature combined.

Information is given on price, energy label, climate class, dimensions and volume as well as existence of a temperature indicator, warning signal and roller/ castor (easy moving).

Belgium

“Test-Achats” does not indicate testing priorities. Freezers have only been tested once in the past five years.

Tested were temperature stability, freezing capacity, temperature increase in case of failure, energy consumption, ease-of-use, ease of defrosting, noise, accuracy of temperature indicator and recommended thermostat setting.

Price, running costs for fifteen years, dimensions, volume, number of racks, drawers, transparent drawers/ covers as well as existence of a temperature indicator and a system to mark the best-before date were indicated.

Sweden

“Råd & Rön” does not indicate testing priorities. Freezers have only been tested once in the past five years.

Following criteria were tested: freezing capacity, freezer temperature range, temperature increase in case of failure, energy consumption and noise.

Price, dimensions, volume, energy label, refrigerant, insulation material as well as existence of lighting and an external control panel were indicated.

Denmark

“Test + Tænk” indicates testing priorities by giving the proportion of certain criteria from the final test score. Freezers have only been tested once in the past five years.

35 % each of the final test score were based on combinations of criteria. First combination is formed by temperature stability, freezing capacity, freezer temperature range and temperature increase in case of failure. The second combination consists of energy consumption, energy label, noise, refrigerant, and insulation material.

15 % of the final test score is based on ease-of-use and arrangement, 10 % is based on the user manual and 5 % on ease of cleaning.

Information is given on price, dimensions, volume and ease of defrosting.

Norway

“Forbruker-Rapporten” indicates testing priorities by giving the proportion of certain criteria from the final test score. Freezers have only been tested once in the past five years.

First priority (20 %) lay on energy consumption, second priority with 15 % each lay on freezing capacity, temperature increase in case of failure, ease-of-use and arrangement. 10 % each of the final test score is based on user manual and noise, 8 % is based on room temperature range, 5 % each on ease of cleaning and ease of defrosting and 4 % is based on thermostat setting.

Information is given on price, dimensions, volume, energy consumption given as kWh/year as well as energy label.

<u>EU</u>

<u>Summary</u>

The analysis of consumer magazines in the EU for freezers shows that one feature has been tested in every publication. This feature is freezing capacity. As freezing capacity is one of the features which can be combined to the global characteristic of freezing performance, this was therefore also tested in every publication. In every country the global freezing performance consists of a variety of different characteristics. The second most tested attribute for performance is temperature increase in case of failure (92,9 %), third is temperature stability (78.6 %). Also tested with first priority are ease-of-use and noise.

Indicated in every publication are price and volume, dimensions are indicated in 92,9 % of all observed publications.

Evaluated in 50 – 75 % of all observed publications are energy label, ease of defrosting, acoustical signal as high temperature warning, energy consumption, thermostat setting as well as number of racks and drawers.

- Overview

The frequency of the tested criteria throughout the observed years and countries has been classified to four priority levels (PL) according to how often they have been evaluated.

For this purpose the frequency of a tested feature is given as percentage of all publications.

Priority level 1 (PL 1) for more than 75 %

Priority level 2 (PL 2) for 50 % - 75 %

Priority level 3 (PL 3) for 25 % - 50 %

Priority level 4 (PL 4) for less than 25 %

Following criteria can be ranked to the highest priority level. They are sorted by percentage, starting with the highest.

Table 2.39 freezer: ranking of criteria per priority level

PL 1	freezing capacity	100,0 %
	freezing performance (global)	100,0 %
	price	100,0 %
	volume	100,0 %
	temperature increase in case of failure	92,9 %
	dimensions	92,9 %
	ease-of-use	85,7 %
	noise	85,7 %
	temperature stability	78,6 %
PL 2	energy label	71,4 %
	ease of defrosting	64,3 %
	high temperature warning, noise	64,3 %
	energy consumption total	57,1 %
	thermostat setting	50,0 %
	number racks	50,0 %
	number drawers	50,0 %
PL 3	energy consumption given as kWh/year	35,7 %
	annual running cost	35,7 %
	temperature indicator	35,7 %
	super frost/ cool	35,7 %
	high temperature warning, light	35,7 %
	roller/ castor (easy moving)	35,7 %
	climate class	28,6 %
	refrigerant	28,6 %
	number cooling batteries	28,6 %
PL 4	only the seven criteria with highest percentage of this priority level are mentioned	
	room temperature range	21,4 %
	ease of cleaning	21,4 %
	user manual	21,4 %
	accuracy of the temperature indicator	21,4 %
	insulation material	21,4 %
	transparent drawers/ covers	21,4 %
	ice cube trays	21,4 %

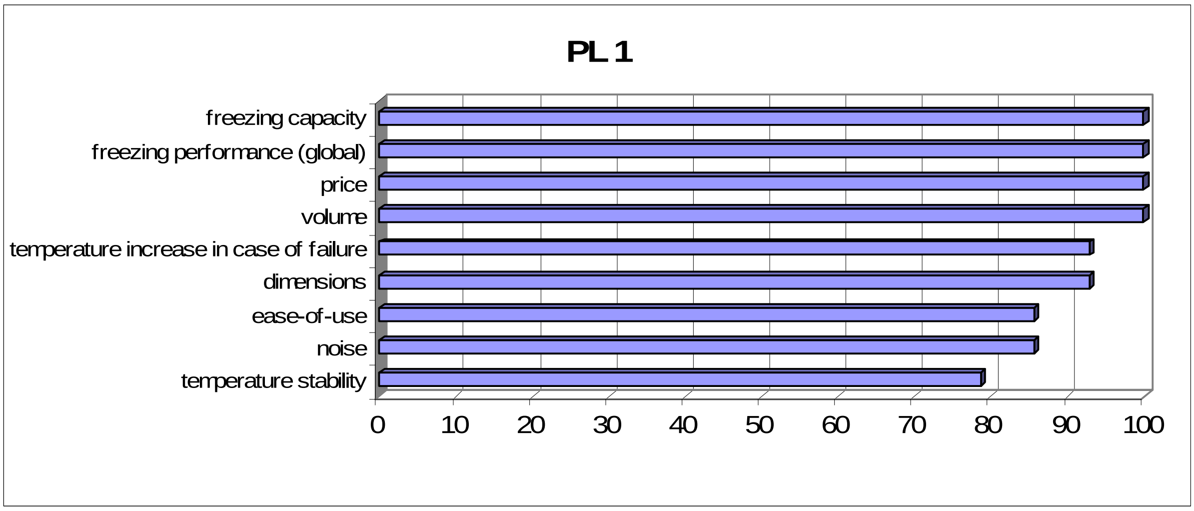


Figure 2.72: freezer: priority level 1: frequency of the tested criteria

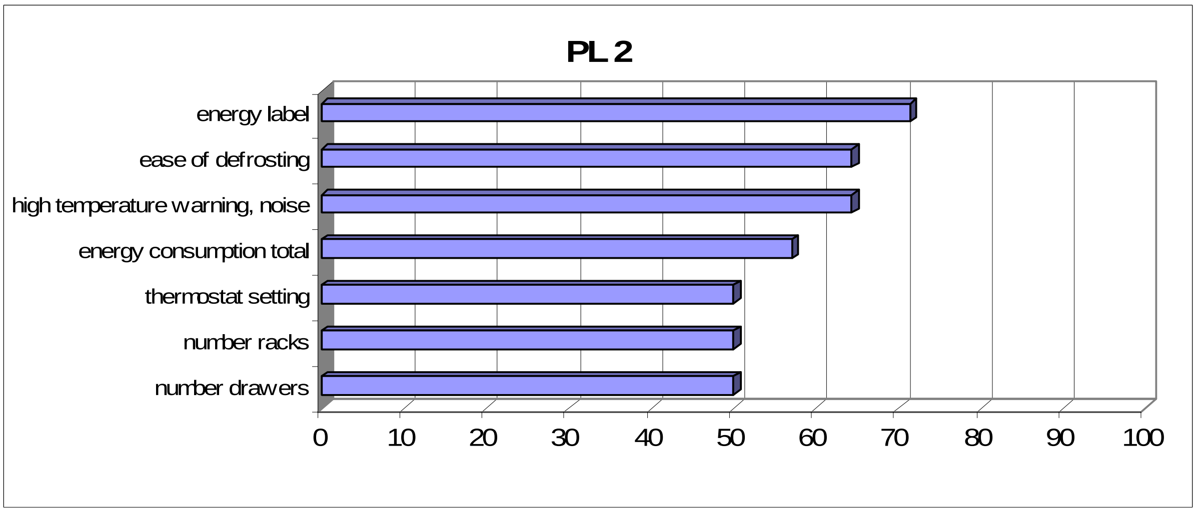


Figure 2.73: freezer: priority level 2: frequency of the tested criteria

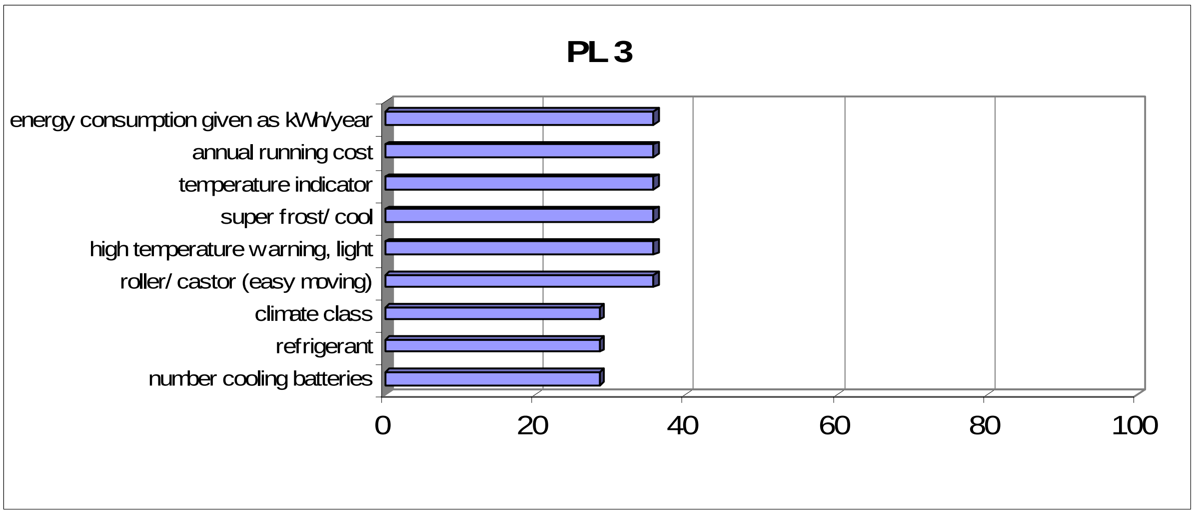


Figure 2.74: freezer: priority level 3: frequency of the tested criteria

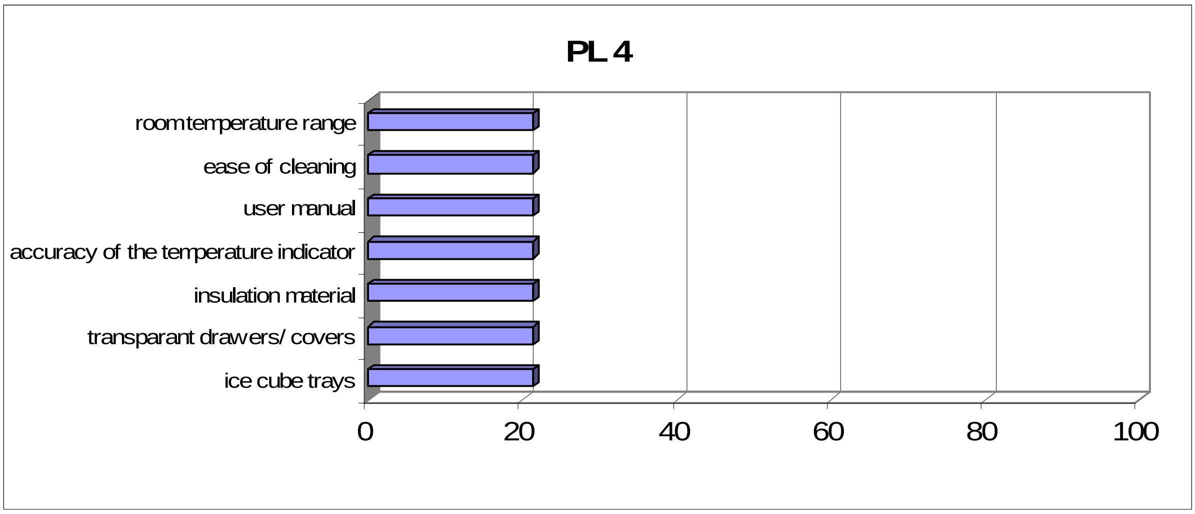


Figure 2.75: freezer: priority level 4: frequency of the tested criteria

2.3.5 Market trends as seen by the consumer

a) Refrigerator

Within the consumer survey (see Task 3) the customers were asked which options or features of cold appliances (refrigerator and freezer) have a high or low priority for them today.

The analysis of the answers should help to make possible estimates of market trends.

The consumers were asked to give points from 1 (low priority) to 10 (high priority) for ranking of several appliance options/features.

For refrigerators following options were listed:

- greater load capacity
- lower energy consumption
- smaller load capacity
- improved cooling performance adapted to the food (several cooling areas)
- improved storage possibilities (larger, removable storage baskets, shelves, bottle racks,...)
- improved cooling control (adjustment to loading, environment, etc.)
- greater convenience offered by the appliance (ice cubes or water dispenser,...)
- new hygienic surfaces or effects
- easy or/and automatic defrosting
- network connectivity; communication between household appliances
- lower running costs
- lower price of the appliance

For the consumers *lower energy consumption* plays the most important role for a refrigerator (8,6) (Figure 2.76). Also the financial aspects like *lower running costs* (8,4) and *lower price of the appliance* (7,5) have a high priority for them today. Options/features concerning an easy handling like *easy or/and automatic defrosting* (8,3) or *improved storage possibilities* (7,7) are very important too. The aspect of security and hygiene with options like *improved cooling control* (7,5), *improved cooling performance* adapted to the food (7,2) or *new hygienic surfaces/effects* (6,9) were also evaluated by the consumer with a high priority level. The results of the questionnaire also show that a *greater load capacity* is required by consumers as well as a *greater convenience offered by the appliance* (6,8; 6,0). The consumers don't want to have *smaller refrigerators*, which is shown by the lowest results of only 3,8 points. The aspect of *networking or possible communication between appliances* is also evaluated with a very low priority level with only 4,2 points.

In comparison with the results of the manufacturers' questionnaire (s. Chap. 2.3.3) the results show that the consumer and the manufacturers agree on the importance of *lower* *energy consumption* (*both* 8,6) (Figure 2.77). But the financial aspect has minor priority for the manufacturers than for the consumers (*lower running costs* Δ = 2,5; lower *price of the appliance* Δ=1,9). The evaluation of the priority of *new hygienic surfaces/effects* shows a comparably big difference of 2,5 points too. Interesting is that the manufactures see a higher priority of *greater load capacity* for their appliances today than the consumer evaluated for this option. Concerning the other options/features only marginal differences can be recorded (Figure 2.77).

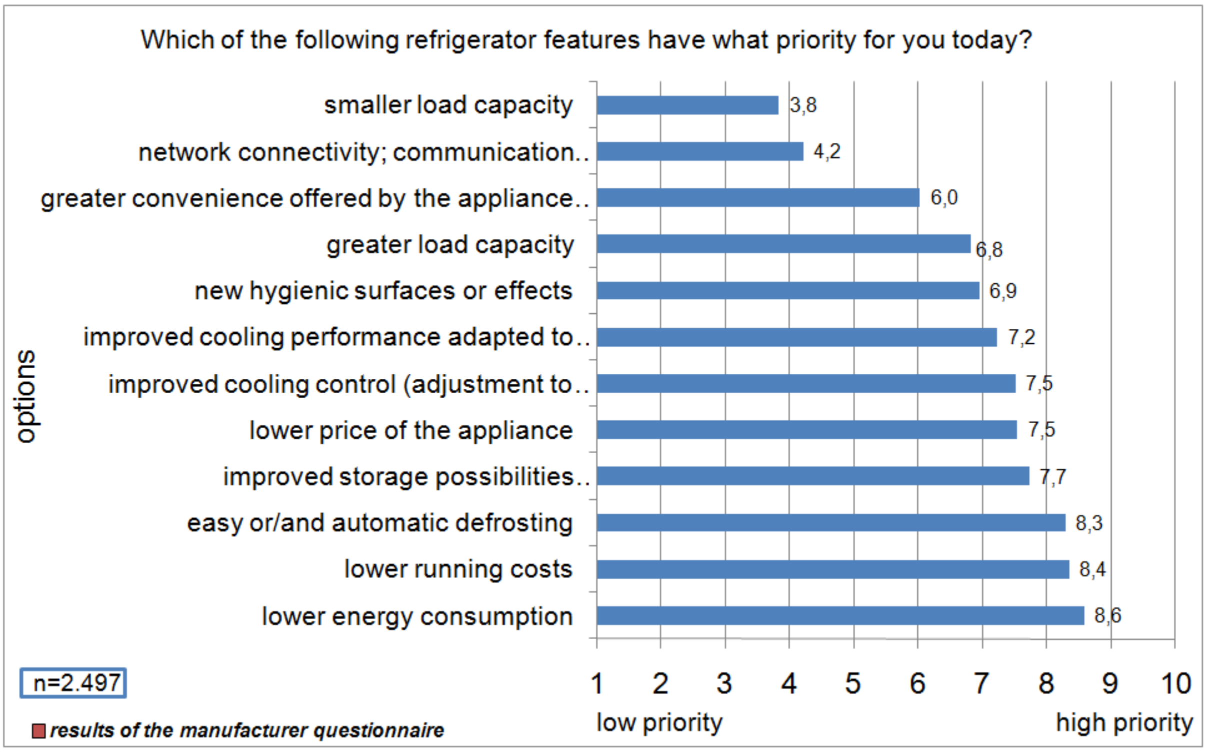


Figure 2.76: refrigerator: ranking of appliance options by the consumer

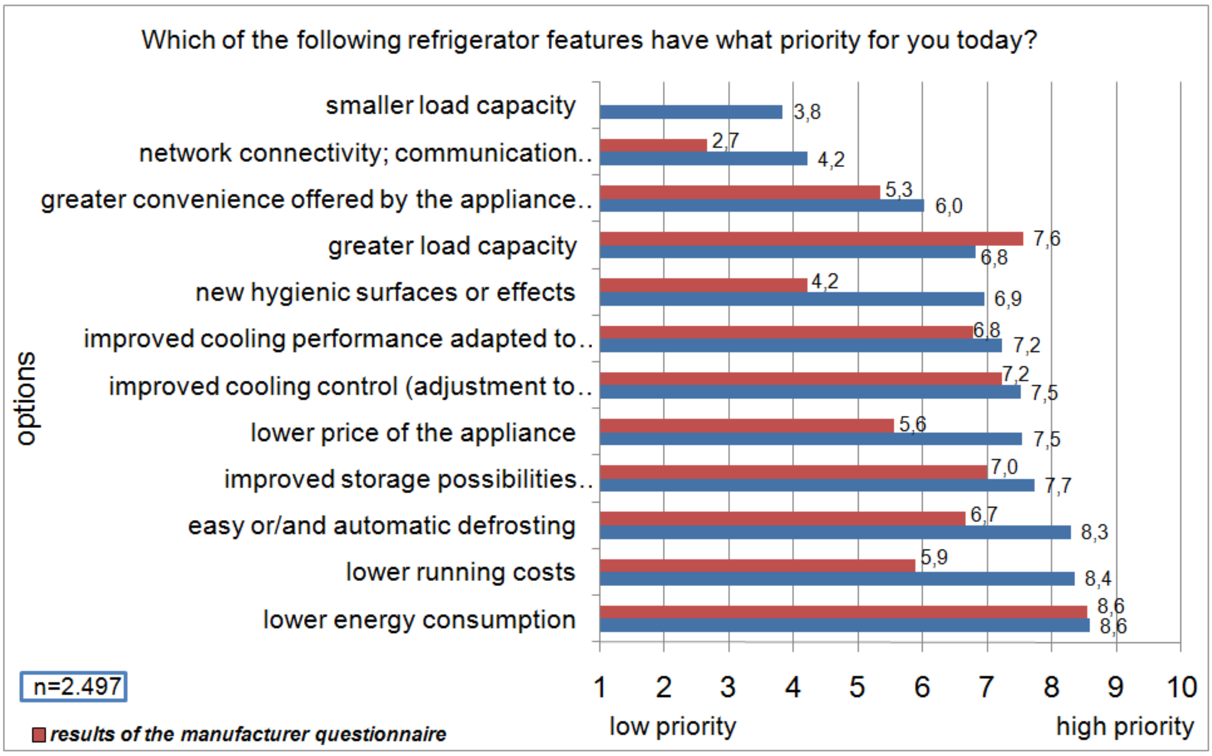


Figure 2.77: refrigerator: ranking of appliance options (consumer vs. manufacturers)

The point *lower energy consumption* is most important for German (9,1), Polish (9,1) and Hungarian (9,0) consumers (Table 2.40). In comparison to the other countries the *lower running costs* (9,0) of the refrigerator also have a higher priority for German consumers. Another difference shows the result of the option *greater convenience offered by the appliances*. Here Swedish and Finish consumers see this option/feature as less important (4,9; 5,1) as the other consumers of the other European countries e.g. Spanish consumers with 6,9 points. Concerning the size of the appliance especially for Hungarian consumers a *greater load capacity* is most important (7,7). The least priority level to this option was assigned by Finish consumers with only 5,9 points. The analysis of the hygienic aspect shows the same results. Again the Hungarian consumers give this option of *new hygienic effects/surfaces* the highest priority level (7,8) in comparison with the other countries. In this context for the Swedish consumers this option plays the least priority (5,8) in contrast to the other European households.

Table 2.40: refrigerator: ranking of appliance options by the consumer (per country)

Refrigerator: Ranking appliance options/features (average)											
country	**UK**	**DE**	**IT**	**FR**	**ES**	**SW**	**PL**	**HU**	**FI**	**CZ**	**total**
greater load capacity	6,5	6,8	7,4	7,0	7,6	6,0	6,7	7,7	5,9	6,6	6,8
lower energy consumption	7,8	9,1	8,3	8,8	8,4	8,0	9,1	9,0	8,5	8,7	8,6
smaller load capacity	3,7	3,5	4,2	4,3	4,1	3,1	3,7	4,0	3,6	4,1	3,8
improved cooling performance adapted to the food (several cooling areas)	6,0	7,8	7,8	7,6	7,7	6,5	7,6	7,7	6,7	7,0	7,2
improved storage possibilities (larger, removable storage baskets, shelves, bottle racks,...)	7,3	7,9	8,0	7,9	8,1	6,8	8,2	8,2	7,5	7,5	7,7
improved cooling control (adjustment to loading, environment, etc.)	6,8	8,0	7,9	7,9	8,0	6,6	7,7	8,2	7,0	7,1	7,5
greater convenience offered by the appliance (ice cubes or water dispenser,...)	6,1	5,3	6,8	6,2	6,9	5,1	6,8	6,2	4,9	5,9	6,0
new hygienic surfaces or effects	6,6	7,2	7,1	6,9	7,4	5,8	7,5	7,8	7,0	6,3	6,9
easy or/and automatic defrosting	8,0	8,4	7,7	8,8	8,2	8,0	8,7	8,9	8,3	8,0	8,3
network connectivity; communication between household appliances	3,6	3,5	5,1	3,9	4,6	3,6	4,7	4,7	4,0	4,7	4,2
lower running costs	7,9	9,0	7,8	8,5	7,9	7,9	8,8	8,8	8,3	8,5	8,4
lower price of the appliance	7,5	8,1	7,3	7,9	8,1	6,6	8,0	7,8	7,0	7,0	7,5

b) Freezer

Within the consumer survey the customers were asked which options or features of freezers have a high or low priority for them today.

The analysis of the answers should help to make possible estimates of market trends.

The consumers were asked to give points from 1 (low priority) to 10 (high priority) for ranking of several appliance options/features.

For freezers following options were listed:

- greater load capacity
- improved storage possibilities (larger, removable storage baskets,...)
- smaller load capacity
- lower energy consumption
- lower price of the appliance
- lower running costs
- new hygienic surfaces or effects
- very good cooling or freezing performance (e.g. short freezing time)
- easy or/and automatic defrosting
- improved cooling control (temperature control, acoustic/optical alarm, load adjustment, environment, etc.)
- network connectivity; communication between household appliances

The options *lower energy consumption* and *easy or/and automatic defrosting* (8,4) reached the highest priority level (Figure 2.78). Also the points of *lower running costs* (8,3) and *lower price of the appliance* (7,5) play a very important role for the consumers. Very significant is a *very good cooling/freezing performance* for all interviewees too (8,0). Between a priority level of 7,5 and 7,6 are options/features like *improved cooling control and storage possibilities*. Concerning the size of the freezer the consumers evaluated a *greater load capacity* (7,2) as more important than a *smaller load capacity* (3,8). Also unimportant for the consumers is the possibility of *networking or communication between appliances* (4,1).

The comparison of the results of manufactures' questionnaire with the answers of consumers (Figure 2.79) shows that both groups agree on the high priority level of the points *greater load capacity* (7,1/7,2), *lower price of the appliances* (7,2/7,5) and *lower energy consumption* (8,1/8,4). Differences can be mentioned relating to the option/feature *new hygienic surfaces/effects*. Here a difference of nearly 4 points can be calculated between the evaluations of the two groups. For consumers this option is more important than for the manufactures. A similar difference can be seen for the points *very good cooling/freezing performance* ($\Delta = 3,0$) and *improved cooling control* ($\Delta = 3,1$). The least priority level is reached by the option *network connectivity/communication between the appliances* for both interviewed groups (2,1; 4,1).

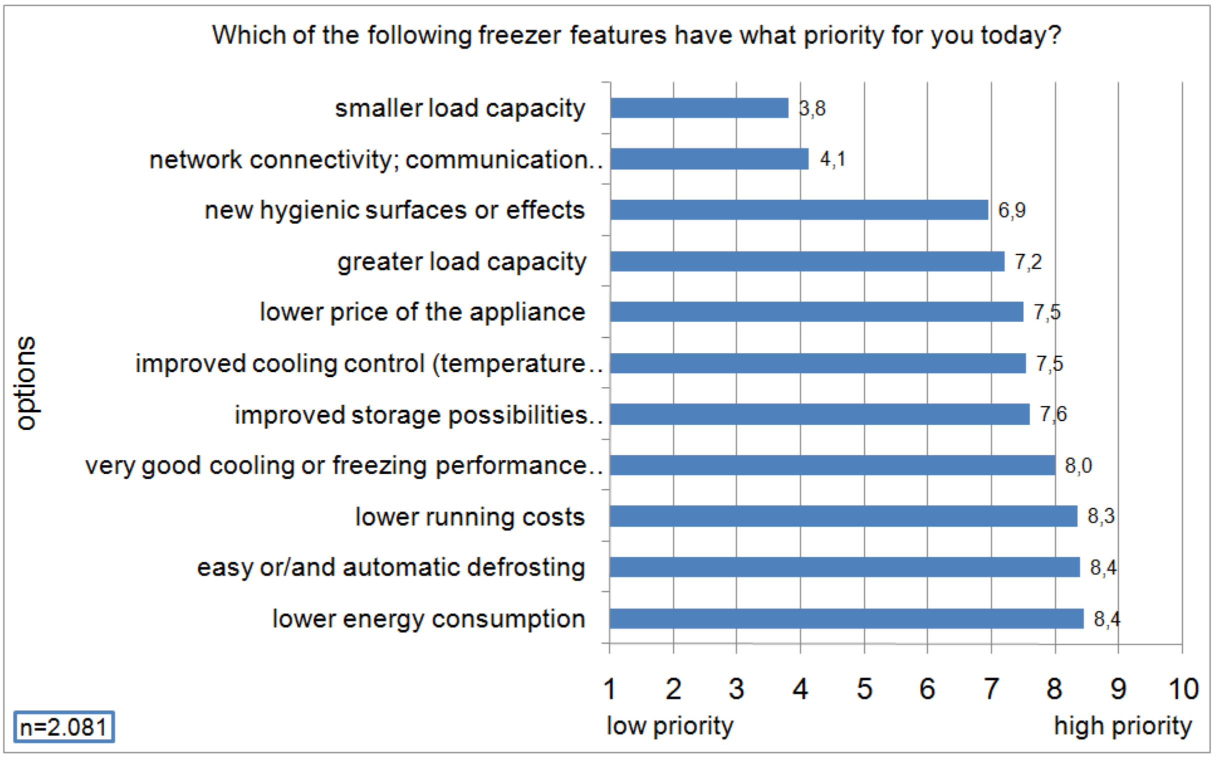


Figure 2.78: freezer: ranking of appliance options by the consumer

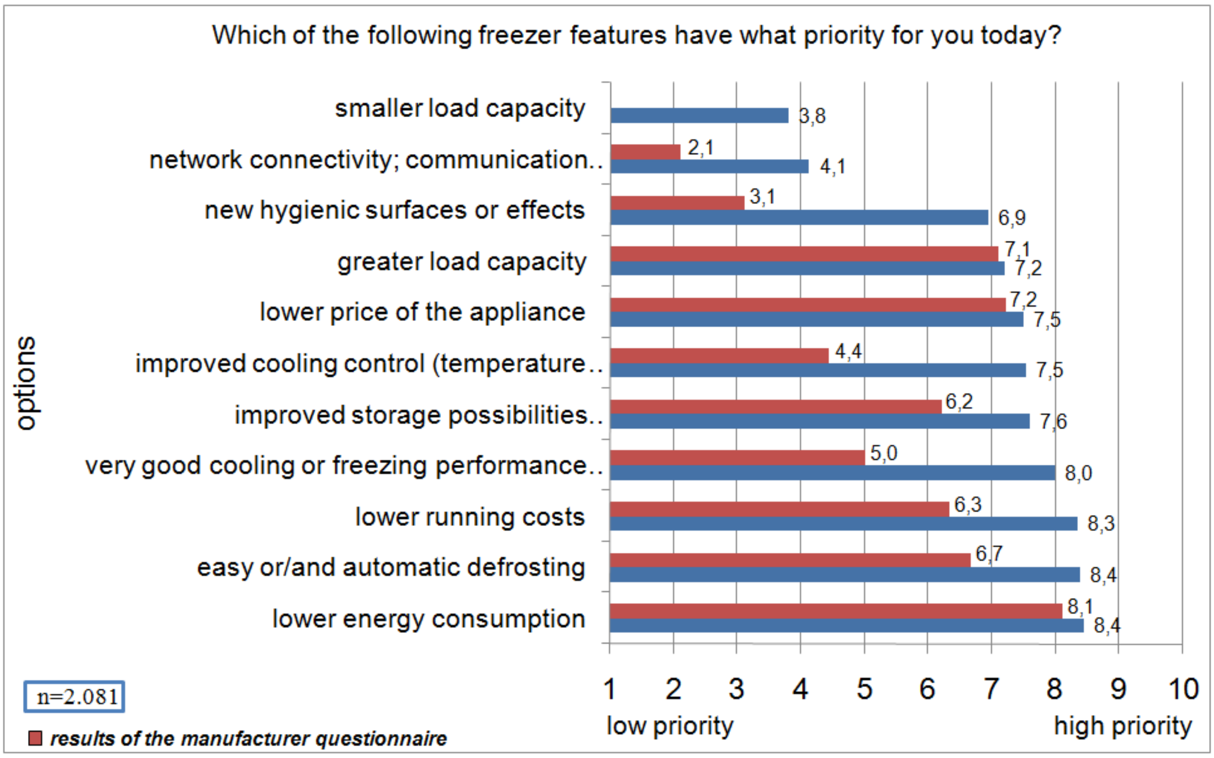


Figure 2.79: freezer: ranking of appliance options (consumer vs. manufacturers)

The analysis of priority ranking of the answers given from the various European countries shows some differences between the evaluations of several options/features. Concerning the size of the appliance the Italian consumers want to have a smaller load capacity (4,4) with the highest priority level above the average (Table 2.41). A *greater load capacity* is most important for Hungarian consumers (8,1) as well as *improved storage possibilities* (8,2) while this option is most unimportant for Swedish consumers (6,4). A *lower energy* *consumption* has first priority for Hungarian consumers and also for the German end users (9,0). In contrast the British consumers rated this feature with only 7,8 points. The hygienic aspect (*new hygienic surfaces/effects*) is very important for the Hungarian consumers again with 8,1 points in comparison to the evaluation of the Swedish end users with a priority level of only 6,0. Concerning the size of the appliance the Italian consumers want to have a *smaller load capacity* (4,4) with the highest priority level above the average.

Table 2.41: freezer: ranking of appliance options by the consumer (per country)

Freezer: Ranking appliance options/features (average)											
country	**UK**	**DE**	**IT**	**FR**	**ES**	**SW**	**PL**	**HU**	**FI**	**CZ**	**total**
greater load capacity	7,1	7,1	7,4	7,7	7,8	6,4	6,9	8,1	6,5	7,3	7,2
improved storage possibilities (larger, removable storage baskets,...)	7,1	7,5	7,9	8,1	7,9	6,8	7,9	8,2	7,3	7,8	7,6
smaller load capacity	3,6	3,3	4,4	4,2	4,1	2,9	4,0	4,2	3,7	4,1	3,8
lower energy consumption	7,8	9,0	8,1	8,7	8,4	7,9	8,8	9,0	8,4	8,8	8,4
lower price of the appliance	7,4	8,1	7,2	7,9	8,1	6,6	8,1	7,7	7,3	7,1	7,5
lower running costs	7,9	8,9	7,9	8,5	7,9	7,9	8,8	8,8	8,3	8,5	8,3
new hygienic surfaces or effects	6,3	7,2	7,0	6,8	7,3	6,0	7,5	8,1	7,1	6,4	6,9
very good cooling or freezing performance (e.g. short freezing time)	7,5	8,3	8,0	8,2	8,0	7,2	8,3	8,7	8,0	8,0	8,0
easy or/and automatic defrosting	8,2	8,6	7,9	8,8	8,1	8,3	8,7	8,7	8,6	8,1	8,4
improved cooling control (temperature control, acoustic/optical alarm, load adjustment, environment, etc.)	6,9	8,0	7,8	8,0	7,9	6,9	7,6	8,2	7,6	6,8	7,5
network connectivity; communication between household appliances	3,5	3,4	5,1	3,8	4,7	3,6	4,3	4,6	4,1	4,6	4,1

2.3.6 Summary on market trends

Market trends for refrigerators and freezers were evaluated using several different sources and approaches, as well as from different points of view.

The manufacturers' side was analyzed through the product database of the past 10 years, product brochures, web presentations as well as a questionnaire.

Trends from the consumers' point of view were estimated by looking at European consumer magazines as well as by a questionnaire which was conducted in several European countries.

Also studies about the buying behaviour of consumers and the desired information when buying appliances were cited.

Current studies on consumers showed that most households in Europe possess a refrigerator and about half own a freezer, many of the appliances being "over-aged".

From sales assistances, advertisements, and brochures most consumers get information when planning on buying a new appliance. The primary aspect for the decision on an appliance is its' energy consumption, followed by price and size and arrangement of the interior.

Most people, especially men and employed, are aware that there is an energy label for cold appliances and are familiar with the energy classes.

The most important conclusions which could be made from the product database of the past 10 years were, e.g. that the number of models offered has increased significantly whereas the number of different categories offered has decreased from 10 to merely 4, whereof category 7 is dominant in the market. It could be seen that most appliances of category 7 (refrigerator-freezer combinations) now work with only one compressor and one thermostat (approx. 60 %) which limits them in adjustability. Storage capacity has stayed relatively constant throughout the years, there has only been an increase of about 10 %. A look at the climate classes showed that the distribution has shifted towards sub-tropical (ST) and tropical (T). A continuous decrease occurred for annual energy consumption of about 32 to 39 % in total compared to 1995. In 2005 about 80 % of cold appliances were declared class A and better. The most inefficient classes have disappeared from the market. Only chest freezers are less often represented in class A than other cold appliances.

In product brochures and web presences of manufactures different aspects are emphasised. These are functionality, comfort, design attributes, ecological and hygienic aspects as well as food safety. Energy efficiency is seen as very good already but very important none the less. Another trend is seen in increasing the possible storage time for foods, e.g. using different temperature zones with variable atmospheric conditions.

For freezers trends lead to lower energy consumption, lower running cost, new hygienic surfaces, and automatic defrosting.

Manufactures pointed out the primary importance for consumers to be low energy consumption of appliances as well as financial aspects. The greatest trend is seen in network connectivity, a feature where the highest increase in importance is seen for the next five years.

Similar results were found for freezers, energy consumption being the most important attribute, followed by price and running costs as well as bigger capacity.

Consumer magazines show slight differences between countries but nevertheless some similarities could be found. For refrigerators energy consumption increased in importance, as well as cooling and freezing performance. Another important attribute was temperature stability. Volume of the refrigerator was always mentioned, price, ease-of-use, and noise were characteristics which were assessed in almost every publication.

Looking at freezers the most important property was freezing performance, including freezing capacity, temperature increase in case of failure, and temperature stability. Price and volume were also very important, followed by ease-of-use, noise and the energy label.

According to the consumer survey energy consumption and low running costs played the most important roles, followed by easy/automatic defrosting and low price of the appliance.

Very important as well were improved storage possibilities, cooling control, and cooling performance.

Consumers and manufacturers agreed in most points, especially low energy consumption, cooling performance and cooling control. The greatest disagreement could be found between new hygienic surfaces and financial aspects, both prioritized by the consumers more often than the manufacturers. There were some differences in priorities given by consumers from different European countries, but tendencies were comparable.

For freezers a good cooling/freezing performance was considered as very important by the consumers as well. In great compliance were the answers of consumers and manufacturers considering load capacity and low price of freezers. Greatest disagreement could be found concerning new hygienic surfaces, with were found to be more important to consumers than manufacturers. Similar results were found for freezing performance and improved cooling control.

2.4 CONSUMER EXPENDITURE BASE DATA

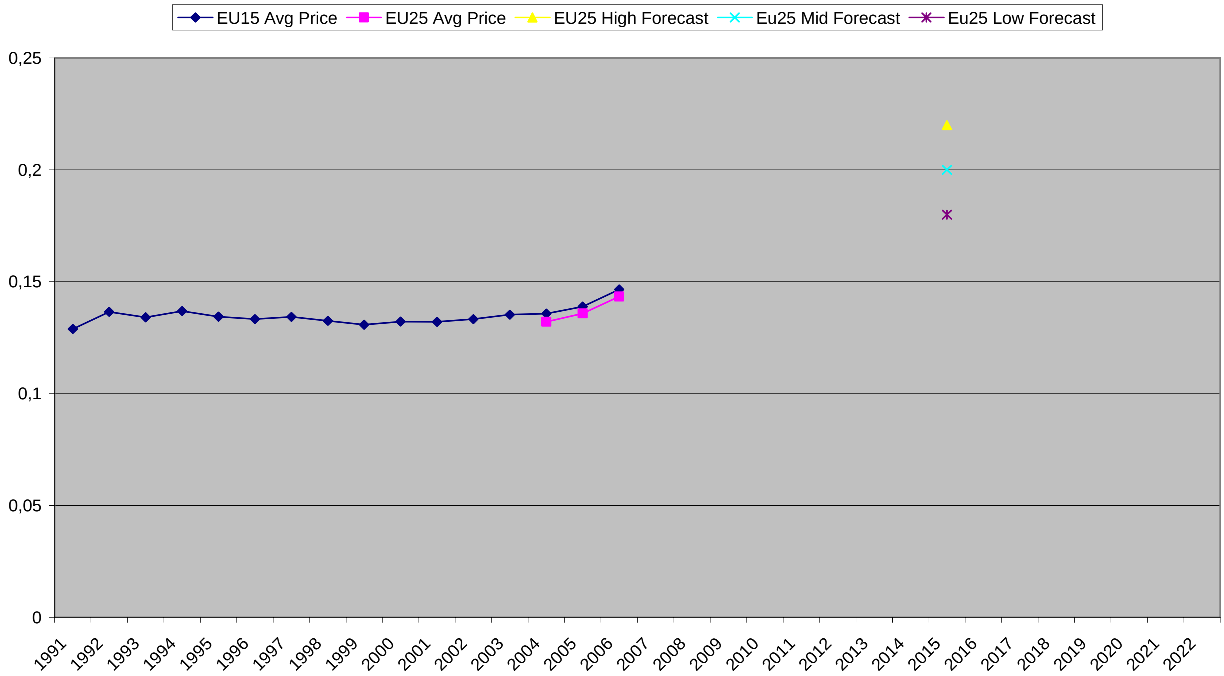
These data constitute the economic parameters for the Life Cycle Cost Analysis.

2.4.1 Electricity Prices

The evolution of the electricity prices including all taxes for the group EU15 and EU25 is shown in Figure 2.80: The evolution of the weighted average electricity prices including all taxes for EU15 and EU25[136]. Hypotheses of high and low forecasts are made for the EU25 average price of the future period of 0,22 and 0,18 Euro/kWh respectively.

[136] Source: Eurostat, January 2007.

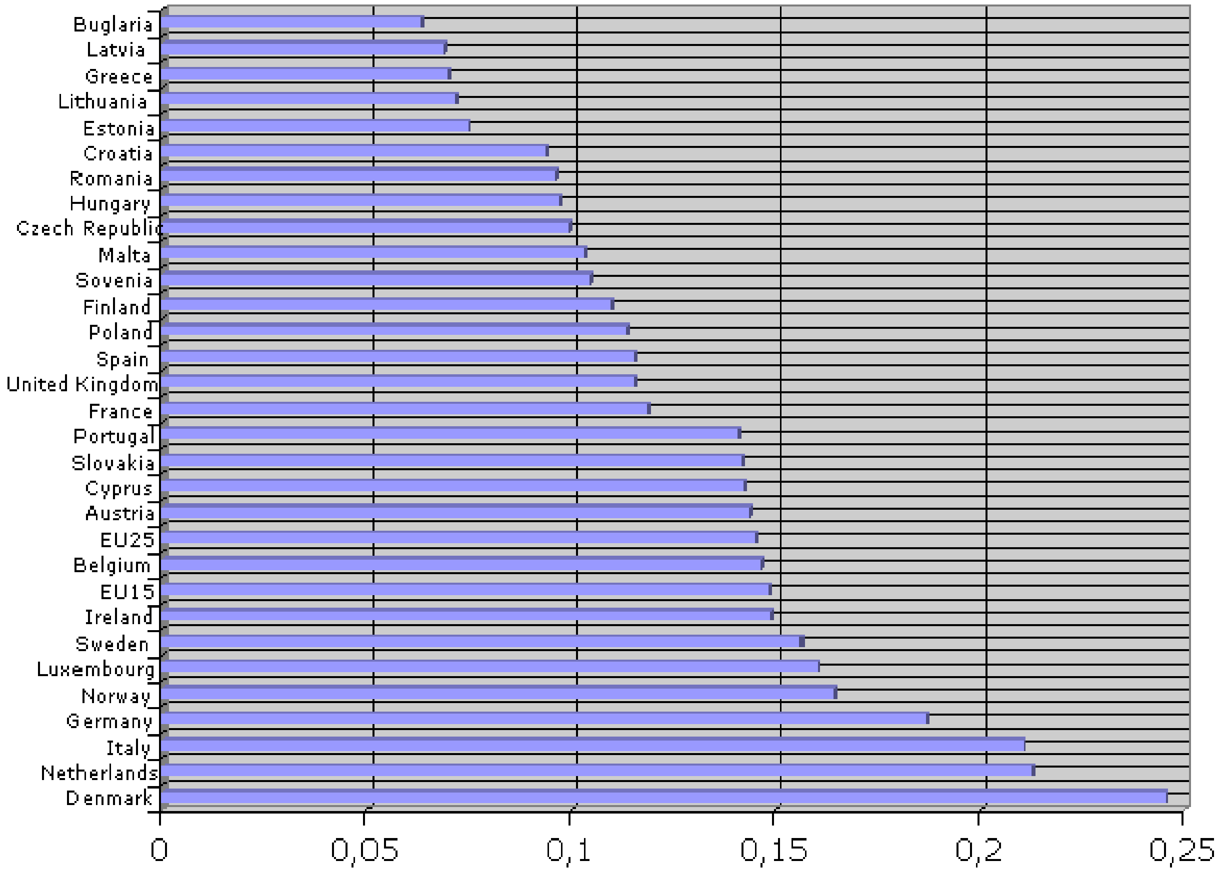
Figure 2.80: The evolution of the weighted average electricity prices including all taxes for EU15 and EU25



On the high side, this represents the scenario of continued energy price increases and moderate progress in rationalization and efficiency improvements within the sector. The low price scenario represents the contrary, stable energy prices and more progress in rationalization and efficiency improvements. These are the extremes; actually higher prices should stimulate more efficiency and thus favour a mid-range value. In fact, the middle range forecast price, in nominal terms, is €0,20/kWh. **This in real terms is €0,17/kWh, the value proposed for the study.**[1] Sensitivity analysis will be performed around this value. Note, average Europe25 prices are presently €0,14/kWh as shown below.

The second semester 2006 prices (in Euro/kWh) of member countries are shown in Figure 2.81 for comparison.

Figure 2.81: Household electricity prices (2006 2H), all taxes included, 3 500 kWh)



It is interesting to compare the differences in electricity prices for the new twelve countries recently joining the EU with respect to the EU15, as shown in Table 2.42 for the second semester of the last three years.

Table 2.42 Electricity Prices in the EU15 and the EU 'New 12' (€cents/kWh)

				2006/2004
	2004 2nd S.	2005 2nd S.	2006 2nd S.	Change
Bulgaria	6,14	6,54	6,34	3,3%
Czech Rep.	8,05	8,71	9,95	23,6%
Estonia	6,78	7,13	7,5	10,6%
Cyprus	10,49	12,03	14,26	35,9%
Latvia	6,82	8,29	6,9	1,2%
Lithuania	6,32	7,18	7,18	13,6%
Hungary	10,5	11,47	9,71	-7,5%
Malta	6,74	7,69	10,34	53,4%
Poland	9,54	10,59	11,9	24,7%
Romanial	9,47	9,47	9,62	1,6%
Slovania	10,33	10,49	10,48	1,5%
Slovakia	12,43	13,3	14,2	14,2%
the New 12 (1)	8,63	9,41	9,87	14,3%
EU15	13,54	13,91	14,85	9,7%
(1) Arithmetic average of the 12 country prices, not weighted for value of electricity sold.				

The prices on average are significantly lower in the 'New 12' countries, 9,87 vs. 14,85 €cents/kWh, one-third less during the latest semester. This is important because it implies that that unless the purchase prices are also one-third less, the returns on the same type of energy savings investment will be less in the 'New 12' countries. However, as expected prices are tending to converge with the 'New 12' Member States growing at 14 percent per year versus 10 percent per annum for the EU15.

2.4.2 Recycling and System Costs

On Figure 19 of Task 1, we recall that recycling and system costs are given for six European countries that have experience in recycling of electric and electronic equipment. The range is from 1,90 to 0,92 Euro/kg with an average of 1,21 Euro/kg. According to this data, a household appliance having a weight of 50 kilograms has an average recycling and system cost of 61 Euro at the time of recycling.

2.4.2.1 Maintenance and Repair

If cost input do not vary with different technical options, they are irrelevant to the design and optimization calculations. They are included to show total costs to the consumer and to compare to other studies. An average cost of repair and maintenance is estimated to be 5,5 Euro/year. Naturally in real life this is non-linear in time and is eventually the reason for replacing the appliance.

2.4.2.2 Discount Factor

A real discount factor of 5 % as used in previous studies for the Commission is maintained. This represents a mid value between the cost of capital for the firm and the consumer and the opportunity costs for both. The real cost of borrowing for large firm may be considered, for example, the cost of issuing corporate bonds minus inflation, which is around three to four percent. The consumer may borrow from his savings account, which pays even less. Whatever their opportunity costs, what they can obtain on other new investments is considerably higher and they demand more because of the risks inherent in new investments. Firms typically use a real discount rate on new investments above 10 %. Also in explaining consumer purchasing behaviour, consumers often expect rather short payback times (with discount rates even above 10 %) and refuse purchases with longer paybacks. Thus 5 % real discount rate is probably biased on the low side. However from a social and political point of view it may be preferable to keep it as such.

2.4.2.3 Real price growth, nominal price growth and the net present value

Given a certain reference year, such as 2007, one may imagine the price of a general basket of goods that is defined by the national statistical office as the consumer price index and is taken as a measure of inflation. If the price at the beginning of year is 100 and this general price index should grow at a rate of two percent each year for the next two years then we would have at the beginning of third year a price:

$$P_{2009} = P_{2007}*(1+2\%)^2 = 100*(1{,}0404) = 104{,}04$$

Now consider a specific good/service such as electricity that is growing faster, at a compound rate, than the general price index. Let us suppose that it is growing 1%/year faster than the above rate of inflation. We represent this as follows:

$P_{2009} = P_{2007}*(1+2\%)^2 *(1+1\%)^2 = 100*(1,0404)*(1,0201) = 104,04*(1.0201)=106,131204$

We refer to the compound growth rate in excess (or in deficit) of the general rate of inflation as the **real price growth** rate, one percent/year in our example above. Every specific good/service may have possible real price growth rate different above or below that of inflation and in general we may write for reference year i and a later year i+n.

$$\mathbf{P_{i+n} = P_i*(1+\text{rate of inflation}\%)^n *(1+\text{real price growth rate}\%)^n}$$

These rates together are referred to as the nominal price growth rate:

(1+nominal price growth rate) = (1+rate of inflation)*(1+real price growth rate)

Nominal price growth rate ≅ rate of inflation + real price growth rate.

This is the price rate that we normally observe without removing the impact of inflation.

With the net present value (NPV) equation or (life cycle cost) we have usually a sum of economic benefits and costs, which are characterized by a price, say of price of electricity, multiplied times the amount saved. All these benefits and costs refer to specific years in the future and must be discounted by a cost of capital, which also is in excess of the inflation rate.

NPV= Investment cost + annual benefits discounted – annual costs discounted

$$\mathbf{NPV= \text{investment cost} - Q\sum_{j=1,2\ldots n} (P_0*(1+\text{rate of inflation}\%)^j *(1+\text{real price growth rate}\%)^j)/ ((1+\text{rate of inflation}\%)^j *(1+\text{real cost of capital}\%)^j)}$$

Where Q is the quantity of the good or service for example the annual kWh saved, P_0 is the price at the reference year or year zero, and the real cost of capital is defined as the cost of capital in excess of the inflation rate. The above NPV is shown for only one specific annual benefit and the actual equation includes others such as water savings, but each annual benefit or cost has the same form, only with different Q's and P_0 's.

Notice that the 1+rate of inflation is in the numerator and denominator, thus we can simplify the equation and cancel this term. This simplifies our task in that we do not have to estimate long-term inflation. We must remember always that this simplified equation refers only to the real price growth rate and real cost of capital. We have:

$$\mathbf{NPV=\text{investment cost} - Q\sum_{j=1,2\ldots n} (P_0 *(1+\text{real price growth rate}\%)^j)/(1+\text{real cost of capital}\%)^j}$$

If a good/service has a real price growth equal to zero, that is it is growing with inflation, then the price is equal to P_0 in all the years. In fact we have hypothesized average future electricity prices with a P_0 equal to 0,17 Euro/kWh, with a zero real growth rate.