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J R C T E C H N I C A L R E P O R T S

Ecodesign for Commercial Refrigeration

TECHNICAL PROPOSALS
(Draft) Background Document

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Acronyms and abbreviations

ATEX	ATmosphères EXplosives
BAT	Best Available Technique
BAU	Business As Usual
BIO IS	BIO Intelligence Service
CEN/TC	European Committee for Standardization/Technical Committee
CLASP	Collaborative Labeling and Appliance Standards Program
DEC	Direct Electrical energy Consumption
DG	Directorate General
EC fans	Electronically Commutated fans
ECA	Enhanced Capital Allowance
ED	Ecodesign Directive
EEI	Energy Efficiency Index
EIA	Environmental Investigation Agency
EMAS	Eco-Management and Audit Scheme
EMD	Energy Management Device
EOL	End Of Life
EPA	Environmental Protection Agency
EVA	European Vending Association
EVA-EMP	European Vending Association - Energy Measurement Protocol
GWP	Global Warming Potential
HACCP	Hazard Analysis and Critical Control Points
HC	HydroCarbon
HFC	HydroFluorCarbon
HS/CN reference	Harmonized System/Combined Nomenclature
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IES	Institute for Environment and Sustainability
IPTS	Institute for Prospective Technological Studies
ISO	Organisation internationale de normalisation (International Organization for Standardization)
JRC	Joint Research Centre
LCA	Life Cycle Analysis
LED	Light Emitting Diode
LCA	Life Cycle Analysis
MAC	Mobile Air Conditioning system
MAC	Maximum Accepted Concentration
Meerp	Methodology for the Ecodesign of Energy-related Products
MEEuP	Methodology for the Ecodesign of Energy-using Products
MEPS	Minumum Energy Performance Standard
ODP	Ozon Depleting Potential
PED	Pressure Equipment Directive
PRODCOM	PRODuction COMmunautaire (Community Production)

RAC	Refrigeration and Air Conditioning
REC	Refrigeration Electrical energy Consumption
RH	Relative Humidity
RoHS	Restriction of Hazardous Substances
RSEC	Reference Specific Energy Consumption
SEAD	Super-Efficient Equipment and Appliance Deployment
SEC	Specific Energy Consumption
TDA	Total Display Area
TEC	Total Energy Consumption
TEWI	Total Equivalent Warming Impact
TNO	Nederlandse organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (Netherlands Organisation for Applied Scientific Research)
TWG	Technical Working Group
UK	United Kingdom
US	United States
VM	Vending Machine
WEEE	Waste Electrical and Electronic Equipment
WSR	Waste Shipment Regulation

1 INTRODUCTION

1.1 Background

Directive 2009/125/EC on Ecodesign[1] establishes a framework for EU Ecodesign requirements for energy-related products with a significant potential for reduction of energy consumption. The implementation of such requirements would contribute to reach the 20% of energy savings potential identified by 2020 in the Energy Efficiency Action Plan[2].

The Directive provides the setting of requirements which the energy-related products must fulfil in order to be placed on the European market and/or put into service.

There is currently no EU legislation specifically dealing with the energy consumption of commercial refrigeration appliances.

A preparatory study (Lot 12) prepared in 2006-2007 by BIO Intelligence Service[3] (in the following referred to as the BIO IS study) showed that commercial refrigerating display appliances have a significant potential for improvement in order to reduce environmental impacts and to achieve energy savings through better design. This would lead to economic savings for businesses and end-users. The energy consumption of commercial refrigerating display appliances under the scope of this project was estimated[3,5] to be 57 TWh/yr, rising to 69 TWh/yr by 2015 and 73 TWh/yr by 2020 in the business-as-usual (BAU) scenario. These figures could decline in a best case scenario[3] with greater energy efficiency measures to 55 TWh/yr by 2015 and 47 TWh/yr by 2020 – a saving of up to 26 TWh/yr by 2020.

The aforementioned work concluded that commercial refrigeration appliances are deemed eligible for Ecodesign requirements against the criteria of Article 15 sub 1 of the Ecodesign Directive 2009/125/EC[4] .

Furthermore, commercial refrigeration appliances are deemed eligible for energy labelling requirements of Directive 2010/30/EU[6] on the indication of labelling and standard product information for the consumption of energy and other sources by energy-related products. Energy labelling may reinforce the impact of an implementing measure under Ecodesign.

Following the preparatory study, the implementing phase was initiated in 2008-2010. Further to Article 18 of the 2009/125/EC Directive, a formal consultation of the stakeholders was carried out through the Ecodesign Consultation Forum. A first meeting of the Ecodesign Consultation Forum on commercial refrigerators and freezers took place on 23 April 2010. A background impact assessment study[5] was carried out from October 2008 till July 2010 in order to assist the Commission in analysing the likely impacts of the planned measures. The work has not yet been concluded.

1.2 Objectives

1.2.1 Ecodesign on commercial refrigeration project

The Ecodesign project on commercial refrigeration is being continued by DG Energy in 2012, with support from the JRC.

The assistance from the JRC comprises all phases of the formulation of this policy:

- A revision and update of key data from the preparatory phase. This will develop the analysis to a stage where policy makers are able to take decisions regarding the favourable mix of policy instruments for the product group in question;
- The implementation phase. This phase deals with the implementation of the chosen policy instruments through the elaboration of the required measures;
- The standardisation phase. This phase addresses the standardisation procedures following the development of implementing measures.

The first phase of updating the preparatory work, and the initial formulation of technical options for the implementing measure, will be undertaken by the JRC with the contribution from stakeholders, by means of a structured Technical Working Group (TWG).

The Technical Working Group on commercial refrigeration is composed of experts from Member States' administration, industry, NGOs and academia. The experts of the group have voluntarily joined through the website of the project[7], and are expected to contribute with data, information and/or written comments to interim draft versions of this report, and through participation in expert workshops organised by the JRC-IPTS. The first workshop will be held on 23 April 2013, the second will take place end of 2013/beginning 2014.

1.2.2 This report

The objective of this first background document is to:

- Structure the status of knowledge so far collected in connection with the preparatory and impact assessment work undertaken in 2006-2010. Identify the areas where additional and complementary data collection is necessary. The work will build on existing knowledge for this product group as far as possible, not necessarily created in connection with the earlier project history.
- In particular, the following subjects are dealt with:
    - Energy consumption, and associated technologies
    - Energy efficiency calculation
    - Structure of the supply chain, current market developments
    - Refrigerant choice
    - End-of-Life options of appliances

This document is prepared to serve as input for the first Workshop of the Technical Working Group, to be held 23 April 2013 in Seville. Experts not able to come to this meeting are welcome to provide written comments.

1.3 Structure of this document

This document only highlights the major discussion points where no clear conclusion was drawn from the two major studies undertaken in the 2006-2010 phase (preparatory study by BIO IS[3] and Impact Assessment by the Wuppertal Institute[5]) or where an essential update is seen necessary. The present document lays out the status of knowledge after these debates, and outlines the areas where additional, newer and/or complementary data collection is necessary.

Each of the following chapters are structured in the 3 sections below:

a) STATUS:
Summary of status of discussions and key controversial elements;

b) REMAINING QUESTIONS
Questions which still need to be solved for moving forward;

c) DATA
Data needed for answering those remaining questions.

For conciseness, this report focuses on key information for the discussions to be held on 23 April 2013. All background and supplementary information is presented in the Annexes.

Once the necessary data has been collected, this background document will be enlarged to address all sections prescribed in MEErP[8] .

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2 SCOPE DEFINITION AND TERMINOLOGY

2.a) STATUS

The sections below present the JRC's interpretation of the status of the discussions that concern definitions and scope of Lot 12.

Commercial refrigerated cabinets are considered as energy related products within the meaning of Article 2 (1) of Directive 2009/125/EC[1]. The definition of commercial refrigeration and the scope of appliance types included in Lot 12 have already been discussed and to a large extent agreed upon in the earlier phases of the project, based on the input from the BIO IS study[3], and the subsequent impact assessment by the Wuppertal Institute[5]. Only minor adjustments have been made to the definition (see also the definition proposal of the Questionnaire distributed in December 2012) to streamline it with:

- existing definitions in the Working Documents on professional refrigeration currently discussed in the Consultation Forum[a], and
- definition list in household refrigeration appliance legislation[10].

The following definition and scope are used as default, subject to further refinement.

2.1 Definition

A **commercial refrigerated cabinet** is a refrigerated appliance intended for the storage and display for merchandising, at specified temperatures below the ambient temperature, of chilled and/or frozen products[b], and are accessible directly through open sides or via one or more doors, and/or drawers.

Commercial refrigerated cabinets are designed for the use by commercial, institutional or industrial facilities which display the chilled and/or frozen products.

Examples

Commercial refrigeration equipment can take many forms and combinations:

- 'self-contained (or plug-in) appliance' means a factory made assembly of refrigerating components designed to compress, liquefy, expand and evaporate a specific refrigerant that are an integral part of the refrigerated equipment and consists of a storage space, one or more refrigerant compressors, refrigerant evaporators, condensers and expansion devices, eventually accompanied with additional heat exchangers, fans, motors and factory supplied accessories.
- remote display cabinets work with a remote refrigerating unit which is not an integral part of the display cabinet;
- for chilled or for frozen products;

[a] http://www.taitconsulting.co.uk/Ecodesign_Consultation.html

[b] Typically food and drinks, but also other perishable goods like flowers, live bait, or medicines where refrigeration is used to extend the lifetime.

- vertical, semi-vertical or horizontal equipment;
- with or without doors (also referred to as 'open' or 'closed' cabinets);
- with or without built-in vending systems (*e.g.* coins, cards, tokens, banknotes).

The minimum energy performance standards (MEPS) to be developed shall in principle cover, but not prescribe any of the forms and combinations presented above. MEPS will be discussed at a later stage, and may or may not differentiate between plug-in and remote cabinets.

For the cabinets with a remote condensing unit, the approach taken in the 2006-2010 phase has been to only take into account the cabinet in the Ecodesign requirements, and not the full cooling system including the condensing part. From a wider, total system approach, taking *e.g.* the whole retailer's space/building into account, even larger energy savings can be obtained. An efficient cabinet is therefore to be seen as a key building brick of an overall efficient system, and the need for *e.g.* a retailer to also look at the enveloping system shall not hinder the development of more efficient cabinets.

Regarding temperature, the following considerations are important:

Depending on the product on sale, different temperature requirements apply, some of them requiring constant temperature, and some allowing controlled temperature variations. Chilling means a working temperature above 0°C, freezing implies a working temperature below 0°C.

A **commercial refrigerator** or chiller is a commercial refrigerated cabinet intended to store and maintain products at a temperature above 0°C, with reference point at +5°C (M1 temperature class)

A **commercial freezer** is a commercial refrigerated cabinet intended to store and maintain products at a temperature below 0°C, with reference point at -18°C (L1 temperature class)

Refrigerated vending machines are commercial refrigerated cabinets designed to accept consumer payments or tokens to dispense chilled or frozen products without on-site labour intervention. Vending machines are most often plug-in appliances.

Among the various possible product categories, the following typical examples of product types were selected in 2006-2010 for the purpose of the preparatory study[3] and the Impact Assessment calculations[5]:

Figure 1 Open-chilled vertical multi-deck remote refrigerating display cabinet (category RVC2 according to EN ISO 23953), with 7 m² TDA, operating in temperature class M2 (-1°C to 7°C), using R404a as refrigerant, with a product life of 9 years.

Figure 2 Open remote horizontal frozen island (category RHF4 according to EN ISO 23953), with 7 m² TDA, operating in temperature class L2 (-18°C to -12°C), using R404a as refrigerant, with a product life of 9 years.

Figure 3 Beverage cooler with one glass door, operating at temperature classes H1 and H2 (5°C), with a net volume of 500 litres, using R134a as refrigerant, with a product life of 8 years. Plug-in.

Figure 4 Packaged horizontal ice cream freezer with lids (category IHF6 according to EN ISO 23953), with a net volume of 291 litres, operating in temperature class L1 (-23°C to -18°C), using R507 as refrigerant, with a product life of 8 years. Plug-in.

Figure 5 Spiral vending machine, with a net volume of 750 litres, operating in temperature class M2 (-1°C to 7°C), using R134a as refrigerant, with a product life of 8.5 years. Plug-in.

It should be born in mind, as a general principle for the policy-making process for which the present study feeds into, that it is most appropriate to make implementing measures design-neutral, technology-neutral, and as simple as possible. Any implementing measure has to generally address the sector and not just product types as outlined above. The examples provided are not to be used as a point-of-reference to later set the Ecodesign criteria, but are representative, illustrative cases of the largest-selling subtypes of commercial refrigerated cabinets, and are only analysed in detail in connection with the (later) Impact Assessment.

Nonetheless, it has been pointed out in earlier discussions in Lot 12 that in particular refrigerated vending machines are sufficiently large in numbers and homogeneous in design as to merit being covered by a separate 'stand-alone' measure, or even separate Ecodesign Regulation.

2.2 Scope

All appliances fulfilling the definition outlined above are to be covered by a regulation on commercial refrigeration. Figure 6, Figure 7 and the explanations below clarify the interface with other refrigeration appliance groups not included in the scope.

Interface with household refrigeration:
Household refrigerated cabinets are intended for the storage, but not the sale or display of chilled and/or frozen foodstuff, and are not designed for the use by commercial, institutional or industrial facilities. Regulation 643/2009 lays out Ecodesign requirements for household refrigerating appliances.[10,11] In addition, household refrigerators are subject to energy labelling following Commission Delegated Regulation (EU) No 1060/2010.[12]

Interface with professional refrigeration:
Contrary to commercial refrigeration cabinets, professional refrigerated cabinets are intended for the storage, but not the sale and display, of chilled and/or frozen foodstuff.

In principle, equipment used in gastronomy (refrigerated salad bars, vitrines, etc.) and non-household refrigerating equipment for storage purposes without any display or merchandising function are not included in Lot 12 but are currently subject of analysis for an Ecodesign Regulation as ENTR Lot 1 (professional refrigeration).

Commercial refrigerators are found in areas where customers normally[c] have access. Professional refrigeration appliances are found in areas where customers do not have access, such as back shops, below counters, or professional kitchens. The devices are intended exclusively for professional use[9].

For a number of product groups it is contentious if they are to be covered by this implementing measure (Lot 12) or not. Figure 6 and Figure 7 illustrate the scope and boundaries of the different refrigeration cabinets.

1. In some supermarkets, closed chest freezers function as commercial refrigeration: they do not display the products, but they have attached, above or close to it an image representing the content of the freezer. Closed chest freezers are also found in professional refrigeration, and in households. Household-quality products would fall under Regulation 643/2009 (Ecodesign for household refrigerating appliances)[10]. If intended for commercial or professional use, the frequency of openings may increase considerably, resulting in underperformance due to underdimensioning of the refrigeration power necessary. (overlap with Lot 1, and household refrigeration)

2. Some professional cabinets have transparent doors and display the items inside. However, they are not intended to use for selling the items. (overlap with Lot 1)

[c] A bottle cooler behind a counter is a commercial refrigeration appliance, located for display, but without access by the end-user.

3. Some serve-over counters, mainly intended to display and sell items, can have closed, integrated chest space for the storage of items. (overlap with Lot 1)

Figure 6 displays additionally in the interface with Lot 1, Lot 12 and household refrigeration the label WEEE, indicating the current need of clarification of the scope of application of the WEEE Directive (2012/19/EU)13 to the end-of-life of commercial refrigeration products except vending machines. In its current formulation, this Directive allows Member States until 15 August 2018 to interpret whether or not non-household refrigeration appliances are subject to the prescriptions of WEEE. After this date, all refrigeration appliances are under the scope of the WEEE Directive.

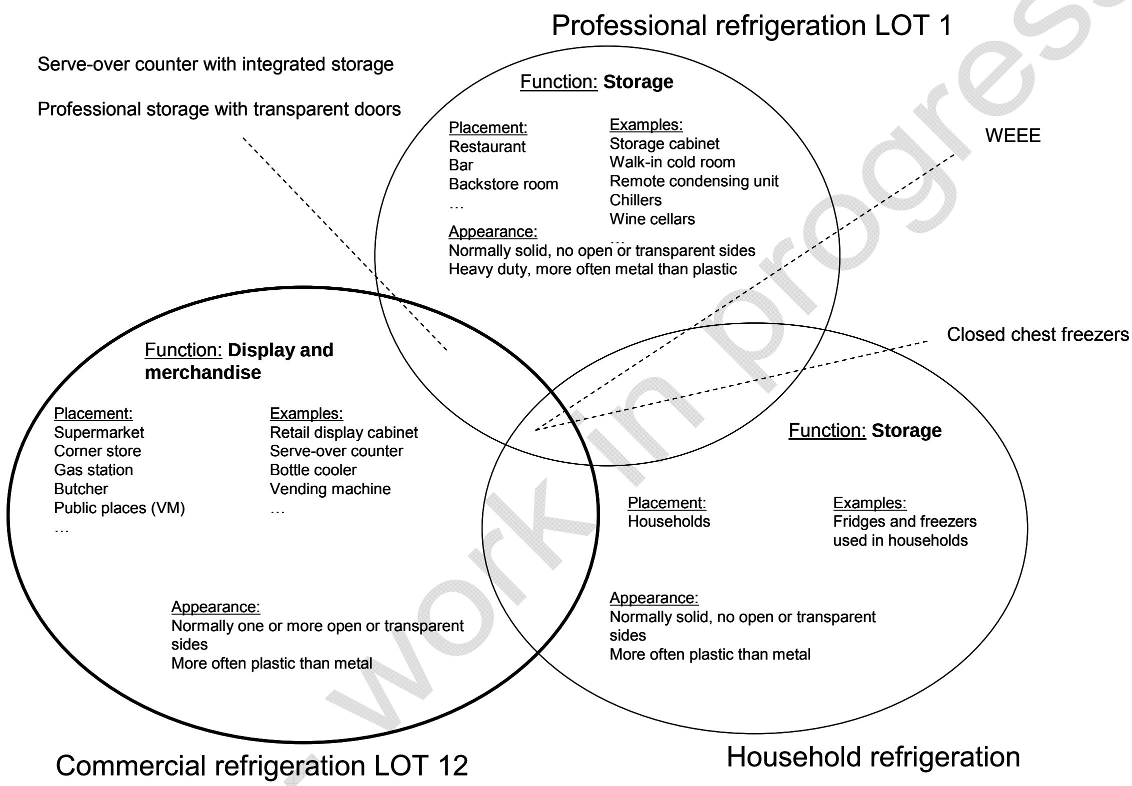

Figure 6 Scope and boundaries of the different refrigeration cabinet types.

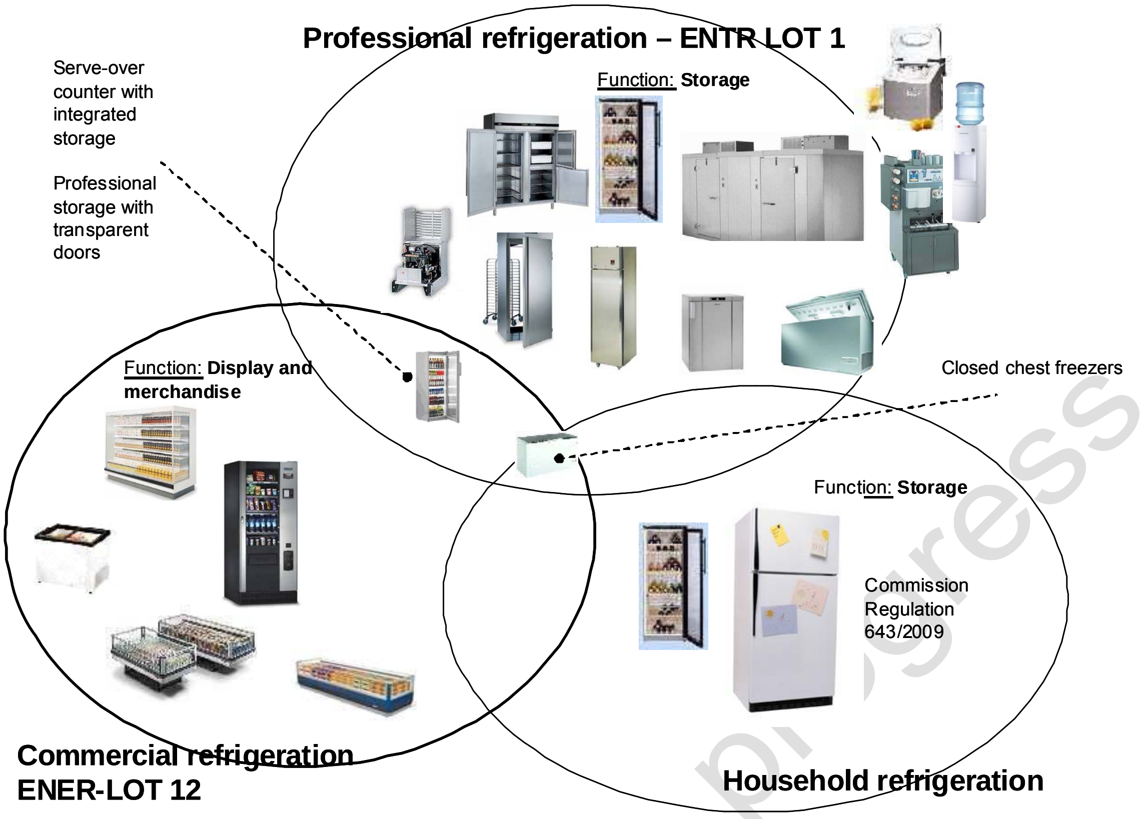

Figure 7 Image examples of the different refrigeration cabinets.

Exclusions:
Some product groups such as wine cellars, minibars, ice-cream makers, ice-makers, chilled water dispensers, or life fish/shellfish displays are currently out of the scope of the three mentioned legislative groups.

There are additional product groups that may fall under the scope of commercial refrigeration but cannot currently be categorized by existing standards, most notably ISO 23953. An example is a serve-over counter for display and selling of non-prepacked ice-cream, a so called *gelato freezer*. They operate at a temperature of -10°C, which is outside the predefined temperature classes of the ISO standard.

2.b) REMAINING QUESTIONS

2.b.1) Do you agree with the definition of commercial refrigeration proposed above?

2.b.2) Are there any additional definitions that you find necessary for Lot 12? A list of complementary definitions is provided for reference in Annex 7.5.

2.b.3) Do you agree with the scope proposed above? Are there any appliances that in your view should be included/excluded from this scope?

2.b.4) Relating to the previous question, which is your view on the inclusion/exclusion of:
- **closed chest freezers used for commercial purposes using product images. Should they comply with legislation on household refrigeration? Are there types not fitting into household refrigeration legislation?**
- **minibars**
- **wine cellars**

- 'production' devices such as ice-cream makers, ice-makers, chilled water dispensers
- gelato display cabinets. These cabinets fit into the scope of Lot 12, however as operating at -10°C they can not be classified in a temperature class according to ISO 23953.

2.c) DATA

Should you disagree with the proposals on scope and definitions above, please provide at the workshop 23 April 2013 your alternative proposal, supported where necessary by data and evidence.

3 LEGISLATION AND STANDARDS/CERTIFICATION

3.a) STATUS

The section below presents the JRC's interpretation of the status of the discussions that concern legislation, standards and certification.

In the BIO IS study[3], relevant standard and legislations are shortly described. The main developments since then affecting legislation and standards are on the one hand, legislative amendments, and on the other hand, the uptake of technology developments.

On the legislative side, the following areas need to be re-analysed:

- Refrigerant gas use.
- End-of-life management assessment.

Rapid uptake of alternative refrigerants such as hydrocarbons and CO_2 were triggered by the first F-gas regulation (EC/842/2006)[16], at the moment under revision[17,18]. Changing to alternative refrigerants brings however to the forefront safety issues, with associated standards and legislation related to flammability and high pressure equipment. Specific national (intra- and extra-EU) legislation is listed in Annex 7.1.

Moreover, the presentation of end-of-life legislation in the BIO IS study[3] was not followed by an assessment of its consequences for Ecodesign. An initial review by the JRC has identified that the current enforcement of the WEEE Directive[13] and the Waste Shipment Regulation[14] differs largely in Member States. This divergence is of concern (1) in itself, as a coherent approach to the correct management and fate of the appliances shall be ensured across the EU, and (2) for ensuring the correct assessment of the impact of any Ecodesign implementing measure proposal that focuses on end-of-life management, *e.g.* the removal of hazardous components such as electronic printed circuits or batteries.

The existing EU legislation related to refrigeration can basically be categorised in three groups (see Table 1): environmental, energy, and safety legislation. There is currently in Europe no specific legislation concerning commercial refrigerators and freezers. Although the environmental and energy legislations are the most important for Ecodesign requirements, safety regulations become important when flammable and/or toxic refrigerants such as ammonia or hydrocarbons are used as alternative refrigerants. As mentioned before, legislation relating to (high) pressure equipment is particularly important for refrigeration systems using CO_2 as refrigerant.

Table 1 Relevant EU legislation related to commercial refrigeration

Domain	LEGISLATION
Environment	
Entire product	Waste Electrical and Electronic Equipment Directive 2012/19/EU
	Restriction of the use of certain Hazardous Substances in electric and electronic equipment Directive 2011/65/EC
Refrigerating Fluids	Ozone Depleting Substances Regulation 1005/2009
	Fluorinated Greenhouse Gases Regulation 842/2006 (update in progress)
Shipment as waste	Waste Shipment Regulation 1013/2006
Energy	
Lighting	Energy efficiency requirements for ballasts for fluorescent lighting- Directive 2000/55/EC
Safety	
Entire product	Machinery Directive 95/16/EC
	General Product Safety Directive 2001/95/EC
	Low Voltage Equipment Directive 73/23/EEC
	Equipment and protective systems intended for use in potentially explosive atmospheres Directive 94/9/EC (ATEX)
	Pressure Equipment Directive 97/23/CE

Also different test standards are available, relating to energy use, testing and safety. The most relevant standards are listed in Table 2.

Table 2 Relevant standards for Lot 12 products

TYPE	STANDARD
International Standards	
Safety	ISO 5149:1993(2004): Mechanical refrigerating systems used for cooling and heating – safety requirements
	IEC 60335:2012 part 2-75: Household and similar electrical appliances – safety –: Particular requirements for commercial dispensing appliances and vending machines – part 2-89: particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor
Energy use	ISO 23953-2:2005/Amd 1:2012 refrigerated display cabinet – part 2: classification, requirements and test conditions
European Standards	
Safety	EN378 1:2008+A2:2012: Refrigerating systems and heat pumps - Safety and environmental requirements
Product specific test standards in other countries	
Safety	*USA*
	ANSI/ASHRAE 34(2001): designation and safety classification of refrigerants
Energy use	*Canada*
	CAN/C657-04: Energy performance standard for commercial refrigerated display cabinets and merchandisers CSA C82798 (R2003): Energy Performance Standard for Food Service Refrigerators and Freezers
	CAN/CSA-C804:96: Energy performance of vending machines
	USA

	ANSI/ASHRAE Standard 72-2005, Method of Testing Commercial Refrigerators and Freezers.
	AHRI Standard 1200 (2010) Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets (I-P version; SI units version AHRI 1201)
	Japan
	JRA 4032 (1993): commercial refrigerators, refrigerator-freezers and freezers
	South Africa
	SANS 60335-2-89(2003): part 2-89: household and similar electrical appliances – safety – particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor
	SABS 1406:1998 - Commercial refrigerated food display cabinets
	Korea
	KS B 6031
	Mexico
	NOM-022-ENER/SCFI-2008
	China
	GB 26920.1-2011
	GB/T 21001
	AS 1731, ARI standard 1200

3.1 Refrigerants

If refrigerants are released into the environment, they have an environmental impact in case of high global warming potential (GWP) and/or ozone-depleting potential (ODP). At the moment, the most common refrigerants are fluorinated gases. HCFC and CFC refrigerants will be phased out by the Montreal Protocol and must be treated in accordance with Regulation (EC) No 1005/2009 on substances that deplete the ozone layer[19]. HFC refrigerants replace the ozone-depleting substances, but generally have medium to high GWP. The EU controls emissions of fluorinated greenhouse gases, also called F-gases, through two legislative acts, the F-Gas Regulation[16] and the MAC Directive[20].

In addition to the above and also on refrigerants, the WEEE Directive[13] contains provisions for the safe collection of refrigerant gases at the end-of-life of appliances: *"… equipment containing gases that are ozone depleting or have a global warming potential (GWP) above 15, such as those contained in foams and refrigeration circuits: the gases must be properly extracted and properly treated. Ozone-depleting gases must be treated in accordance with Regulation (EC) No 1005/2009."*

In parallel, Article 4 of the 2006 F-gas regulation[16] also imposes a proper recovery of the gases. This regulation is currently being updated[17,18]. The Regulation covers a wide range of sectors, and will not target specific sectors like commercial refrigeration, but the measures adopted will likely affect commercial refrigeration, as fluorinated refrigerants are widely used in this product group (*e.g.* R134a, R404a).

In the discussions on Lot 12 in 2006-2010, consideration to the concerns of the 2006 F-gas Regulation motivated the proposal of a bonus-malus system as part of the energy efficiency formula. The goal was to motivate refrigerant substitution to lower GWP refrigerants, such as hydrocarbons, ammonia or CO_2. Notwithstanding this, the life-cycle assessment part of BIO IS study[3] clearly highlights that the main environmental gains of refrigerant substitution are not related to the GWP of the gas per se[d], which can be released if there a leaks, but to the better refrigeration performance of the non-HFC refrigerants. Additional technical details on this issue are provided in Section 5.3.

3.2 Safety

One of the main Directives to take in to account is the ATEX Directive. The ATEX directive consists of two EU Directives describing safety conditions for equipment and work environment with an explosive atmosphere:

> (1) ATEX 95 equipment Directive 94/9/EC (Equipment and protective systems intended for use in potentially explosive atmospheres);
> (2) ATEX 137 workplace directive 99/92/EC (Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres).

The ATEX equipment Directive prescribes certain design requirements when dealing with an explosive atmosphere which possible could be created by a refrigerant leak, among others:

- ATEX 95 Annex II 1.3.1. Potential ignition sources such as sparks, flames, electric arcs, high surface temperatures, acoustic energy, optical radiation, electromagnetic waves and other ignition sources must not occur.

- ATEX 95 Annex II 2.3.1.1. Equipment must be so designed and constructed as to prevent foreseeable ignition sources which can occur during normal operation.

These generic prescriptions make it challenging to use hydrocarbons in *e.g.* vending machines, which are quipped with moving mechanical parts. The legislative developments in this field are not fully aligned: in the US, the hydrocarbon mixture HCR188C (R441a) may be used in new vending machines as of May 2012.

Appliances with a charge of more than 150g of flammable refrigerant in each separate refrigerant circuit are not covered by the standard IEC 60335. For appliances with a charge greater than 150g of flammable refrigerant in each refrigerant circuit and for the installation, ISO 5149 applies.

For CO_2 using appliances, the pressure in the cooling system can exceed 100 bar. Thus, CO_2 systems are subject to additional reporting and safety assessments according to the Pressure Equipment Directive (PED)[21]. The EN 378 standard supports the essential requirements of the PED (and the Machinery Directive) prescribing strict conditions. According to a TNO study[22,23] based on laboratory tests on bottle coolers, these strict conditions are not necessary for CO_2 refrigeration appliances. The tests revealed that the weakest points of the refrigeration system are weldings, not components, and in case of failure the release of CO_2 would take place in the weak points, without explosion. One consequence is that overdimensioning may be a current concern in CO_2 equipment, due to duplication and not coordination of safety measures (temperature relay compressor, vent for higher pressure, and thickness of tubing).

[d] Leaks of HFCs, including a potential release of all the gas at dismantling, account for <5% of total TEWI in the life cycle of these appliances. The remaining TEWI are related to the energy use during the appliance's use phase.

Table 3 provides a summary of the key regulatory barriers for the uptake of low-GWP refrigerants.

Table 3 Summary of key regulatory barriers to implementing low-GWP refrigerants (Source: adapted from ASHRAE Journal 2010).

European Union					
	Pressure Equipment Directive	**IEC 60335-2-40**	**IEC 60335-2-75**	**IEC 60335-2-89**	**EN 378**
Carbon dioxide	D, R				
Ammonia	D, R	D			
Hydrocarbons	D, R	D	D	D	P, D

P - Prohibition of certain types of refrigerants in certain applications
D - Design implications, such as charge limits or safety requirements
R - Reporting requirements to ensure health and safety

3.3 Energy

As indicated above, there is currently in Europe no specific legislation concerning commercial refrigerators and freezers, and this also refers to energy performance. Worldwide, these examples are not abundant, but exist. Different standards, in some cases supported by legislation, are used worldwide to define energy performance of commercial refrigeration appliances, including regulatory minimum energy performance standards (MEPS). Cross-comparisons of these standards are complex. A comprehensive overview of the different test standards is provided in a recent study by Refrigeration Developments and Testing Ltd.[24], and test methodologies are compared in an ongoing study launched by CLASP[25].

The most important standard relating to this project is the ISO 23953 standard. It describes vocabulary, classification, requirements and test conditions related to refrigerated display cabinets used for the sale and display of foodstuffs.

A voluntary certification scheme developed by the Eurovent association[e], uses the ISO 23953 standard to verify the performance of display cabinets. This scheme uses an energy efficiency label (A, B, C, D, E, F) which is based on European average values for different cabinet types. These values will be further discussed in section 5.2. This energy label was created in order to better rank the products on the market.

For vending machines, the key test standard is ASHRAE 32.1, which underpins minimum efficiency performance standards (MEPS) (incl. proposed) and/or labeling in USA, California, Canada, Australia and New Zealand. In Europe, manufacturers and importers may make voluntary use of the European Vending Association's Energy Measurement Protocol (EVA-EMP). Comparison of the energy performance of vending machines measured under EVA-EMP or ASHRAE 32.1 is possible after normalisation.[26] The European Vending Association also provides a voluntary energy labelling scheme.

Both the ISO 23953 standard and the EVA-EMP for vending machines are currently the most suited standard references for testing the energy performance of the products in the scope of

[e] European Committee of Air Handling & Refrigeration Equipment Manufacturers

this study. The ISO standard ISO 23953 covers refrigerated display cabinets and is currently under revision by CEN TC44 under the guidance of European Commission mandate 495. The European Vending Association will propose their measurement protocol EVA-EMP to the European Committee for Electrotechnical Standardization (CENELEC) in the summer of 2013.

3.b) REMAINING QUESTIONS

Questions which still need to be solved for moving forward:

Safety

3.b.1) CO_2 and safety: some stakeholders have raised concerns of safety due to the high pressure required for operational CO_2 systems (> 100 bar). Is there any hard evidence (*e.g.* test results) of such concerns? The only related test results identified (TNO study[22,23]) refute such safety concerns. What is the exact (if any) legislative barrier to the use of CO_2 at high pressure?

3.b.2) HC and safety: according to safety legislation and standards the maximum charge of refrigerant of 150g limits the size of the equipment using this refrigerant. Does this mean that HC is only a viable option for small-sized plug-in cabinets? Which technical improvements could one envisage in order to comply with safety regulations/standards for bigger plug-in appliances and vending machines? Are there not options for separating physically the product area from the refrigerant area, as in household appliances and some chest freezers?

3.b.3) Vending machines and HC: some stakeholders have raised concerns of safety due to the risk of ignition originating in the mechanical parts of vending machines if HC leaks vent into the product area. Is there any hard evidence of the explosion risk hypothesis? Which are the options to redesign the evaporator so the gas does not vent to the cabinet (*e.g.* like in passive systems and household equipment)? Which limitations would this have? Is it a matter of legislation or technical viability? How is this dealt with in US vending machines using R441a as refrigerant?

3.b.4) It is not clear how vending machines with HC are dealt with in the US following guidelines of the US EPA. The same holds for rules applying to the use of CO_2 in US vending machines.

3.b.5) The exact link between the ATEX Directives and the different standards is not 100% clear for the moment. *E.g.* Is the limit of 150g HC merely a guideline or is it legislation? An indication where exactly these numbers are stated is welcome. The same holds for legislation/standards related to the use of high pressures for CO_2.

3.b.6) Are you aware of any (upcoming) change in safety standards with respect to commercial refrigeration *e.g.* in ATEX or EN 378?

3.b.7) Which standards/legislation currently limits the introduction of climate-friendly alternatives? Where could these standards be changed, safety concerns still taken in to account.

Energy measurement

3.b.8) Which are in your view the product groups that currently are not adequately covered by ISO 23593? Which are the specific aspects of conflict? Examples:
- **Beverage coolers (Are they covered by IVC4: integrated, vertical, chilled , glass door, temperature class M2)**
- **Ice cream (*gelato*) freezers? If not, why are they not covered in ISO 23953, any technical reason?**

3.b.9) Are presence detector steering controls (especially for beverage coolers) accountable in any way in ISO 23593? Are they accountable in the EVA-EMP for vending coolers? If not, is it advisable to change these standards to account for such technology developments?

3.b.10) At the moment the EVA-EMP is not yet sufficiently consolidated. Is it appropriate to use another standard, *e.g.* extra-EU ASHRAE 32.1, to define the energy consumption of a vending machine? Which one would be most appropriate and why?

3.b.11) Would you agree on a specific climate class (*e.g.* class 3: 25°C, 60% RH) to test the energy consumption of commercial refrigeration cabinets in EU Ecodesign measures? If not, why? Apparently, for professional refrigeration (Lot 1) climate class 4 is being proposed.

General

3.b.12) Is there any technical aspect in Member State or non-EU standards that you believe would be useful in a EU regulation? Is there any aspect that in your view shall be harmonised?

3.c) DATA
Data needed for answering those remaining questions:

3.c.1) Safety: only one reference of CO_2 testing for bottle coolers has been identified. The data evidence on this field, both for CO_2 and HC, and for non-cooler devices needs to be more solid.

3.c.2) End-of-life management and enforcement of WEEE/WSR: Please provide data/contacts from your region/Member State on the application of WEEE Directive and the Waste Shipment Regulation for commercial refrigeration appliances.

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4 MARKETS

4.a) STATUS

The section below presents the JRC's interpretation of the status of the discussions that concern markets.

In the BIO IS study[3], besides a valuable qualitative sector description, market data was collected, the newest of it dated 2006. The study also included projections running into 2010. All this information was used to set up development scenarios in the Impact Assessment by the Wuppertal Institute[5]. Seen in perspective, and once contrasted with real data that accounts for the market developments in 2006-2012, it is clear that sales projections do not correspond with the situation today. Market structure and segmentation data seems to be still valid.

Some stakeholders have indicated that one of the tangible consequences of the BIO IS study[3] was an increased interest in energy efficiency by appliance buyers and manufacturers. Increasing energy prices since 2006 have additionally reinforced this interest.

The fundamental objective of market data collection is to enable, at a later phase, a prediction of the potential impacts (in a wider sense, including life-cycle cost calculations) of different MEPS proposals. The impact assessment has to be as accurate as possible, and therefore requires up-to-date information on the production and stocks of commercial refrigeration appliances in the EU27, at the most detailed appliance type breakdown level feasible.

4.1 Generic market and trade data

As a point of departure, preliminary aggregated market and trade data is available from Eurostat, broken down by PRODCOM classification codes (see detailed data in Annex 7.3). However, PRODCOM classification is not detailed enough for the purpose of this study, and may not cover the full scope of commercial refrigeration products identified in chapter 2. Table 4 below shows the different PRODCOM categories relevant for the product group of commercial refrigeration.

Table 4 Description of PRODCOM classifications with the HS/CN reference relevant for the product group of commercial refrigeration.

Description	HS/CN reference
Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator for frozen food storage	8418 50 11
Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator (excluding for frozen food storage)	8418 50 19
Deep-freezing refrigerating furniture (excluding chest freezers of a capacity ≤ 800 litres, upright freezers of a capacity ≤ 900 litres)	8418.50.91
Refrigerating furniture (excluding for deep-freezing, show-cases and counters incorporating a refrigerating unit or evaporator)	8418.50.99
Automatic goods-vending machines incorporating heating or refrigerating devices	8476[.21 + .81]

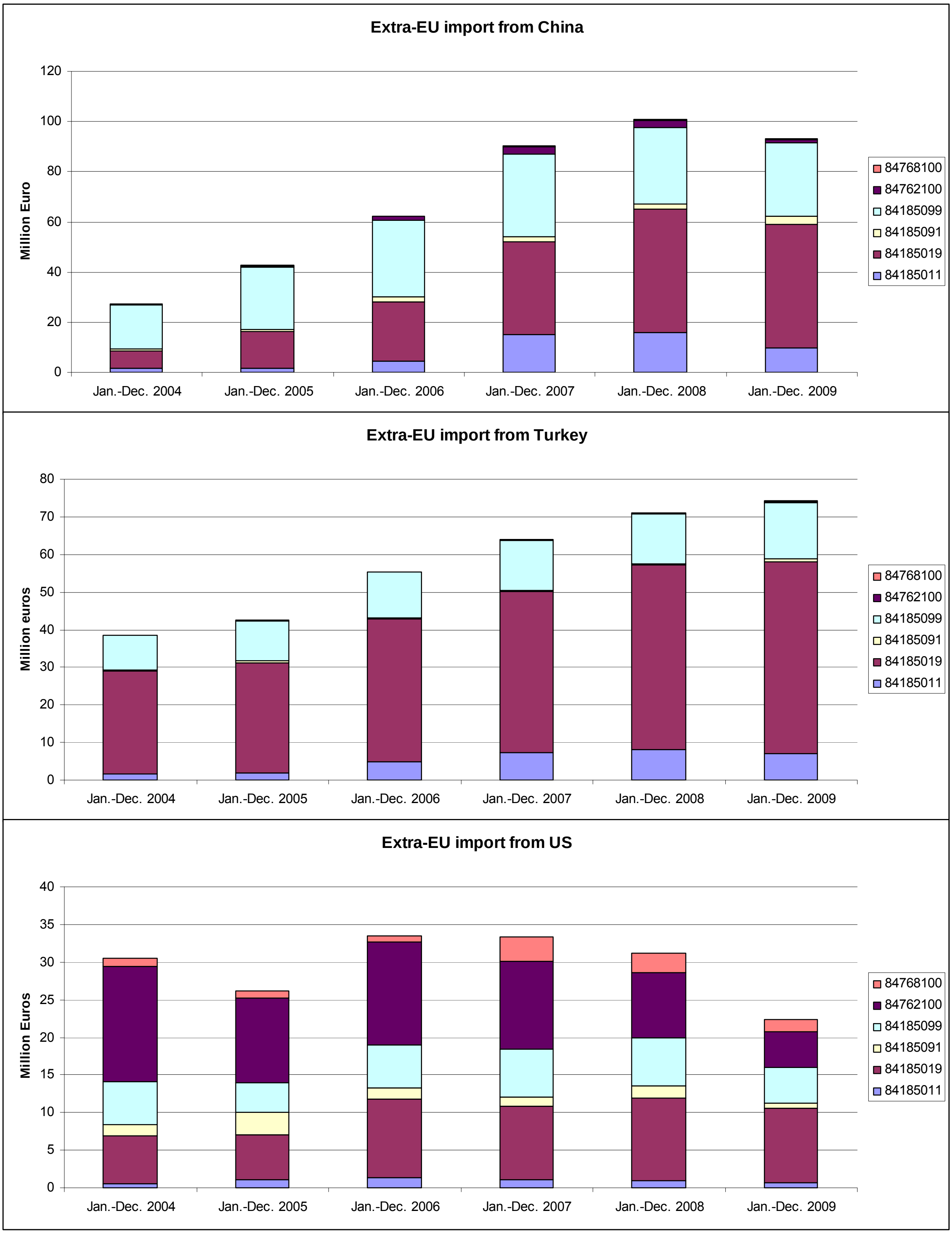

Figure 8 EU27 import in million euros from China, Turkey, and the United States. Source: Eurostat, 2012.

Figure 8 depicts some examples of trade data evolution to the EU. In overall terms, extra EU trade does not account for more than 10% of the total EU production for commercial refrigeration.[3] Figure 8 illustrates substantial changes in some individual trade partners, *e.g.*

imports from Turkey and China seem to have more than doubled when comparing year 2005 with 2009, while imports from the US remained more or less stable for this period.

Eurostat's database does not contain at the moment more recent data than 2009.

Additional more detailed market and stock data are based on information received from stakeholders, most notably the European umbrella associations Eurovent and EVA.

Eurovent collects regularly data on display cabinets for the supermarket segment, both plug-in and remote types. However, there is no collection of data for non-supermarket plug-in appliances like bottle coolers and ice-cream freezers.

The association EVA collects regularly data directly from manufacturers on vending machines.

Most data collected by these associations do not cover all the 27 EU countries. In 2006, Eurovent provided data for 25 EU countries (excluding Bulgaria and Romania) for the BIO IS study[3]. Including the figures for Bulgaria and Romania will not alter significantly the aggregated figures.

EVA data for vending machines cover 21 Member States. Also here, the omissions are judged non-significant, as only 6 Member States cover 80% of the stock and sales figures.

4.1.1 Remote display cabinets

4.1.1.1 Sales data for remote display cabinets

Eurovent's aggregated sales data for remote display cabinets in the EU25 (estimated number of units delivered and installed) are provided in Table 5 (left column). The detailed sales data per EU25 country for remote display cabinets are provided in Annex 7.3.

A comparison of Eurovent's published figures with the estimates (linear sales projections) made by BIO IS[3] illustrates clearly the overestimation made and the need of market data update.

Table 5 Current estimation of sales compared with linear projections from the BIO IS report. Sources: Eurovent, 2013; BIO IS, 2007.

Year	Average EU-25 estimations of sales	Average EU-25 estimations of sales linear extrapolation for 2008-2010
2004	225 884	225 884
2005	231 400	231 400
2006	239 073	239 073
2007	245 255	245 255
2008	219 723	251 849
2009	224 395	258 428
2010	196 488	265 006

Eurovent's estimation of the stock of remote display cabinets is shown in Table 6. More than 70% of the demand for remote display cabinets is to replace existing units. This is most significant for Western Europe, while in East and Central Europe end-users such as retailers are still expanding. Moreover, East and Central European countries use more refurbished/second-hand cabinets.

Table 6 Estimated EU25 stock for remote display cabinets. Source: Eurovent, 2013

	STOCK
2004	2 032 959
2005	2 082 600
2006	2 151 654
2007	2 207 295
2008	2 266 642
2009	2 325 849
2010	2 385 055

4.1.1.2 Share of product category and price for remote cabinets

According to Eurovent, and confirmed by end-users, open vertical chilled cabinets (semi-vertical, multi-deck and roll-in) represent the most important market segment in the remote cabinet family (Table 7).

Table 7 also shows the average price of the different cabinet types. The price mostly depends on the size of the cabinet and can be influenced choosing different (energy-saving) options.

Table 7 Estimation of the share of each product category for remote display cabinets and the average selling price (Source: Eurovent, 2013).

Product category	Eurovent classification	Average EU 25 Selling price (in euro)	% of units in this product category
Multidecks & semi-verticals	RVC1/RVC2/RVC3	3437 ± 507	61%
Counters: service & self service	RHC1/RHC2/RHC7/RHC8/RHF1/RHF7	3017 ± 560	16%
Frozen food islands	RHC3 to RHC6 & RHF3 to RHF6	3966 ± 718	13%
Glass doors & frozen multidecks/SV	RVF4 & RVC4 + RVF1 & RVF2	5935 ± 2040	4%
Combis	RYC1 to RYC4 & RYF1 to RYF4	6779 ± 1187	6%

A more detailed market analysis for remote display cabinets for the year 2010 is shown in Table 8.

Table 8 Detailed estimates of sales figures for 2010 per cabinet type. Source: Eurovent, 2013.

Cabinet type, ISO 23953	Temp. Class	Weight %	Sales EU	% Family	Sales/Family
RVC1, RVC2	3H	0,61	111.976	0,10	11.198
	3M2	0,61		0,50	55.988
	3M1	0,61		0,15	16.796
	3M0	0,61		0,10	11.198
RVC3	3H	0,61		0,05	5.599
	3M2	0,61		0,10	11.198
RVF1	3L3	0,04	7.343	0,05	367
RVF4	3L1	0,04		0,35	2.570
RVC4	3H	0,04		--	--
	3M2	0,04		0,10	734
	3M1	0,04		0,30	2.203
	3M0	0,04		0,20	1.469
RHC1	3H	0,16	29.371	--	--
	3M2	0,16		0,60	17.623
	3M1	0,16		0,40	11.748
RHF1	3L3	0,13	23.864	0,02	477
RHC3, RHC4	3M2	0,13		0,15	3.580
	3M1	0,13		0,15	3.580
	3M0	0,13		0,05	1.193
RHF3, RHF4	3L1	0,13		0,02	477
	3L2	0,13		0,08	1.909
	3L3	0,13		0,20	4.773
RHC5, RHC6	3H	0,13		--	--
	3M2	0,13		0,04	955
	3M1	0,13		0,08	1.909
RHF5, RHF6	3L1	0,13		0,10	2.386
	3L2	0,13		0,08	1.909
	3L3	0,13		0,03	716
RYF3	3L2	0,06	11.014	0,35	3.855
	3L3	0,06		0,35	3.855
RYF4	3L2	0,06		0,15	1.652
	3L3	0,06		0,15	1.652
		Tot. EU 27 2010	**183.568**		

In conclusion, it is clear from the figures that:

- Production and stock data of remote cabinets have been fairly stable in the last years
- The by far largest sales on remote cabinets are for multidecks & semi-verticals, followed at distance by counters, and frozen food islands. These three groups account altogether for ca. 90% of total production of remote cabinets.

4.1.2 Plug-in display cabinets

Plug-in refrigerated display cabinets have a high market fragmentation (Figure 9). Most of the plug-in appliances on the market (88%) are glass door merchandisers - also known as beverage coolers -, or ice-cream freezers. Only 12% of the plug-in display cabinets on the market are for the supermarket segment. As Eurovent data is from supermarkets, this means that up-to-date market data (production, stocks, average prices) is lacking for the biggest share of plug-in appliances.

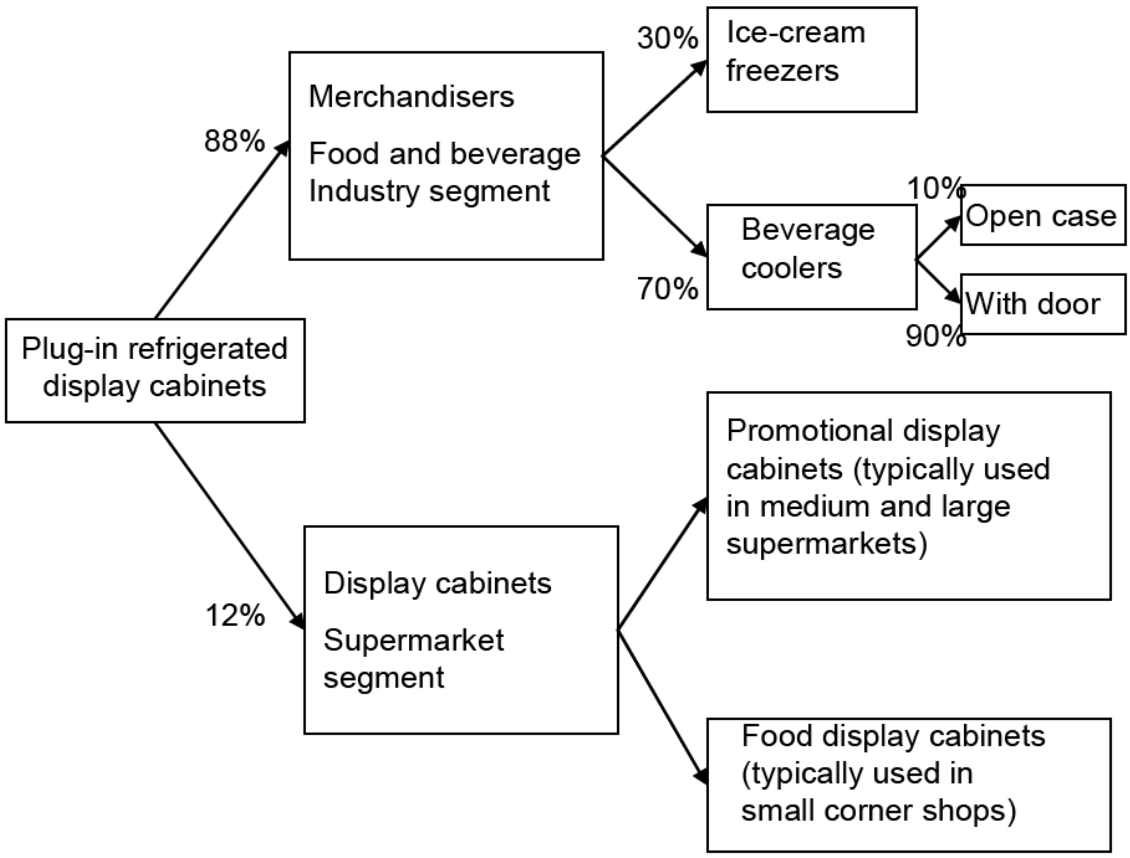

Figure 9 Market fragmentation of the plug-in segment. Source: BIO IS, 2007

4.1.2.1 Sales data for plug-in display cabinets, supermarket segment

Eurovent's aggregated sales data for plug-in display cabinets of the supermarket segment in the EU25 (estimated number of units delivered and installed) are provided in Table 9.

Table 9 Aggregated sales data for plug-in display cabinets of the supermarket segment. Source: Eurovent, 2013

	2004	2005	2006	2007	2008	2009	2010
Total	144 000	154 000	165 000	176 500	189 000	202 000	216 000

Note that comparing Table 5 and Table 9 reveals that more plug-in cabinets than remote cabinets of the supermarket segment were sold in 2010.

Eurovent's estimation for the stock of plug-in display cabinets in the EU25 is given in Table 10. In the BIO IS study[3], the stock of beverage coolers in 2006 was estimated to be 6.3 million units, while the stock for plug-in display cabinets for the supermarket segment was estimated to be 1.9 million units. This figure for supermarket plug-in display cabinets is more than double the figure provided for 2006 by Eurovent (825 000, Table 10), a clear indicator of the need to double-check data sources and estimates.

Table 10 Estimated EU25 stock for plug-in display cabinets of the supermarket segment. Source: Eurovent, 2013.

	2004	2005	2006	2007	2008	2009	2010
Total	720 000	770 000	825 000	882 500	945 000	1 010 000	1 080 000

No up-to-date share of replacement sales is available for plug-in appliances.

4.1.2.2 Share of product category and price for plug-in cabinets

Table 11 shows the average price of the different cabinet types together with the market share of different plug-ins of the supermarket segment.

Table 11 Estimation of the share of each product category for plug-in display cabinets of the supermarket segment and the average selling price. Source: Eurovent, 2013

Product category	Eurovent classification	Average EU 25 Selling price (in euro)	% of units belonging to this product category (delivered to EU 25)
Multidecks & semi-verticals	IVC1/IVC2/IVC3	2225	9,3%
Counters: service & self service	IHC1/IHC2/IHC7/IHC8/IHF1/IHF7	1845	31,0%
Frozen food islands	IHC3 to IHC6 & IHF3 to IHF6	1855	59,7%
Glass doors & frozen multidecks/SV	IVF4 & IVC4 + IVF1 & IVF2		
Combis	IYC1 to IYC4 & IYF1 to IYF4		

A more detailed estimate of market shares for plug-in display cabinets of the supermarket segment for the year 2010 is shown in Table 12, as communicated by Eurovent. Very rough market shares (similar to the ones used for remote cabinet types) have been used as weighing factor for obtaining the sales per family

Table 12 Detailed sales estimates for 2010 per cabinet type for plug-in display cabinets of the supermarket segment. Source: Eurovent, 2013.

Cabinet type, ISO 23953	Temp Class	Weight %	Sales EU	% Family	Sales/Family
IVC1, IVC2	3H	0,61	103.815	0,35	36.335
	3M2	0,61		0,35	36.335
	3M1	0,61		0,1	10.381
	3M0	0,61		0,05	5.191
IVC3	3H	0,61		0,1	10.381
	3M2	0,61		0,05	5.191
IVF1	3L3	0,04	6.808	--	--
IVF4	3L1	0,04		0,35	2.383
IVC4	3H	0,04		0,1	681

	3M2	0,04		0,2	1.362
	3M1	0,04		0,3	2.042
	3M0	0,04		0,05	340
IHC1	3H	0,16	27.230	0,15	4.085
	3M2	0,16		0,6	16.338
	3M1	0,16		0,25	6.808
IHF1	3L3	0,13	22.124	0,02	442
IHC3, IHC4	3H	0,13		0,15	3.319
	3M2	0,13		0,15	3.319
	3M1	0,13		0,05	1.106
IHF3, IHF4	3L1	0,13		0,02	442
	3L2	0,13		0,08	1.770
	3L3	0,13		0,2	4.425
IHC5, IHC6	3H	0,13		--	--
	3M2	0,13		0,04	885
	3M1	0,13		0,08	1.770
IHF5, IHF6	3L1	0,13		0,1	2.212
	3L2	0,13		0,08	1.770
	3L3	0,13		0,03	664
IYF3	3L2	0,06	10.211	0,35	3.574
	3L3	0,06		0,35	3.574
IYF4	3L2	0,06		0,15	1.532
	3L3	0,06		0,15	1.532
		Tot. EU 27 2010	**170.188**		

4.1.3 Vending machines

The cold vending machine segment is distributed as follows: 55-60% are spiral machines (for snacks and drinks), 30% are bottled and canned beverage machines and 10-15% are drum machines (Figure 10).

An average cold vending machine's product price is ca. 3500 euro.

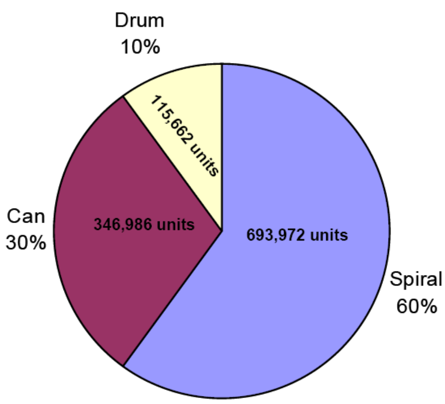

Figure 10 Market segmentation for cold vending machines (2004). Note that the absolute numbers will be different for up-to-date data. The relative percentage is still up-to-date.
Source: BIO IS, 2007

Market data for vending machines for the years 2010 and 2011 was collected by the European Vending Association, but are treated confidential as requested.

Table 13 shows an assumed market growth rate for vending machines.[27]

Table 13 Past and predicted UK market growth rate for cold vending machines. Source: UK Market Transformation Program, 2009.

Year	2000	2002	2006	2008	2010	2016	2020	2025	2030
Assumed market growth rate	1%	0%	-4%	-2%	0%	2%	2%	2%	2%

4.b) REMAINING QUESTIONS

Questions which still need to be solved for moving forward:

4.b.1) At the moment, assumptions are based on projections from the older data and estimates in the BIO IS study. As shown above for both remotes and plug-ins, these estimates are in general not correct. Up-to-date market data is thus needed on :

- **remote cabinets**
- **all plug-ins (supermarket, bottle coolers, ice-cream freezers vending machines)**
- **historical data 2005-2009 for vending machines**

4.b.2) One important element of the MEPS options may be a bonus-malus system linked to the GWP of the refrigerant. In order to estimate the impact of such an option, updated figures on stocks and/or annual sales of the refrigerants used in the different main cabinet types will be needed.

4.b.3) Even if future sales and stock figures are difficult to predict, expert judgments and guiding concepts for a market forecast will be needed for the impact assessment.

4.c) DATA

Data needed for answering those remaining questions:

4.c.1) We are lacking updated figures on stocks and annual sales (2006-2012) for the different main cabinet types. Which possible data sources exist for updated market figures (stocks, average prices, annual sales) for the EU 27 on the different cabinet types?

Most important is the lack of data for plug-ins (bottle coolers, ice-cream freezers, vending machines), as the two first together had ca. 50% of the total market of commercial refrigeration in 2006, according to BIO IS study.

4.c.2) Estimates of the use of refrigerants in the different cabinet types in stock will be needed. Hints on data sources to produce such estimates are thus requested.

4.c.3) Expert judgments and guiding concepts for a market forecast will be needed for the impact assessment.

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5 TECHNOLOGIES, ENVIRONMENT AND DESIGN

5.a) STATUS

The section below presents the JRC's interpretation of the status of the discussions that concern technologies, environment and deisgn.

5.1 Environmental impacts

The life-cycle estimates included in the BIO IS study[3] confirmed that from a life cycle perspective, energy use during the use phase and refrigerant leaks to the atmosphere are the two main environmental impacts of commercial refrigeration.[28] One could add to this list the potential impacts from end-of-life management, an area that was insufficiently assessed in the BIO IS study.

The implications of the statement above are large for the preparation of Ecodesign proposals, as it helps to prioritize the areas where proposals are necessary.

Regarding the end-of-life of the products, Ecodesign measures would be geared towards supporting a correct enforcement of existing legislation in all Member States (see chapter 3).

Regarding energy efficiency and refrigerant substitution, the essential goal is to identify and characterise the technology options for energy use reduction that are currently mature and operational, and for which one could expect substantial uptake in the next 5-10 years.

5.2 Energy

Energy consumption related to refrigeration in the retail sector is significant. Refrigeration is responsible for more than 60% of the carbon footprint of a typical retailer in Europe.[29]

A clear picture of the current energy performance and the possible improvements are necessary to define ambitious, realistic implementing measures. However, this ambition clashes with the existence of reliable and comparable data.

Most reported data in Europe on the energy performance of retail cabinets originate from the Eurovent Certification scheme. In the Eurovent certification program two cabinet types per year, which are provided by the associated manufacturers, are randomly tested. Currently, four manufacturers are affiliated with the Eurovent Certification scheme, representing almost 50% of the European market according to Eurovent.

Another interesting source of energy efficiency data is the Enhanced Capital Allowance scheme in the UK.[30]

Data from other world regions are hard to compare, as they are usually measured under different conditions and use different units to express the energy consumption (*e.g.* per volume versus per total display area). In a benchmarking study from IEA´s 4E initiative[31], data has been normalized to similar ambient and testing environment. It is difficult to determine the accuracy of such normalization adjustments. However, the study shows a significant scope for improvement of retail display cabinets, with best performing cabinets achieving an energy consumption less than one third that of average cabinets.

Given the boundary conditions above, for European benchmarking the core data are the Eurovent database, complemented with data received directly from food producers, equipment manufacturers, retailers and end-users.

5.2.1 Energy efficiency

In the Lot 12 Impact Assessment by the Wuppertal Institute (2010)[5], formulas were proposed to define energy efficiency. The data base available at that moment (2008 Eurovent data; older data from the European ProCool project; and data received from manufacturers via EVA and Eurovent) was used for statistically estimating constants and coefficients for the formulas.

The formulas were defined as a function of ambient temperature and product temperature class, and take into account energy needed for lighting, and vertical cabinets, compared to horizontal ones.

The idea is to set specific thresholds of maximum allowable annual energy consumption (minimum energy efficiency requirement) in terms of an Energy Efficiency Index (EEI). The thresholds would be decided politically at a later stage.

The EEI for these appliances is calculated as follows:

$$EEI = (SEC / RSEC) \times 100$$

with SEC being the Specific Energy Consumption, and RSEC the Reference Specific Energy Consumption. RSEC is defined separately for three types of product groups as follows:

For remote open appliances, to which EN ISO 23953 can be applied (or a similar further developed norm), SEC is calculated in kWh/(m².year) and recorded to two decimal places, as

$$SEC = TEC / TDA,$$

where:

- TEC is the total energy consumption in kilowatt hours per 24 h period, and
- TDA is the total display area as calculated by reliable, accurate and reproducible measurement procedures,

RSEC is calculated in kWh/(m².year) and recorded to two decimal places, as:

$$RSEC = [5.6 + VERT + L + 16 (Ta - Tmc) / Tmc]$$

where

- VERT is a function, which allows additional energy consumption for vertical or semi-vertical open cabinets compared to horizontal ones, here set at 2 kWh/(m².year),
- L is the additional electricity allowed for lighting of shelves, which is set here at 1.3 kWh/(m².year),

- Ta = θambient + 273.15, with θambient = ambient temperature (dry bulb temperature) of the test room climate class [in °Celsius] at which the respective TEC of the refrigerated display cabinet has been measured.
- Tmc = θmc + 273.15, with θmc as the arithmetic mean temperatures of all M-packages for the test period [in °Celsius] measured by reliable, accurate and reproducible measurement procedures.

For cold vending machines, to which the EVA-EMP can be applied (or a similar to be developed norm), SEC is the measured energy consumption in the idle state for the duration of 24 hours multiplied by 365, and, RSEC is calculated in kWh/(m³.year) and recorded to two decimal places, as:

RSEC = [1,500 + 16 x EC]

with EC = $\sum_i V_i \times \frac{T_a - Tmc_i}{Tmc_i}$

where

i = different compartments within a vending machine which are operated at different temperature levels Tmc_i, for example, differentiating between the following areas: non-perishable goods, perishable goods, pre-cooling, other areas,

V = volume of the respective compartment multiplying width, depth and height of the “boxes”, measured in dm³.

For other (closed) appliances, SEC is calculated in kWh/(m³.year) and recorded to two decimal places, as

SEC = TEC / net volume of the appliance

and with RSEC calculated in kWh/(m³.year) and recorded to two decimal places, as:

RSEC = 1.8 x [5.6 + VERT + L + 16 (Ta - Tmc) / Tmc]

The formulas proposed above were not widely agreed by stakeholders. By way of example, Eurovent claimed it did not provide the same incentives for improvement for all cabinet types.

The discussion on one or more energy efficiency formulas will have to be taken in detail in the course of this study. The critical point of departure for a science-based discussion is the availability of detailed energy consumption data for all cabinet types.

In the paragraphs below, additional information is provided on the current data available and data gaps for the different cabinet types.

5.2.2 Energy labelling

Next to an implementing measure relating to the energy efficiency of an appliance, mandatory energy labelling (A, B, C, D E, F, G) could be an additional option for Ecodesign requirements, as previously investigated in the Wuppertal Impact Assessment[5]. An energy label will allow a better ranking of the appliances on the market according to their energy efficiency.

An energy labelling scheme for display cabinets could be similar to the labelling provided in the Eurovent Certification scheme which is based on European average values for different cabinet types. These average values are discussed in the next section.

As for display cabinets, Ecodesign implementing measures could include energy labelling for vending machines. In Table 14, an indicative labelling scheme according to EVA's Energy Measurement Protocol (EVA-EMP) is shown. As the EVA-EMP scheme has been developing since 2010, it is possible that the scheme in Table 14 is outdated.

Table 14 Indicative consumption figures for each energy label class, according to the EVA-EMP taken from ref. 27. Note: Figures given are for a typical machine with internal volume of 500 dm^3 (*i.e.* 500 litres) for non-perishable food/drink.

Label	kWh/24hr less than:	kW less than:
A+	3.68	0.15
A	4.82	0.20
B	6.58	0.271
C	7.89	0.33
D	8.77	0.37
E	9.65	0.40
F	10.96	0.46
G	>10.96	>0.46

5.2.3 Remote display cabinets

5.2.3.1 Current available energy performance data

Eurovent collects average values of energy use per cabinet type classified following ISO 23953 (Table 15). These values are used in the Eurovent labelling scheme to define the energy efficiency classification (A, B, C, D, E, F, G) (see also section 3.3). According to Eurovent (2013), the average values were up-to-date in February 2012.

Table 15 also presents energy use data for the best performer for remote display cabinets, specified per cabinet type, as extracted from the Eurovent Certification website in March 2013. No data on plug-in display cabinets was available. It is important to remark that Eurovent data is non-sales weighted.

Table 15 Average energy consumption value and best performer per cabinet type. (Source: Eurovent Certification website, March 2013)

Cabinet type, ISO 23953	Temperature class	Eurovent's European average value TEC/TDA kWh/(day.m²)	Best performer Eurovent database TEC/TDA kWh/(day.m²)
RVC1, RVC2	3H	10,1	5.3
	3M2	12,3	6.2
	3M1	13,4	7.4
	3M0	14,5	8.4
RVC3	3H	13,8	no data
	3M2	16,0	7.25
RVF1	3L3	29,0	no data
RVF4	3L1	28,5	20.5
RVC4	3H	6,1	3.2
	3M2	7,4	3.7
	3M1	8,0	4.9
	3M0	8,7	6.8
RHC1	3H	6,2	3.7
	3M2	6,7	3.9
	3M1	7,2	4.2
RHF1	3L3	21,0	13.7
RHC3, RHC4	3H	no data	4.6
	3M2	5,5	4.9
	3M1	5,8	5.9
	3M0	6,2	no data
RHF3, RHF4	3L1	15,0	no data
	3L2	14,0	9.5
	3L3	13,0	7.1
RHC5, RHC6	3H	4,3	no data
	3M2	4,7	no data
	3M1	5,0	no data
RHF5, RHF6	3L1	12,0	7.8
	3L2	11,2	9.9
	3L3	10,4	5.3
RYF3	3L2	30,0	25.9
	3L3	29,0	24.3
RYF4	3L2	28,5	no data
	3L3	27,6	24.4

Eurovent's European average values are potentially a starting point for defining Ecodesign minimum energy consumption thresholds. However, an important mismatch has been detected between the published data and the average values used as reference for labelling, as explained further below.

Eurovent data was extracted from their website in March 2013 and has been analyzed merging different temperature classes together (see plots in Figure 11). Clustering different temperature classes is not an ideal option for an implementing measure proposal, but it is illustrative for the analysis. The plotted dots give a clear hint of the current spread and average values of the different appliances certified. For the sake of simplicity, only temperature classes M0, M1 and M2 are shown in Figure 11. Comparison for the other temperature classes can be found in Annex 7.4.

Figure 11 also depicts the average values published by Eurovent, which are used as reference for energy labelling. A clear discrepancy between the average value of the data plots and these labelling averages is observed. The labelling averages proposed are significantly higher than the mean of the data examples. One possible explanation is that the European average value, basically defined in 1997, is not up-to-date anymore.

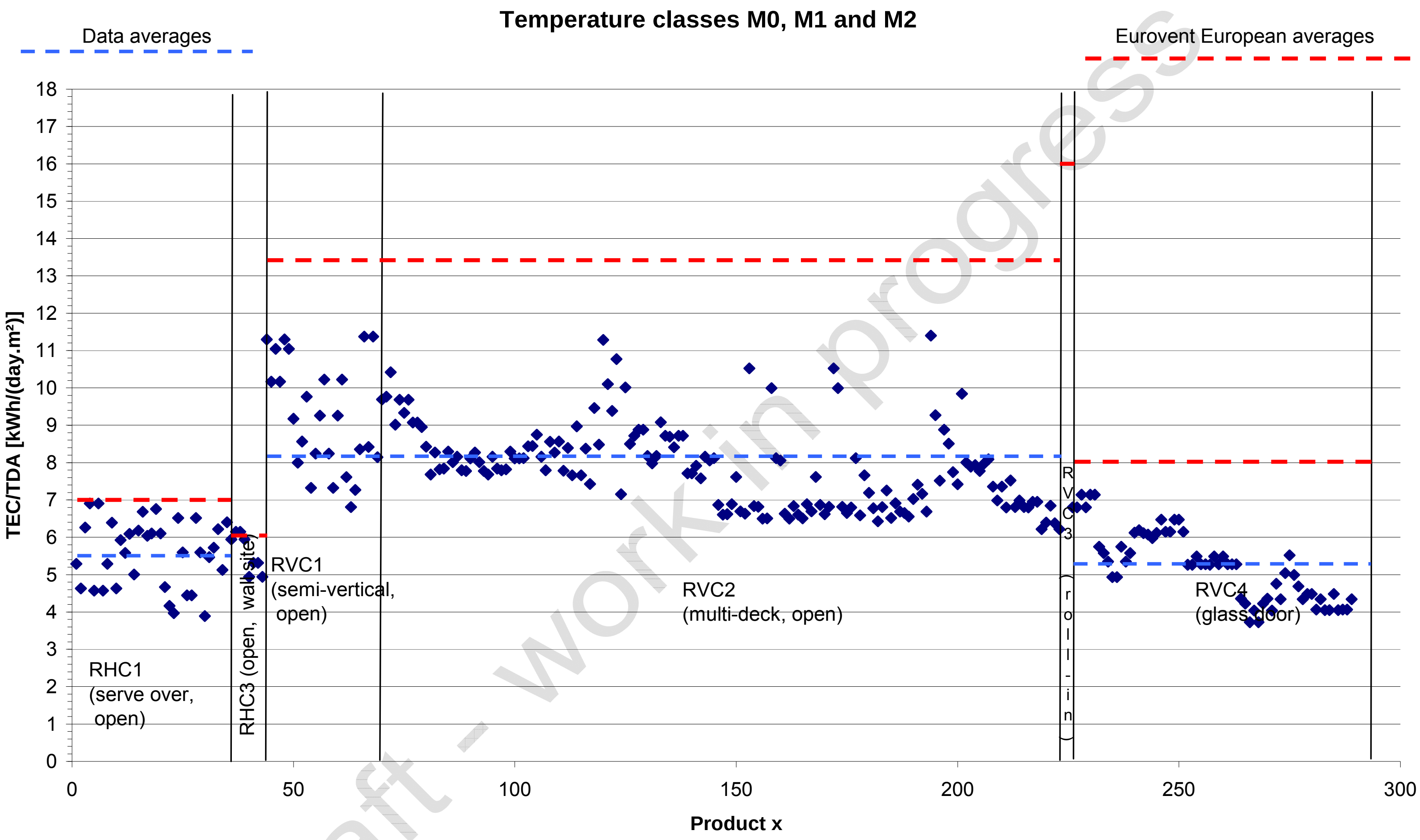


Figure 11 Energy consumption of remote cabinets in the Eurovent certification data base, and average values proposed for labelling. Eurovent's European averages are means of the 3 different temperature classes. Source: Eurovent, 2013.

5.2.3.2 Historical trend of energy performance for remote display cabinets

As in this phase of the project, updating data from the BIO IS study[3] is essential, and comparing historical trends in energy performances are of utmost importance. Historical Eurovent data was provided by S.M. van der Sluis (2013).[32]

Tracking down Eurovent's database year by year for an RVC2 cabinet in temperature class M2 (climate class 3) shows a clear trend for reduction of the average energy consumption (Figure 12). Note that in this case the energy consumption is expressed in TEC/meter length, but similar conclusions could be drawn by presenting the energy performance in TEC/m².

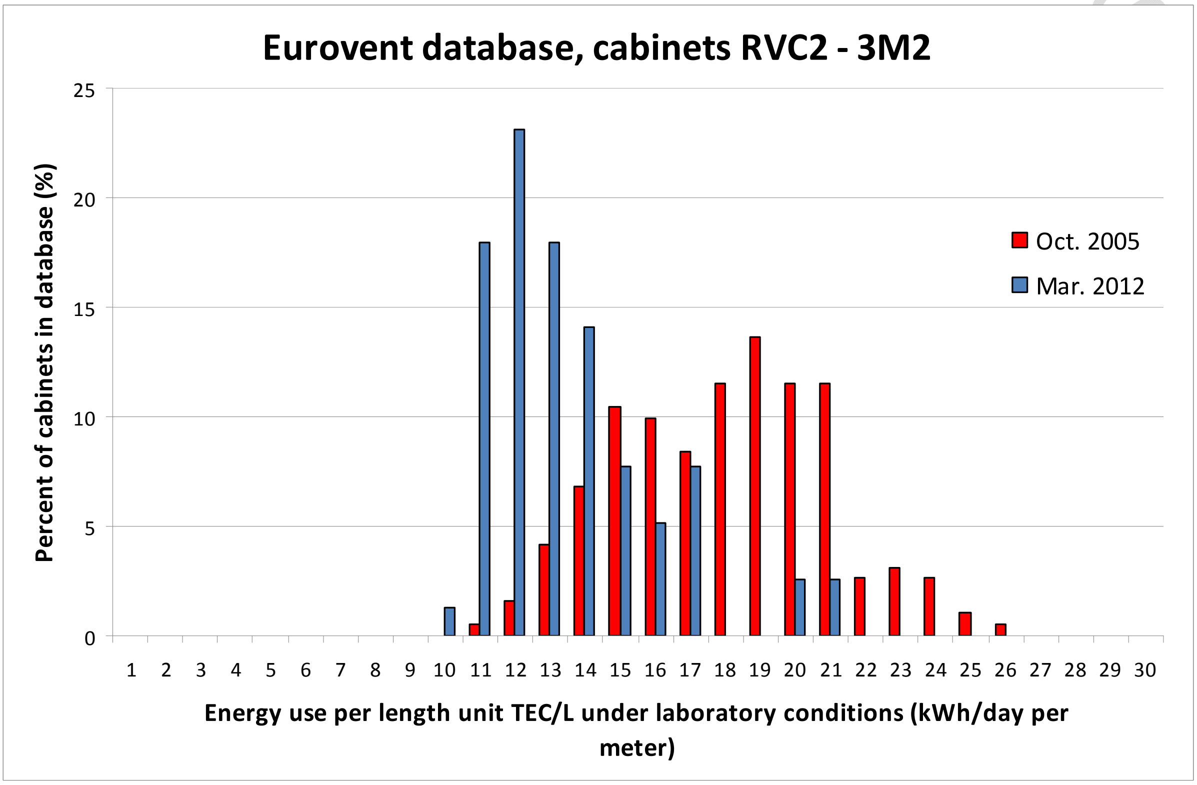


Figure 12 Comparison of data in the Eurovent database from the year 2005 and 2012 given the percentage of cabinets in function of the energy use. Note that the energy consumption is expressed per m length. **Source: S.M. van der Sluis[32], 2013.**

Figure 12 illustrates that in the course of 7 years, the average energy consumption has decreased by 30% - 40% for this type of cabinet. Following the comments from stakeholders, there are indications that this trend has been followed by all remote cabinet types and not only by the bestseller RVC2 cabinet. This is also in line with data for bottle coolers which prove to be 30-40% more efficient compared to a baseline set in the year 2000.[33]

Since 1997, an almost linear improvement of the energy consumption of an RVC2 cabinet is noticed with 40% improvement over 16 years (Table 16 and Figure 13), *i.e.* 2.5% improvement per year. Given an average lifetime of 8 years per cabinet, this also means an improvement in energy consumption per cabinet generation of 20%.

Table 16 Historical RVC2 cabinet energy consumption improvement. Source: S.M. van der Sluis[32], 2013.

Year	Year*	TEC/m
1997	0	21,42
2004	7	17,88
2005	8	18,05
2010	13	15,11
2012	15	13,50
2013	16	12,80

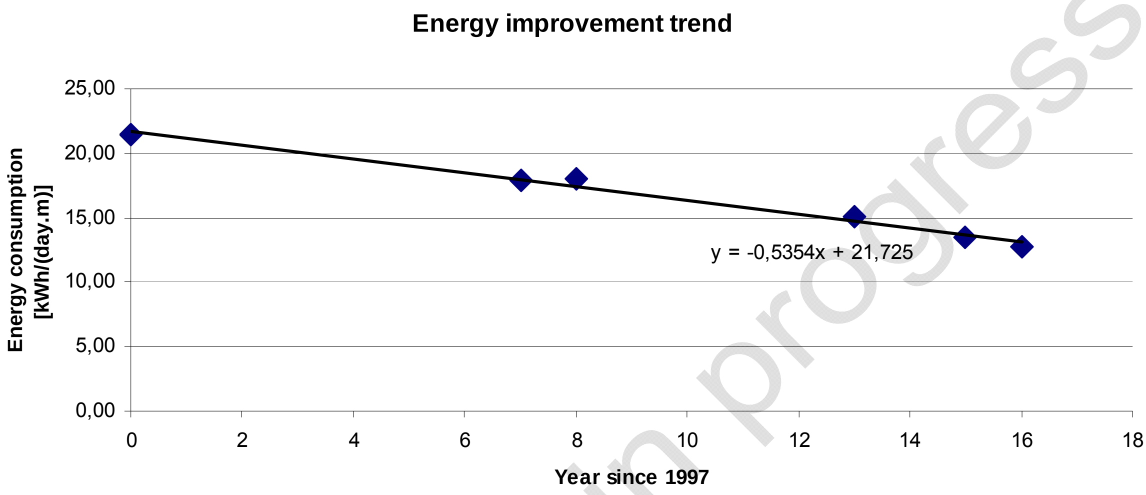


Figure 13 Energy improvement trend for RVC2 (M2, climate class 3) since 1997. Note that the energy consumption is expressed per m length**. Source: S.M. van der Sluis[32], 2013.**

The pace of energy improvement is likely to slow down in the following years. From communication with stakeholders, an energy efficiency gain of 5% - 10% seems a more likely figure of the improvements to be seen in the coming 5-10 years. This could mean that by 2020 the average consumption for an RVC2 cabinet, M2 operating temperature could be around 7.2 kWh/(day.m²) or 12.2 kWh/(day.m). This average is about 10% higher than the value predicted for BAT 2016 in the impact assessment by the Wuppertal Institute[5] (6.6 kWh/day.m²), and 14% higher than the current best performer of RVC2 cabinets in the Eurovent database (6.2 kWh/day.m²), confirming that the predicted 2020 average value would be a reasonable figure. Moreover, these mentioned figures are in line with the policy scenario described in the UK Market Transformation Programme for refrigerated display cases.[34] (see Annex 7.4)

5.2.4 Plug-in display cabinets

There is a general lack of data for plug-in cabinets (supermarket segment, bottle coolers, ice-cream freezers). Eurovent average values used for labeling of plug-ins is provided in Annex 7.4.

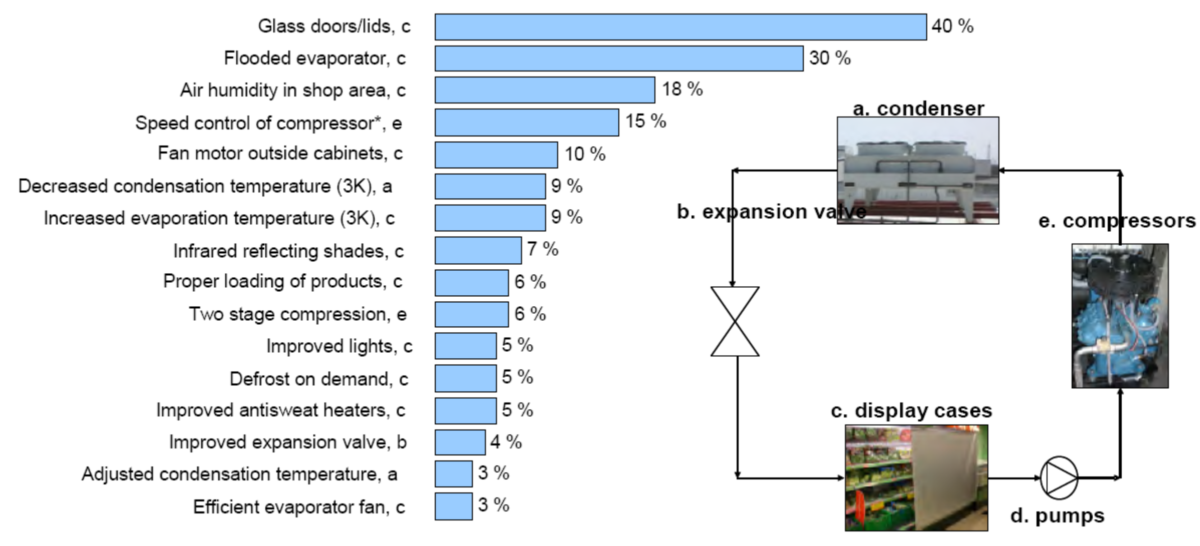
In the absence of updated data for plug-ins, these will be dealt with similarly to remote cabinets. No scientific basis or data has been found to assume a substantial difference in energy consumption between plug-in and remote cabinets. Different numbers have been brought forward by stakeholders, some suggesting up to 20% increase in energy consumption for plug-in compared to remote cabinets, while others claim a 20% decrease in energy consumption for plug-in cabinets.

5.2.5 Improvement options for display cabinets

Over the years, different technology options for display cabinets have been developed to improve energy efficiency. When combined on the same cabinet, these options can lead to an improvement of 50% and above compared to the 2005 average values of cabinets not using these technologies. This matches well with the assessment of the Wuppertal Institute[5] of cumulative savings in energy consumption from several options in excess of 50%.

Several measures have already been taken up as standard practice by certain manufacturers. It is important to know the extent of this uptake, and, in order to formulate realistic improvement potentials, which other options are available and how much energy efficiency gain they can generate.

Several studies describe the potential energy efficiency gains of the application of different technologies. An overview of different technologies for saving options is delivered in the Carbon Trust's Refrigeration Road Map[15] (Annex 7.4). Note that this road map is for retailers in general and not for display cabinets in particular. Another reference is the JRC´s EMAS sectoral best practice document for the retail sector.[29] Finally, a comprehensive study published in 2009 by the Federal Environmental Agency of Germany[35] outlines the environmental benefit of several measures, some of them quantitatively. These measures and their benefits are reproduced in Figure 14, with an indication of the location of the measure within the refrigeration cycle.



(*) Also fan or pump speeds at a, c and d
NB: The location of the measure in the refrigeration cycle (a, b, c, d, e) is shown
Source: Rhiemeier et al., 2009

Figure 14 Refrigeration energy saving measures and associated energy savings. Source: EMAS sectoral best practice document[29], 2011.

Not included in these measures are the possible aerodynamic improvements resulting from intrinsic cabinet design and the change of refrigerant, both of which can also lead to a better energy efficiency. Smart sensors or energy management devices are shortly described under user-behaviour (section 6.2.2). The focus for these sensors or devices is on vending machines and bottle coolers rather than on display cabinets of the supermarket segment.

5.2.6 Vending machines

Information about benchmarking for refrigerated vending machines can be found in a benchmarking report for refrigerated vending machines by IEA's 4E Inititiative.[26] For beverage can machines, it shows that an average US Energy Star machine uses just over half the energy per can of the average EU machine. EU machines appear to have the worst average specific consumption, but when comparing the EU average to those of other regions, it is important to bear in mind the differences in market and in type and size of machines that are used in the EU:

- The majority of machines in the EU are glass fronted.
- EU machines tend to contain snack or food items as well as beverages and so the whole contents are refrigerated to the same temperature, rather than the majority of stock being held at a slightly higher temperature until it is close to the front of the queue to be vended.
- EU machines tend to be smaller which is inherently less efficient per can (they stock fewer cans/bottles and delivery visits are more regular).

The study shows an energy consumption of 7.5 kWh/day for an average European vending machine. The study also shows considerable room for improvement in the energy consumption of vending machines.

One of the explanations for the poor performance of European vending machines is the absence of MEPS, compared to other world regions where these measures are in place, accompanied by related legislation. Several experts mention that energy efficiency is currently not a very demanded factor in purchase, and has therefore not fully permeated to manufacturers. However, activity is starting in two areas: green public procurement, and corporate responsibility policies in large food and beverage producers and retailers.

To quantify the room for improvement, data have been taken from UK's Market Transformation Programme[27], strongly related to the Ecodesign Directive. Energy values are given for a typical basic refrigerated vending machine. Table 17 provides figures for a reference scenario, while Table 18 presents values for a scenario including the best available techniques (BAT). Energy saving options related to machine configurations are shown in Table 19.

Table 17 Energy values for vending machines in the reference scenario of the UK Market Transformation Programme, 2009.

consumption (kWh/day)				
Year	**Basic machine**	**Basic with lighting timer**	**High efficiency**	**With motion sensor**
1980	14.4	13.2	11.5	7.6
1990	12.0	11.0	9.6	6.3
2000	10.6	9.7	8.5	5.6
2008	9.3	8.5	7.4	4.9
2020	8.3	7.6	6.7	4.4
2030	8.3	7.6	6.7	4.4

Table 18 Energy values for vending machines in the BAT scenario of the UK Transformation Programme

consumption (kWh/day)				
Year	**Basic machine**	**Basic with lighting timer**	**High efficiency**	**With motion sensor**
1980	14.4	13.2	11.5	7.6
1990	12.0	11.0	9.6	6.3
2000	10.6	9.7	8.5	5.6
2010	9.3	8.5	4.8	4.0
2020	(no sales)	(no sales)	4.1	(no sales)
2030	(no sales)	(no sales)	4.1	(no sales)

Table 19 Energy savings for vending machines attributed to different machine configurations according to the UK Transformation Programme reference scenario

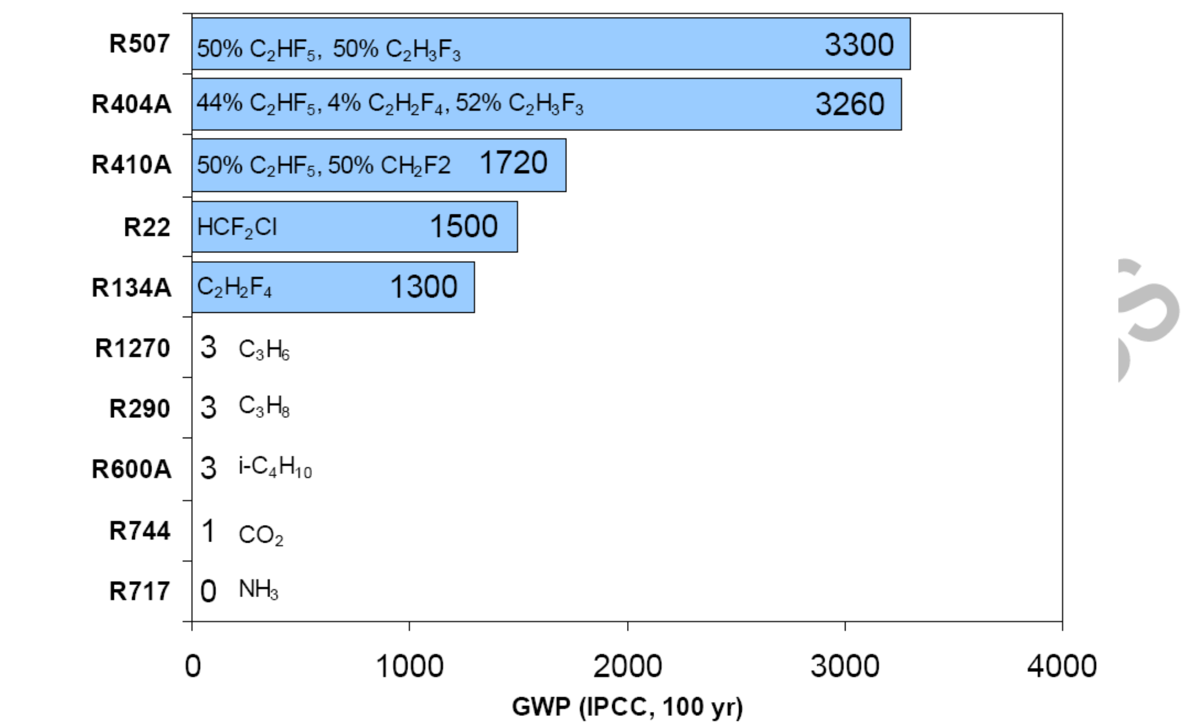
Configuration	**Rationale / justification**	**Resultant % reduction in annual consumption compared to "basic" machine**
Basic machine - no efficiency features	n/a – base efficiency	0%
Basic machine with lighting timer	Lighting accounts for a weighted mean of 21.6% of all consumption for cold machines (37% of can/bottle and 15% of spiral/drum); switched off for 38% of the time (9 pm to 6 am seven days per week).	8%
High efficiency machine – lights timer and optimized refrigeration pack	Refrigeration savings of 4% from tighter temperature controls, and plus lighting saving as above, plus 10% extra for optimised refrigeration pack.	20%
Retrofitted motion or usage sensor to switch off in silent hours	Machine is switched off 50% of the time, but sensor is still working.	48%

5.3 Refrigerants

As mentioned in the introduction of this chapter, the choice of refrigerant can significantly improve energy use during the use phase. The choice of refrigerant is thus an important issue to be addressed in this project. As the efficiency of refrigerants varies with climatic conditions, care has to be taken that an alternative choice of refrigerant will not increase the total energy consumption, leading to an overall higher environmental impact.

Most of the refrigeration appliances currently use fluorinated gases as cooling medium. The environmental concern of these refrigerants is their high global warming potential. In Figure 15, the global warming potential of the most popular refrigerants in commercial refrigeration is shown. It is clear that 'natural' refrigerants like propane (R290), isobutane (R600a), CO_2 (R744) and ammonia (R717) have a negligible GWP compared to for example R404a and R134a, which are currently the two most widespread in commercial refrigeration.

Table 20 indicates additionally the main pros and cons of the main alternative refrigerants to HFCs.



N.B: (CHFCs:R507, R404A, R410A, R134A, HCFCs: R22. HCs. R1270, R290, R600A and natural refrigerants CO_2 and NH_3)

Figure 15 Global warming potential of several commercial refrigerants. Source: EMAS sectoral best practice document[29], 2011.

Table 20 Alternative refrigerants with their benefits, drawbacks and applications. Source: BIO IS, 2007

<table>
<tr><th>Refrigerant</th><th>Properties</th><th>Benefits</th><th>Drawbacks</th><th>Application</th></tr>
<tr><td>CO₂</td><td>Boiling Point: -78°C
Critical Temperature: 31°C
Flammability limits: non flammable
Compatibility: risks of corrosion to ferrous steel with humidity</td><td>Low ODP – Low GWP
Very low cost respect to traditional refrigerants
High efficiency
Non toxic / Non flammable
Small displacement for the compressor
Small pipe dimensions</td><td>Less efficient than HFCs at high ambient temperatures
High pressures in the system
High capital cost due to low mass production of CO_2 compressors</td><td>For remotes, used in several supermarkets, and seems to be the better alternative to HFCs
For plug-ins, already used in small quantity
For vending machines, already used in small quantity</td></tr>
<tr><td>Ammonia</td><td>Boiling Point: -33°C
Critical Temperature: 133°C
Flammability Limits: 15 - 28 % in Air
Compatibility: Corrosive to copper alloys</td><td>Low ODP – Low GWP
Good thermal properties ⇨ Good efficiency
Ammonia’s recognisable smell is its greatest safety asset.
Low cost
Refrigeration systems cost 10 - 20 % less.
Low charge of refrigerant</td><td>Toxicity, leakages not permitted
Flammability
Limited charge permitted (150g)</td><td>For remotes, only usable in indirect systems
For plug-ins, not suitable
For vending machines, not suitable</td></tr>
<tr><td>Propane</td><td>Boiling Point: -42°C
Critical Temperature: 97°C
Flammability Limits: 2.1 - 9.5 % in Air
Compatibility: Non corrosive</td><td rowspan="2">Low ODP – Low GWP
Evaporators will have to be designed similar as for R22 or R404A
Good thermal properties ⇨ Good efficiency
Low cost
Less noisy due to the reduction of pressure in the compressor</td><td rowspan="2">Flammability
Limited charge permitted (150g)
High installation cost in supermarkets due to safety fittings</td><td>For remotes, only usable in indirect systems
For plug-ins, already used
For vending machines, use planned</td></tr>
<tr><td>Isobutane</td><td>Boiling Point: -12°C
Critical Temperature: 135°C
Flammability Limits: 1.6 - 8.4 % in Air
Compatibility: Non corrosive</td><td>For remotes, only usable in indirect systems
For plug-ins, already used
For vending machines, use planned</td></tr>
<tr><td>Unsaturated HFCs</td><td colspan="4">New developments; properties and applications can differ for different products, benefits and drawbacks have to be studied</td></tr>
</table>

The European Union has taken action to control fluorinated gases as part of its policy to combat climate change. The F-gas regulation is an important piece of legislation in this respect. The first F-gas regulation[16] was passed in 2006, but since 2012 the European Commission has tabled an update of it and discussions and negotiations on it are currently ongoing.[17,18] An update of the most important developments for this project are provided in Annex 7.5.

The currently proposed amendments to the F-Gas Regulation indicate that Ecodesign implementing measures can by definition not 'overrule' the F-gas regulation. Possible Ecodesign measures in this regard may aim at steering the market towards the use of refrigerants with reduced overall impact on the environment, *e.g.* a bonus-malus system, similar to the Ecodesign requirements for air conditioners and comfort fans.[36]

In response of this regulation and a growing general environmental awareness, a market trend to low GWP refrigerants is already noticed. As an example to demonstrate the willingness to move to low GWP refrigerants, the Consumer Goods Forum's Board[f] stated in November 2010[37] : *"The companies recognize the major and increasing contribution to total greenhouse gas emissions from HFCs and derivative chemical refrigerants. The companies are taking action to mobilize resources within their respective businesses to begin phasing out HFC refrigerants by 2015 and replace them with non-HFC refrigerants (natural refrigerant alternatives) where these are legally allowed and available for new purchases of point-of-sale units and large refrigeration installations"*.

5.3.1 Alternative refrigerants

The most common alternative refrigerants with their benefits, drawbacks and applications are summarized in Table 20. The sections below provide additional details on considerations to be made for each of the alternatives.

5.3.1.1 Hydrocarbons (Propane, Isobutane)

This section is partly taken from the reference *Availability of low GWP alternatives to HFCs: feasibility of an early phase-out of HFCs by 2020* by M. Kauffeld for the EIA (2012).[39]

Refrigeration systems running on hydrocarbons are usually more efficient than systems running on HFCs, under the same operating conditions. Components for machines running on one of these refrigerants are similar and hydrocarbons are essentially less expensive than synthetic refrigerants.

Isobutane (HC-600a) is the standard refrigerant for European and many Asian domestic refrigerators and freezers. Isobutane is also used for smaller commercial plug-in units, *e.g.* chest freezers for ice cream. Due to lower pressure levels and pressure ratios of isobutane, isobutane refrigeration units run more silently than comparable HFC-134a units.

Propane (HC-290) is used by some producers for plug-in bottle coolers, chest freezers and food service cabinets. Those units usually have higher refrigeration capacities than household

[f] The Consumer Goods Forum brings together CEOs and senior management of over 400 retailers, manufacturers, service providers and other stakeholders across 70 countries and reflects the diversity of the industry in geography, size, product category and format. Another global company committed to only purchase appliances using non-HFC refrigerants by the end of 2015.

refrigerators requiring the higher pressure refrigerant propane. When the statutory requirements for safety are met (*i.e.* IEC 60335-2-89), propane is the ideal refrigerant for such units. It can be used together with available components, is well mixable with mineral oils and causes lower compression end temperatures and often has 10% to 15% better energy efficiency than the comparable HFC unit. Furthermore, the pressure ratios and pressure differences are lower than with HFC resulting in lower noise emissions.

The main concern for using hydrocarbons is safety. Systems with less than 150g hydrocarbon can be located anywhere. For systems with more than this charge, there are restrictions. In any other than domestic residences, the ATEX directive[41] should be followed.

However, it is unclear whether hydrocarbon refrigeration systems, which are designed to contain a relatively small and finite amount of flammable gas, are covered by the ATEX directive, and if so to what degree they should comply. Discussions are on-going between the RAC industry and the Health and Safety Executive to clarify the situation regarding ATEX and HC systems.[42]

Even if the charge is lower than 150g, maintenance and refilling on site could be an issue. Next to safety measures, this requires appropriate training for technicians dealing with this product. In addition, a safety study has to be linked to the local installation and such technologies are usually refused by the local authorities.[40]

Following the comments from experts, vending machines would be more vulnerable to safety requirements, as they include more electronic and mechanical moving parts which can produce sparks and ignite an air-HC mixture. So far, no scientific evidence of test results has been found of such a scenario, neither re-design solutions that may help overcome this problem. Vending machines are usually relatively small appliances, so refrigerant charge could stay well below 150g of hydrocarbon.

The hydrocarbons used as refrigerant are heavier than air. Ignitable blends with air are therefore formed in low areas. When larger refrigerant charges are used, appropriate gas sensors and air removal devices need to be installed at floor level.

5.3.1.2 Carbon dioxide (CO_2)

This section is partly taken from the reference *Availability of low GWP alternatives to HFCs: feasibility of an early phase-out of HFCs by 2020* by M. Kauffeld for the EIA (2012).[39]

CO_2 operates with significantly higher pressures than other refrigerants. In plug-in bottle coolers CO_2 achieves pressure levels up to 130 bar on the high pressure side. The high operational pressures require stronger materials and/or thicker piping walls. On the other hand, the volumetric refrigeration capacity of CO_2 is much higher than that of traditional refrigerants, allowing system designs with smaller volumes and components. Pressure drops lead to significantly smaller temperature losses and thus to smaller losses in energy efficiency. Due to higher heat transfer coefficients, *e.g.* evaporation temperatures can be increased by about 2 K compared to HFCs.

The critical temperature of a refrigerant is an important parameter in the effectiveness and efficiency of equipment unless explicitly designed for transcritical operation (as is often the case with CO_2 systems). In the conventional vapour-compression cycle equipment, the condensing temperature is kept well below the critical temperature, because thermodynamic properties and principles result in declining capacity and efficiency as heat-rejection (refrigerant condensing) temperatures increase and approach the critical temperature.

As the critical temperature of CO_2 is low (31ºC), the CO_2 system will operate in a transcritical cycle most of the time in high ambient temperatures. Heat rejection then takes place by cooling the compressed fluid at supercritical high-side pressure. The low-side conditions remain subcritical. Usually, the energy efficiency of transcritical refrigeration systems is lower than that of conventional refrigeration. This characteristic can be partially compensated by application of an internal heat exchanger, which has a greater positive impact on energy efficiency in the transcritical CO_2 process than with other refrigerants.

At ambient temperatures around 26 °C an air-cooled CO_2 refrigeration system achieves comparable energy efficiency to an HFC direct evaporation refrigeration system. At lower ambient temperatures (below 24 °C), the CO_2 system achieves better energy efficiency

A safety study by TNO[22] has shown that risks related to rupture of the CO_2 compressor are negligible. A desk study[23] revealed that rupture of the CO_2 compressor would result in propelling fragments of the compressor casing. Hypothetically, these could have a mechanical impact that could seriously injure a person within the reach of such a fragment. However, the recent study by TNO[22] concluded that other failure situations like cracks in piping or heat exchangers would result in increased CO_2 concentrations, noise or cold gas releases, but would not cause significant injuries to the public.

5.3.1.3 Unsaturated HFCs

This section is partly taken from the reference *Availability of low GWP alternatives to HFCs: feasibility of an early phase-out of HFCs by 2020* by M. Kauffeld for the EIA (2012).[39]

Unsaturated HFCs – molecules with double carbon bonds, also called hydrofluoro-olefins (HFO) – have been developed as alternatives to HFCs. Unsaturated HFCs are either used as single substance, *e.g.* HFC-1234yf for automotive air conditioning systems, or in mixtures with HFCs, where they reduce the GWP of the blend. Unsaturated HFCs have a high reactivity and therefore shorter lifetimes in the troposphere resulting in low GWPs.

There are however concerns about the potential environmental impact and toxicity of large-scale use of HFOs. Therefore, unsaturated HFCs are not considered as a long term alternative.

5.3.1.4 Ammonia (NH_3)

This section is partly taken from the reference *Availability of low GWP alternatives to HFCs: feasibility of an early phase-out of HFCs by 2020* by M. Kauffeld for the EIA (2012).[39]

Ammonia (R717) has the lowest GWP (0) of all refrigerants suitable for large refrigeration systems. Ammonia refrigeration systems also usually achieve higher energy efficiency than HFC refrigeration systems. Although ammonia is toxic (maximum-workplace-concentration value (MAC) is 50 ml/m³), it has a pungent odor and thus a high warning effect. Certain ammonia air mixtures can be ignited. Ignition limits lie between 15 and 30 per cent by volume in air.

In refrigeration systems, ammonia causes high compression end temperatures, so refrigeration systems for low temperature applications must be designed in two stages with intermediate cooling between both compression stages. Ammonia is not miscible with mineral oil, consequently ammonia refrigeration systems must be planned and installed very carefully with respect to their oil balance. Ammonia has been the standard refrigerant for industrial refrigeration systems for more than 125 years. Because of its toxicity, it is only used with indirect systems in public access areas, *e.g.* systems with liquid and evaporating secondary refrigerant for the medium temperature and/or low temperature range. Recently ammonia has also been used as the higher temperature stage in CO_2 cascade refrigeration systems.

Given the toxicity of ammonia, this refrigerant is not an option for plug-in appliances.

5.4 End-of-life environmental and technology hotspots

5.4.1 Recovery scenarios

According to the analysis of the literature, the EoL of commercial refrigerators is similar to the EoL of household refrigerators. The big dimension of commercial refrigerators is the main difference with household refrigerators so that for instance, during the recycling process it has to be cut for easier handling. This was also confirmed by recyclers and associations of recyclers.

The end-user of commercial refrigerator usually replaces it for commercial reasons and not at the end of the technical life of the refrigerator. This makes them able to be sold in the second-hand market (including or not potential refurbishments) .The re-use of commercial refrigerators is possible through remanufacturing. *The process of remanufacturing involves disassembling a product, inspecting and replacing worn parts and consumables, applying a surface finish, reassembling the product and thoroughly testing it to ensure that the product complies with original performance specifications*[38].

Few data are available concerning the flows of commercial refrigerators to second-hand markets (including exports to non-EU countries). In particular, it was observed that small flows of commercial refrigerators from supermarkets reach recycling plants. Characteristics and potentials for exploitation of remanufacturing and reuse of commercial refrigerators require additional investigation.

Waste of commercial refrigerators at the EoL is generally treated in the EU in the same recycling plants as household refrigerators. Main constraints in the extraction and treatment are related to the management of refrigerant gases and gases blown in insulating foams.

Recently, a European standard (EN 50574)[g] establishes some best practices *for the transportation, sorting and treatment of household appliances containing volatile fluorocarbons or volatile hydrocarbons*. However these types of gases as well as others have been banned by current legislation.[16,19]

The recycling of commercial refrigerators is usually done in 3 main steps: pre-treatment, shredding and sorting for recovery.

[g] EN 50574 (May 2012): Collection, logistics & treatment requirements for end-of-life household appliances containing volatile fluorocarbons or volatile hydrocarbons.

Pre-treatment

The pre-treatment of commercial refrigerators is the only step where this waste is treated differently than household refrigerators. The large dimensions of commercial refrigerators (supermarket refrigerators, freezers, etc.) represent a problem during the waste collection, delivery and treatment in the plants. Large refrigerators are usually cut in smaller pieces in order to be treated by shredders.

During the pre-treatment some components and materials are extracted/removed manually from the refrigerators. These include refrigerant gases, oils and some recoverable materials (mainly glass, plastics and metals from the glass door, compressors, crispers and shelves, cables of the refrigerators). The glass is manually extracted from doors and other parts of the refrigerators with difficulty. When included, potentially hazardous components (e.g. fluorescent lamps, switches potentially containing mercury and other electronics) are removed and sent to further treatment.

The treatment of insulating foams (PUR) blown with CFC gases can be different including: identification, manual removal and storage for further treatment into specific waste plants, or the mechanical aspiration during the shredding.

Shredding

This process takes place in one (or more) shredders that shred the refrigerator in pieces of different sizes. In some cases, during the first shredding, suction of gases (CFC-11 and CFC-12 among others) contained in insulation foam (PUR) happens. The shredding is usually done in a low O_2 atmosphere to reduce the risks of explosions.

Separation of recoverable fractions happens through different phases as e.g.: magnets and eddy currents, density separators. From this step metal fractions (ferrous and non-ferrous materials) and some mixes of recyclable plastics are sorted.

Recovery

Main valuable materials from the recovery processes are: ferrous materials, non-ferrous materials (mainly copper from compressors), some recyclable plastics and glass.

Shredding residues, mainly constituted by not recyclable plastics (as e.g. PUR dusts) are incinerated and/or landfilled.

5.4.2 End-of-life hot spots

The main hot spots of the EoL treatment of commercial refrigerators are:

- Dimension of the devices: represents a problem during the waste collection, delivery and treatment in the plants.
- Refrigerants and oils: potentially pollutants, they have to be extracted/ treated carefully to avoid dispersion to the environment.
- Glass components: difficult to be extracted and potentially abrasive for some plants.
- Fluorescent lamps: difficult to be extracted and potentially dangerous due to the content of some hazardous substances.
- Electronics (e.g. printed circuit boards, capacitors, switches): difficult to be extracted and potentially dangerous for the content of some hazardous substances.
- PUR dust: potentially containing dangerous substances. PUR dust is mainly landfilled.

5.b) REMAINING QUESTIONS

Energy

5.b.1) What is your opinion on the energy efficiency index formula proposed by the Wuppertal Institute in section 5.2.1? Does such a formula cover all appliances defined in the scope, including ice-cream freezers, bottle coolers, etc.?

5.b.2) If you do not agree with the energy efficiency index formula proposed by the Wuppertal Institute, how could this be modified or what is your proposal for MEPS?

5.b.3) From historical data in section 5.2.3.2 it is clear that over the years a significant improvement of energy efficiency has occurred. Please indicate which energy-saving measures are now standard compared to *e.g.* 10 years ago.

5.b.4) What is the remaining room for improvement? How much energy can be saved extra at which cost?

5.b.5) What is the current and future performance of display cabinets, vending machines, bottle coolers, ice-cream freezers?

5.b.6) Do you agree with the proposed energy savings of the different improvement options? Are they similar for all cabinet types? What are the energy savings when combining different options?

5.b.7) What is in your view the best way to proceed with an implementing measure concerning energy efficiency? (one formula-fits-all, clustering of different cabinet types; per cabinet type, temperature class, other)? Are you in favour of a bonus-malus system relating to the GWP of the refrigerant?

5.b.8) Is there any evidence of efficiency comparison of refrigerants for the same cabinet type? The comparison is temperature-dependent, so data has to be provided for the same testing temperature, and is only valid for that temperature, as the comparison at a different ambient temperature provides a different result. Some refrigerants work better at low temperatures, some at high.

Refrigerants

5.b.9) We would like to know what are the different options, properties, drawbacks and applications for newly developed unsaturated HFCs (HFOs).

5.b.10) In relation to newly developed refrigerants, *e.g.* unsaturated HFCs (HFOs), we would like to see safety/toxicity studies to track down to what extend they can be used for appliances in public places. We would like to see similar studies for flammability/safety issues for hydrocarbons and CO_2.

5.b.11) CO_2 and high temperatures (above 32°C): Is there evidence of well-working/efficient plug- in cabinets operating at >32°C?

5.b.12) CO_2 and technology availability: Are the components currently available (for remote cabinets, for plug-in cabinets)? If not, when do you think they will be available?

General

5.b.13) Most commercial refrigeration uses forced air convection (*i.e.* uses fans to distribute the cold air from the evaporator). Which are the exceptions? Chest freezers? Any chilling equipment? Any other? Is the reason for this that passive convection does not deliver sufficient chilling capacity?

5.b.14) Are passive systems more/less efficient than the forced convection systems?

5.b.15) Is there any technical aspect in Member State or non-EU voluntary or mandatory efficiency criteria that you believe would be useful in a EU regulation?

Implementing measures

5.b.16) Appropriate level of aggregation: the one-fits all formula proposed in 2010 seems disputed. A higher breakdown of cabinet types could be necessary.

5.b.17) Shall any generic recommendations be compulsory?
- **Night curtains in open cabinets?**
- **LED or fluorescents?**
- **minimum efficiency of fans?**
- **doors or lids?**

Why (not)?

5.b.18) Which factors from the following list do you think shall be part of the energy formula:
- **Volume: two cabinets with same display area can have very different useful volume.**
- **Total Display Area: the main function of the commercial cabinets is to display items.**
- **Other?**

5.b.19) What is your opinion on the proposed formula for Vending Machines. Will it be sufficient to follow EVA's energy label classification (A, B, C, D, E, F, G)?

5.b.20) Most consulted stakeholders, especially retailers, are in favour of mandatory energy labelling for commercial refrigeration. Are there any critical technical arguments for NOT supporting energy labelling?

5.c) DATA NEEDED FOR ANSWERING THE REMAINING QUESTIONS

5.c.1) Up-to-date energy consumption values for different cabinet types (supermarket segment), best, average, worse performing, historical data.

5.c.2) Up-to-date energy consumption values for bottle coolers, best, average, worse performing, historical data.

5.c.3) Up-to-date energy consumption values for ice-cream freezers, best, average, worse performing, historical data.

5.c.4) Up-to-date energy consumption values for vending machines, best, average, worse performing, historical data.

5.c.5) Data on the room for improvement and the cost of extra energy saving meaures.

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6 USERS

6.a) STATUS

The section below presents the JRC's interpretation of the status of the discussions that concern User Behaviour.

Product design influences consumer behaviour, which subsequently influences the environmental impact and the energy efficiency of the product. However, research shows that consumer behaviour has also, independently from design, a significant direct effect on the energy use of commercial refrigeration products.

Since the BIO IS study[3], no specific change of user behaviour has been observed. For some supermarket chains however, a change to more efficient stores is noticed. This can go from a whole building approach looking to heating, refrigeration and air-conditioning systems as a whole to the implementation of doors or lids on all cabinets. Some chains also invest in better training of the personnel and frequent maintenance.

6.1 Supply chain and structure of ownership

When defining Ecodesign options, it is important to know the end-user and who will exactly be affected by such measures. Physical ownership of the appliances has a significant influence on maintenance, and the interest of the owner in energy efficiency.

Refrigerated display cabinets are mostly found in supermarkets, small convenience stores, corner stores, gas stations, etc. Some appliances such as beverage coolers are often not owned by the retailer. Serve-over counters can be found in (self-service) restaurants, canteens, butcher shops, etc., but these appliances usually belong to the shop owner.

For supermarkets, the approach can differ. In some of them, the headquarters selects a palette of providers, and the individual shops may only choose between this limited offer. Other supermarkets and franchised shops may have more freedom in the selection of provider and products.

In general, the retailers will request customized products to the manufacturer, which can lead to the production of differently customized products using a very similar basic structure. It is frequent that many of the optional choices have energy efficiency consequences, *e.g.* abundance, positioning and type of lighting, night covers, glass doors, type of fans and compressors, degree of electronic steering, etc. Experts have commented that energy efficiency has not traditionally been a choice parameter.

As indicated above, beverage coolers and vending machines tend to be leased to the shop owner by beverage and food companies, bottlers or operators. In this case, responsibility of an energy efficient appliance is completely at the provider's side, even if not paying the electricity bill. Most of the larger beverage and food companies embark into supply of efficient devices in order to protect, maintain and/or improve their corporate image, and show environmental/social responsibility.

Large beverage and food brands have developed also their own testing methods to define and certify products for the use of display and sales of the company's items. This can be traced back to energy efficiency and refrigerant use.

Manufacturers welcome the effort to produce energy efficient devices, but according to some of them, retailers still mainly focus on purchase cost rather than on life cycle cost. The BIO IS study[3] indicates, recently confirmed by a manufacturer, that refrigeration energy costs are for retailers a minor part (<5%) of the revenues obtained with product sales. However, this is changing together with rising energy prices and the growing conscience of sustainability.

Most large supermarket chains have their own approach to implement low impact stores. Some will start from a building approach for new stores, while others will retrofit their existing refrigeration products in the existing stores. Frequently, refrigeration appliances are substituted earlier than their lifetime in order to provide a revamping of the retailer's image and attract customers. Moreover, a trend towards smaller supermarkets and appliances is noted, following a saturation of the outskirt hypermarket concept. The new tendency is a move away from extra-large supermarkets to smaller neighbourhood shopping places. If this trend will be confirmed in the future, it will have an impact on retailer's refrigeration systems as a whole. As most remote cabinets can be found in large supermarkets and plug-in cabinets are mostly placed in smaller shops such as convenience stores and neighbourhood shops, a movement to smaller shops could lead to an increase of plug-in cabinets on the market, compared to the share of remote display cabinets.

6.2 User behaviour

Manufacturers of display cabinets offer in most cases different options for the design of a display cabinet. It is up to the customer to decide which (energy-saving) options they want to integrate in the cabinet. Examples are the integration of LED lighting, night covers, glass doors, type of fans and compressors, electronic steering, and other options which have been described in section 5.2.5.

Other elements of the design of the cabinet, *e.g.* the aerodynamics of the air stream or compartments with different temperatures, are controlled by the manufacturers.

Next to the importance of the design of the cabinet stands the importance of proper maintenance and control of the refrigeration system (*e.g.* cleaning of evaporator and ventilation grills). Additionally, retrofitting with energy-saving measures or replacing existing installations for more efficient ones reduces the overall energy consumption.

Several initiatives have worked with retailers to provide a palette of energy-saving initiatives. The Carbon Trust Refrigeration Road Map[15] aims to provide supermarkets with a comprehensive overview of available technologies and options for consideration in reducing greenhouse gas emissions.

The European Commission also works to implement the EU Eco-Management and Audit Scheme (EMAS), a voluntary framework for companies and other organisations to evaluate, report and improve their environmental performance. Within this framework, the EU decided in 2009 to promote best environmental management practices by developing Sectoral Reference Documents. A final draft of the sectoral reference document for the retail trade sector has been available since June 2011.[29] It not only describes best practices for display cabinets, but for the retail sector as a whole.

6.2.1 Training and re-commissioning/cleaning

Training of in-store personnel and technical staff can lead to a significant amount of emission savings. Both direct emissions from refrigerant leakage as indirect emissions from energy savings can be decreased by proper maintenance, including check of leaks, cleaning of appliances, and the proper adjustment and loading of refrigerated display cabinets. Also the location of the refrigeration equipment within the store can influence the energy consumption.

Currently, most refrigeration technicians/engineers are focused on good functioning of the system and less on most energy efficient adjustments. Moreover, technicians/engineers should be properly trained to cope with new, upcoming technologies, *e.g.* products using CO_2 – technology, and safety trainings while working with hydrocarbons.

6.2.2 Electronic control

To ensure that cabinets work at the proper temperature, set-point temperatures should be checked. Reducing the set-point by 1°C typically achieves savings of 3% - 5%.

Smart sensors/energy management devices are currently available. They are especially useful for vending machines and bottle coolers. The device reduces energy consumption up to 35% by allowing the temperature inside the cooler to rise (between 7°C to 14°C) during periods when the outlet is closed or rarely used, and maintains the correct cooler temperature (between 0°C and 7°C) during the active hours. This is only applicable to can/bottle machines with no food safety temperature requirements. For perishable items like sandwiches, the temperature can not rise above 10°C for more than half an hour. For such machines, only switching of lights could save energy.

6.2.3 Covers (doors, night blinds, strips)

Night blinds and insulating covers can significantly reduce the energy consumption. A prerequisite is that the covers are used during closing hours. Cabinets with night blinds automatically operating at set times can be purchased. In the case of doors, care has to be taken that the door seals continue to provide proper insulation to prevent heat leakages.

Trade-offs between the energy efficiency gain of the fitment of doors and a potential drop in sales are considered. However, studies show that doors on cabinets do not significantly influence the sales of products.[43, 44] Consumers even perceive doors on cabinets as comfortable as the cold section does not feel cold anymore and the food items are perceived to be better preserved. While some retail chains remain reluctant to implement/retrofit doors on the cabinets, other chains will not allow open cabinets in their stores. In January 2012, the association of French retailers (Fédération des Entreprises du Commerce et de la Distribution – FCD) made a groundbreaking commitment to roll out doors on fridges to all store formats – hypermarkets, supermarkets and convenience stores. The move will affect 75% of chillers in French supermarkets by 2020.

Impulsive buying from open appliances at the counter or cabinets for the display of fruits and vegetables remain possible exceptions to closed fronts. For such cabinets it seems highly unwanted to have doors or lids, as for fruits, it is important to perceive directly the freshness of the product, and for impulse offers, a physical barrier is known to spoil the impulse of the buyer.

6.2.4 Lighting

Switching off lights during closing hours and opting for energy efficient lighting like LED saves energy. LEDs use less energy and last longer than the conventional fluorescent tube lighting of commercial refrigeration cabinets. Absence of lighting, in particular shelf lighting, obviously decreases the energy consumption. Less and less customers ask for shelf lighting.

Lighting accounts for direct electricity consumption and an increased refrigeration energy consumption. Direct heat radiation combined with heating up the refrigerated items increase the refrigeration energy consumption.

6.2.5 Refrigerant

Refrigerant replacement can have a significant impact on the direct and indirect emissions associated with refrigeration. Low GWP refrigerants will lower the direct emissions, while energy efficiency gains by the use of alternative refrigerants lower the indirect emissions related to electricity use.

6.3 End-of-life behaviour

Section 5.4 outlines the environmental hotspots of the end-of-life of commercial refrigeration. To each of these hotspots, a key concern is the extent to which a harmonized approach to appropriate management across the EU can be ensured, including correct enforcement of the relevant legislation, most notably the WEEE Directive[13] and the Waste Shipment Regulation[14].

An initial investigation has revealed that the interpretation of the application of WEEE and WSR to commercial refrigeration varies among Member States. This leeway is actually provided in WEEE Directive, as only from 15 August 2018 will all refrigeration appliances be under its scope. Until then, Member States have freedom of interpretation of the extent to which commercial refrigeration devices (except vending machines and household-like appliances, clearly included) have or not to comply with WEEE prescriptions.

Investigating this will require a characterization of the current interpretation, levels of implementation and enforcement of WEEE and WSR for EoL commercial refrigeration appliances, through data collection in Member States. It will also require a deep understanding of the current dismantling, cannibalization, refurbishing, reuse and recycling practices and flows.

This will provide a basis for an estimation of the potential impacts of better implementation/enforcement of these legislative areas, and the room for maneuver of related Ecodesign proposals, in particular design-for-dismantling options.

6.b) REMAINING QUESTIONS

Questions which still need to be solved for moving forward;

6.b.1) Which of the technological improvement options of chapter 5 are a responsibility and choice of the manufacturer, and which are in the hands of the retailers and consumers?

6.b.2) Manufacturers frequently argue lack of motivation of retailers for energy efficiency: is this still the case or is it changing?

6.b.3) So far, no proposal for better dismantling/recycling has been tabled. One clear option, in light of the increasing content of electronic steering of cabinets, is to foster the manual removal of electronic components and batteries (the latter mostly in VM) as requested in WEEE, via *e.g.* maximum removal time. How do you see this option? Which additional, non-costly EOL measures would you propose (*e.g.* easier removal of insulation foam, separation of different metals, replacement and modularity of refrigeration parts in *e.g.* cassettes)?

6.c) DATA

Data needed for answering those remaining questions.

Studies concerning the end-of-life of commercial refrigeration appliances, *e.g.*

- **LCA analysing injection foaming vs. attached plates.**
- **Data on how insulation foam is separated from metal plates.**
- **Data on the EoL value of metal mixtures (*e.g.* Al-Cu in evaporators)**
- **Data on WEEE and WSR enforcement and implementation as regards refrigerated cabinets: contacts to dismantlers/refurbishers to find out what happens in the different MS.**

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7 ANNEXES

7.1 Annex I - Legislation

7.1.1 European national legislation[h]

7.1.1.1 Norway

A tax and refund scheme for HFCs applies to both imports as well as national production, whether in bulk or in products. Even though Norway is not a member state of the European Union, it belongs to the European Economic Area (EEA), meaning that all environmental and internal market legislation of the EU applies to Norway.

7.1.1.2 Sweden

The refrigerant charge per system is limited to some 30 or 40 kg. Tax burdens on HFC, following the example of Norway, are in consideration and are under final discussion in the parliament.

7.1.1.3 Denmark

Denmark has one of the most stringent combinations of HFC taxation and a partial ban. The complete Danish refrigeration industry is subject to a gradual phase out of fluorinated greenhouse gases. New refrigeration systems requiring more than 10 kg of fluorinated refrigerant have been banned since 1 January 2007.[i] This ban has had a huge impact on the systems implemented especially in supermarkets, where practically all new supermarkets are built with transcritical CO_2 systems. The ban is further complemented with a tax on the import of fluorinated greenhouse gases.

Following a request by Denmark in February 2012, the European Commission has issued a decision allowing the country to maintain more stringent national legislation than the EU F-gas regulation, authorising a continuation of the national ban on new products containing certain F-gases.

7.1.1.4 United Kingdom

The country does not regulate or tax HFC refrigerants, nor does it offer much in the way of financial incentives for the adoption of natural refrigerants. However, there exists the enhanced capital allowance scheme (ECA) providing business with enhanced tax relief for investments in equipment that meets published energy-saving criteria. In the predetermined list of products, refrigerated display cabinets are occurring.

7.1.1.5 Germany

The Federal Ministry for the Environment operates an incentive scheme that covers 25% of the net investment costs for new or existing commercial refrigeration plants using natural refrigerants. Funding for existing systems being afterwards more energy-efficient but still

[h] Taken from Shecco marketing report 2009, CO2 commercial refrigeration – The European market 2009
[i] Statutory Order no. 552 of 2 July 2002

running on conventional refrigerants will be supported by only 15% of the net investment costs. The question is if this incentive scheme is still running as it was frozen in 2010

7.1.1.6 Switzerland

Substances stable in air, including HFCs, have been regulated in Switzerland since July 2003 through the Ordinance on Chemical Risk Reduction (ORRChem). This HFC regulation encompasses licensing, reporting, leak checks, servicing and end-of-life requirements for equipment containing more than 3kg of such refrigerants. Moreover, the voluntary Minergie-Label mandates proof of energy performance of HVAC&R systems. Retailers themselves have taken the initiative to invest in efficient CO_2 systems.

In October 2012, ORRChem has been amended after 9 years of implementation. The previous mandatory authorisation scheme is replaced by a ban of placing on the market of several stationary refrigeration and air-conditioning systems using F-gas refrigerants. For commercial refrigeration, this means a ban on systems using F-gas refrigerants for

- minus cooling with a cooling capacity of more than 30 kW,
- plus cooling with a cooling capacity of more than 40 kW;
- combined plus and minus cooling with a cooling capacity of more than 40 kW for plus cooling and 8 kW for minus cooling;

7.1.1.7 France

France is taking the F-gas regulation a bit more stringent, setting the target at a minimum refrigerant charge of 2 kg instead of 3 kg as specified in the original EU framework document. From 4 July 2009, anyone having installed or intending to install refrigeration systems including cooling fluids needs to have an attestation of capacity by obligation.

Recently, the French government indicated that it will examine the possibility of an F-gas tax in the “Roadmap for the Environmental Transition” published after the “Environmental Conference” held on 14-15 September 2012 in Paris. The document states that “concerning the fight against climate change, the [French] government […] will perform assessment studies on the appropriateness of levying a tax on fluorinated greenhouse gases used as refrigerants […]”.

In January 2012, the association of French retailers (Fédération des Entreprises du Commerce et de la Distribution – FCD) made a commitment to roll out doors on fridges to all store formats – hypermarkets, supermarkets and convenience stores.

7.1.1.8 Spain

There existed a tax rebate for companies for environmental spending and is only applicable to the use of renewable energy. This rebate had 2011 as expiry date. A draft law from 2009 should account for a more general investment in energy saving and efficiency measures. It is not clear if thedraft law has passed into a formal law and/or if there was any modification.

7.1.1.9 Italy

No specific legislation has been identified for Italy concerning the use of chemical refrigerants in the commercial refrigeration sector.

7.1.2 Extra-EU legislation

7.1.2.1 Canada

CAN/CSA-C827-98: "energy performance standard for food service refrigerators and freezers". This standard applies to self-contained commercial refrigerators, refrigerator-freezers, and freezer cabinets that are intended for storage or holding food products and other perishable merchandise. The CSA standard contains minimum performance criteria for annual energy consumption that vary with the volume of the refrigerator or freezer. (BIO IS study) See also 7.2.2.

7.1.2.2 Australia and New-Zealand

Australia applies taxes on synthetic greenhouse gases as well as minimum energy performance requirements for refrigerated display cabinets.

Under the Clean Energy Future (CEF) legislation, the Australian Government introduced a carbon charge to the import of synthetic greenhouse gases including HFCs as of 1 July 2012. They provide a calculator for the import levy and equivalent carbon price.[j]

From 1 October 2004[k], refrigerated display cabinets manufactured in or imported into Australia and New Zealand must comply with Minimum Energy Performance Standards (MEPS) requirements which are set out in AS 1731.14-2003. The scope of commercial refrigeration MEPS includes both remote and self-contained refrigerated display cabinets primarily used in commercial applications for the storage of frozen and unfrozen food.

The standard also defines minimum efficiency levels for 'High Efficiency' refrigerated display cabinets. Only products which meet the specified efficiency levels can apply this term to promotional or advertising materials.

The Minimum Energy Performance Standards (MEPS) for commercial refrigeration are set out in AS 1731.14-2003 as total energy consumption per total display area (TEC/TDA) in kWh/day/square metre for various unit types. The test procedures for commercial refrigeration are the specified parts AS 1731.

AS 1731 or MEPS does not apply to refrigerated vending machines, cabinets intended for use in catering and similar non-retail applications. However, MEPS for vending machines is under consideration.

MEPS Levels

When measured in accordance with AS 1731.9 and AS 1731.12 the energy consumption of a remote or self contained refrigerated cabinet shall not exceed a specified value. For the purpose of testing compliance, tests shall be conducted under climate Class 3 conditions, with

[j] See http://www.environment.gov.au/atmosphere/ozone/sgg/equivalentcarbonprice/calculator.html

[k] Taken from http://www.energyrating.gov.au/products-themes/refrigeration/commercial-refrigeration/meps/

lighting and anti-sweat heaters running for the duration of test period, unless controlled by a time-clock, smart sensor or similar automatic device. Where night-covers are supplied as a permanent fixture of the cabinet, the test shall be conducted as described in AS 1731.9, Section 4. Reference should be made to the relevant parts of AS 1731 for detailed conditions and test methods.

See 7.2.4 for MEPS and ‘High Efficiency’ values.

7.1.2.3 USA

The MEPS for the USA can be found in 7.2.1. However, if one considered taking the values of the specific requirements set in these regulations as a basis for a European regulation, it should be taken into account that the methods for calculating TDA considerably differ between the US ARI Standard 1200-1800 (that supersedes ARI Standard 1200-2006), Appendix D, and EN ISO 23953, Appendix A. Therefore, a 1:1 transfer into specific requirements for Europe will not be possible. However, a transfer of US requirements to European values could be analysed for typical categories and sizes of European appliances so that the level of requirements and the differences between the methodologies will be better understood.

Alternative refrigerant use

Hydrocarbon R441a may be sold in new vending machines as of May 2012 as stated in a US EPA letter. The Agency has also recently indicated that a draft rule on the use of CO_2 in vending machines is in the works before the end of the year.

The letter also states that R441a may be sold “in stand-alone refrigerators and freezers in retail food refrigeration in the US as of June 27, 2012;” the approval also includes use in stand-alone refrigerated display cases.

Following the determination of the submission as “complete,” the US EPA will initiate the rule-making procedure, with R441a expected to be listed on the Federal Register within the next 24 months.

Vending machines**:** In the summer of 2012, the US EPA also found complete another submission requesting SNAP approval for the use of hydrocarbon refrigerant R441a in new vending machines by the US Environmental Protection Agency (EPA). R441a may now be sold in new vending machines as of May 23, 2012. Again, the rule listing R441a on the Federal Register is expected within the next 24 months.

7.1.2.4 California

For MEPS in California see 7.2.3.

7.1.2.5 Washington state

The state of Washington recently issued a regulation comprising minimum efficiency standards (January 2007). To verify the accordance of the appliances with these requirements. The scope of this regulation for commercial refrigerators and freezers excludes all appliances without doors, walk in cabinets and ice cream freezers. For products included in the scope, the requirements which apply are the same as in California except for one category of appliance (Reach-in cabinets, pass-through cabinets, and roll-in or roll-through cabinets that are "pulldown" refrigerators – transparent door - 0.126V+ 3.51 maximum daily consumption in kWh/d) which does not figure in the Californian standard. (BIO IS study)

7.1.2.6 South-Africa

SABS 1406:1999: 'commercial refrigerated food display cabinets'

This standard provides a test methodology and a minimum energy performance standard, based on the gross capacity of the cabinet. The standard specifies requirements for three types and two climate classes of commercial refrigerated display cabinet for the storage, for sale, of frozen and fresh foods, and liquids in containers, and intended for operation on a three-phase 440 V power supply or on a single-phase power supply not exceeding 250 V phase to neutral. The energy requirements of this standard cover energy consumption, test conditions and energy consumption test. (Preparatory study 2007)

7.2 Annex II - Existing MEPS in other countries

7.2.1 U.S.A.

The following table shows the standard levels adopted for different types of non-household refrigerators and freezers in the United States of America. These standards will apply to all commercial refrigeration equipment manufactured for sale in the United States, or imported to the United States on or after January 1, 2012. It includes refrigerating display cabinets as well as appliances with solid doors.

Table 21 Standard levels for commercial refrigeration equipment

Equipment class [2]	Standard level * ** (kWh/day) ***	Equipment class	Standard level * ** (kWh/day)
VOP.RC.M	0.82 × TDA + 4.07	VCT.RC.I	0.66 × TDA + 3.05
SVO.RC.M	0.83 × TDA + 3.18	HCT.RC.M	0.16 × TDA + 0.13
HZO.RC.M	0.35 × TDA + 2.88	HCT.RC.L	0.34 × TDA + 0.26
VOP.RC.L	2.27 × TDA + 6.85	HCT.RC.I	0.4 × TDA + 0.31
HZO.RC.L	0.57 × TDA + 6.88	VCS.RC.M	0.11 × V + 0.26
VCT.RC.M	0.22 × TDA + 1.95	VCS.RC.L	0.23 × V + 0.54
VCT.RC.L	0.56 × TDA + 2.61	VCS.RC.I	0.27 × V + 0.63
SOC.RC.M	0.51 × TDA + 0.11	HCS.RC.M	0.11 × V + 0.26
VOP.SC.M	1.74 × TDA + 4.71	HCS.RC.L	0.23 × V + 0.54
SVO.SC.M	1.73 × TDA + 4.59	HCS.RC.I	0.27 × V + 0.63
HZO.SC.M	0.77 × TDA + 5.55	SOC.RC.L	1.08 × TDA + 0.22
HZO.SC.L	1.92 × TDA + 7.08	SOC.RC.I	1.26 × TDA + 0.26
VCT.SC.I	0.67 × TDA + 3.29	VOP.SC.L	4.37 × TDA + 11.82
VCS.SC.I	0.38 × V + 0.88	VOP.SC.I	5.55 × TDA + 15.02
HCT.SC.I	0.56 × TDA + 0.43	SVO.SC.L	4.34 × TDA + 11.51
SVO.RC.L	2.27 × TDA + 6.85	SVO.SC.I	5.52 × TDA + 14.63
VOP.RC.I	2.89 × TDA + 8.7	HZO.SC.I	2.44 × TDA + 9.
SVO.RC.I	2.89 × TDA + 8.7	SOC.SC.I	1.76 × TDA + 0.36
HZO.RC.I	0.72 × TDA + 8.74	HCS.SC.I	0.38 × V + 0.88

* TDA is the total display area of the case, as measured in the Air-Conditioning and Refrigeration Institute (ARI) Standard 1200–2006, Appendix D.
** V is the volume of the case, as measured in ARI Standard 1200–2006, Appendix C.
*** Kilowatt hours per day.
[2] For this rulemaking, equipment class designations consist of a combination (in sequential order separated by periods) of: (1) An equipment family code (VOP=vertical open, SVO=semivertical open, HZO=horizontal open, VCT=vertical transparent doors, VCS=vertical solid doors, HCT=horizontal transparent doors, HCS=horizontal solid doors, or SOC=service over counter); (2) an operating mode code (RC=remote condensing or SC=self contained); and (3) a rating temperature code (M=medium temperature (38 °F), L=low temperature (0 °F), or I=ice-cream temperature (−15 °F)). For example, "VOP.RC.M" refers to the "vertical open, remote condensing, medium temperature" equipment class. See discussion in section V.A.2 and chapter 3 of the TSD, market and technology assessment, for a more detailed explanation of the equipment class terminology. See Table IV–2 for a list of the equipment classes by category.

Source: DOE 2009

Table 22 Equipment configuration definitions

Equipment family	Description
Vertical Open (VOP)	Equipment without doors and an air-curtain angle ≥0 degrees and <10 degrees from the vertical.
Semivertical Open (SVO)	Equipment without doors and an air-curtain angle ≥10 degrees and <80 degrees from the vertical.
Horizontal Open (HZO)	Equipment without doors and an air-curtain angle ≥80 degrees from the vertical.
Vertical Closed (VC)	Equipment with hinged or sliding doors and a door angle <45 degrees.
Horizontal Closed (HC)	Equipment with hinged or sliding doors and a door angle ≥45 degrees.

Source: DOE 2009

Table 23 Commercial refrigeration equipment classes by category

Equipment category	Condensing unit configuration	Equipment family	Operating temperature (°F)	Equipment class designation
Remote Condensing Commercial Refrigerators, Commercial Freezers, and Commercial Refrigerator-Freezers.	Remote	Vertical Open	≥32	VOP.RC.M
			<32	VOP.RC.L
		Semivertical Open	≥32	SVO.RC.M
			<32	SVO.RC.L
		Horizontal Open	≥32	HZO.RC.M
			<32	HZO.RC.L
		Vertical Closed Transparent	≥32	VCT.RC.M
			<32	VCT.RC.L
		Horizontal Closed Transparent	≥32	HCT.RC.M
			<32	HCT.RC.L
		Vertical Closed Solid	≥32	VCS.RC.M
			<32	VCS.RC.L
		Horizontal Closed Solid	≥32	HCS.RC.M
			<32	HCS.RC.L
		Service Over Counter	≥32	SOC.RC.M
			<32	SOC.RC.L
Self-Contained Commercial Refrigerators, Commercial Freezers, and Commercial Refrigerator-Freezers without Doors.	Self-Contained	Vertical Open	≥32	VOP.SC.M
			<32	VOP.SC.L
		Semivertical Open	≥32	SVO.SC.M
			<32	SVO.SC.L
		Horizontal Open	≥32	HZO.SC.M
			<32	HZO.SC.L
Commercial Ice-Cream Freezers	Remote	Vertical Open	* ≤ −5	VOP.RC.I
		Semivertical Open		SVO.RC.I
		Horizontal Open		HZO.RC.I
		Vertical Closed Transparent		VCT.RC.I
		Horizontal Closed Transparent		HCT.RC.I
		Vertical Closed Solid		VCS.RC.I
		Horizontal Closed Solid		HCS.RC.I
		Service Over Counter		SOC.RC.I
	Self-Contained	Vertical Open		VOP.SC.I
		Semivertical Open		SVO.SC.I
		Horizontal Open		HZO.SC.I
		Vertical Closed Transparent		VCT.SC.I
		Horizontal Closed Transparent		HCT.SC.I
		Vertical Closed Solid		VCS.SC.I
		Horizontal Closed Solid		HCS.SC.I
		Service Over Counter		SOC.SC.I

* Ice-cream freezer is defined in 10 CFR 431.62 as a commercial freezer designed to operate at or below −5 °F (−21 °C) and that the manufacturer designs, markets, or intends for the storing, displaying, or dispensing of ice cream.

Source: DOE 2009

7.2.2 Canada

CAN/CSA-C827-98: “energy performance standard for food service refrigerators and freezers”. This standard applies to self-contained commercial refrigerators, refrigeratorfreezers, and freezer cabinets that are intended for storage or holding food products and other perishable merchandise. The CSA standard contains minimum performance criteria for annual energy consumption that vary with the volume of the refrigerator or freezer (BIO IS study).

Table 24 Maximum annual energy consumption: refrigerator – solid doors

Type	Annual Energy Consumption (AEC_{max}), kWh/y	
	Standard efficiency	High efficiency
Reach-in	59 V + 1010	54 V + 470
Reach-in Wine Cooler	51 V + 300	47 V + 10
Milk or beverage type	31 V + 450	28 V + 260
Worktop table/undercounter	87 V + 780	79 V + 210

Note: V is the refrigerator volume, measured in ft^3

Table 25 Maximum annual energy consumption: refrigerators – glass doors

Type	Annual Energy Consumption (AEC_{max}), kWh/y	
	Standard efficiency	High efficiency
Reach-in	118 V + 2020	108 V + 940
Reach-in Wine Cooler	102 V + 600	94 V + 20
Milk or beverage type	62 V + 900	56 V + 520
Worktop table/undercounter	174 V + 1560	158 V + 520

Note: V is the refrigerator volume, measured in ft^3

Table 26 Maximum annual energy consumption freezers – solid doors

Type	Annual Energy Consumption (AEC_{max}), kWh/y	
	Standard efficiency	High efficiency
Reach-in	172 V + 930	156 V + 1270
Ice cream cabinet	86 V + 1270	78 V + 755
Worktop table/undercounter	367 V + 2200	334 V + 400

Note: V is the refrigerator volume, measured in ft^3

Table 27 Maximum annual energy consumption freezers – glass doors

Type	Annual Energy Consumption (AECmax), kWh/y	
	Standard efficiency	High efficiency
Reach-in	334 V + 1860	312 V + 2540
Ice cream cabinet	172 V + 2540	156 V + 1510
Worktop table/undercounter	734 V + 4400	668 V + 800

Note: V is the refrigerator volume, measured in ft^3

Table 28 Maximum annual energy consumption: refrigerator –freezers – solid

doors

Type	Annual Energy Consumption (AECmax), kWh/y	
	Standard efficiency	High efficiency
Reach-in	92 AV + 1900	84 AV + 1160

Note: AV=Adjusted Volume = refrigerator volume plus 1.63 times the freezer volume (in ft^3).

Energy efficiency regulation is set by the Canadian Office of Energy Efficiency (OEE) and provides energy requirements as well as test methods. The following MEPS (set Maximum Daily Energy Consumption (MDEC) in kWh. The Canadian levels are based on the California levels rather than on CSA C827-98 levels because the CSA standard does not contain enough data to specify performance levels for some of the more common types of reach-in refrigerators and freezers; these units would therefore fall outside the regulations. Reach-in cabinets include: buffet tables, ice cream cabinets, milk, beverage and ice cream cabinets, milk or beverage cabinets, preparation tables, undercounter cabinets, wine chillers, and worktop tables (BIO IS study).

Table 29 Maximum daily energy consumption for commercial refrigerators

Product	Type of cabinet doors	Date	MDEC (kWh/day)
Reach-in cabinets, pass-through cabinets and roll-in or roll-through cabinets that are refrigerators, and wine chillers that are not consumer products	Opaque	January 1, 2007 to December 31, 2007	0.00441 V + 4.22
		January 1,2008	0.00441 V + 2.76
	Transparent	January 1, 2007 to December 31, 2007	0.00607 V + 5.78
		January 1,2008	0.00607 V + 4.77
Reach-in cabinets without doors where the cabinet is specifically designed for display and sale of bottled or canned beverages	No doors	January 1, 2007	0.00607V + 4.77
Reach-in cabinets, pass-through cabinets and roll-in or roll-through cabinets that are freezers	Opaque	January 1, 2007 to December 31, 2007	0.0141 V + 2.83
		January 1,2008	0.0141 V + 2.28
	Transparent	January 1,2007	0.0332 V + 5.10
Reach-in cabinets that are refrigerator-freezers	Opaque	January 1, 2007 to December 31, 2007	0.00964 AV + 2.63
		January 1,2008	0.00964 AV + 1.65

V = is the refrigerator volume measured in litres

AV = (adjusted volume, in litres) is equal to the refrigerator volume plus 1.63 times the freezer volume

7.2.3 California

Table 30 Exclusively California standards for different commercial refrigeration equipment

Appliance	Doors	Maximum Daily Energy Consumption (kWh)			
		March 1, 2003	August 1, 2004	January 1, 2006	January 1, 2007
Reach-in cabinets, pass-through cabinets, and roll-in or roll-through cabinets that are refrigerators; and wine chillers that are not consumer products	solid	0.125 V+4.22	0.125 V+2.76	0.10 V+2.04	0.10 V+2.04
	transparent	0.172 V+5.78	0.172 V+4.77	0.172 V+4.77	0.12 V+3.34
Reach-in cabinets, pass-through cabinets, and roll-in or roll-through cabinets that are freezers (except ice cream freezers)	solid	0.398 V+2.83	0.398 V+2.28	0.40 V+1.38	0.40 V+1.38
	transparent	0.940 V+5.10	0.940 V+5.10	0.940 V+5.10	0.75 V+4.10
Reach-in cabinets, pass-through cabinets, and roll-in or roll-through cabinets that are freezers that are ice cream freezers	solid	0.398 V+2.83	0.398 V+2.28	0.398 V+2.28	0.39 V+0.82
	transparent	0.940 V+5.10	0.940 V+5.10	0.940 V+5.10	0.88 V+0.33
Reach-in cabinets that are refrigerator-freezers and that have and adjusted volume (AV) of 5.19ft3 or greater	solid	0.273 AV+2.63	0.273 AV+1.65	0.273 AV+1.65	0.27 AV-0.71
Reach-in cabinets that are refrigerator-freezers and that have and adjusted volume (AV) less than 5.19ft3	solid or transparent			0.70	0.70
Refrigerated canned and bottled beverage vending machines when tested at 90°F ambient temperature except multi-package units	Not applicable			0.55(8.66+0.009x C)	0.55(8.66+0.009x C)
Refrigerated canned and bottled beverage vending machines when tested at 75°F ambient temperature	Not applicable			0.55(8.66+0.009x C)	0.55(8.66+0.009x C)

V=total volume (ft^3)

AV=Adjusted Volume = 1.63xfrezzer volume (ft^3)+refrigerator volume(ft^3)

C = rated capacity (number of 12 ounce cans)

Source: BIO IS study

7.2.4 Australia and New-Zealand

Table 31 MEPS: Maximum energy consumption – Remote cabinets

Type	**Maximum energy consumption TEC/TDA (kWh/day/m2)**
RS 1 – Unlit Shelves	12.55
RS 1 – Lit Shelves	17.76

Type	Maximum energy consumption TEC/TDA (kWh/day/m2)
RS 2 – Unlit Shelves	12.73
RS 2 – Lit Shelves	16.98
RS 3 – Unlit Shelves	14.84
RS 3 – Lit Shelves	18.39
RS 4 – Solid Door	no value
RS 4 – Glass Door	9.73
RS 5 – Solid Door	no value
RS 5 – Glass Door	no value
RS 6 – Gravity Coil	14.21
RS 6 – Fan Coil	14.16
RS 7 – Gravity Coil	no value
RS 7 – Fan Coil	14.79
RS 8 – Gravity Coil	12.25
RS 8 – Fan Coil	13.19
RS 9 – Gravity Coil	no value
RS 9 – Fan Coil	12.09
RS 10 – High	no value
RS 10 – Medium	no value
RS 10 – Low	18.67
RS 11	38.13
RS 12	66.33
RS 13 – Solid Sided	19.48
RS 13 – Glass Sided	19.58
RS 14 – Solid Sided	15.49
RS 14 – Glass Sided	19.29
RS 15 – Solid Door	no value
RS 15 – Glass Door	37.08
RS 16 – Solid Door	no value
RS 16 – Glass Door	40.56
RS 17 – Solid Door	no value
RS 17 – Glass Door	no value
RS 18	48.58
RS 19	36.15
RS 20	no value

Table 32 MEPS: Maximum energy consumption – Self-contained cabinets

MAXIMUM ENERGY CONSUMPTION TEC/TDA (kWh/day/m2)					
Type	**M-package temperature classes (see AS1731.6 Clause 5)**		**Type**	**M-package temperature classes(See AS1731.6 Clause 5)**	
	M1	**M2**		**L1**	**L2**

MAXIMUM ENERGY CONSUMPTION TEC/TDA (kWh/day/m2)					
Type	**M-package temperature classes (see AS1731.6 Clause 5)**		**Type**	**M-package temperature classes(See AS1731.6 Clause 5)**	
	M1	**M2**		**L1**	**L2**
HC1	11.50	11.50	HF1	no value	no value
HC2	no value	no value	HF2	no value	no value
HC3	no value	no value	HF3	no value	no value
HC4	15.50	15.50	HF4	26.50	26.50
HC5	no value	no value	HF5	no value	no value
HC6	no value	no value	HF6	8.00	8.00
VC1	37.50	28.00	VF1	no value	no value
VC2	27.00	25.50	VF2	no value	no value
VC3	no value	no value	VF3	no value	no value
VC4(a) Solid Door(b) Glass Door	17.0017.00	17.5017.50	VF4(a) Solid Door(b) Glass Door	44.0044.00	39.0039.00
YC1	no value	no value	YF1	no value	no value
YC2	no value	no value	YF2	no value	no value
YC3	no value	no value	YF3	no value	no value
YC4	no value	no value	YF4	no value	no value

High Efficiency Levels

A remote or self-contained refrigerated display cabinet may be designated 'high efficiency only if its energy consumption, measured in accordance with AS 1731.9 and AS 1731.12 does not exceed that value specified below. For the purpose of testing compliance, tests shall be conducted under climate Class 3 conditions, with lighting and anti-sweat heaters running for the duration of test period, unless controlled by a time-clock, smart sensor or similar automatic device. Where night-covers are supplied as a permanent fixture of the cabinet, the test shall be conducted as described in AS 1731.9, Section 4. Reference should be made to the relevant parts of AS 1731 for detailed conditions and test methods.

Table 33 Maximum energy consumption for 'high efficiency' remote display cabinets

Type	**Maximum Energy Consumption TEC/TDA (kWh/day/m2)**
RS 1 – Unlit Shelves	8.37
RS 1 – Lit Shelves	10.66
RS 2 – Unlit Shelves	8.49
RS 2 – Lit Shelves	11.32
RS 3 – Unlit Shelves	10.32
RS 3 – Lit Shelves	12.26
RS 4 – Solid Door	no value
RS 4 – Glass Door	6.77
RS 5 – Solid Door	no value
RS 5 – Glass Door	no value

Type	Maximum Energy Consumption TEC/TDA (kWh/day/m2)
RS 6 – Gravity Coil	9.88
RS 6 – Fan Coil	9.85
RS 7 – Gravity Coil	no value
RS 7 – Fan Coil	9.86
RS 8 – Gravity Coil	8.52
RS 8 – Fan Coil	9.17
RS 9 – Gravity Coil	no value
RS 9 – Fan Coil	8.06
RS 10 – High	no value
RS 10 – Medium	no value
RS 10 – Low	12.99
RS 11	26.52
RS 12	46.14
RS 13 – Solid Sided	12.99
RS 13 – Glass Sided	13.62
RS 14 – Solid Glass	11.45
RS 14 – Glass Sided	12.86
RS 15 – Solid Door	no value
RS 15 – Glass Door	27.41
RS 16 – Solid Door	no value
RS 16 – Glass Door	29.98
RS 17 – Solid Door	no value
RS 17 – Glass Door	no value
RS 18	39.75
RS 19	29.57
RS 20	no value

Table 34 Maximum energy consumption for 'high efficiency' self-contained display cabinets

MAXIMUM ENERGY CONSUMPTION TEC/TDA (kWh/day/m2)					
Type	**M-package temperature classes**		**Type**	**M-package temperature classes**	
	M1	**M2**		**L1**	**L2**
HC1	8.50	8.50	HF1	no value	no value
HC2	no value	no value	HF2	no value	no value
HC3	no value	no value	HF3	no value	no value
HC4	11.40	11.40	HF4	19.50	19.50
HC5	no value	no value	HF5	no value	no value
HC6	no value	no value	HF6	5.90	5.90
VC1	27.60	20.60	VF1	no value	no value
VC2	19.90	18.80	VF2	no value	no value
VC3	no value	no value	VF3	no value	no value

MAXIMUM ENERGY CONSUMPTION TEC/TDA (kWh/day/m2)					
Type	**M-package temperature classes**		**Type**	**M-package temperature classes**	
	M1	**M2**		**L1**	**L2**
VC4(a) Solid Door(b) Glass Door	7.3010.70	7.3010.70	VF4(a) Solid Door(b) Glass Door	32.4032.40	28.7028.70
YC1	no value	no value	YF1	no value	no value
YC2	no value	no value	YF2	no value	no value
YC3	no value	no value	YF3	no value	no value

7.3 Annex III - Markets

Not included in Eurovent market statistics 2010 are marked in yellow. These classes are not included because of a very low market share.

Table 35 ISO classification for refrigerated display cabinet families

Classification for refrigerated display cabinet families

(See Annex A of pr EN ISO 23953-2:2004(E))

Application	Positive Temperature		Negative Temperature	
To be used for	Chilled foodstuffs		Frozen, quick frozen foodstuffs and ice cream	
Horizontal	Chilled, serve-over counter open service access	HC1	Frozen, serve-over counter open service access	HF1
	Chilled, serve-over counter with integrated storage open service access	HC2		
	Chilled, open, wall site	HC3	Frozen, open, wall site	HF3
	Chilled, open, island	HC4	Frozen, open, island	HF4
	Chilled, glass lid, wall site	HC5	Frozen, glass lid, wall site	HF5
	Chilled, glass lid, island	HC6	Frozen, glass lid, island	HF6
	Chilled, serve-over counter closed service access	HC7	Frozen, serve-over counter closed service access	HF7
	Chilled, serve-over counter with integrated storage closed service access	HC8		
Vertical	Chilled, semi-vertical	VC1	Frozen, semi-vertical	VF1
	Chilled, multi-deck	VC2	Frozen, multi-deck	VF2
	Chilled, roll-in	VC3		
	Chilled, glass door	VC4	Frozen, glass door	VF4
Combined	Chilled, open top, open bottom	YC1	Frozen, open top, open bottom	YF1
	Chilled, open top, glass lid bottom	YC2	Frozen, open top, glass lid bottom	YF2
	Chilled, glass door top, open bottom	YC3	Frozen, glass door top, open bottom	YF3
	Chilled, glass door top, glass lid bottom	YC4	Frozen, glass door top, glass lid bottom	YF4
	Multi-temperature, open top, open bottom			YM5
	Multi-temperature, open top, glass lid bottom			YM6
	Multi-temperature, glass door top, open bottom			YM7
	Multi-temperature, glass door top, glass lid bottom			YM8

Table 36 Eurovent aggregated sales data for remote display cabinets per country of EU25 (estimated number of units delivered and installed)

	2004	2005	2006	2007	2008	2009	2010
Aus	5524	5661	5936	6066	4024	4068	4032
Bel	6291	3822	3940	4050	3369	3483	3639
Cypr	346	394	470	558	900	975	300
CZ	4253	4497	4672	4770	2350	2433	2325
DK	6256	3361	3642	3865	3035	3158	2705
Eire	5546	2654	2941	3132	3234	3300	3196
Esto	1597	705	809	955	820	878	667
Fin	9761	4187	4494	4672	4068	4160	3897
Fra	31445	31144	31817	32109	32026	32411	32195
Ger	45546	45766	46174	46770	43705	44077	36283
Gree	3101	3373	3756	3960	3133	3317	3800
Hung	9083	9892	10802	11350	3460	3660	4190
Ital	26228	26482	26938	27404	26219	26328	26172
Latvia	813	475	589	649	725	800	417
Lithu	1103	774	898	953	1083	1145	510
Lux	892	884	892	919	1215	1258	1509
Malta	124	135	145	165	165	215	30
NL	8948	6595	6887	7193	6288	6477	4664
Pol	11019	10071	10935	11493	11429	11946	9274
Port	4679	4908	5089	5347	5092	5238	3445
Slova	3012	3100	3206	3302	1367	1567	1150
Slove	1590	1787	1962	2229	1550	1775	850
Spain	18317	19140	19533	19924	18214	18693	15210
Swed	7783	5738	6264	6501	5843	6000	5064
UK	39463	26000	26714	27483	25650	26100	20433
Total	**225 884**	**231 400**	**239 073**	**245 255**	**219 723**	**224395**	**196 488**

7.3.1 Generic economic data based on Eurostat statistics and Prodcom

7.3.1.1 Inside EU27

Table 37 PRODCOM categories relevant for this project

Code	Description	HS/CN reference	Year Prodcom list	BIO IS Prodcom code used
28.25	Manufacture of non-domestic cooling and ventilation equipment			
28.25.13	Refrigeration and freezing equipment and heat pumps, except household type equipment			
28.25.13.33	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator for frozen food storage	8418 50 11	2011	29.23.13.33
28.25.13.35	Refrigerated show-cases and counters incorpora0ting a refrigerating unit or evaporator (excluding for frozen food storage)	8418 50 19	2011	29.23.13.35
28.25.13.40	Deep-freezing refrigerating furniture (excluding chest freezers of a capacity ≤ 800 litres, upright freezers of a capacity ≤ 900 litres)	8418.50.91	2009	29.23.13.40
28.25.13.50	Refrigerating furniture (excluding for deep-freezing, show-cases and counters incorporating a refrigerating unit or evaporator)	8418.50.99	2009	29.23.13.50
28.29.43	Automatic goods-vending machines			
28.29.43.30	Automatic goods-vending machines incorporating heating or refrigerating devices	8476[.21 + .81]	2011	Not taken into account

The categories do not exactly represent the scope of this study, but they give a good indication.

EU production

Yearly production of different product groups in euro from Prodcom database (Nace Rev. 2). No data available for group 28251340 and 28251350 for 2010 and 2011.

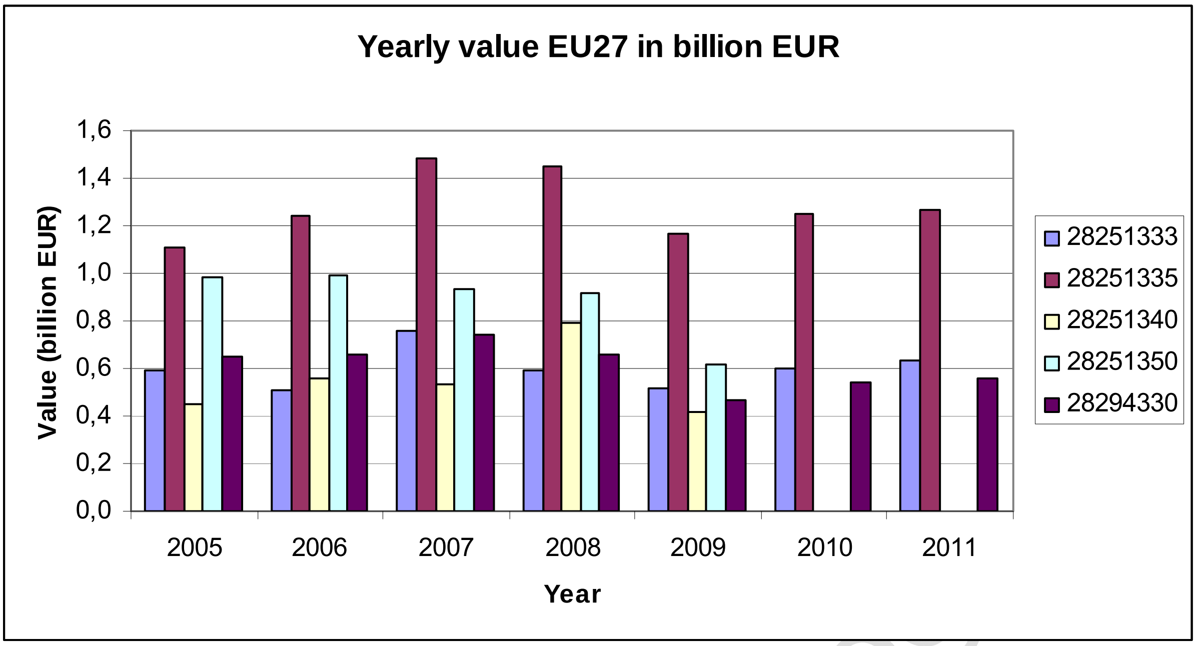

Figure 16 Yearly value in the EU27 of the selected product groups

28251333	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator for frozen food storage
28251335	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator (excluding for frozen food storage)
28251340	Deep-freezing refrigerating furniture (excluding chest freezers of a capacity <= 800 litres, upright freezers of a capacity <= 900 litres)
28251350	Refrigerating furniture (excluding for deep-freezing, show-cases and counters incorporating a refrigerating unit or evaporator)
28294330	Automatic goods-vending machines incorporating heating or refrigerating devices

Product Group	2005	2006	2007	2008	2009	2010	2011
28251333	0.595112	0.512398	0.757555	0.589247	0.516954	0.596352	0.630000
28251335	1.110160	1.241560	1.480521	1.450000	1.166815	1.246961	1.268123
28251340	0.446800	0.561646	0.537430	0.789618	0.419297		
28251350	0.981913	0.989519	0.932576	0.914111	0.616000		
28294330	0.646987	0.659438	0.742977	0.658802	0.469307	0.540547	0.559845

Value in billion euro

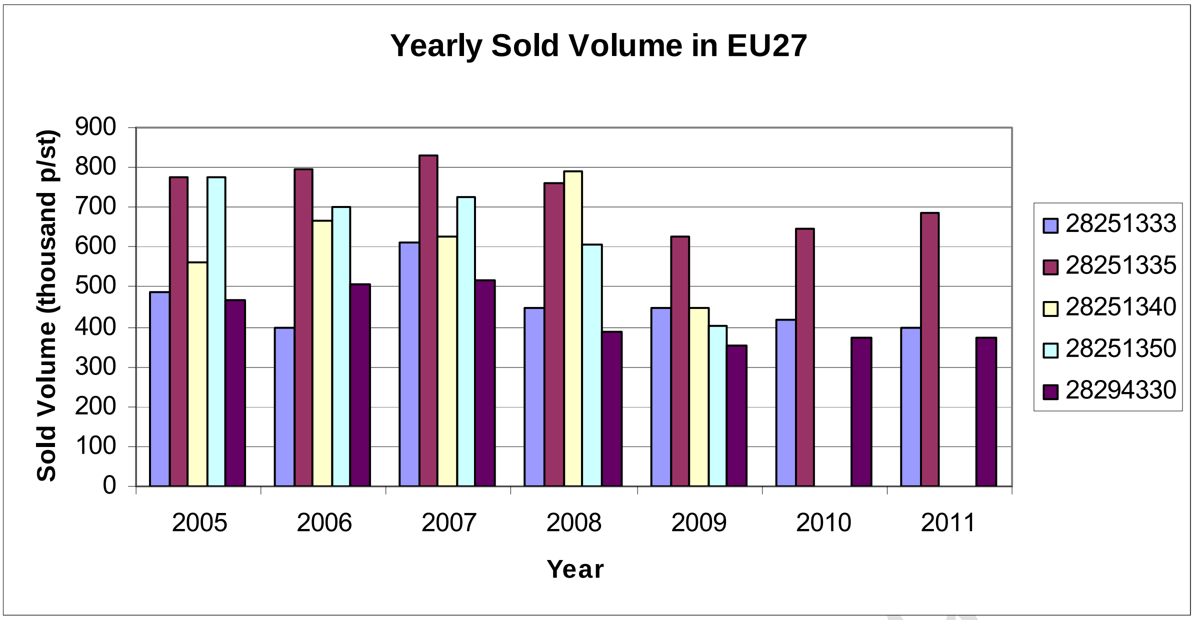

Figure 17 Yearly sold volume in the EU27 of the selected product groups

28251333	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator for frozen food storage
28251335	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator (excluding for frozen food storage)
28251340	Deep-freezing refrigerating furniture (excluding chest freezers of a capacity <= 800 litres, upright freezers of a capacity <= 900 litres)
28251350	Refrigerating furniture (excluding for deep-freezing, show-cases and counters incorporating a refrigerating unit or evaporator)
28294330	Automatic goods-vending machines incorporating heating or refrigerating devices

Product Group	2005	2006	2007	2008	2009	2010	2011
28251333	489	399	613	450	450	420	400
28251335	776	797	831	762	628	648	684
28251340	562	667	628	789	445		
28251350	775	701	725	606	402		
28294330	467	506	516	388	354	375	371

Sold volume in thousand (p/st)

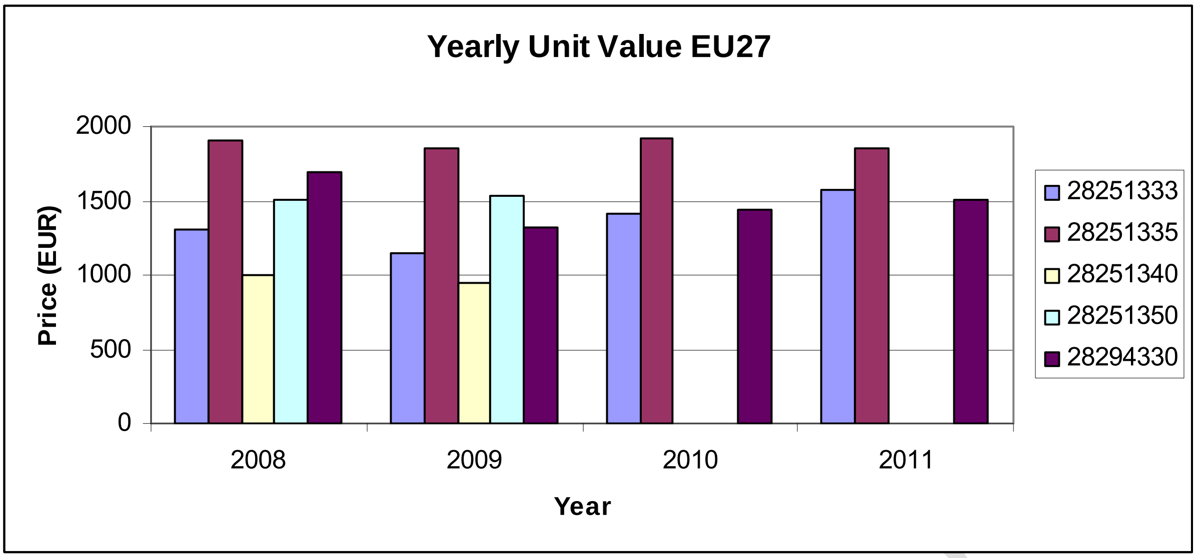

Figure 18 Yearly unit value in the EU27 for the selected product groups

28251333	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator for frozen food storage
28251335	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator (excluding for frozen food storage)
28251340	Deep-freezing refrigerating furniture (excluding chest freezers of a capacity <= 800 litres, upright freezers of a capacity <= 900 litres)
28251350	Refrigerating furniture (excluding for deep-freezing, show-cases and counters incorporating a refrigerating unit or evaporator)
28294330	Automatic goods-vending machines incorporating heating or refrigerating devices

Unit Value	2008	2009	2010	2011
28251333	1309,44	1148,79	1419,89	1575,00
28251335	1902,89	1859,14	1924,41	1853,17
28251340	1001,06	941,31		
28251350	1508,10	1532,34		
28294330	1697,18	1326,00	1442,42	1511,04

Intra-EU trade

<u>All 5 product groups together</u>, from database EU27 Trade Since 1988 By CN8 [DS-016890]

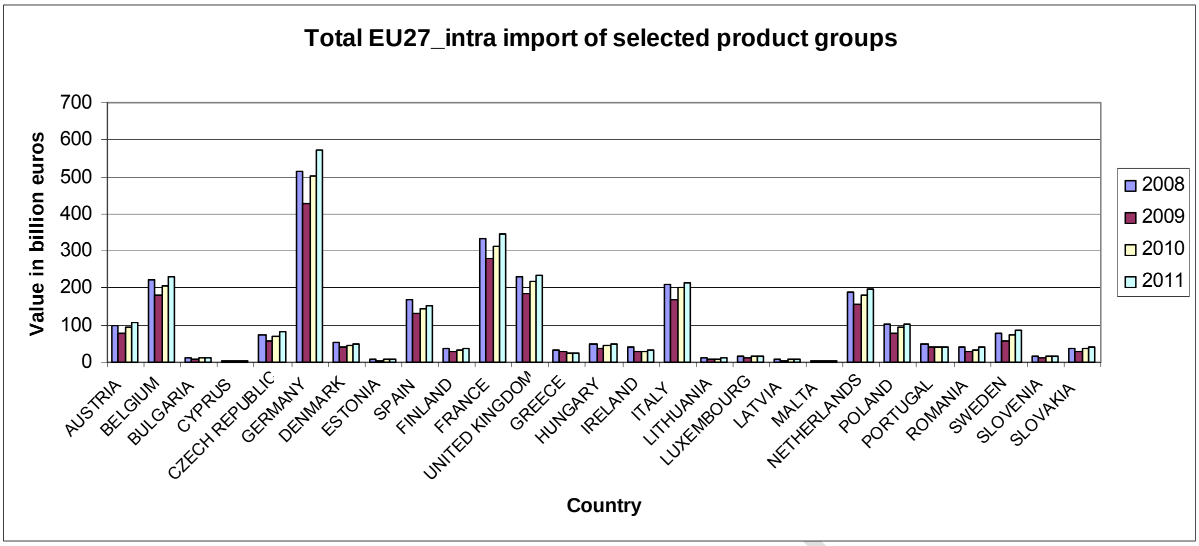

Figure 19 Total EU27 import of the selected product groups inside the EU27

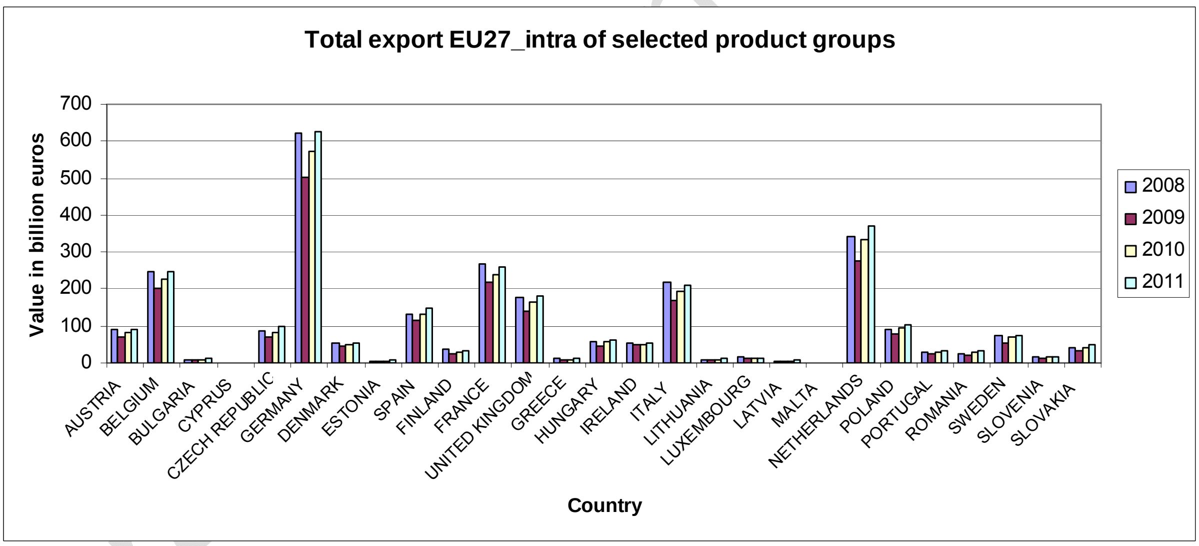

Figure 20 Total EU27 export of the selected product groups inside the EU27

Per product group

For simplicity, only the product group 84185011 (Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator for frozen food storage) is shown in this document.

EU27 import inside EU27

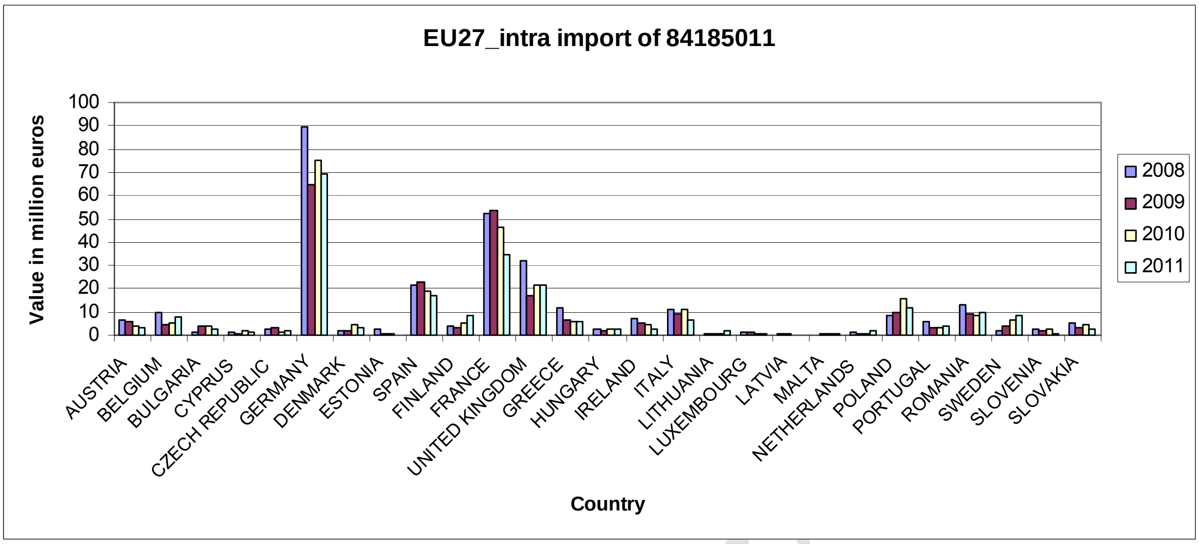

Figure 21 Value of EU27 import of product group 84185011 inside the EU27

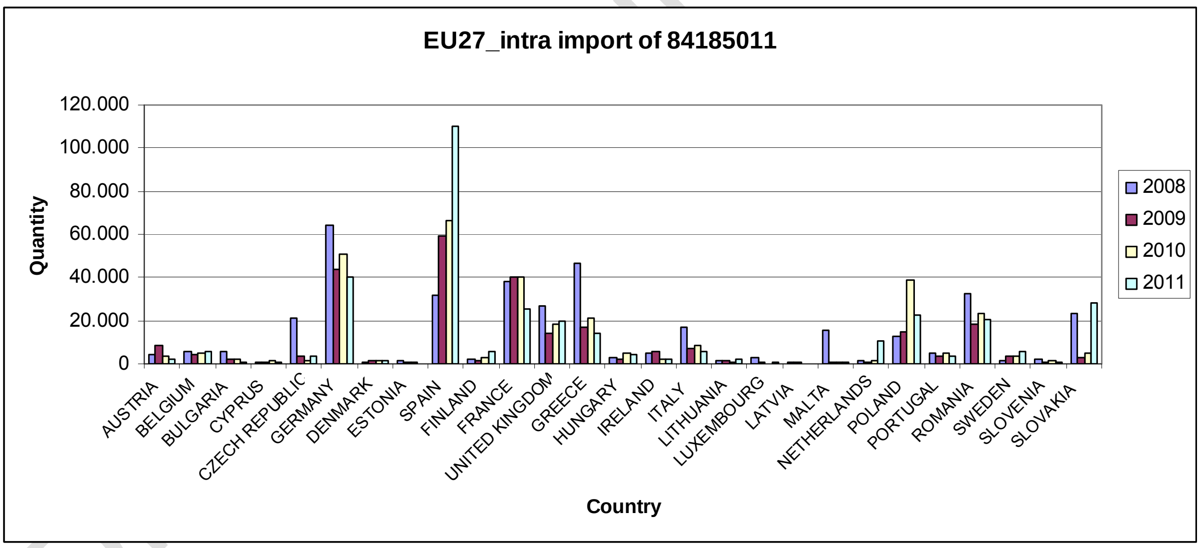

Figure 22 Quantity of EU27 import of product group 84185011 inside the EU27

EU27 export inside EU27 of 84185011

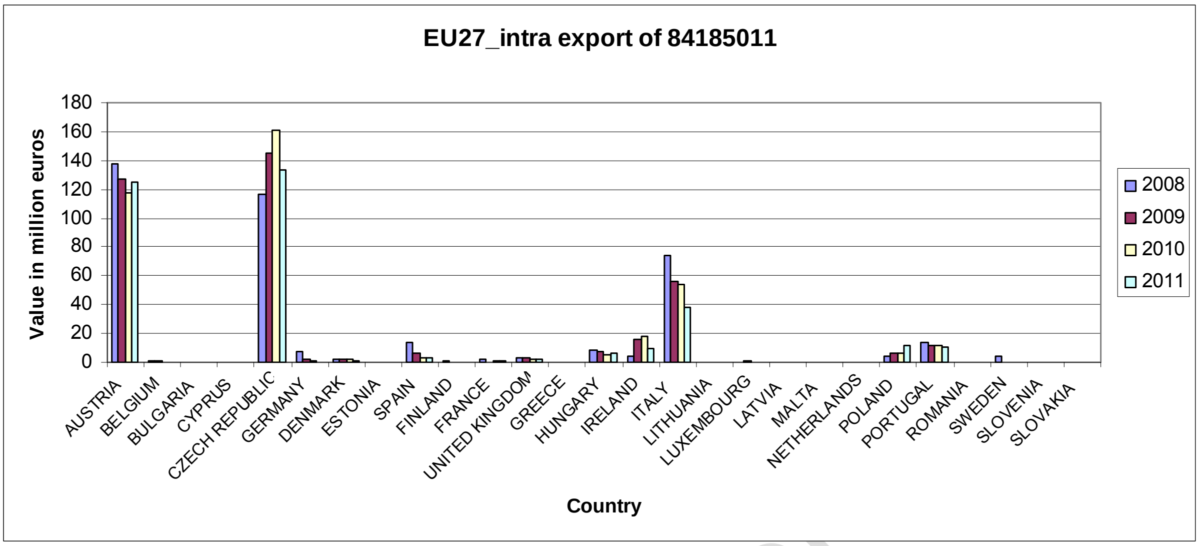

Figure 23 Value of EU27 export of product group 84185011 inside the EU27

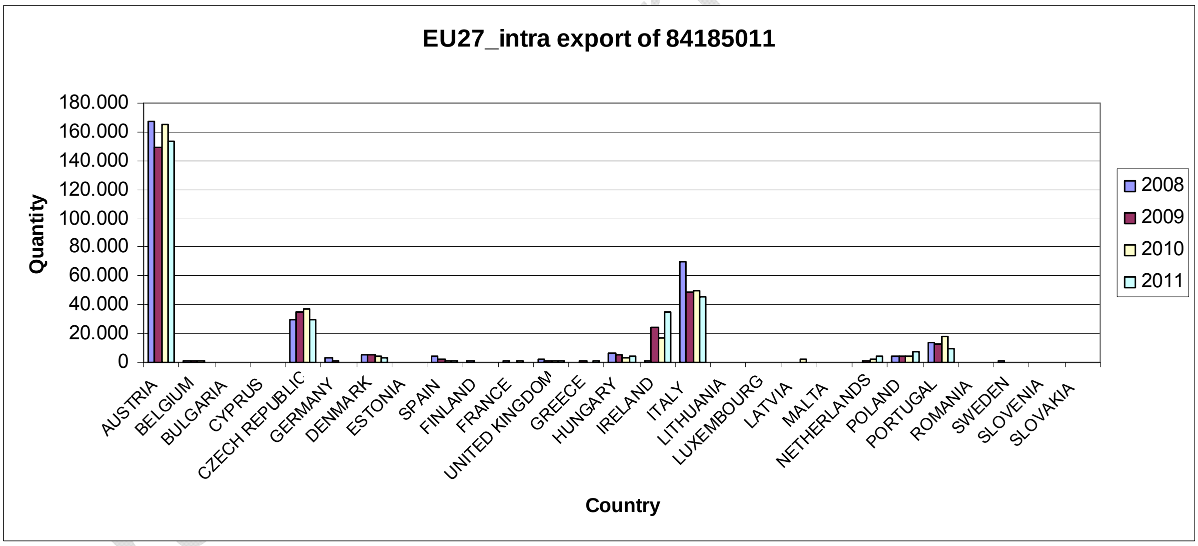

Figure 24 Quantity of EU27 export of product group 84185011 inside the EU27

Selected product groups:

28251333	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator for frozen food storage	8418 50 11
28251335	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator (excluding for frozen food storage)	8418 50 19
28251340	Deep-freezing refrigerating furniture (excluding chest freezers of a capacity <= 800 litres, upright freezers of a capacity <= 900 litres)	8418.50.91
28251350	Refrigerating furniture (excluding for deep-freezing, show-cases and counters incorporating a refrigerating unit or evaporator)	8418.50.99
28294330	Automatic goods-vending machines incorporating heating or refrigerating devices	8476[.21 + .81]

Extra-EU trade

Quantity from China. Investigations are ongoing regarding the values for 2007 and 2008 as they look overestimated at first sight.

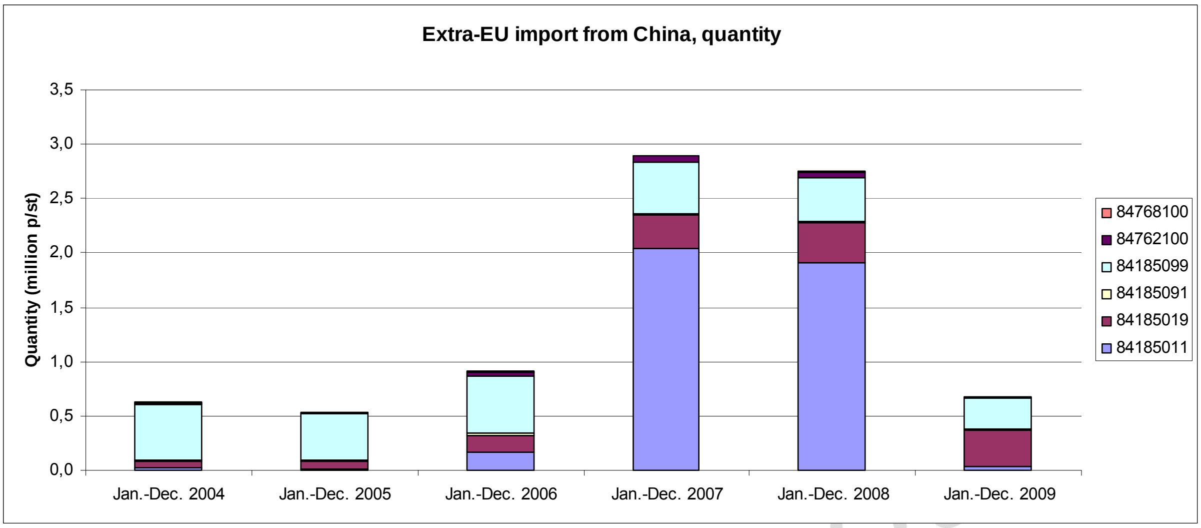

Figure 25 Quantity of EU27 import from China for the slecetd product groups.

Selected product groups:

28251333	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator for frozen food storage	8418 50 11
28251335	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator (excluding for frozen food storage)	8418 50 19
28251340	Deep-freezing refrigerating furniture (excluding chest freezers of a capacity <= 800 litres, upright freezers of a capacity <= 900 litres)	8418.50.91
28251350	Refrigerating furniture (excluding for deep-freezing, show-cases and counters incorporating a refrigerating unit or evaporator)	8418.50.99
28294330	Automatic goods-vending machines incorporating heating or refrigerating devices	8476[.21 + .81]

7.4 Annex IV - Technologies

Table 38 Eurovent European average values and Eurovent's best performer for remote display cabinets (march 2013)

Cabinet type, ISO 23953	Temperature class	European average value TEC/TDA kWh/(day.m²)	Best performer Eurovent database TEC/TDA kWh/(day.m²)
RVC1, RVC2	3H	10,1	5.3
	3M2	12,3	6.2
	3M1	13,4	7.4
	3M0	14,5	8.4
RVC3	3H	13,8	no data
	3M2	16,0	7.25
RVF1	3L3	29,0	no data
RVF4	3L1	28,5	20.5
RVC4	3H	6,1	3.2
	3M2	7,4	3.7
	3M1	8,0	4.9
	3M0	8,7	6.8
RHC1	3H	6,2	3.7
	3M2	6,7	3.9
	3M1	7,2	4.2
RHF1	3L3	21,0	13.7
RHC3, RHC4	3H	no data	4.6
	3M2	5,5	4.9
	3M1	5,8	5.9
	3M0	6,2	no data
RHF3, RHF4	3L1	15,0	no data
	3L2	14,0	9.5
	3L3	13,0	7.1
RHC5, RHC6	3H	4,3	no data
	3M2	4,7	no data
	3M1	5,0	no data
RHF5, RHF6	3L1	12,0	7.8
	3L2	11,2	9.9
	3L3	10,4	5.3
RYF3	3L2	30,0	25.9
	3L3	29,0	24.3
RYF4	3L2	28,5	no data
	3L3	27,6	24.4

From the table, discrepancy for average values. E.g. a best performer in the database proves to have a higher energy consumption than the average value. An average value defined while there is no data.

Table 39 Eurovent European average values for integral display cabinets (March 2013)

Cabinet type, ISO 23953	Temperature class	European average value TEC/TDA kWh/(day.m²)
IVC1, IVC2	3H	12,4
	3M2	15,1
	3M1	16,5
	3M0	17,8
IVC3	3H	17,0
	3M2	19,7
IVF1	3L3	36,5
IVF4	3L1	35,9
IVC4	3H	7,5
	3M2	9,1
	3M1	9,8
	3M0	10,7
IHC1	3H	7,6
	3M2	8,2
	3M1	8,9
IHF1	3L3	26,5
IHC3, IHC4	3H	5,5
	3M2	5,8
	3M1	6,2
IHF3, IHF4	3L1	16,4
	3L2	17,6
	3L3	18,9
IHC5, IHC6	3H	5,3
	3M2	5,8
	3M1	6,2
IHF5, IHF6	3L1	13,1
	3L2	14,1
	3L3	15,1
IYF3	3L2	36,5
	3L3	37,8
IYF4	3L2	34,8
	3L3	35,9

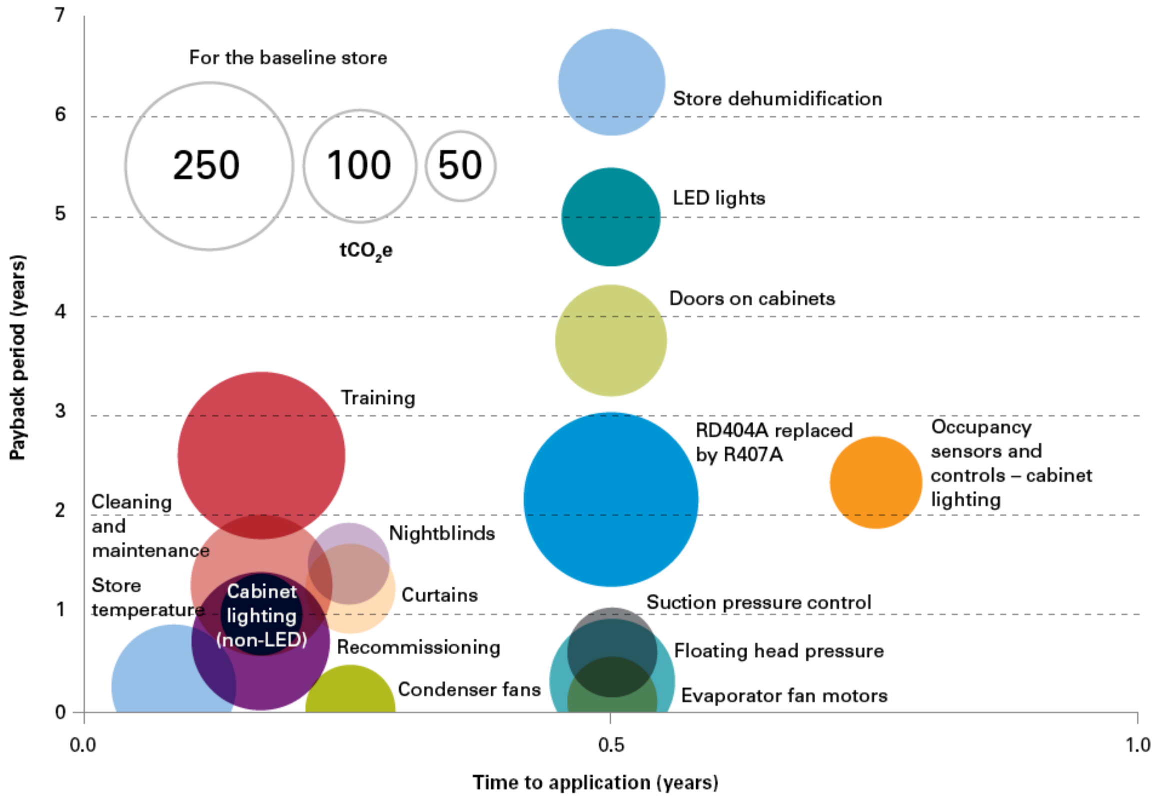

Figure 26 Technologies that can be retrofitted with potential to save > 50tCO2e pa (Taken from Carbon Trust's Refrigeration Road Map[15])

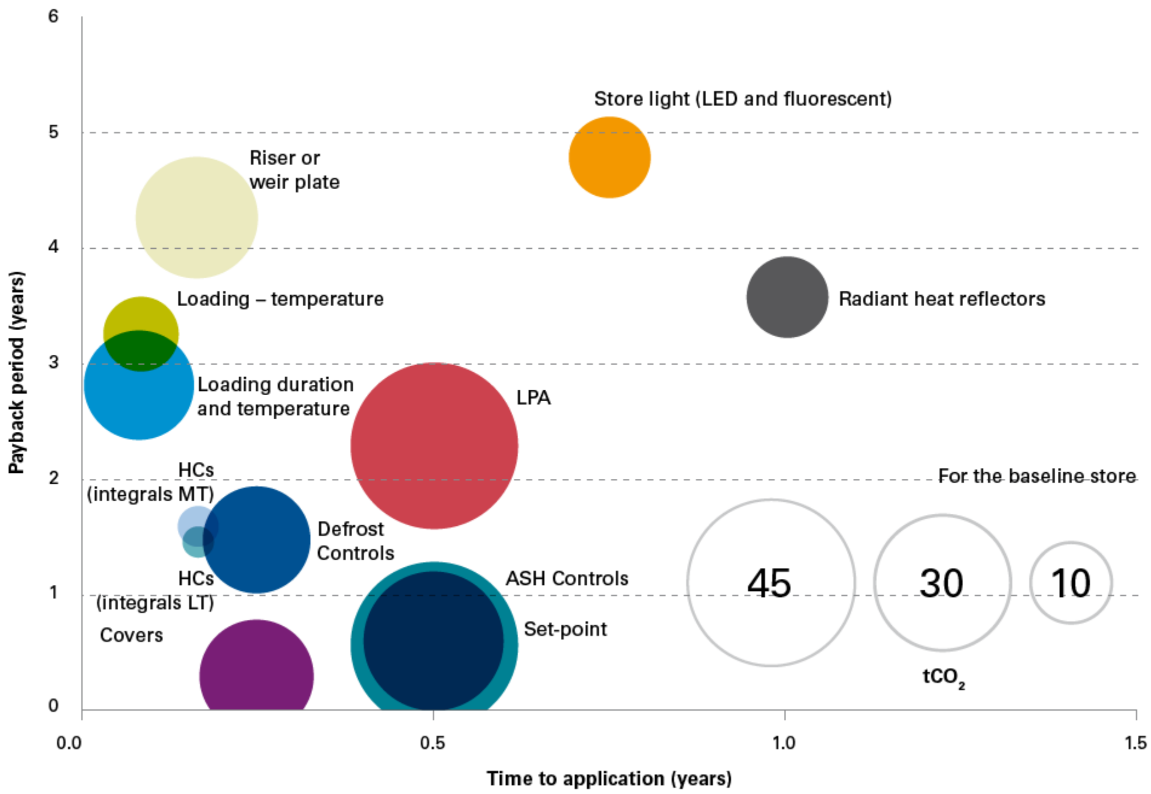

Figure 27 Technologies that can be retrofitted with potential to save < 50tCO2e pa (Taken from Carbon Trust's Refrigeration Road Map[15])

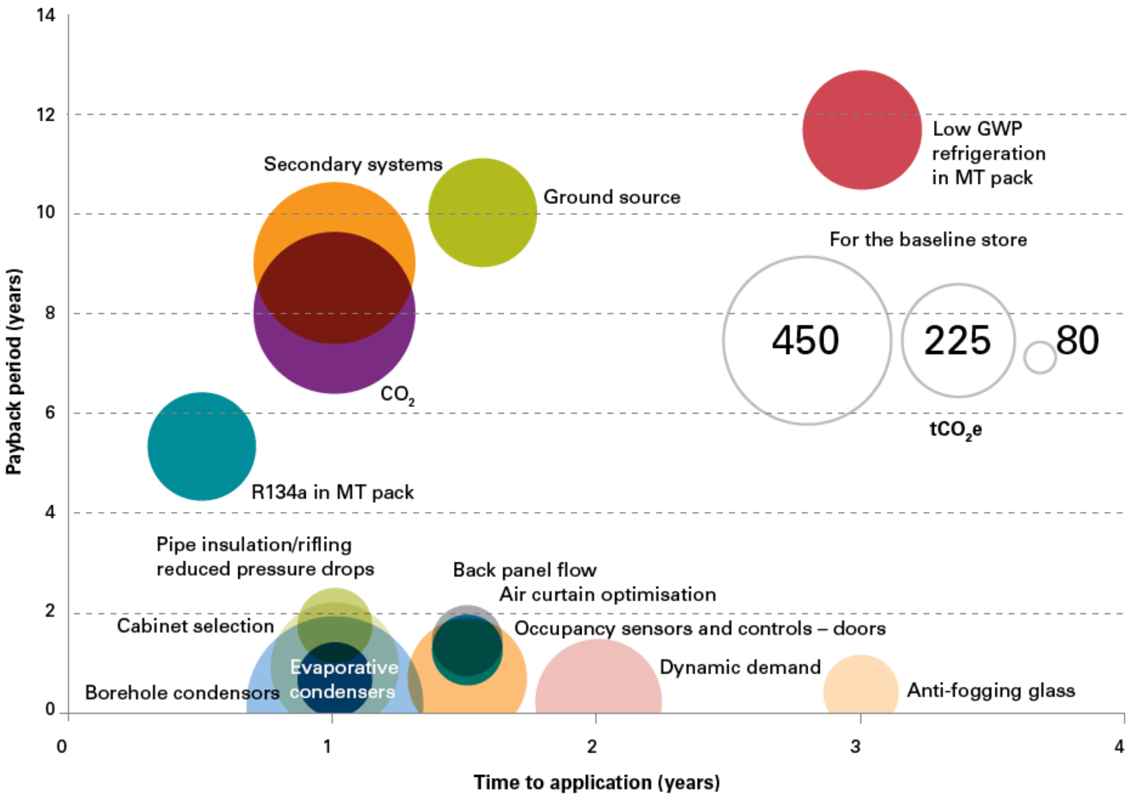

Figure 28 Technologies that are available during a store refit with potential to save > 50tCO2e pa (Taken from Carbon Trust's Refrigeration Road Map[15])

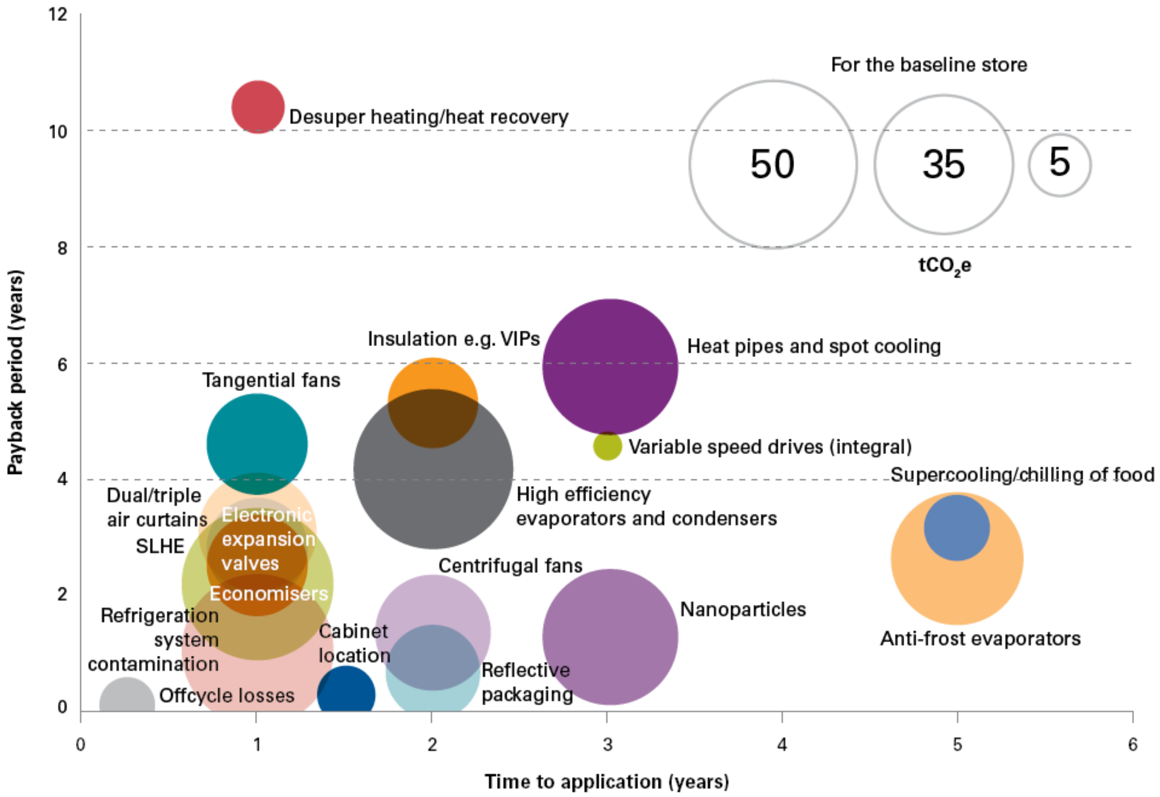

Figure 29 Technologies that are available during a store refit with potential to save < 50tCO2e pa (Taken from Carbon Trust's Refrigeration Road Map[15])

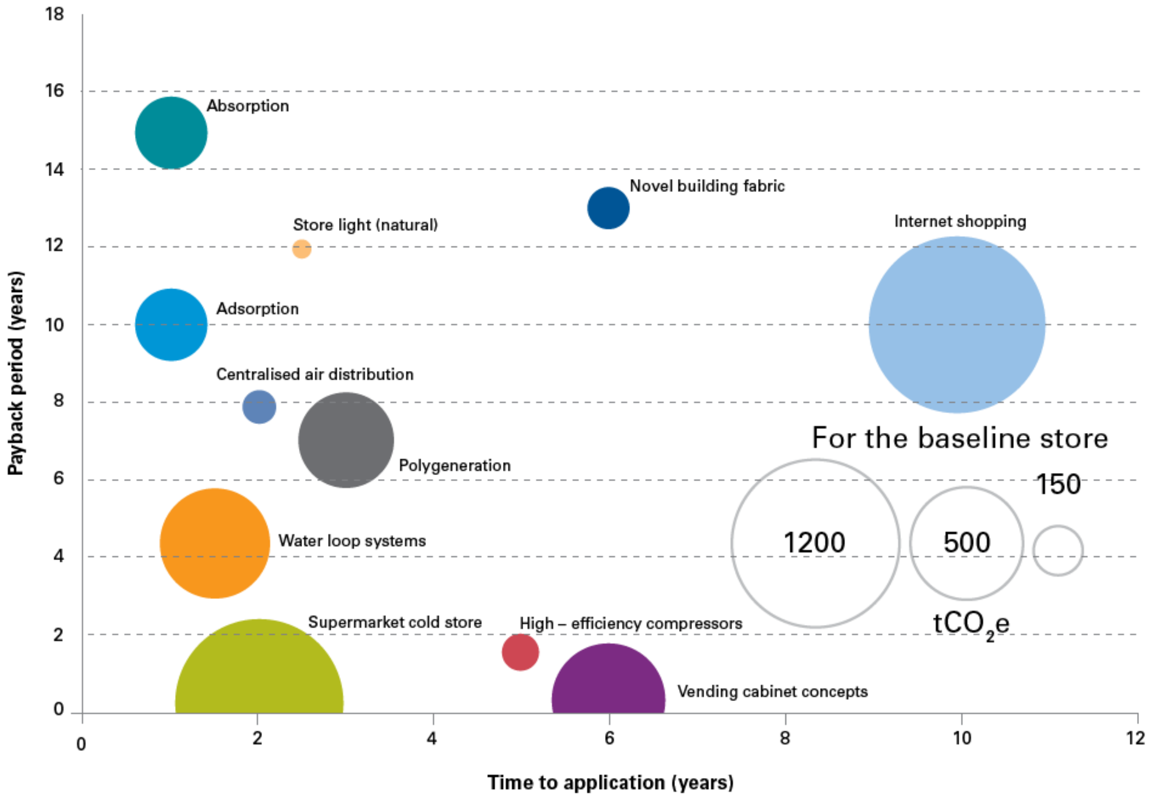

Figure 30 Technologies that are available when designing a new store/retail concept (Taken from Carbon Trust's Refrigeration Road Map[15])

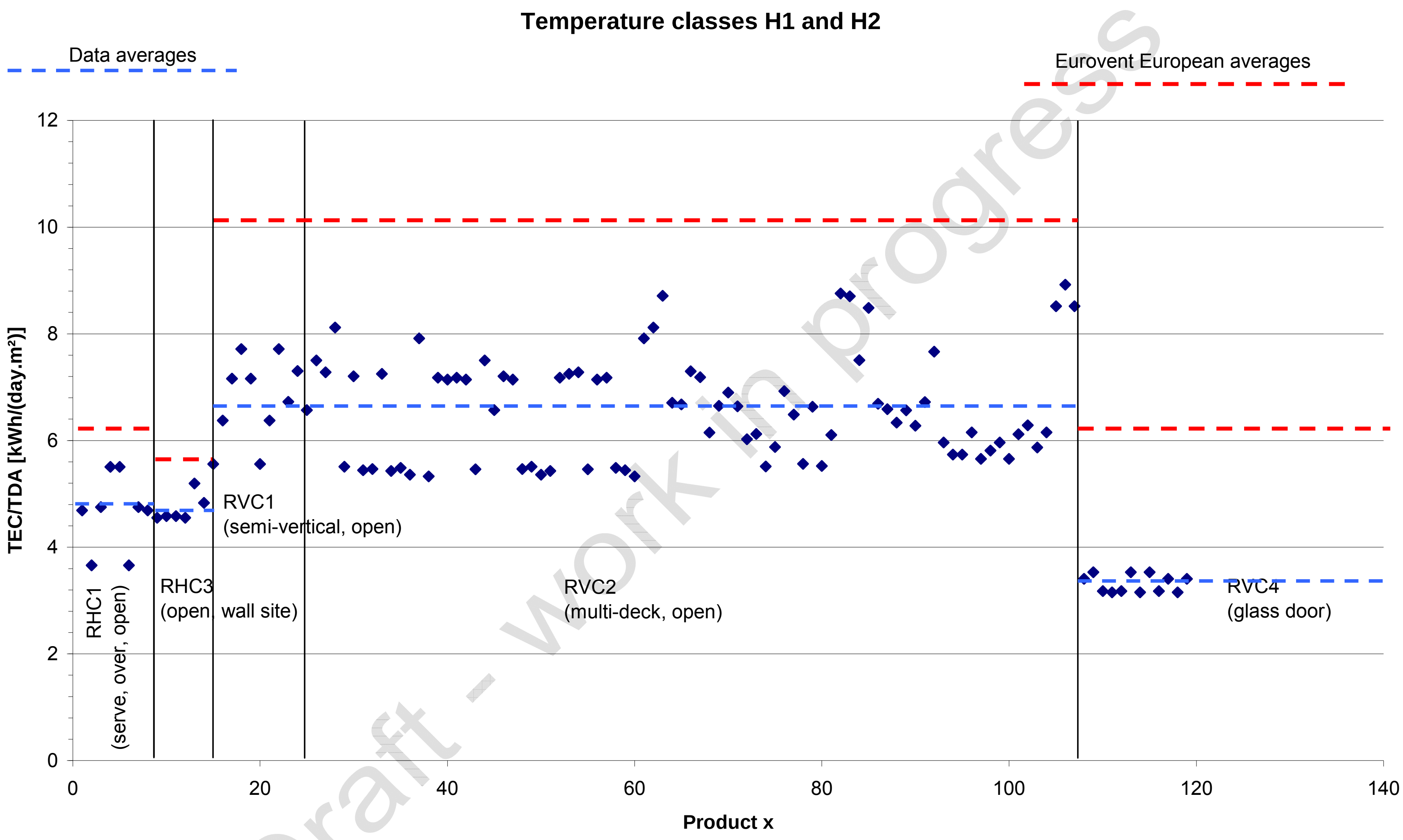

Figure 31 Energy performance of the cabinets in the Eurovent certification data base together with their average and the ad-hoc provided European average values. The Eurovent European average value is the average of the 2 different temperature classes. (March 2013)

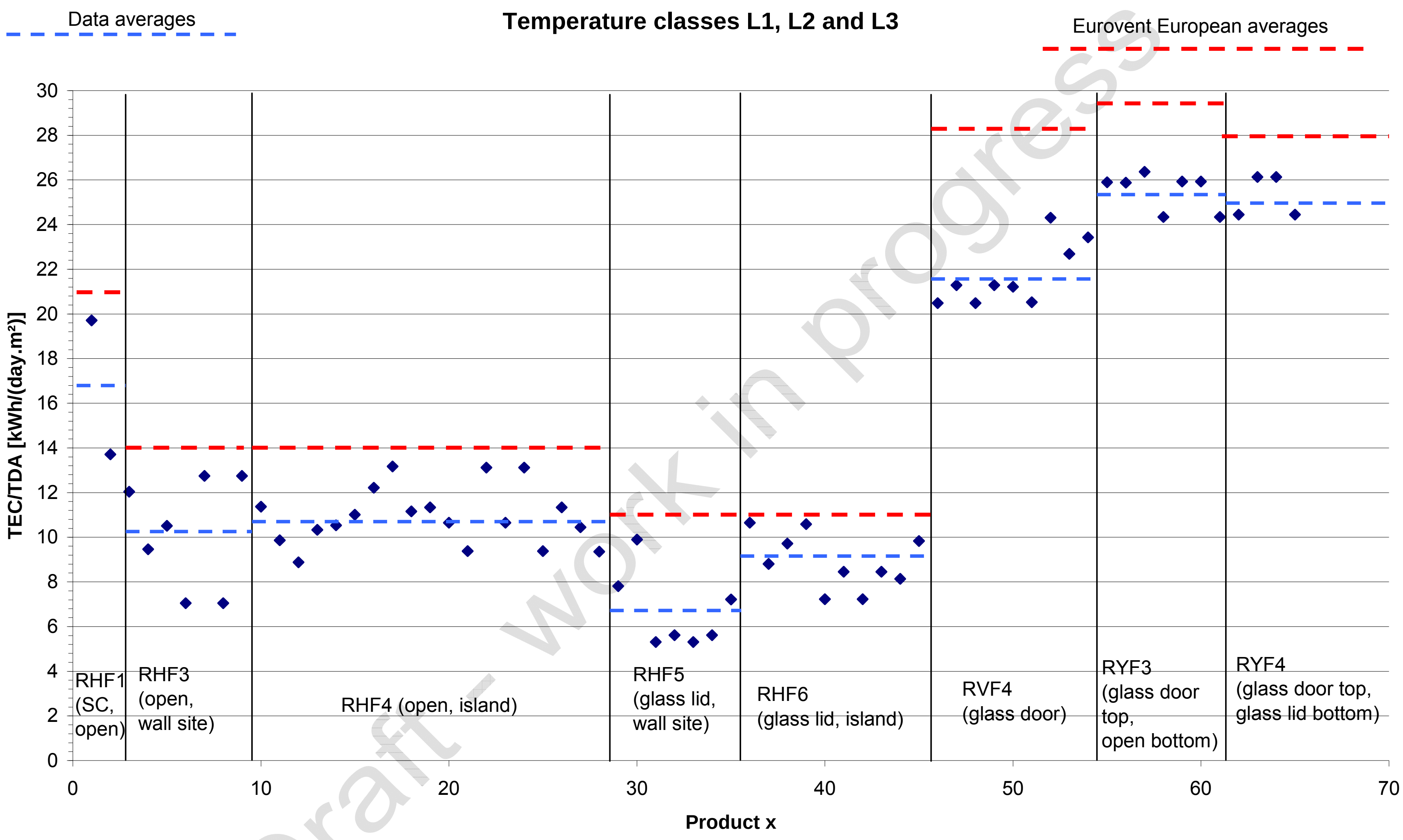

Figure 32 Energy performance of the cabinets in the Eurovent certification data base together with their average and the ad-hoc provided European average values. The Eurovent European average value is the average of the 3 different temperature classes. (March 2013)

Table 40 Average energy efficiency levels for refrigerated display cases (Class 3 performance data), UK Market Transformation Program Policy scenario[34]

Remote Display Cases						
Energy Consumption (kWh/m²/day)						
Temp Class	**M0**	**M1**	**M2**	**H1**	**H2**	**L1**
2009	15.18	13.30	11.61	9.67	9.82	22.00
2010	14.33	12.57	10.84	9.05	9.18	21.14
2011	13.48	11.83	10.07	8.42	8.54	20.28
2012	12.64	11.10	9.31	7.80	7.89	19.42
2025	10.02	8.78	7.66	6.38	6.48	19.30
2030	10.02	8.78	7.66	6.38	6.48	19.30
Plug-in Display Cases						
Energy Consumption (kWh/m²/day)						
Temp Class	**M0**	**M2**	**H2**	**L1**		
2009	14.17	15.69	13.79	24.06		
2010	13.37	14.14	12.70	22.75		

7.5 Last developments of the new F-gas Regulation

In 2012, the European Commission made a proposal[17] to strengthen the F-gas regulation in order to cut F-gas emissions by two-thirds of today's levels by 2030. A draft report by MEP Rapporteur Bas Eickhout tightens up the latest proposal for an update of the F-gas regulation.[18] The Rapporteur's recommendations will be discussed in June 2013 by the ENVI Committee, the parliamentary committee for Environment, Public Health and Food Safety.

Table 41 presents relevant parts of the update of the F-gas regulation. Of concern for this project are the measures for hermetically sealed systems which include all plug-in appliances (plug-in display cabinets for the supermarket segment, bottle coolers as well as vending machines).

Table 41 Summary overview over new equipment restrictions according to the proposed update of the F-gas regulation.

Products and equipment	Date of prohibition
Use of HFC-23 in fire protection systems and fire extinguishers	1 January 2015
Domestic refrigerators and freezers with HFCs with GWP of 150 or more	1 January 2015
Refrigerators and freezers for commercial use (hermetically sealed systems)	1 January 2017 for HFCs with GWP of 2500 or more 1 January 2020 for HFCs with GWP of 150 or more
Movable room air-conditioning appliances (hermetically sealed) with HFCs with GWP of 150 or more	1 January 2020

7.5.1 Proposal by the European Parliament´s Rapporteur

The Rapporteur amended the proposal for update with an earlier ban of HFCs and the relation with their GWP (Table 42).

Table 42 Proposal by the Rapporteur for equipment restrictions most important for this project.

Products and equipment	Date of prohibition
Refrigerators and freezers for commercial use (hermetically sealed systems)	1 January 2015 for HFCs with GWP of 2150 or more 1 January 2018 for HFCs

Other amendments are directly related with the Ecodesign Directive.

7.5.1.1 Rapporteur amendments related to the Ecodesign directive

Amendment 3
Proposal for a regulation

Recital 9 *Text proposed by the Commission*	*Amendment*
(9) Such bans should only be introduced where they will result in lower overall greenhouse gas emissions, in particular from both the leakage of any fluorinated greenhouse gases and the CO_2 emissions resulting from their energy consumption. ***Equipment containing fluorinated greenhouse gases should thus be allowed if their overall greenhouse gas emissions are***	(9) Such bans should only be introduced where they will result in lower overall greenhouse gas emissions, in particular from both the leakage of any fluorinated greenhouse gases and the CO_2 emissions resulting from their energy consumption.

less than those that would result from an equivalent equipment without fluorinated greenhouse gases, which has the maximum allowed energy consumption set out in relevant implementing measures adopted under Directive 2009/125/EC (Ecodesign)	

Amendment 24
Proposal for a regulation

Article 9 – paragraph 2 *Text proposed by the Commission*	*Amendment*
2. The prohibition set out in paragraph 1 shall not apply to equipment for which it has been established in Ecodesign requirements adopted under Directive 2009/125/EC that due to higher energy efficiency during its operation its lifecycle CO_2 emissions would be lower than that from equivalent equipment which meets relevant Ecodesign requirements and does not contain hydrofluorocarbons.	***Deleted***

Justification

This provision could create a loophole and undermine market certainty that could otherwise be provided by bans. There are wide differentials in energy efficiency of equipment relying on HFCs as well as equipment relying on natural refrigerants. The F-gas regulation could therefore potentially be undermined through selecting specific equipment for the comparison between the energy efficiency of non-HFC and HFC equipment.

7.5.1.2 Rapporteur amendments related to a ban on certain refrigerants

Amendment 44
Proposal for a regulation

ANNEX III – table – line 10 a (new)	*Amendment*
	10a. Refrigeration equipment that contains fluorinated greenhouse gases with GWP of 2150 or more ***1 january 2015***

Justification

Article 11(3) prohibits the use of fluorinated greenhouse gases with GWP of 2150 or more to service or maintain refrigeration equipment from the year 2015. In order to be consistent with this service ban, the placing on the market of new refrigeration equipment containing F-gases with GWP of 2150 or more should also be prohibited from the same year.

Amendment 47
Proposal for a regulation

ANNEX III – table – line 11 – part one		
Text proposed by the Commission		
11. Refrigerators and freezers for the storage, display or distribution of products in retail and food service ("commercial use") - hermetically sealed systems	that contain HFCs with GWP of ***2500*** or more	***1 January 2017***
Amendment		
11. Refrigerators and freezers for the storage, display or distribution of products in retail and food service ("commercial use") - hermetically sealed systems	that contain HFCs with GWP of ***2150*** or more	***1 January 2015***

Amendment 48
Proposal for a regulation

ANNEX III – table – line 11 – part two		
Text proposed by the Commission		
11. Refrigerators and freezers for the storage, display or distribution of products in retail and food service ("commercial use") - hermetically sealed systems	that contain HFCs ***with GWP of 150 or more***	***1 January 2020***
Amendment		
11. Refrigerators and freezers for the storage, display or distribution of products in retail and food service ("commercial use") - hermetically sealed systems	that contain HFCs	***1 January 2018***

7.6 Annex V – Definitions

Taken directly from EU legislation texts:

- *Energy-related product* : (a 'product'), means any good that has an impact on energy consumption during use which is placed on the market and/or put into service, and includes parts intended to be incorporated into energy-related products covered by Directive 2009/125/EC which are placed on the market and/or put into service as individual parts for end-users and of which the environmental performance can be assessed independently;
- *Components and sub-assemblies*: means parts intended to be incorporated into products which are not placed on the market and/or put into service as individual parts for end-users or the environmental performance of which cannot be assessed independently;
- *Implementing measure*: means measure adopted pursuant to a Directive laying down e.g. specific Ecodesign requirements for defined products or for environmental aspects thereof;
- *Placing on the market*: means making a product available for the first time on the Community market with a view to its distribution or use within the Community, whether for reward or free of charge and irrespective of the selling technique;
- *Putting into service*: means the first use of a product for its intended purpose by an end-user in the Community;
- *Manufacturer*: means the natural or legal person who manufactures products and is responsible for their conformity in view of their being placed on the market and/or put into service under the manufacturer's own name or trademark or for the manufacturer's own use. In the absence of a manufacturer or of an importer, any natural or legal person who places on the market and/or puts into service products shall be considered a manufacturer;
- *Importer*: means any natural or legal person established in the Community who places a product from a third country on the Community market in the course of his business;
- *Materials*: means all materials used during the life cycle of a product;
- *Product design*: means the set of processes that transform legal, technical, safety, functional, market or other requirements to be met by a product into the technical specification for that product;
- *Environmental aspect*: means an element or function of a product that can interact with the environment during its life cycle;
- *Environmental impact*: means any change to the environment wholly or partially resulting from a product during its life cycle;
- *Life cycle*: means the consecutive and interlinked stages of a product from raw material use to final disposal;
- *Reuse*: means any operation by which a product or its components, having reached the end of their first use, are used for the same purpose for which they were conceived, including the continued use of a product which is returned to a collection point, distributor, recycler or manufacturer, as well as reuse of a product following refurbishment;
- *Recycling*: means the reprocessing in a production process of waste materials for the original purpose or for other purposes but excluding energy recovery;

- *Energy recovery*: means the use of combustible waste as a means to generate energy through direct incineration with or without other waste but with recovery of the heat;
- *Recovery*: means any of the applicable operations provided for in Annex II B to Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste (1);
- *Waste*: means any substance or object in the categories set out in Annex I to Directive 2006/12/EC which the holder discards or intends, or is required, to discard;
- *Hazardous waste*: means any waste which is covered by Article 1(4) of Council Directive 91/689/EEC of 12 December 1991 on hazardous waste (2);
- *Environmental profile*: means a description, in accordance with the implementing measure applicable to the product, of the inputs and outputs (such as materials, emissions and waste) associated with a product throughout its life cycle which are significant from the point of view of its environmental impact and are expressed in physical quantities that can be measured;
- *Environmental performance* (of a product): means the results of the manufacturer's management of the environmental aspects of the product, as reflected in its technical documentation file;
- *Improvement of the environmental performance*: means the process of enhancing the environmental performance of a product over successive generations, although not necessarily in respect of all environmental aspects of the product simultaneously;
- *Ecodesign*: means the integration of environmental aspects into product design with the aim of improving the environmental performance of the product throughout its whole life cycle;
- *Ecodesign requirement*: means any requirement in relation to a product, or the design of a product, intended to improve its environmental performance, or any requirement for the supply of information with regard to the environmental aspects of a product;
- *Generic Ecodesign requirement*: means any Ecodesign requirement based on the ecological profile as a whole of a product without set limit values for particular environmental aspects;
- *Specific Ecodesign requirement*: means a quantified and measurable Ecodesign requirement relating to a particular environmental aspect of a product, such as energy consumption during use, calculated for a given unit of output performance;
- *Harmonised standard*: means a technical specification adopted by a recognised standards body under a mandate from the Commission, in accordance with the procedure laid down in Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations, for the purpose of establishing a European requirement, compliance with which is not compulsory.

- *Foodstuffs*: means food, ingredients, beverages, including wine, and other items primarily intended for consumption which require refrigeration at specified temperatures;
- *Household refrigerating appliance*: means an insulated cabinet, with one or more compartments, intended for refrigerating or freezing foodstuffs, or for the storage of refrigerated or frozen foodstuffs for non-professional purposes, cooled by one or more energy-consuming processes including appliances sold as building kits to be assembled by the end-user;
- *Commercial refrigeration appliance*: means an insulated cabinet, with one or more compartments, intended for refrigerating or freezing foodstuffs on display, for

professional purposes, but accessible to the end user, cooled by one or more energy-consuming processes including remote and plug-in appliances;

- *refrigerator*: means a refrigerating appliance intended for the preservation of foodstuffs with at least one compartment suitable for the storage of fresh food and/or beverages, including wine;
- *compression-type refrigerating appliance*: means a refrigerating appliance in which refrigeration is effected by means of a motor-driven compressor;
- absorption-type refrigerating appliance: means a refrigerating appliance in which refrigeration is effected by an absorption process using heat as the energy source;
- *refrigerator-freezer*: means a refrigerating appliance with at least one fresh-food storage compartment and at least one other compartment suitable for the freezing of fresh food and the storage of frozen foodstuffs under three-star storage conditions (the food-freezer compartment);
- *frozen-food storage cabinet*: means a refrigerating appliance with one or more compartments suitable for the storage of frozen foodstuffs;
- *food freezer*: means a refrigerating appliance with one or more compartments suitable for freezing foodstuffs with temperatures ranging from ambient temperature down to –18 °C, and which is also suitable for the storage of frozen foodstuffs under three-star storage conditions; a food freezer may also include two-star sections and/or compartments within the compartment or cabinet;
- *wine storage appliance*: means a refrigerating appliance that has no compartment other than one or more wine storage compartments;
- *multi-use appliance*: means a refrigerating appliance that has no compartment other than one or more multi-use compartments;
- *equivalent refrigerating appliance*: means a model placed on the market with the same gross and storage volumes, same technical, efficiency and performance characteristics, and same compartment types as another refrigerating appliance model placed on the market under a different commercial code number by the same manufacturer.
- *other-type refrigerating appliances*: means a refrigerating appliance in which refrigeration is effected by any other technology or process than compression or absorption-types;
- *frost-free system*: means a system automatically operated to prevent the permanent formation of frost, where cooling is provided by forced air circulation, the evaporator or evaporators are defrosted by an automatic defrost system, and the water from defrosting is disposed of automatically;
- *frost-free compartment*: means any compartment defrosted by a frost-free system;
- *built-in appliance*: means a fixed refrigerating appliance intended to be installed in a cabinet, in a prepared recess in a wall or similar location, and requiring furniture finishing;
- *refrigerator-cellar*: means a refrigerating appliance where at least one fresh-food storage compartment and one cellar compartment, but no frozen-food storage, chill or ice making compartments, are present;
- *cellar*: means a refrigerating appliance where only one or more cellar compartments are present;
- *refrigerator-chiller*: means a refrigerating appliance where at least a fresh-food storage compartment and a chill compartment, but no frozen-food storage compartments, are present;
- *compartments*: means any of the compartments listed in points below:

  - fresh-food storage compartment: means a compartment designed for the storage of unfrozen foodstuffs, which may itself be divided into sub-compartments;
  - cellar compartment: means a compartment intended for the storage of particular foodstuffs or beverages at a temperature warmer than that of a fresh-food storage compartment;
  - chill compartment: means a compartment intended specifically for the storage of highly perishable foodstuffs;
  - ice-making compartment: means a low-temperature compartment intended specifically for the freezing and storage of ice;
  - frozen-food storage compartment means a low-temperature compartment intended specifically for the storage of frozen foodstuffs and classified according to temperature as follows:
    - ‘one-star compartment’: a frozen-food storage compartment in which the temperature is not warmer than – 6 °C;
    - ‘two-star compartment’: a frozen-food storage compartment in which the temperature is not warmer than – 12 °C;
    - -‘three-star compartment’: a frozen-food storage compartment in which the temperature is not warmer than – 18 °C;
    - -‘food freezer compartment’ (or ‘four-star compartment’): a compartment suitable for freezing at least 4,5 kg of foodstuffs per 100 l of storage volume, and in no case less than 2 kg, from ambient temperature down to – 18 °C over a period of 24 hours, which is also suitable for the storage of frozen food under three-star storage conditions, and may include two-star sections within the compartment;
    - -‘0-star compartment’: a frozen-food storage compartment in which the temperature is < 0 °C and which can also be used for the freezing and storage of ice but is not intended for the storage of highly perishable foodstuffs;
  - wine storage compartment: means a compartment exclusively designed either for short-term wine storage to bring wines to the ideal drinking temperature or for long-term wine storage to allow wine to mature, with the following features:
    - continuous storage temperature, either pre-set or set manually according to the manufacturer’s instructions, in the range from + 5 °C to + 20 °C;
    - storage temperature(s) within a variation over time of less than 0,5 K at each declared ambient temperature specified by the climate class for refrigerating appliances;
    - active or passive control of the compartment humidity in the range from 50 % to 80 %;
    - constructed to reduce the transmission of vibration to the compartment, whether from the refrigerator compressor or from any external source;
- *multi-use compartment*: means a compartment intended for use at two or more of the temperatures of the compartment types and capable of being set by the end-user to continuously maintain the operating temperature range applicable to each compartment type according to the manufacturer’s instructions; however, where a feature can shift temperatures in a compartment to a different operating temperature range for a period of limited duration only (such as a fast-freeze facility) the compartment is not a ‘multi-use compartment’ as defined here;

- *other compartment*: means a compartment, other than a wine storage compartment, intended for the storage of particular foodstuffs at a temperature warmer than + 14 °C;
- *two-star section*: means part of a food-freezer, a food-freezer compartment, a three-star compartment or a three-star frozen-food storage cabinet which does not have its own individual access door or lid and in which the temperature is not warmer than – 12 °C;
- *chest freezer*: means a freezer in which the compartment(s) is accessible from the top of the appliance or which has both top-opening type and upright type compartments but where the gross volume of the top-opening type compartment(s) exceeds 75 % of the total gross volume of the appliance;
- *top-opening type or chest type*: means a refrigerating appliance with its compartment(s) accessible from the top of the appliance;
- *upright type*: means a refrigerating appliance with its compartment(s) accessible from the front of the appliance;
- *fast freeze*: means a reversible feature to be activated by the end-user according to the manufacturer's instructions, which decreases the storage temperature of the freezer or freezer compartment to achieve a faster freezing of unfrozen foodstuffs.

- *Authorised representative*: means any natural or legal person established in the Community who has received a written mandate from the manufacturer to perform on his behalf all or part of the obligations and formalities connected with e.g. a Directive;

8 REFERENCES

1. Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of of Ecodesign requirements for energy-related products.
2. Communication from the Commission, Action Plan for Energy Efficiency: Realising the Potential**,** COM(2006)454
3. Preparatory Studies for Eco-design requirements of EuPs (TREN/D1/40-2005/LOT12/S07.56644), Lot 12, Commercial refrigerators and freezers, Final Report, 2007, BIO Intelligence Service.
4. An energy-related product (ErP), or a group of ErPs, shall be covered by Ecodesign implementing measures, or by self-regulation (cf. Criteria in Article 17), if the ErP represents significant sales volumes, while having a significant environmental impact and significant improvement potential (Article 15). The structure and content of an Ecodesign implementing measure shall follow the provisions of the Ecodesign Directive (Annex VII). Article 16 provides the legal basis for the Commission to adopt implementing measures on this product category. Consultation of stakeholders is based on the Ecodesign Consultation Forum as foreseen in Article 18 of the Directive (see next section for details). Article 19 of the Directive 2009/125/EC foresees a regulatory procedure with scrutiny for the adoption of implementing measures. Subject to qualified majority support in the regulatory committee and after scrutiny of the European Parliament, the adoption of the measure by the Commission can take place.
5. Impact Assessment accompanying the Proposal for a Commission Regulation implementing Directive 2009/125/EC with regard to Ecodesign requirements for ENER Lot 12: Commercial Cold Appliances (ENER/D3/92-2007, Final report, 2010, Wuppertal Institute.
6. Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products (recast).
7. http://susproc.jrc.ec.europa.eu/comrefrig/index.html
8. Methodology for the Ecodesign of Energy-related Products (MEErP), developed as an update of MEEuP. MEEuP is a methodology developed for the Commission's Directorate General for Enterprise and Industry (DG ENTR) in 2005 to allow evaluating whether and to which extent various energy-using products fulfil criteria of the Ecodesign Directive that make them eligible for implementing measures. MEErP has been endorsed by stakeholders and is used by all Ecodesign preparatory studies. www.meerp.eu
9. Professional refrigeration products are found in food retail outlets such as supermarkets, groceries and butcheries, restaurants, hotels, pubs, cafés, industrial facilities and professional kitchens (e.g. schools, hospitals, canteens etc.). Professional refrigeration products are primarily used for compliance with hygiene rules related to food safety (HACCP). Professional users often perceive these refrigeration equipments as a necessary investment due to hygiene constraints, but with no great added value for their "core business" (i.e. cooking).
10. Commission Regulation (EC) No 643/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to Ecodesign requirements for household refrigerating appliances.
11. A 'household refrigerating appliance' is defined in 643/2009/EC as 'an insulated cabinet, with one or more compartments, intended for refrigerating or freezing foodstuffs, or for the storage of refrigerated or frozen foodstuffs for non-professional

purposes, cooled by one or more energy-consuming processes including appliances sold as building kits to be assembled by the end-user'.
12. Commission Delegated Regulation (EU) No 1060/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household refrigerating appliances.
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