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# Ecodesign for Commercial Refrigeration

TECHNICAL PROPOSALS  
(Draft) Background Document  
Version 2, November 2013

European Commission  
Joint Research Centre  
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## Acronyms and abbreviations

ATEX	ATmosphères EXPlosives
B2B	Business to Business
BAT	Best Available Technique
BAU	Business As Usual
BC	Beverage Cooler
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	Direktorate General
DTI	Danish Technological Institute
EC fans	Electronically Commutated fans
ECA	Enhanced Capital Allowance
ED	Ecodesign Directive
EEE	Electrical and Electronic Equipment
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	HydroFluoroCarbon
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	Minimum Energy Performance Standard
ODP	Ozone Depleting Potential
PED	Pressure Equipment Directive
PRODCOM	PRODUCTION COMmunautaire (Community Production)
RAC	Refrigeration and Air Conditioning
RDC	Refrigerated Display Cabinet
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
UNEP	United Nations Environmental Programme
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<sup>1</sup> 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<sup>2</sup>.

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 (so-called *Lot 12* in the distribution of Ecodesign product groups by lots made by DG Energy and DG Enterprise) prepared in 2006-2007 by BIO Intelligence Service<sup>3</sup> (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 in 2010<sup>3,5</sup> 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<sup>3</sup> 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<sup>4</sup>.

Furthermore, commercial refrigeration appliances are deemed eligible for energy labelling requirements of Directive 2010/30/EU<sup>6</sup> 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<sup>5</sup> 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

After a period of latency, since 2012 the Ecodesign project on commercial refrigeration is being continued by DG Energy, 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, is being 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<sup>7</sup>, 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 was held on 23 April 2013, the second will take place on 10 December in Brussels. Complementarily, three questionnaires have been distributed to the TWG especially addressing data gaps and general information update, scope and definition, and energy consumption.

### 1.2.2 This report

This document is prepared to serve as input for the second workshop of the Technical Working Group, to be held 10 December 2013 in Brussels.

The objective of this second background document is to:

- Building on the 1<sup>st</sup> background document, structure and update the status of knowledge so far collected in connection with the preparatory and impact assessment work undertaken in 2006-2010.
- Present the collected data on the areas where additional and complementary data collection and update was judged necessary. The work has built on existing knowledge for this product group as far as possible, not necessarily created in connection with the earlier project history.
- Compared to the 1<sup>st</sup> background document, the following subjects have been considerably developed in this second document:
  - Energy consumption data and reference equations, as basic reference for the development of minimum energy performance standards (MEPS) on energy efficiency, if needed together with energy labelling;
  - Collection of sample assessments from the retail sector, not sufficiently represented in earlier phases of the project;
  - Refinement of the assessment of end-of-life (EoL) practice, supporting potential future proposals for MEPS on this issue.

### 1.3 Structure of this document

The structure of this document is similar to the 1<sup>st</sup> background document, consolidating the existing chapters on:

- Scope and definition;
- Legislation and standards;
- Markets;
- Technologies, design and use (including refrigerants).

New chapters have been developed on the issues that are likely to be further developed into MEPS/Ecodesign requirements, namely:

- Energy consumption reference values (energy efficiency, energy labelling);
- End of life (EoL).

For conciseness, this report focuses on key information for the discussions to be held on 10 December 2013. Additional background and supplementary information is presented in the Annexes.

This document does not reiterate valid information from the two major studies undertaken in the 2006-2010 phase (preparatory study by BIO IS<sup>3</sup> and Impact Assessment by the Wuppertal Institute<sup>5</sup>). It complements these studies, updates the data where necessary, and brings the underlying technical data closer to technical proposals that can underpin a later debate on MEPS.

As one of the objectives of this report is to help structure the discussions of the second workshop of the Technical Working Group (10 December 2013), each of the chapters includes one or more question boxes, identifying and summarising the key open points where input from the TWG will be needed as follows.

#### **Q.0) REMAINING QUESTION**

##### **Question(s)/Issue(s) which still need to be debated and/or refined with the TWG**

These issues will be debated on 10 December 2013, and experts are invited to submit written comments to them no later than **20 January 2014**.

Experts not able to come to the meeting are also welcome to provide written comments to the document.

The email address for submission of comments is:

[JRC-IPTS-COMREFRIG@EC.EUROPA.EU](mailto:JRC-IPTS-COMREFRIG@EC.EUROPA.EU)

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## 2 SCOPE DEFINITION AND TERMINOLOGY

Commercial refrigerated cabinets are considered as energy related products within the meaning of Article 2 (1) of Directive 2009/125/EC<sup>1</sup>. The definitions 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, including:

1. Input from the BIO IS study<sup>3</sup>,
2. Impact assessment by the Wuppertal Institute<sup>5</sup>,
3. Questionnaires distributed in December 2012 and June 2013.

The definitions have been adjusted to streamline with:

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

The following definitions and scope are proposed.

### 2.1 Definitions

Commercial refrigerated cabinets are considered as energy related products within the meaning of Article 2 (1) of Directive 2009/125/EC<sup>1</sup>.

**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<sup>b</sup>, and are accessible directly through open sides or via one or more doors, and/or drawers.

**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.

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

#### 2.1.1 Examples

Commercial refrigeration equipment can take many forms and combinations:

- ‘self-contained (or plug-in or integral) appliance’ means a factory made assembly of refrigerating components that are an integral part of the refrigerated equipment and consists<sup>c</sup> 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 (above 0°C) or for frozen (below 0°C) products;

<sup>a</sup> [http://www.taitconsulting.co.uk/Ecodesign\\_Consultation.html](http://www.taitconsulting.co.uk/Ecodesign_Consultation.html)

<sup>b</sup> Typically food and drinks, but also other goods like flowers, live bait, etc. where refrigeration is used to extend the lifetime.

<sup>c</sup> for refrigeration based on the use of refrigerant fluids

- 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).

An overview of different cabinet categories is presented in Table 1. The classification according to the ISO 23953 standard can be found in section 8.9.

**Table 1 Taxonomy of cabinet categories<sup>d</sup>**

Condensing unit	Operating temperature	Orientation / shape	Closure
Plug-in	Chilled	Under-counter	Open
		Pass-through	
	Frozen	Island	Glass door
		Wall site	Solid door
		Vertical	
		Chest	Drawer
		Horizontal	
		Semi-vertical	Combination
		Multi-deck	
		Combined	
Remote	Multi-temperature Ice cream	Serve-over	
		Roll-in	

At a later stage in this project, minimum energy performance standards (MEPS) will be proposed by the European Commission. The 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 is to only take the cabinet into account 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. The need for *e.g.* a retailer to also look at the enveloping system shall not hinder the development of more efficient cabinets.

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<sup>3</sup> and the Impact Assessment calculations<sup>5</sup>:

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<sup>d</sup> Adapted from SEAD report<sup>25</sup>



**Figure 1** Open vertical multi-deck remote refrigerating display cabinet for chilled products (category RVC2 according to EN ISO 23953), with 7 m<sup>2</sup> 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 island for frozen products (category RHF4 according to EN ISO 23953), with 7 m<sup>2</sup> TDA, operating in temperature class L1 (-18°C to -15°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 (1°C to 10°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 (-18°C to -15°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.

Please note that some of the specifications considered standard practice when these product examples were proposed (2006) may currently (2013) be obsolete, *e.g.* the use of HFC as refrigerants instead of HCs, or the proposal of open cabinets instead of closed cabinets.

It should also 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 shall in principle be covered by a regulation on commercial refrigeration. Figure 6 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.<sup>10</sup> In addition, household refrigerators are subject to energy labelling following Commission Delegated Regulation (EU) No 1060/2010.<sup>12</sup>

### 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 and non-household refrigerating equipment for storage purposes without any display or merchandising function are not included in Lot 12. These are currently subject of analysis for an Ecodesign Regulation as ENTR Lot 1 (professional refrigeration)<sup>e</sup>.

Commercial refrigerators are found in areas where customers have visual contact with the products and normally<sup>f</sup> have access (supermarket segment, bottle coolers, refrigerated salad bars, self-service buffet vitrines, etc.). Professional refrigeration appliances are found in areas where customers neither have visual contact nor direct access, such as back shops, below or behind counters, or professional kitchens. The devices are intended exclusively for professional use<sup>g</sup>.

For a number of product groups it is contentious if they are to be covered by this implementing measure (Lot 12) or not. Figure 1 illustrates the scope and boundaries of the different refrigeration cabinets.

<sup>e</sup> [http://www.taitconsulting.co.uk/Ecodesign\\_Consultation.html](http://www.taitconsulting.co.uk/Ecodesign_Consultation.html)

<sup>f</sup> A bottle cooler behind a counter is a commercial refrigeration appliance, located for display, but without access by the end-user.

<sup>g</sup> 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).

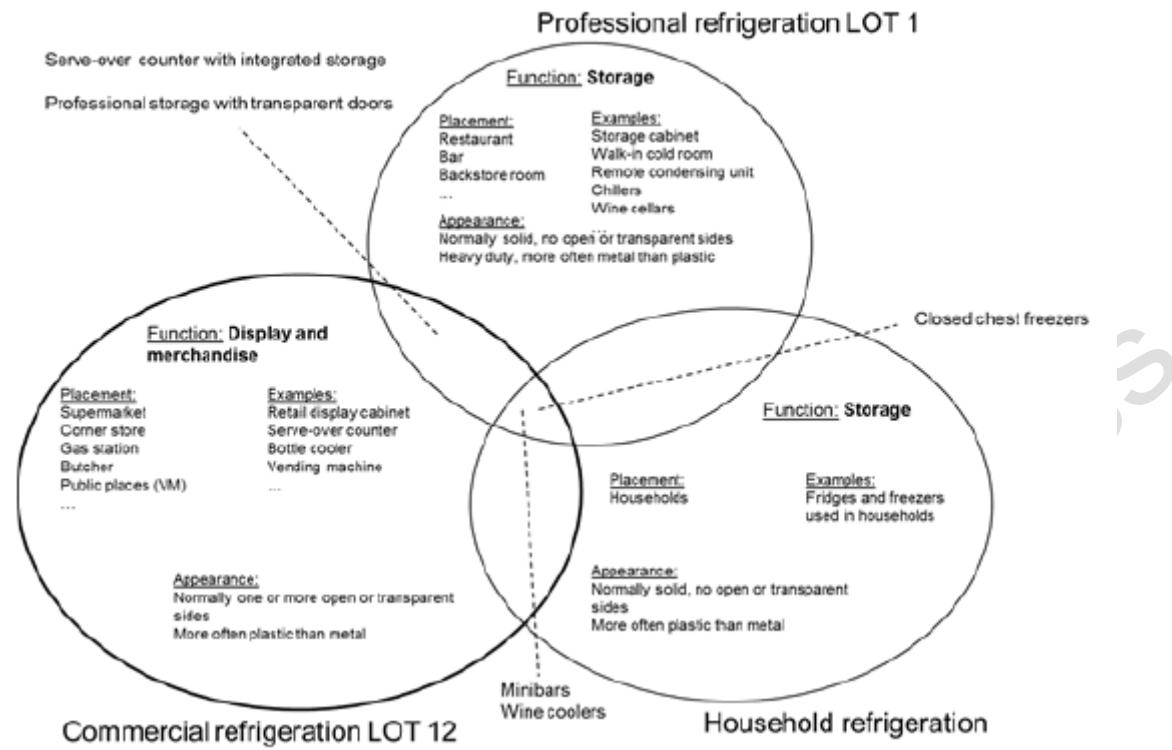


Figure 6 Scope and boundaries of the different refrigeration cabinet types.

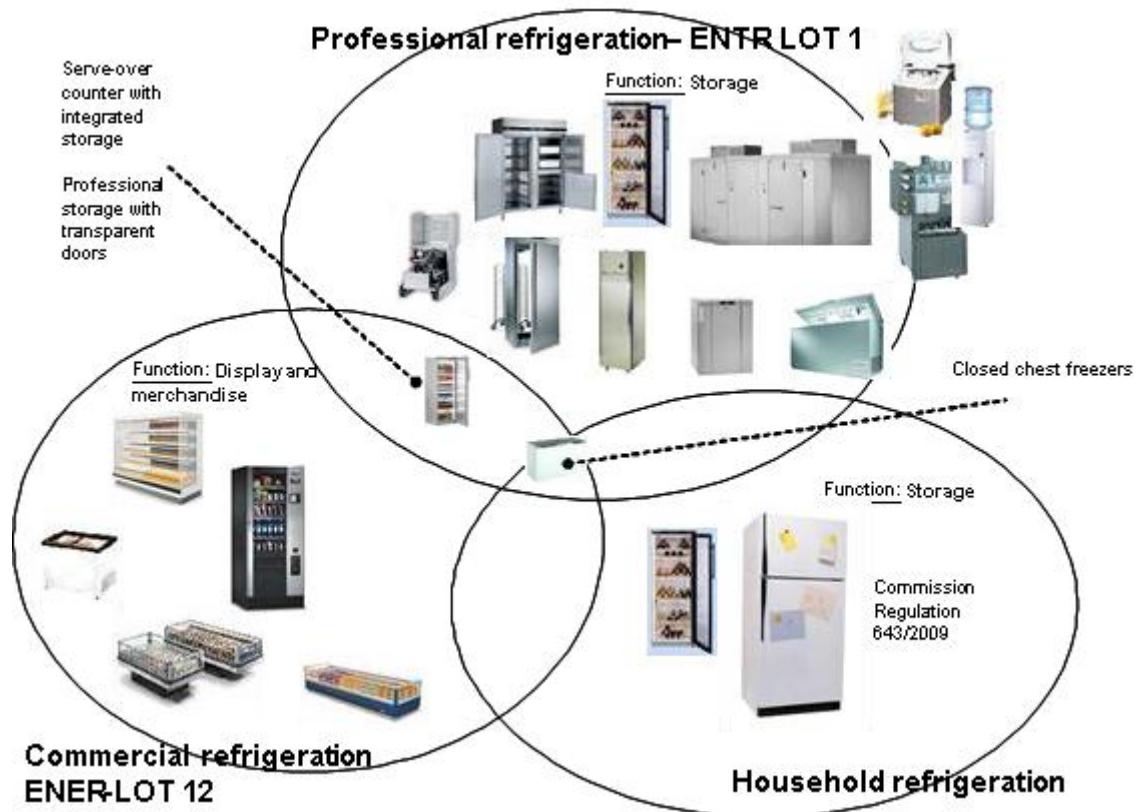


Figure 7 Image examples of the different refrigeration cabinets.

## 2.2.1 Appliances included and excluded

This section explains in detail the rationale for exclusion or inclusion of the different product groups. Two tables are additionally presented to give an overview of which product groups are included or excluded from the scope of this preparatory study.

The following general criteria have been used for the exclusion of certain product groups:

A product group is **excluded** from the update of the preparatory study if:

- The appliances are used for storage, and not for the additional functions of display and sales as described in the definition;
- The appliances include additional functions not specified in the definition, such as food processing. Examples of these are ice-cream makers, ice makers, or microwave-equipped vending machines;
- Substantial absence of data;
- A very low volume of production and share of the market.

**Table 2 Products included in the scope of Lot 12 Commercial Refrigeration together with the rationale and energy consumption method.**

	<b>INCLUDED in the scope</b>	<b>Reason</b>	<b>Energy consumption measurement method</b>
i.1.	Refrigerated retail display cabinets for the sale and display of foodstuffs, mostly supermarket segment (vertical, horizontal, semi-vertical, with or without doors, with or without drawers, etc.)	General application of Commercial Refrigeration, clearly for sale and display	EN ISO 23953:2005 + A1:2012
i.2.	Refrigerated retail display cabinets for the sale and display of other goods than foodstuffs ( <i>e.g.</i> flowers, live bait).	Small niche of Commercial Refrigeration, but similar in shape and function to those used for foodstuff and are categorised following EN ISO 23953:2005+ A1:2012	EN ISO 23953:2005 + A1:2012
i.3.	Serve-over counters	General application of Commercial Refrigeration, clearly for sale and display	EN ISO 23953:2005 + A1:2012

i.4.	Serve-over counter with integrated storage	Mix of Commercial Refrigeration and Professional Refrigeration, but the primary function is Commercial Refrigeration	EN ISO 23953:2005 + A1:2012. The refrigeration system cools the integrated storage compartment but this storage volume is not included in the TDA calculation. A methodology to include the storage volume could theoretically be developed (and included in EN23953).
i.5.	Beverage coolers (both transparent and solid doors).	General application of Commercial Refrigeration, clearly for sale and display	A number of B2B methods coexist, developed by food/beverage companies. Could be measured by EN ISO 23953:2005 + A1:2012.
i.6.	Refrigerated vending machines (cans and beverages, snacks, food)	General application of Commercial Refrigeration	EVA-EMP 3.0a, if confirmed by CENELEC (in preparation)
i.7.	<i>Gelato</i> ice cream freezers, scooping cabinets.	General application of Commercial Refrigeration, but very small market niche. The specific working temperature (-10°C) classifies it in the ISO23953 special temperature class S. Subtle technical differences compared to display cabinets.	Not defined. A new working group (N 5) for 'Refrigerated display cabinets for artisan self-made gelato' is established in CEN/TC 44. A specific testing procedure is under preparation at CEN/TC 44 with a first meeting scheduled in December 2013.

i.8.	Ice-cream freezers (open or closed). These ice-cream freezers can be installed in the retail sector or used on streets, beaches, etc.	General application of Commercial Refrigeration	EN ISO 23953:2005 + A1:2012
i.9.	Self-service counters (e.g. salad/dessert bars) in canteens and restaurants	Products are for sale and display	EN ISO 23953:2005 + A1:2012

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**Table 3 Products excluded in the scope of Lot 12 Commercial Refrigeration together with the rationale and energy consumption method.**

	<b>EXCLUDED from the scope</b>	<b>Reason</b>	<b>Energy consumption measurement method</b>
e.1.	Refrigerated retail display cabinets for the sale and display of goods which are non-foodstuffs (flowers, live bait, etc.) and are <b>not similar</b> in shape and function to the types used for foodstuffs described in EN ISO 23953.	They are normally tailored to the specific use, making the development of harmonised measurement methods very difficult. The market of these products is marginal.	None
e.2.	Refrigerated retail display cabinets for the sale and display of live foodstuff <i>e.g.</i> fish and shellfish refrigerated aquaria and water tanks, displayed at restaurants and some supermarkets.	The market of these products is marginal. They are normally tailored to the specific use, making the development of harmonised measurement methods very difficult.	None
e.3.	Domestic chest freezers used for commercial appliances	Covered by the Household Refrigeration regulation. Similar products under Lot 1 (professional closed chest freezers) are to be subject to same energy requirements and energy label as domestic chest freezers.	c.f. Household Refrigeration regulation
e.4.	Walk-in cold rooms	Should be treated under Lot 1	

		Professional Refrigeration	
e.5.	Water dispensers	Different technical specifications. Usually designed to chill and keep cool 1-5 litres of water.	None
e.6.	Ice makers	Different technical specifications and function (food/drink processing element)	None
e.7.	Ice-cream makers	Different technical specifications and function (food processing element)	None
e.8.	Minibars for household use	If for domestic use, these fall under the Household Refrigeration Regulation.	The requirements are defined in the household Regulation.
e.9.	Wine coolers for domestic use	If for domestic use, these fall under the Household Refrigeration.	Labelling regulation already applies. DG Energy will soon launch preparatory work for Ecodesign requirements.
e.10.	Wine coolers for commercial use	Although for commercial use, the products are usually not displayed for sale, rather stored. They are not regulated at the moment, but could be included in the Regulation for Lot 1 or the Household Refrigeration Regulation.	The measurement can be the same as wine coolers for domestic use, and be part of forthcoming Ecodesign preparatory work.

e.11.	Professional service cabinets	Will stay under Lot 1, given the difference in technical details and the difference in operation and performance.	See Lot 1 standard development
e.12.	Storage for medicines and scientific research	These are usually not intended for the storage, display and sale of products and usually have solid doors.	None
e.13.	Ice-cream freezers on vehicles ( <i>e.g.</i> motorbikes, vans)	They are normally tailored to the specific use, making the development of harmonised measurement methods very difficult. The market of these products is marginal.	None
e.14.	Vending machines with combined heating and cooling parts, or food preparation	General application of Commercial Refrigeration, but with food processing element. Different technical specifications.	EVA-EMP to be confirmed by CENELEC (under preparation)
e.15.	Commercial minibars (used extensively in hotels)	If for domestic use, these fall under the Household Refrigeration regulation. No Regulation at the moment for commercial minibars.	Test method should be the same as for domestic minibars, thus using the household test method.
e.16.	Niche applications like <i>e.g.</i> Café Zero small open cabinets	Products are for sale and display, specific working temperature of -	EN ISO 23953:2005 + A1:2012, temperature class S

		7°C. Can be horizontal or vertical.	
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**Q.1) REMAINING QUESTIONS**

**Should you disagree with the proposals on scope and definitions above, please provide at the workshop 10 December 2013 or in written form by 20 January 2014 your alternative proposal, duly supported by data and evidence.**

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### 3 LEGISLATION AND STANDARDS/CERTIFICATION

In the BIO IS study<sup>3</sup>, 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 have been re-analysed:

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

Rapid uptake of alternative refrigerants such as hydrocarbons and CO<sub>2</sub> were triggered by the first F-gas regulation (EC/842/2006)<sup>16</sup>, at the moment under revision and under a triologue between the European Commission, the European Parliament and the European Council<sup>17,18</sup>. Changing to alternative refrigerants brings to the forefront safety issues that were not that determinant in the use of CFCs and HFCs, with associated standards and legislation related to flammability and high pressure equipment. Specific national (intra- and extra-EU) legislation is listed in Annex 8.1.

Moreover, the presentation of end-of-life legislation in the BIO IS study<sup>3</sup> 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<sup>13</sup> and the Waste Shipment Regulation<sup>14</sup> 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 printed circuits boards or batteries.

The existing EU legislation related to refrigeration can basically be categorised in three groups (see Table 4): 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 pressure equipment is particularly important for refrigeration systems using CO<sub>2</sub> as refrigerant, which operate at significantly higher pressures (~ 100 bar) than other refrigerants (5-15 bar).

**Table 4 Relevant EU legislation related to commercial refrigeration**

Domain/Scope	LEGISLATION
<i>Environment</i>	
Entire product	Waste Electrical and Electronic Equipment Directive 2012/19/EU (WEEE) Restriction of the use of certain Hazardous Substances in electric and electronic equipment Directive 2011/65/EC (RoHS)
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

<i>Energy</i>	
Lighting	Energy efficiency requirements for ballasts for fluorescent lighting- Directive 2000/55/EC
Fans	Ecodesign requirements for fans driven by motors with an electric input power between 125 W and 500 kW, Commission regulation (EU) No 327/2011
Electric motors	Ecodesign requirements for electric motors, Commission Regulation (EC) No 640/2009
<i>Safety</i>	
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

### 3.1 Refrigerants

When refrigerants are released into the environment, they have an environmental impact, mainly as contributions to global warming and/or ozone-depletion. The magnitude of the impact varies largely from substance to substance, and is characterised by the global warming potential GWP and ozone depletion 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 (storage, charge, use, disposal) in accordance with Regulation (EC) No 1005/2009 on substances that deplete the ozone layer<sup>19</sup>. 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<sup>16</sup> and the MAC Directive<sup>20</sup>.

The F-gas Regulation (EC/842/2006) prescribes the labelling of fluorinated gases. The appliances containing them shall have a label clearly indicating “*that the product or equipment contains fluorinated greenhouse gases covered by the Kyoto Protocol and their quantity, and this shall be clearly and indelibly stated on the product or equipment, adjacent to the service points for charging or recovering the fluorinated greenhouse gas*”.

If F-gases are present, Regulation (EC) No 1494/2007 on additional labels for F-gases stipulates that appliances shall be marked with a label containing the following the text: ‘*Contains fluorinated greenhouse gases covered by the Kyoto Protocol*’; the abbreviated chemical names for the fluorinated greenhouse gases contained; the quantity of the fluorinated greenhouse gases, the text ‘*hermetically sealed*’ (where applicable).

In parallel, Article 4 of the 2006 F-gas regulation<sup>16</sup> also imposes a proper recovery of the gases. This regulation is currently being updated and under discussion in a triologue between the European Commission, the European Parliament and the European Council<sup>17,18</sup>. The Regulation covers horizontally a wide range of sectors, and will probably not target specific sectors like commercial refrigeration. 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 encourage refrigerant substitution to lower GWP refrigerants, such as hydrocarbons, ammonia or CO<sub>2</sub>. Notwithstanding this, the life-cycle assessment part of the BIO IS study<sup>3</sup> clearly highlights that the main environmental gains (in terms of GWP over the life cycle) of refrigerant substitution are not related to the GWP of any leaked gas<sup>h</sup>, but to better heat exchange properties and refrigeration performance of some of the non-HFC refrigerants, compared to HFCs.

In addition to the above, the WEEE Directive<sup>13</sup> contains also 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.*"

## 3.2 Safety

One of the main Directives to take in to account regarding safety 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 equipped 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. It should be noticed however that in the US the ATEX equipment Directive is not applicable. Under the UNECE/IECEx<sup>i</sup> programme,

<sup>h</sup> In a comparison of two or more refrigerants, leaks of HFCs, including a potential release of all the gas at dismantling, account for <5% of total TEWI differences in the life cycle of these appliances. The remaining TEWI are related to the energy use during the appliance's use phase.

<sup>i</sup> United Nations Economic Commission for Europe/IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres.

a process exists to develop international harmonisation of ‘explosive atmosphere’ legislation and standards.

Regarding flammability and toxicity, ISO 5149 applies. However, ISO 5149 is not that relevant and useful for the products under study. The most important standard is EN 378 which is harmonized with the European Pressure Equipment Directive.

EN 378 is a horizontal standard and governs the selection of refrigerant fluids and permitted charge sizes for given applications (in terms of the occupancy classification) and prescribes criteria for equipment design, construction/installation, and maintenance. If EN378 is applied, all safety requirements are expectedly met.

If the charge of a flammable refrigerant exceeds 150g in an appliance, usually a risk assessment is carried out following EN 1127. Note that the 150g value is not a legislative limit. Some stakeholders<sup>j</sup> argue that it is an arbitrary value that was originally placed in the EN 60335-2-24 standard for domestic fridges to limit the scope of the standard; and then spread to many others. It was a value chosen because it represented the upper boundary for the needs of the European domestic refrigeration industry. In EN 60335-2-24 and EN 60335-2-89, it says that these standard(s) only applies to systems that use up to 150g in a single circuit. Thus, for systems that use more than 150g (per circuit) one should refer to EN 378. EN 378 gives an (also arbitrary) limit of 1.5kg of HC for refrigeration systems in public spaces (2.5kg in non-public spaces), provided that room size is accounted for. These limits/values are voluntary and not mandated by EU legislation; they are merely a guideline that is followed by industry. If one only applies ATEX, there are no charge limits. It is only required that judgement is made in order to ensure that the level of risk is of an acceptable level.

Technically, there is no problem to produce safe appliances. Cost barriers, however, could play an important role.

For CO<sub>2</sub> using appliances, the pressure in the cooling system can exceed 100 bar. Thus, CO<sub>2</sub> systems are subject to additional reporting and safety assessments according to the Pressure Equipment Directive (PED)<sup>21</sup>. The EN 378 standard supports the essential requirements of the PED (and the Machinery Directive) prescribing strict conditions. For plug-in cabinets, IEC 60335-2-89 requires a pressure relief device. However, there seem to be different interpretations by 3<sup>rd</sup> parties as far as the meaning of this device is concerned.

According to a TNO study<sup>22,23</sup> based on laboratory tests on bottle coolers, these strict conditions are not necessary for CO<sub>2</sub> refrigeration plug-in appliances. The tests reveal that the weakest points of the refrigeration system are weldings, not components, and in case of failure the release of CO<sub>2</sub> would take place in the weak points, without explosion. One consequence is that overdimensioning may be a current concern in CO<sub>2</sub> equipment, due to duplication and not coordination of safety measures (temperature relay compressor, vent for higher pressure, and thickness of tubing).

Apart from mandatory technical requirements, there are also labelling obligations related to safety in the use of refrigerants. The pressure equipment Directive 97/23/EC prescribes the provision of the following information for pressure refrigerants (with a maximum allowable

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<sup>j</sup> Colbourne, D., personal communication (2013)

pressure greater than 0.5 bar): identification of the pressure equipment according to its nature, such as type, series or batch identification and serial number.

In addition, depending on the type of pressure equipment, further information should be provided, including, among the other, the safety device set pressure (in bar). The required information must be given on the pressure equipment or on a data plate firmly attached to it.

### **3.3 EoL and waste**

Under the previous WEEE Directive (2006), vending machines were the only type of commercial refrigeration appliances explicitly covered by its scope, specifically in category 10 “Automatic dispensers”. After the recent recast of the WEEE Directive (2012/19/EU), the inclusion of all commercial refrigeration appliances is foreseen, with an adaptation time until 15 August of 2018. Until then, it is still up to the competent authorities in member states (MS) to interpret whether commercial refrigeration appliances other than vending machines are part of the scope of the WEEE Directive or not. Nevertheless, commercial appliances are more likely to be classified within the scope if they are small sized, and resemble household appliances, under ‘category 1’ “Large household appliances”<sup>47</sup>.

All commercial refrigeration appliances are under the scope of the RoHS Directive<sup>57</sup> regarding the restriction of the use of certain hazardous substances in WEEE<sup>48</sup>.

Regarding refrigerant gases and some foam gases, CFC-11, CFC-12, HCFC-22, and HCFC-141b are not permitted anymore since they deplete the ozone layer<sup>74</sup>. The use of some fluorinated greenhouse gases has been also restricted by the EU Regulation<sup>k</sup><sup>70</sup>. However there are still gases, currently used as refrigerants or foaming agents in commercial refrigeration appliances, which have high Global Warming Potential (GWP) such as R-404A and R-507 with a GWP of 3,260 kg<sub>CO2eq</sub>/ kg and 3,300 kg<sub>CO2 eq</sub>/kg respectively<sup>71</sup>. According to the WEEE Directive gases with a GWP factor higher than 15 kg<sub>CO2eq</sub>/kg have to be extracted from the refrigeration appliance and properly treated.

According to the Waste Shipment Regulation (WSR)<sup>72</sup>, waste of electrical and electronic equipment or scrap (and therefore potential waste of commercial refrigeration appliances) containing, batteries or accumulators including mercury switches, and polychlorinated biphenyls-capacitors or contaminated with hazardous substances (e.g. cadmium, mercury, lead, polychlorinated biphenyls) (see Annex V of WSR) cannot be exported to countries in which OECD decision on transboundary movement of waste for recycling<sup>53</sup> does not apply.

### **3.4 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-comparison of these standards is complex, as often neither the same metrics nor measurement standards are used. A comprehensive overview of the different test standards is provided in a

<sup>k</sup> Such Regulation claims for the recycling or destruction of the fluorinated greenhouse gases before the final disposal of the equipment.

recent study by Refrigeration Developments and Testing Ltd.<sup>24</sup>, and test methodologies are compared in a study launched by CLASP<sup>25</sup>.

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 Certification<sup>1</sup>, 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. This energy label was created in order to better rank the products on the market.

For vending machines, one of the operational key test standards is ASHRAE 32.1, which underpins minimum efficiency performance standards (MEPS) (incl. proposed) and/or labelling in USA, California and Canada. For Australia, AS/NZS 4864.2:2008 is the key test standard. In Europe, manufacturers and importers may voluntary use the European Vending Association's Energy Measurement Protocol (EVA-EMP). This protocol is currently under revision by CENELEC. Comparison of the energy performance of vending machines measured under EVA-EMP or ASHRAE 32.1 is possible after normalisation.<sup>26</sup> The EVA protocol also provides a voluntary energy labelling scheme.

For vending machines, it is worth mentioning the Japanese Top Runner programme. This programme is intended to improve energy efficiency of end-use products and to develop 'world's most energy-efficient products'. By 2009, the program had achieved mandatory energy efficiency standards for 21 products, including vending machines.<sup>m</sup>

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

### **3.5 Standards and certification**

Also different test standards are available, relating to energy use, testing and safety. The most relevant standards are listed in Table 5.

**Table 5 Relevant standards for Lot 12 products**

TYPE	STANDARD
<b>International Standards</b>	
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

<sup>1</sup> <http://www.eurovent-certification.com/>

<sup>m</sup> [http://www.eccj.or.jp/top\\_runner/](http://www.eccj.or.jp/top_runner/)

	unit or compressor
<b>Energy use</b>	ISO 23953-2:2005/Amd 1:2012 refrigerated display cabinet – part 2: classification, requirements and test conditions
<b>European Standards</b>	
<b>Safety</b>	EN378 1:2008+A2:2012: Refrigerating systems and heat pumps - Safety and environmental requirements
<b>Product specific test standards in other countries</b>	
<b>Safety</b>	<p style="text-align: center;"><i>USA</i></p> ANSI/ASHRAE 34-2004: designation and safety classification of refrigerants UL 471: Commercial Refrigerators and Freezers UL 541: Refrigerated Vending Machines
	<p style="text-align: center;"><i>South Africa</i></p> 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
<b>Energy use</b>	<p style="text-align: center;"><i>Canada</i></p> 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
	<p style="text-align: center;"><i>USA</i></p> ANSI/ASHRAE Standard 72-2005, Method of Testing Commercial Refrigerators and Freezers. ANSI/AHRI Standard 1200 (2010) Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets (I-P version; SI units version AHRI 1201)
	<p style="text-align: center;"><i>Japan</i></p> JRA 4032 (1993): commercial refrigerators, refrigerator-freezers and freezers
	<p style="text-align: center;"><i>South Africa</i></p> SANS 1406 Ed.3 (2006) - Commercial refrigerated food display cabinets
	<p style="text-align: center;"><i>Korea</i></p> KS B 6031
	<p style="text-align: center;"><i>Mexico</i></p> NOM-022-ENER/SCFI-2008
	<p style="text-align: center;"><i>China</i></p> GB 26920.1-2011 GB/T 21001
	<p style="text-align: center;"><i>Australia</i></p> AS 1731.14-2003 (R2013): Refrigerated display cabinets - Minimum energy performance standard (MEPS) requirements
	AS/NZS 4864.2:2008: Performance of refrigerated beverage vending machines, Part 2: Minimum energy performance standard (MEPS) requirements

Regarding EoL issues, no standards of compulsory fulfilment related to dismantling or recycling of refrigeration appliances have been registered.

Regarding voluntary specifications related to the end-of-life (EoL) of refrigeration appliances, two relevant documents have been identified: EN 50574 (2012)<sup>61</sup> and RAL-GZ 728 (2007)<sup>69</sup>. The first one is included in the WEEELABEX<sup>n</sup> certification scheme created specifically for

<sup>n</sup> WEEE Forum. WEEELABEX Project <http://www.weee-forum.org/weeelabexproject> (access June 2013)

electrical and electronic equipment (EEE). The second one has been created by the German Institute for Quality, Assurance and Certification.

Both standards give good guidance on the collection and treatment of refrigerators' waste. Although these specifications focus on household refrigerators, they could be also applicable to a great extent to commercial refrigeration appliances. Requirements are set up in both specifications during the transport and handling of such wastes to avoid releases of neither refrigerant nor foaming agents. Procedures are suggested for safe removal of components, monitoring processes and documentation. Three main steps are mainly included in both EN 50574 (2012)<sup>61</sup> and RAL-GZ 728 (2007)<sup>69</sup> when dismantling a refrigerator:

1. Extraction of refrigerant.
2. Extraction of the insulating foam and other potentially hazardous substances.
3. Proper management of substances extracted.
4. Recovery of materials extracted.

EN 50574 and RAL-GZ 728 also propose performance test for each of these treatment's steps.

In addition, IEC/TR 62635 (2012)<sup>65</sup> sets up guidelines on Electric and Electronic Equipment (EEE) for the calculation of the recyclability/recoverability rates. Moreover, it defines methods that allow exchanges of information on products between the manufacturers and recyclers.

### **Q.2) REMAINING QUESTIONS**

**Should you disagree with the description on legislation, standards and certification above, please provide at the workshop 10 December 2013 or in written form by 20 January 2014 your alternative proposal, duly supported by data and evidence.**

## 4 MARKETS

In the BIO IS study<sup>3</sup>, 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<sup>5</sup>. 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. However, market structure and segmentation data seems to be still valid.

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

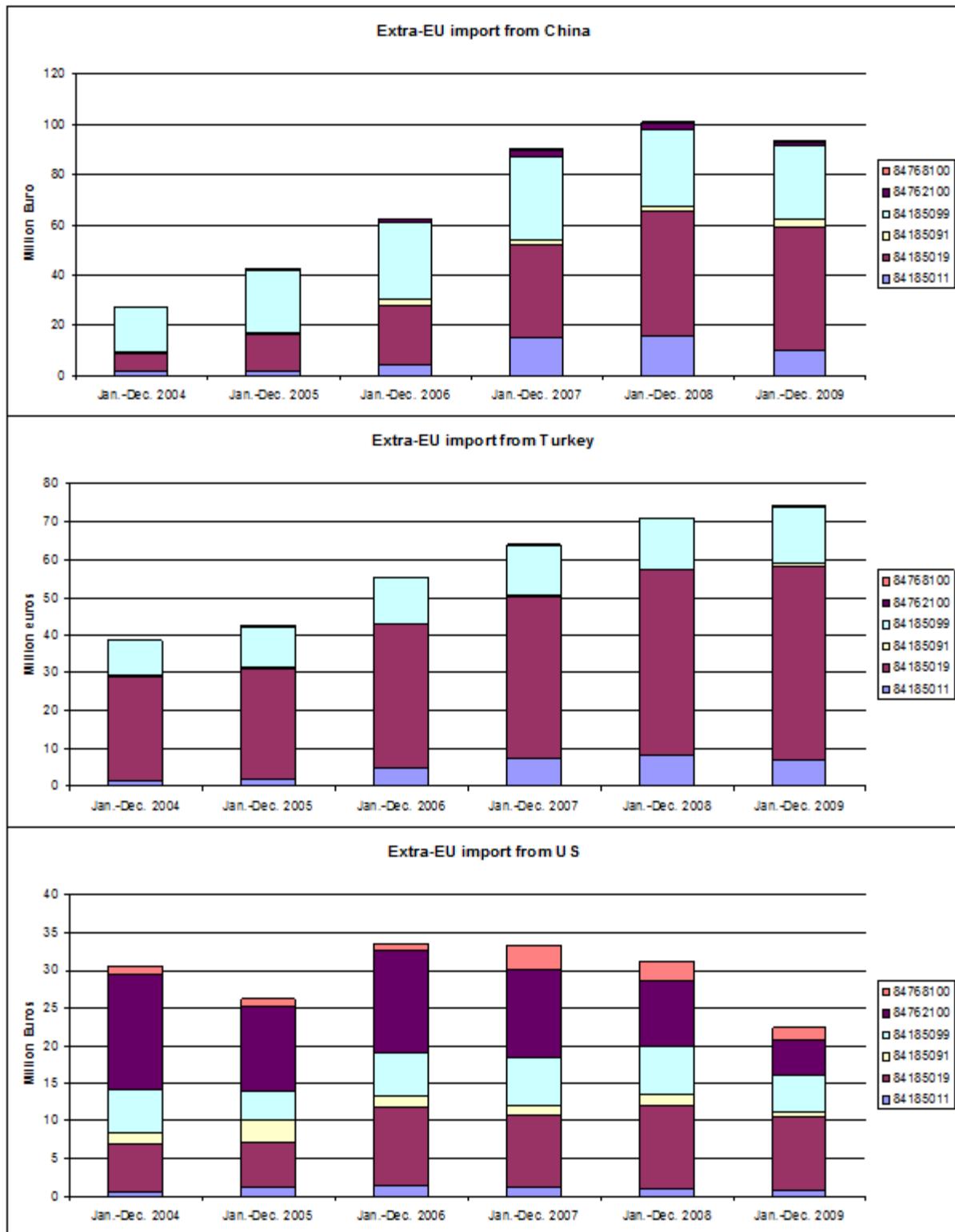
The fundamental objective of market data collection is to enable, at a later phase, a prediction of the potential impacts (in a wider sense, including life-cycle cost calculations) of different MEPS proposals. The impact assessment has to be as accurate as possible, and therefore requires up-to-date 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 8.3). 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 6 below shows the different PRODCOM categories relevant for the product group of commercial refrigeration.

**Table 6 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.<sup>3</sup> 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 did not contain more recent data than 2009 when the database was consulted (end 2012).

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, and later in 2010, Eurovent provided data for 25 EU countries (excluding Bulgaria and Romania) for the BIO IS study<sup>3</sup>. These data are shown in this document. Eurovent has also shared with the JRC unpublished recent EU28 sales data for the years 2010, 2011 and 2012 segmented in plug-in versus remote display cabinets. These sales data cover around 50% of the European market.

EVA data for vending machines cover 21 Member States. The omissions for certain Member States 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 7 (left column). The detailed sales data per EU25 country for remote display cabinets are provided in Annex 8.3.

A comparison of Eurovent's published figures with the estimates (linear sales projections) made by BIO IS<sup>3</sup> shows an overestimation of about 15% in the projection of 2010.

**Table 7 Estimation of sales compared with linear projections from the BIO IS report. Sources:**  
**Eurovent, 2010; BIO IS, 2007.**

<b>Year</b>	<b>Average EU-25 estimations of sales, Eurovent 2010</b>	<b>Average EU-25 estimations of sales linear extrapolation for 2008-2010, BIO IS 2007</b>
<b>2004</b>	225 884	225 884
<b>2005</b>	231 400	231 400
<b>2006</b>	239 073	239 073
<b>2007</b>	245 255	245 255
<b>2008</b>	219 723	251 849
<b>2009</b>	224 395	258 428
<b>2010</b>	229 957	265 006

Eurovent's estimation of the stock of remote display cabinets is shown in Table 8. 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 8 Estimated EU25 stock for remote display cabinets. Source: Eurovent, 2010**

<b>STOCK</b>	
<b>2004</b>	2 032 959
<b>2005</b>	2 082 600
<b>2006</b>	2 151 654
<b>2007</b>	2 207 295
<b>2008</b>	2 266 642
<b>2009</b>	2 325 849
<b>2010</b>	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 9).

Table 9 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 9 Estimation of the share of each product category for remote display cabinets and the average selling price (Source: Eurovent, 2010).**

<b>Product category</b>	<b>Eurovent classification</b>	<b>Average EU 25 Selling price (in euro)</b>	<b>% of units in this product category</b>
<b>Multidecks &amp; semi-verticals</b>	RVC1/RVC2/RVC3	3437 ± 507	61%
<b>Counters: service &amp; self service</b>	RHC1/RHC2/RHC7/RHC8/RHF1/RHF7	3017 ± 560	16%
<b>Frozen food islands</b>	RHC3 to RHC6 & RHF3 to RHF6	3966 ± 718	13%
<b>Glass doors &amp; frozen multidecks/SV</b>	RVF4 & RVC4 + RVF1 & RVF2	5935 ± 2040	4%
<b>Combis</b>	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 10.

**Table 10 Detailed estimates of sales figures for 2010 per cabinet type. Source: Eurovent, 2010.**

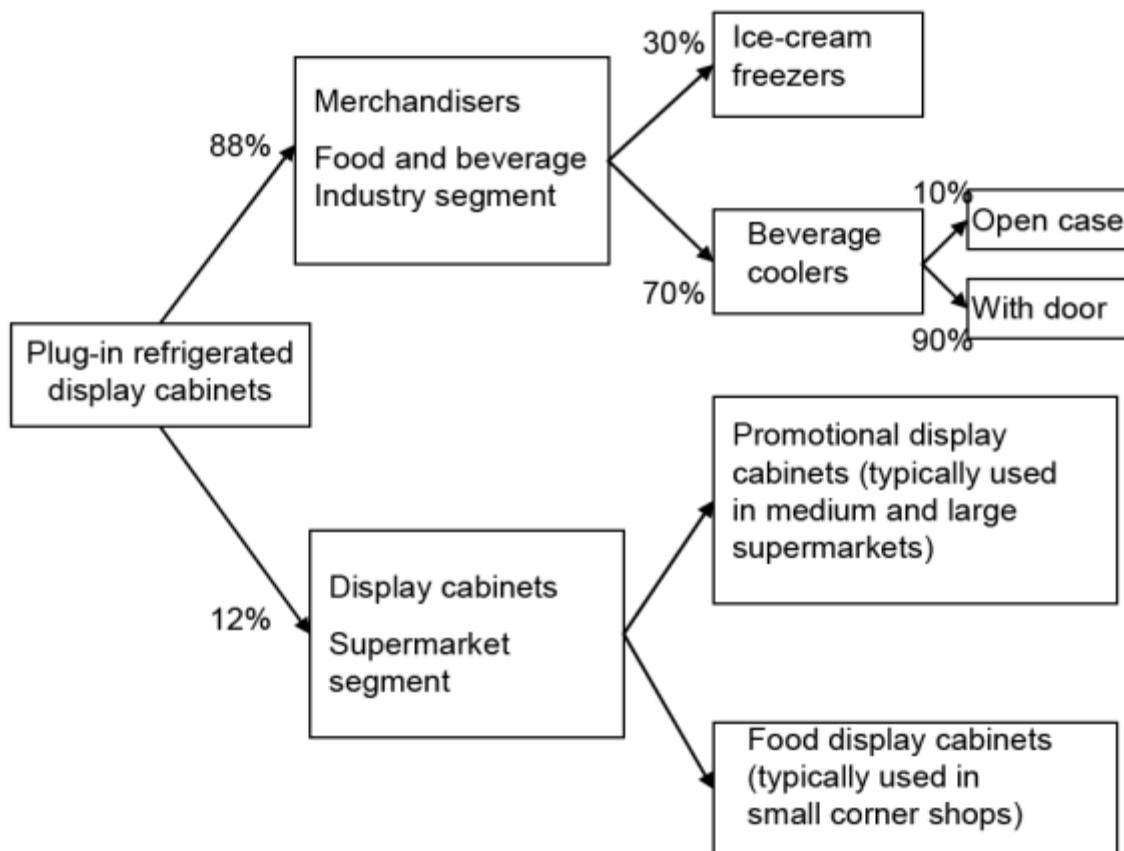
Cabinet type, ISO 23953	Temp. Class	Weight %	Sales EU	% Family	Sales/Family
RVC1, RVC2	3H	0,61	111.976	0,10	11.198
	3M2	0,61		0,50	55.988
	3M1	0,61		0,15	16.796
	3M0	0,61		0,10	11.198
RVC3	3H	0,61	7.343	0,05	5.599
	3M2	0,61		0,10	11.198
RVF1	3L3	0,04		0,05	367
RVF4	3L1	0,04		0,35	2.570
RVC4	3H	0,04		--	--
	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		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	23.864	--	--
	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
		<b>Tot. EU 27 2010</b>		<b>183.568</b>	

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.



**Figure 9** Market fragmentation of the plug-in segment, excluding vending machines. 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 11.

**Table 11** Aggregated sales EU25 data for plug-in display cabinets of the supermarket segment.  
Source: Eurovent, 2010

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

Note that comparing Table 7 and Table 11 reveals that figures of sales of plug-in cabinets and remote cabinets of the supermarket segment roughly compare. More recent Eurovent data for the time period 2010-2012 shows that there is a slow decrease of plug-in sales in the last years (-4%), compared to stable sales of remote cabinets (+1%).

Eurovent's estimation for the stock of plug-in display cabinets in the EU25 is given in Table 12. In the BIO IS study<sup>3</sup>, 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 in the EU25. This figure for supermarket plug-in display cabinets is more than double the figure provided for 2006 by Eurovent (825 000, Table 12), a clear indicator of the need to double-check data sources and estimates.

**Table 12 Estimated EU25 stock for plug-in display cabinets of the supermarket segment.**  
**Source: Eurovent, 2010.**

	2004	2005	2006	2007	2008	2009	2010
<b>Total</b>	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 13 shows the average price of the different cabinet types together with the market share of different plug-ins of the supermarket segment.

**Table 13 Estimation of the share of each product category for plug-in display cabinets of the supermarket segment and the average selling price. Source: Eurovent, 2010**

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 14, 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 14 Detailed sales estimates for 2010 per cabinet type for plug-in display cabinets of the supermarket segment. Source: Eurovent, 2010.**

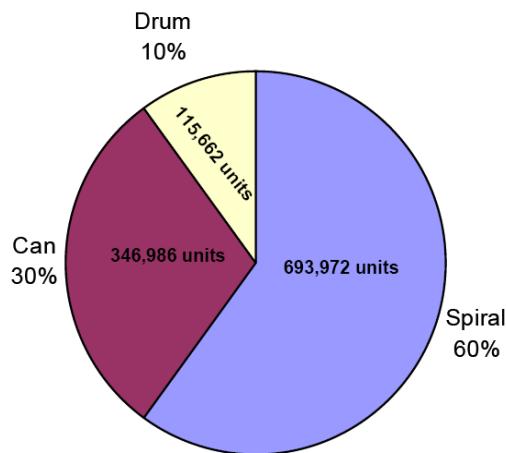
Cabinet type, ISO 23953	Temp Class	Weight %	Sales EU	% Family	Sales/Family
IVC1, IVC2	3H	0,61	103.815	0,35	36.335
	3M2	0,61		0,35	36.335
	3M1	0,61		0,1	10.381
	3M0	0,61		0,05	5.191
IVC3	3H	0,61	6.808	0,1	10.381
	3M2	0,61		0,05	5.191
IVF1	3L3	0,04	6.808	--	--
IVF4	3L1	0,04		0,35	2.383

<b>IVC4</b>	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
<b>IHC1</b>	3H	0,16	27.230	0,15	4.085
	3M2	0,16		0,6	16.338
	3M1	0,16		0,25	6.808
<b>IHF1</b>	3L3	0,13		0,02	442
<b>IHC3, IHC4</b>	3H	0,13		0,15	3.319
	3M2	0,13		0,15	3.319
	3M1	0,13		0,05	1.106
<b>IHF3, IHF4</b>	3L1	0,13	22.124	0,02	442
	3L2	0,13		0,08	1.770
	3L3	0,13		0,2	4.425
<b>IHC5, IHC6</b>	3H	0,13		--	--
	3M2	0,13		0,04	885
	3M1	0,13		0,08	1.770
<b>IHF5, IHF6</b>	3L1	0,13	10.211	0,1	2.212
	3L2	0,13		0,08	1.770
	3L3	0,13		0,03	664
<b>IYF3</b>	3L2	0,06		0,35	3.574
	3L3	0,06		0,35	3.574
<b>IYF4</b>	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: ca. 694.000 units (55-60% of the stocks) are spiral machines for snacks and drinks, ca. 347.000 units (30% of stocks) are bottled and canned beverage machines, and ca. 115000 units (10-15% of stocks) are drum machines (Figure 10). These figures illustrate that the total magnitude of stocks (about 1.1 million units) in the EU is large and comparable to the stock figures of other commercial appliance segments (1 million non-vending plug-ins, 2.4 million remote cabinets).

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 15 shows an assumed market growth rate for vending machines.<sup>27</sup>

**Table 15 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%

### Q.3) REMAINING QUESTIONS

#### Markets

Should you disagree with the description on markets above, please provide at the workshop 10 December 2013 or in written form by 20 January 2014 your alternative proposal, duly supported by data and evidence.

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Draft - work in progress

## 5 TECHNOLOGIES, DESIGN AND USE

### 5.1 Environmental impacts

The life-cycle estimates included in the BIO IS study<sup>3</sup> 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.<sup>28</sup> One could add to this list the potential impacts from end-of-life management (see Chapter 7), 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.

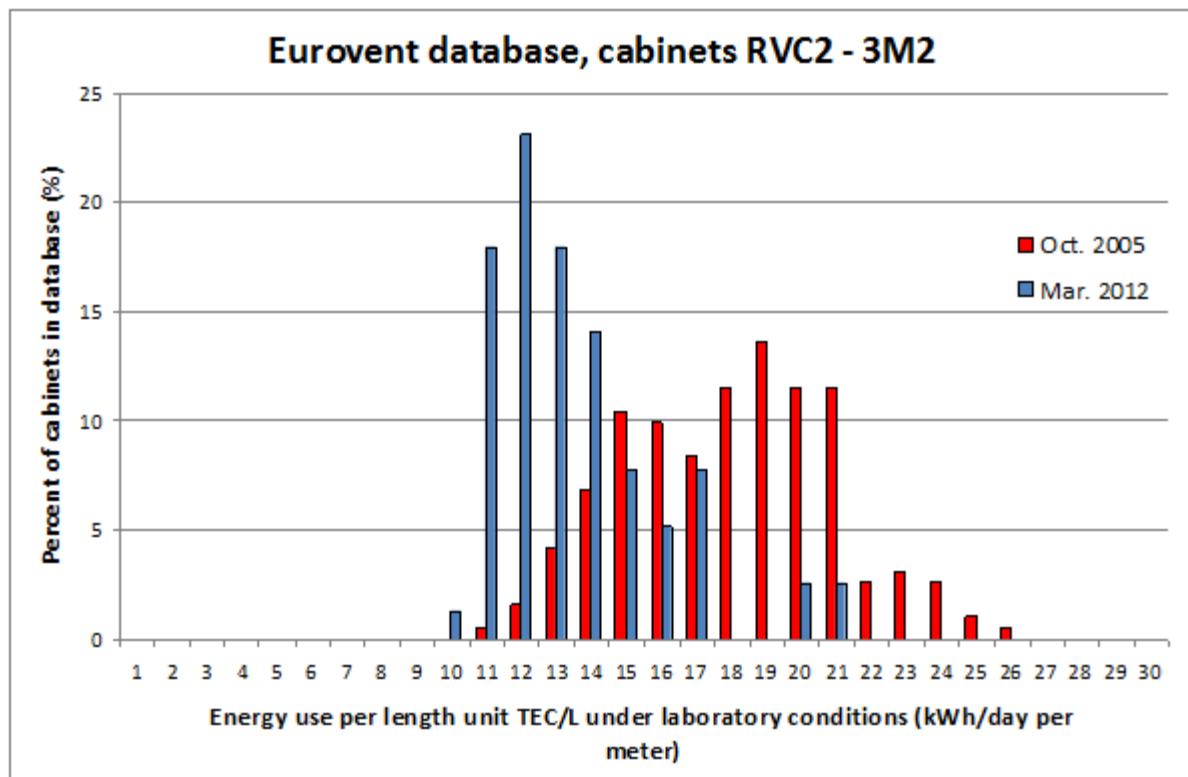
Regarding the end-of-life of the products, Ecodesign measures would be geared towards supporting a correct enforcement of existing legislation in all Member States (see Chapter 7).

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 Historical trend of energy performance for remote display cabinets

In this phase of the project, updating data from the BIO IS study<sup>3</sup> and comparing historical trends in energy performances are of utmost importance. Historical Eurovent data was provided by S.M. van der Sluis (2013).<sup>32</sup>

Tracking down the Eurovent Certification 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 11). 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/m<sup>2</sup>.



**Figure 11 Comparison of data in the Eurovent Certification 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<sup>32</sup>, 2013.

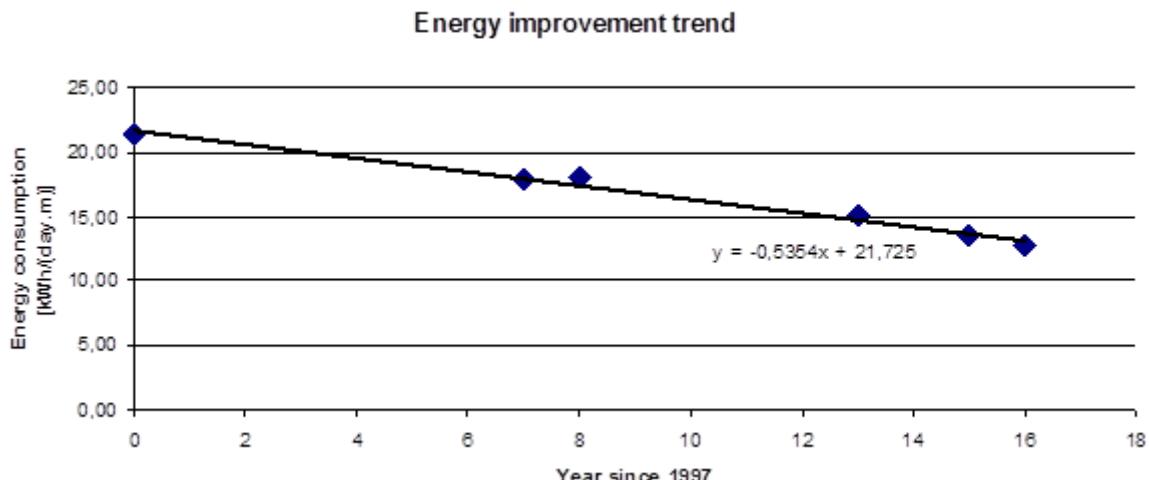
Figure 11 illustrates that in the course of 7 years, the average energy consumption has decreased by 30% - 40% for this type of cabinet. Following the comments from stakeholders, there are indications that this trend has been followed by all remote cabinet types and not only by the bestseller RVC2 cabinet. 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.<sup>33</sup>

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 12), *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<sup>32</sup>, 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 12. 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<sup>32</sup>, 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.m<sup>2</sup>) 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<sup>5</sup> (6.6 kWh/(day.m<sup>2</sup>)), and 14% higher than the current best performer of RVC2 cabinets in the Eurovent database (6.2 kWh/(day.m<sup>2</sup>)), 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.<sup>34</sup> (see Annex 8.5)

### 5.3 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<sup>5</sup> 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.

According to retailers, the following approximate energy savings can be estimated:

- LED: -50% compared to older lighting forms (e.g. fluorescent) (around -5% in total cabinet efficiency), and 5-10% compared to older LED lighting technology. Also depending on location, amount of lighting, and external light sources.
- Electronic fans: -5% in total cabinet energy efficiency.

- Night curtains and double air curtains: -10% in total cabinet energy efficiency.
- Doors and closing of open cabinets: -40% in total cabinet energy efficiency.
- Refrigerant substitution: -10% in total cabinet energy efficiency.

Not included in these measures are the possible aerodynamic improvements resulting from intrinsic cabinet design. Smart sensors or energy management devices are shortly described under user-behaviour (section 5.5.4). The focus for these sensors or devices is on vending machines and bottle coolers rather than on display cabinets of the supermarket segment.

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<sup>15</sup> (Annex 8.5). Note that this road map is for retailers in general and not for display cabinets in particular. Another reference is the JRC's Scientific and Policy Report on Best Environmental Management Practice in the Retail Trade Sector.<sup>29</sup> Finally, a comprehensive study published in 2009 by the Federal Environmental Agency of Germany<sup>35</sup> outlines the environmental benefit of several measures, some of them quantitatively.

### **Q .4) REMAINING QUESTIONS**

Energy saving options

**In case you do not agree with the estimations provided for different saving options, please provide your proposal based on data or logic reasoning.**

**In case more standard energy saving measures can be applied, please inform us about it.**

## **5.4 Improvement options for vending machines**

Information about benchmarking for refrigerated vending machines can be found in a benchmarking report for refrigerated vending machines by IEA's 4E Initiative.<sup>26</sup> 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 which is confirmed by one of the stakeholders. 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 much 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<sup>27</sup>, 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, 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
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, 2009.**

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%

## 5.5 Use

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<sup>3</sup>, 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.

### 5.5.1 User behaviour

Manufacturers of display cabinets offer in most cases different options for the design of a display cabinet. It is normally fully 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, expansion valves, electronic steering, and other options which have been highlighted in section 5.3.

Other elements of the design of the cabinet, *e.g.* the aerodynamics of the air stream, compartments with different temperatures or insulation thickness, 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<sup>15</sup> 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 and a Scientific and Policy Report on Best Environmental Management Practice in the Retail Trade Sector was developed.<sup>29</sup> It not only describes best practices for display cabinets, but for the retail sector as a whole.

### 5.5.2 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. Most appliances for a generic offer of food and dairy are owned by the retailer, while brand appliances such as beverage coolers or ice-cream freezers are typically not owned by the retailer. Serve-over counters can be found in (self-service) restaurants, canteens, butcher shops, etc., and usually are also owned by the retailer.

For supermarkets, different approaches to ownership and the choice of manufacturer have been detected. In some supermarkets and franchised shops, the headquarters selects a palette of providers, and the individual shops may only choose among a limited, pre-screened offer. Other companies provide more freedom in the selection of provider and products.

Most supermarket chains and retailers apply a life-cycle cost approach in their procurement and purchase of display cabinets. Purchases supported by a payback time of 2 years or less receive often green light. There are still some few retailers where the purchase is essentially based on the purchase price (investment cost). When the technical department of the retailer is involved in the tender specifications, normally life-cycle costs are considered. It has been detected that these may be disregarded if the marketing department has the most prominent role in procurement.

The calls of tender specify the basic technical characteristics that the offer must include (dimensions, number of shelves, etc.), but also often the optional characteristics that have significant influence on energy consumption (glass doors, night blinds, lighting location and type, refrigeration components, etc.). Sometimes maximum consumption is prescribed.

For the retailers, a variety in complexity of applying life-cycle costs is noticed. Some do very detailed cost calculations over the lifetime of a cabinet, including all possible technical energy saving options, while others do very simple calculations. Some retailers cross-check and test themselves the information provided by manufacturers, while others use the manufacturer's data sheets as the sole source of information. In occasions, the certification data (e.g. from

Eurovent) is also requested and used as communication instrument. Maintenance costs can be included in the price calculation as well, together with the choice of refrigerant.

Most retailers have commented that they would welcome an energy labeling system for display cabinets, provided that the certification protocols are clear and the organisms are reliable and recognized. This would give them more confidence in the energy consumption data currently provided by manufacturers. It would also make it easier for them to select energy efficient cabinets, especially for those retailers that currently do not use in their purchase mechanisms extended life-cycle cost calculations. It may also help retailers to show environmental awareness in their environmental policy communication.

In general, retailers request customized products to the manufacturer, which can lead to the production of differently customized products using a similar basic structure. It is frequent that many of the optional choices have energy efficiency consequences, e.g. positioning, power 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, but in the latest years it seems to be increasingly considered in procurement, as confirmed by the retailers who implement life-cycle costing calculations.

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 supply 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. The BIO IS study<sup>3</sup> indicates, as recently confirmed by a manufacturer, that refrigeration energy costs are for retailers a small amount (<5%) compared to the revenues obtained with product sales. Still, a number of large supermarket chains in Spain, and expectedly also for similarly populated countries, report annual energy bill figures measured in tens of euro millions. In the past, retailers have not paid much attention to the energy saving potential of refrigeration over the operation lifetime. However, this is changing together with rising energy prices and growing environmental awareness.

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, either when replacement is due, or sometimes earlier. 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 detected in some countries. New tendencies are detected moving away from extra-large supermarkets to smaller neighbourhood shopping places. If this trend expands and/or continues in the future, it will have an impact on retailer's refrigeration systems as a whole. 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, as these are more flexible to re-arrange or substitute by modules accommodating to the recent developments in refrigerant constraints (legal, taxation). This is however contrasted with a small decrease in sales of plug-in cabinets, while the sales of remote cabinets remained stable the last years.

### **5.5.3 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<sub>2</sub>– technology, and safety trainings while working with hydrocarbons.

### **5.5.4 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. Such a device can reduce the 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 cannot rise above 10°C for more than half an hour. For such machines, only switching of lights could save energy.

### **5.5.5 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<sup>44, 45</sup>. 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 ground-breaking 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.

For freezers, most stakeholders agree that they should be closed because energy efficiency reasons. Retailers also claim better preservation of the frozen goods in closed cabinets.

### **5.5.6      Lighting**

Switching off lights during closing hours and opting for energy efficient lighting like LED can save 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.

### **5.5.7      Refrigerant**

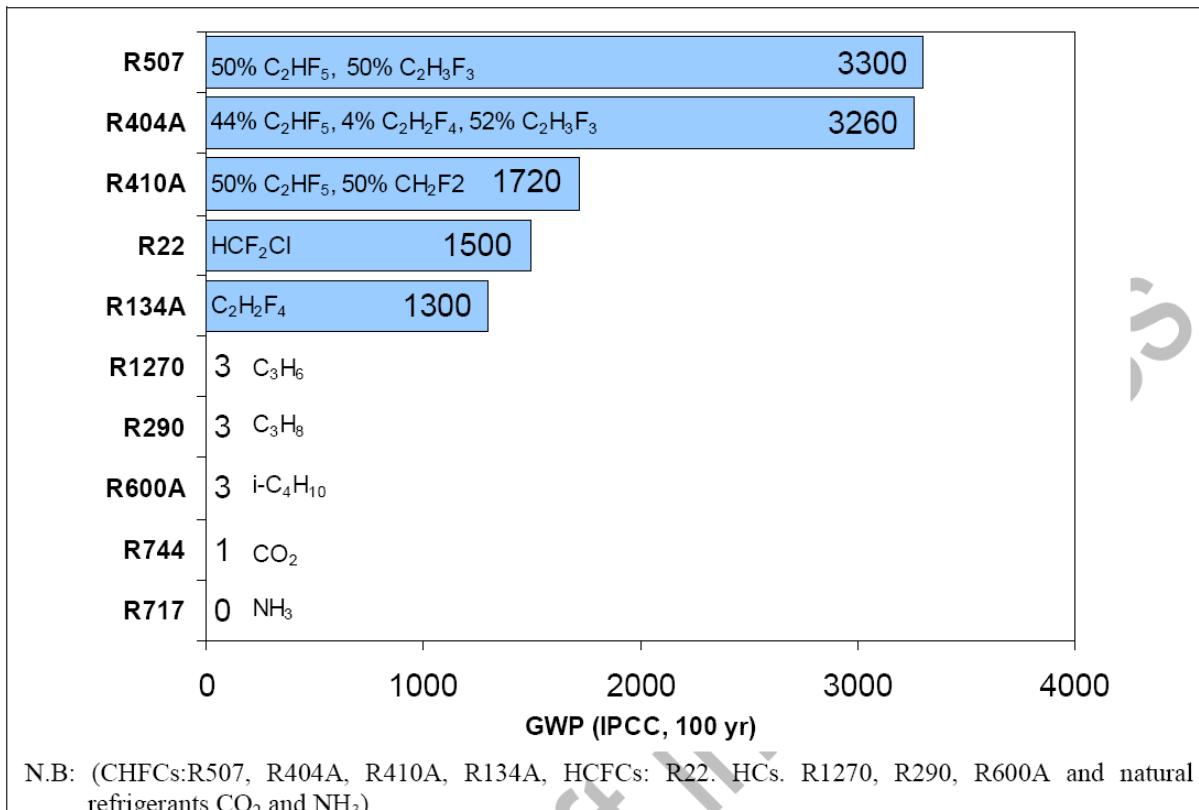
Refrigerant replacement can have a significant impact on the direct and indirect emissions associated with refrigeration. Low GWP refrigerants will lower the direct emissions. More energy efficiency refrigerants lower the indirect emissions related to electricity use.

The choice of refrigerant is thus an important issue to be addressed in this project, mainly when it relates to energy consumption. However, climate change implications of the use of F-gases are consistently dealt with in climate policy and the F-gas Regulation, which is currently being updated. Duplication of legislation or interference in climate policy on F-gases is not desirable.

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 commercial refrigeration appliances currently use fluorinated gases and hydrocarbons as cooling medium. The environmental concern of fluorinated refrigerants is their high global warming potential. In Figure 13, 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<sub>2</sub> (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.



**Figure 13 Global warming potential of several commercial refrigerants, time horizon 100 years.**

Source: Scientific and Policy Report on Best Environmental Management Practice in the Retail Trade Sector<sup>29</sup>

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

Refrigerant	Properties	Benefits	Drawbacks	Application
<i>CO<sub>2</sub> (R744)</i>	Boiling Point: -78°C Critical Temperature: 31°C Flammability limits: non flammable Compatibility: risks of corrosion to ferrous steel with humidity	Zero ODP – Low GWP Very low cost respect to traditional refrigerants High efficiency Non-toxic / Non-flammable Small displacement for the compressor Small pipe dimensions	Less efficient than HFCs at high ambient temperatures  High pressures in the system  High capital cost due to low mass production of CO <sub>2</sub> compressors	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
<i>Ammonia (R717)</i>	Boiling Point: -33°C Critical Temperature: 133°C Flammability Limits: 15 - 28 % in Air Compatibility: Corrosive to copper alloys	Zero ODP – Low GWP Good thermal properties ➔ Good efficiency Ammonia's recognisable smell is its greatest safety asset. Low cost Low charge of refrigerant	Toxicity, leakages not permitted  Flammability  Limited charge permitted	For remotes, only usable in indirect systems For plug-ins, not suitable For vending machines, not suitable
<i>Propane (R290)</i>	Boiling Point: -42°C Critical Temperature: 97°C Flammability Limits: 2.1 - 9.5 % in Air Compatibility: Non corrosive	Zero ODP – Low GWP Good thermal properties ➔ Good efficiency Low cost Less noise due to the reduction of pressure in the compressor	Flammability  Limited charge permitted in occupied spaces (150g, 1.5kg, 2.5kg)	For remotes, only usable in indirect systems For plug-ins, already used For vending machines, commercial use planned
<i>Propene (R1270)</i>	Boiling Point: -47.8°C Critical Temperature: 91°C Flammability Limits: 2.0 - 11.0 % in Air Compatibility: Non corrosive	Zero ODP – Low GWP Good thermal properties ➔ Good efficiency Low cost Less noise due to the reduction of pressure in the compressor	Flammability  Limited charge permitted in occupied spaces (150g, 1.5kg, 2.5kg)	For remotes, only usable in indirect systems. For plug-ins, already in use
<i>Isobutane(R600a)</i>	Boiling Point: -12°C Critical Temperature: 135°C Flammability Limits: 1.6 - 8.4 % in Air Compatibility: Non corrosive	Zero ODP – Low GWP Good thermal properties ➔ Good efficiency Low cost Less noise due to the reduction of pressure in the compressor	Flammability  Limited charge permitted in occupied spaces (150g, 1.5kg, 2.5kg)	For remotes, only usable in indirect systems For plug-ins, already used For vending machines, commercial use planned

<i>Unsaturated HFCs</i>	New developments; properties and applications can differ for different products, benefits and drawbacks have to be studied			
<b>R-1234yf</b>	Boiling Point: -30°C Critical Temperature: 95°C Flammability Limits: 6.2 - 13 % in Air Compatibility: Non corrosive	Zero ODP – Low GWP Reasonable thermal properties $\Rightarrow$ reasonable efficiency (poorer than R134a)	High cost  Flammability  Cannot be used in direct centralised systems	For centralised systems, only usable in indirect systems  For plug-ins, feasible to use  For vending machines, feasible to use

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<sup>16</sup> 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.<sup>17,18</sup> An update of the most important developments for this project are provided in Annex 8.6.

The currently proposed amendments to the F-Gas Regulation address thoroughly the use of F-gases in all applications, also commercial refrigeration. In the past, Ecodesign measures have indeed been taken in this regard, aimed at steering the market towards the use of refrigerants with reduced overall impact on the environment, *e.g.* a bonus-malus system in the Ecodesign requirements for air conditioners and comfort fans.<sup>36</sup> Ecodesign implementing measures for commercial refrigeration need in principle not intervene on this issue, and in any case not interfere or duplicate climate policy under development.

Some stakeholders have clearly opposed a bonus-malus system, arguing that such a system could reduce the transparency of the energy efficiency calculation. A risk that should be absolutely avoided is to stimulate worse energy performance for equipment with low-GWP refrigerants. Proposals related to refrigerant gas choice should not undermine the focus of the commercial refrigeration Ecodesign Regulation on energy efficiency, because energy consumption is responsible for the main environmental impacts of this type of appliances.

Moreover, a bonus-malus system for refrigerants would work only for plug-ins, because only for these appliances the manufacturer makes the decision about which refrigerant is used in the cabinets. A large share of plug-in appliances is already running with hydrocarbons and CO<sub>2</sub>, and the F-gas review will accelerate this transformation. Only vending machines have additional safety concerns related to the ignition risk of HC atmosphere caused by mobile mechanical parts.

For remote display cabinets, defining requirements relating to the refrigerant could be problematic. As with remotes, it is very often the end-customer who will decide what the refrigerant will be. The remote cabinet itself can operate with different refrigerants operating within a similar range of pressures and temperatures, well knowing that different refrigerants have different heat transfer behaviour and physicochemical properties that influence directly the design and sizing of piping and components (compressor, valves, etc.). It is very difficult to set regulative requirements on the whole refrigeration system as it would easily lead to a whole building approach which is out of the scope of this study.

While low-GWP refrigerants are less common in remote cabinets, they are today ready to become the standard in ice-cream freezers, beverage coolers and small plug-in supermarket display cabinets.

Because of 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<sup>o</sup> stated in November 2010<sup>37</sup>:

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<sup>o</sup> 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,

*“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”.*

The ‘Refrigerants, Naturally!’ initiative promotes a shift in the point-of-sale cooling technology in the food and drink, food service and retail sectors towards F-gas-free refrigeration technologies. On top, energy efficiency has to improve compared to existing fluorocarbon-based technology. The initiative is supported by Greenpeace, the United Nation Environment Programme (UNEP) and companies like Coca-Cola, Unilever, Red Bull and PepsiCo.

Chilling facts V<sup>38</sup>, an EIA annual report, describes the progress in major supermarket chains in the UK to move away from hydrofluorocarbons (HFCs).

#### 5.5.7.1 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. They are partly based on the following 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).<sup>40</sup>

##### a) Hydrocarbons (Propane, Propene, Isobutane)

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. Propene (R1270) is used for larger capacity cabinets. Those units usually have higher refrigeration capacities than household refrigerators requiring the higher pressure refrigerant propane and propene. When the requirements for safety are met (e.g. IEC 60335-2-89), propane or propene 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.

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product category and format. Another global company committed to only purchase appliances using non-HFC refrigerants by the end of 2015.

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<sup>42</sup> should be followed (see Section 3.2).

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.<sup>43</sup>

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, as with any other refrigerant.

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 using hydrocarbons exist, but are costly. 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 can therefore be formed in low areas. When larger refrigerant charges are used, appropriate gas sensors and air removal devices may need to be installed at floor level. The necessity of such measures also depends on how the system and associated parts of the equipment are designed, together with a risk assessment.

### b) Carbon dioxide (CO<sub>2</sub>)

CO<sub>2</sub> operates with significantly higher pressures than other refrigerants. In plug-in bottle coolers CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> is low (31°C), the CO<sub>2</sub> 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 secondary (cascade) heat exchanger, which has a greater positive impact on energy efficiency in the transcritical CO<sub>2</sub> process than with other refrigerants.

At ambient temperatures, around 26 °C, an air-cooled CO<sub>2</sub> refrigeration system achieves comparable energy efficiency to an HFC direct evaporation refrigeration system. At lower ambient temperatures (below 24 °C), the CO<sub>2</sub> system achieves better energy efficiency. Above 26-28 °C, CO<sub>2</sub> systems need auxiliary cooler systems (*e.g.* ammonia in cascade) to complete efficiently the condensation of CO<sub>2</sub>.

A safety study by TNO<sup>22</sup> based on tests has shown that risks related to rupture of the CO<sub>2</sub> compressor are negligible. Conversely, a desk study<sup>23</sup> revealed that rupture of the CO<sub>2</sub> 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 study by TNO<sup>22</sup> concluded that CO<sub>2</sub> escapes due to overpressure would not happen in the compressor, but in other weaker parts of the refrigeration system (weldings of piping). Other failure situations like cracks in piping or heat exchangers would result in increased CO<sub>2</sub> concentrations, noise or cold gas releases, but would not cause significant injuries to the public.

### c) Unsaturated HFCs

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. Many companies are currently testing, trialling and developing prototypes in different types of equipment.

### d) Ammonia (NH<sub>3</sub>)

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/m<sup>3</sup>), 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<sub>2</sub> cascade refrigeration systems.

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

**Q.5) REMAINING QUESTIONS**

**Should you disagree with the description on technologies, design, use and refrigerants above, please provide at the workshop 10 December 2013 or in written form by 20 January 2014 your alternative proposal, duly supported by data and evidence.**

## 6 REFERENCE ENERGY CONSUMPTION

One of the intermediate necessary steps of this project is to define the reference energy consumption of commercial refrigeration appliances. This means defining the ‘average’ energy consumption of the appliances currently on the market. This will allow in a later stage of the project to define minimum energy performance requirements, and if needed also energy labelling classes. Please note thus that the proposed energy values are NOT minimum energy requirements, but are intended to present the current status of the market.

Well-defined reference energy consumption values are key for industry and retailers, as well as NGOs, policy makers and society as a whole. Why do we want a well-defined reference energy value? Over-estimated values would lead to too strict MEPS (Minimum Energy Performance Standards), and may cause unintended difficulties and costs for industry in the production of appliances meeting such requirements. Under-estimated reference energy values would lead to very lenient MEPS and a situation where the improvement potential is not exploited, innovating companies are not rewarded for their efforts in developing energy efficient appliances, and the EU industry loses competitive opportunities vis-à-vis non-EU industry.

Only balanced reference energy consumption values based on the most up-to-date data will lead to realistic implementing measures, long-term competitiveness gains for the EU industry, and a controlled development towards lower overall energy consumption of the EU stock of commercial refrigeration appliances.

The equations for estimation of average energy use presented in this report have been developed after extensive data gathering and stakeholder consultation during 2013. The equations proposed may be further fine-tuned based on additional data that manufacturers and/or retailers may make available to the JRC.

The database of reference energy consumption values will be used to develop energy consumption equations formulas, and ultimately be essential in the proposal of legally-binding MEPS.

### 6.1 Data sources

Different data sources have been consulted for the development of the proposed reference energy formulas:

1. Eurovent. One of the programmes of the Eurovent Certification Company deals with refrigerated display cabinets, and resulted in the publication of a dataset on their website.<sup>p</sup> These data (March 2013) were initially used in the present study. In September-October 2013, an additional and more up to date (2013 data) dataset of more than 2500 data entries was also shared with the JRC. The companies behind this dataset represent about 65% of the EU market of refrigerated display cabinets.

<sup>p</sup> [http://www.eurovent-certification.com/en/Certification\\_Programmes/Programme\\_Descriptions.php?rub=03&srub=01&ssrub=&g=en](http://www.eurovent-certification.com/en/Certification_Programmes/Programme_Descriptions.php?rub=03&srub=01&ssrub=&g=en)

2. The Enhanced Capital Allowance (ECA) Scheme. This scheme is part of the UK Government's program to manage climate change. Relevant data registered at that scheme in October 2013 has been made available to JRC by the Carbon Trust. It consists of 1430 data entries, including remote and plug-in appliances and different types of cabinets (horizontal, vertical, combined, frozen, chilled, etc.).
3. Assofoodtec/ACOMAG, the Association of Gelato Machines, Shop fittings and Equipment Manufacturers, has provided 73 data entries for artisan gelato ice-cream display cabinets.
4. Other. Datapoints provided by stakeholders (mostly manufacturers) and organizations (*e.g.* TopTen<sup>q</sup>) through questionnaires or on a voluntary basis as a general rule, and in all cases when requested by the data owners, confidential data has been anonymised. These data points manage to include the appliance types (ice-cream freezers, beverage coolers, vending machines) not covered by the two larger databases above (Eurovent and ECA).

Data from other world regions, *e.g.* where MEPS are in place, are hard to compare, as they are usually measured under different conditions (temperature, humidity, duration of the test, sequence of door opening, test packages, etc.) 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<sup>31</sup>, 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.

## 6.2 Development of reference energy consumption formulas

### 6.2.1 Metrics

Total display area (TDA) is expressed in m<sup>2</sup>, total energy consumption (TEC) in kWh/day and volume (V) in litres net refrigerated volume.

The ISO 23953 standard is defined for display cabinets, *i.e.* display cabinets of the supermarket segment. The energy consumption of beverage coolers and ice-cream freezers can also be tested by using the ISO 23953 standard. However, the energy savings of some elements such as presence detectors cannot be currently accounted for.

For *artisan gelato* display cabinets, displaying artisanal home-made ice-cream, a new standard is under preparation in the CEN 44 committee. This shows that the ISO 23953 standard is not suited to test this type of cabinet.

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<sup>q</sup> TopTen is an independent international program to create a dynamic benchmark for the most energy efficient products. <http://www.topten.eu>

The reference energy consumption formulas refer to appliances measured according to the ISO 23953 +A1:2012 standard. For vending machines, the EVA-EMP 3.0a test protocol<sup>r</sup> is used to define the energy consumption.

### 6.2.2 Generic structure of the energy consumption formula

The generic structure proposed for the energy consumption formulas of all product categories is as follows:

$$\text{TEC} = C_1 + C_2 * X$$

Where:

- TEC is the Total Energy Consumption, measured in kWh/day
- X is either TDA (Total Display Area, measured in m<sup>2</sup>) or V (net refrigerated volume, measured in litres), depending on the functionality of each product category
- C<sub>1</sub> is an offset constant (kWh/day)
- C<sub>2</sub> is a constant multiplier (in kWh/(day.m<sup>2</sup>) or kWh/(day.litre))

In all cases, it is assumed that the energy consumption is a linear function of the total net refrigerated volume (chilled/frozen) or the total display area. The constants and multiplication factors (C<sub>1</sub>, C<sub>2</sub>) will vary depending on the product category, and can be absent or be the result of additional calculations (*e.g.* the sum and weighting of volumes or areas of different compartments of the appliance).

These functions and coefficients are empirical and are derived by linear regression, using the available data. This approach has been used in the past for similar calculations in the Household Refrigeration Regulation (EC/643/2009), the upcoming Professional Refrigeration Regulation, and the MEPS on commercial refrigeration in place in other world regions (USA, Canada, California, New Zealand, Australia).

The offset constant C<sub>1</sub> is still a point of discussion for supermarket display cabinets. Some stakeholders argue that C<sub>1</sub> should be different from zero, mainly because for bigger volumes or bigger TDA the energy consumption would be overestimated in the case of C<sub>1</sub> = 0. However, defining C<sub>1</sub> is a difficult task because of the lack of data for appliances with small TDA. For some product categories the linear regression results in a negative, absurd C<sub>1</sub> value and no counter proposals from stakeholders have been received so far. Theoretically, and also welcomed by other stakeholders, C<sub>1</sub> should equal zero as an appliance with zero volume or zero TDA has no cooling capacity and should thus consume zero energy (TDA = 0, TEC = 0). Different approaches over different world regions can be seen: in the USA and Canada C<sub>1</sub> ≠ 0, while in Australia C<sub>1</sub> = 0.

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<sup>r</sup> The EVA-EMP 3.0a test protocol has been developed and is since August 2013 under revision by CENELEC TC59X, Performance of household and similar electrical appliances, working group CLC/TC 59X/WG11, Power consumption of vending machines.

### 6.2.3 Segmentation

For consistency, care has been taken that the approach to the proposal of reference energy formulas is the same as in the Household Refrigeration Regulation (EC/643/2009) and the upcoming Professional Refrigeration Regulation. The analysis of the available datasets has resulted in proposing a segmentation of commercial refrigeration appliances (freezers for frozen products, refrigerators for chilled products) into the following five categories:

- Retail/supermarket display cabinets (both refrigerators and freezers)
- *Artisan gelato* ice-cream freezers
- Ice-cream freezers for merchandising ( $V \leq 500$  litre and  $\leq 1.1 \text{ m}^2$ )
- Beverage coolers (refrigerators only)
- Vending machines (both refrigerators and freezers)

The rationale and background information for this segmentation is provided in Table 21 below.

**Table 21. Rationale for the segmentation in reference energy consumption formulas**

Segmentation	Discussion	Remarks	JRC proposal
Open vs. closed	It is clear that currently open appliances consume much more energy than their closed counterparts. This is especially true for freezers.	The reference energy consumption formula for freezers is based on data for closed freezers.	No segmentation will be made in the formulas for open vs. closed. This will intrinsically be a part of the parameters defining the formulas for freezers. For beverage coolers, an exception could be made if more data becomes available (see further).
Refrigerators vs. Freezers	A clear difference for freezers versus refrigerators is observed from the data.	Segmentation in reference formulas is proposed. It is judged not necessary to develop a mathematical function $E=f(T)$ of energy consumption to the working temperature. Based on the data available, discrete differentiation in temperature classes is seen sufficient.	Segmentation for refrigerators versus freezers is proposed.
Horizontal vs. vertical	It is clear from available data that more heat loss results from vertical than from horizontal appliances.	Segmentation proposed, but later in the project, care has to be taken that verticals and horizontal cabinets are treated equally and that inefficient vertical cabinets are not promoted over the intrinsically more efficient horizontal ones.	Segmentation is proposed.

<b>Segmentation</b>	<b>Discussion</b>	<b>Remarks</b>	<b>JRC proposal</b>
Plug-in vs. remote	No data found supporting differentiation between remote and plug-in appliances. Theoretically, remote cabinets are more efficient because of economy of scale and more efficient compressors. The available data shows that differences between remote and plug-in appliances mainly result from the type of appliance, <i>e.g.</i> beverage cooler or small ice-cream freezer.	Differentiating between display cabinets, beverage coolers and small ice-cream freezers will partly solve the differences that could exist for plug-in appliances versus remote appliances. Available data comparing supermarket plug-in and remote cabinets is contradictory, sometimes in favour of plug-ins, sometimes in favour of remotes.	Based on the data currently available, no specific segmentation plug-in versus remote is proposed. Moreover, if the segmentation for small ice-cream freezers and beverage coolers (both plug-in appliances) is maintained, most plug-in appliances are treated specifically. The remaining plug-in supermarket segment could have the same conditions as the remote cabinets.
Per temperature class (L1, L2, M1, M2, etc., according to ISO 23953, see Table 23)	Appliances use more energy when the working temperature is lower. This is clear for frozen vs. chilled product appliances, but is also checked for the different ISO temperature classes within frozen/chilled product appliances (L1, L2, M1, M2, etc.).	For vertical refrigerators and horizontal refrigerators, differences are observed. For freezers, the lack of consistent data hampers drawing conclusions, especially relating to temperature class L2.	A differentiation for working temperature is proposed. Defining energy consumption at one particular temperature class (L1 for freezers, M2 for refrigerators) could be another proposal.
Per cabinet classification VC1, VC2, HC1, HC2, etc.	Following such detailed segmentation could lead to a complicated regulation. Moreover, there is a high risk that niche applications can fall out, because there is no data on energy use available for each of the small market categories (including plug-in/remote, different temperature classes, etc.).	Too detailed segmentation would complicate legislation and appliances with small stocks and market niches could fall out.	No segmentation is proposed.
Beverage cooler	Beverage coolers have a big share of the plug-in display cabinets. Technically they could be classified as vertical refrigerators. However, usually they are designed to pull-down the temperature of products at ambient temperature (while supermarket cabinets keep cooled products at	The collected data sets for beverage coolers are not homogeneous with respect to the measurement protocol. Only some data points were measured by ISO 23953 and provide energy consumption in function of net volume as well as TDA. Most other data points were measured with protocols different from ISO 23953, even though conversion factors were	Segmentation is proposed for beverage coolers to account for the large energy saving potential compared to refrigerated display cabinets and the technical difference relating to pull-down temperature mechanisms.

<b>Segmentation</b>	<b>Discussion</b>	<b>Remarks</b>	<b>JRC proposal</b>
	a certain temperature). Other shapes are possible and proven energy saving measures ( <i>e.g.</i> presence detector) can be applied because of the non-perishable nature of canned/bottled beverages. Most available data is expressed in volume instead of TDA.	estimated.	
Ice-cream freezer	A segmentation could be made with a cut-off limit for the net refrigerated volume, <i>e.g.</i> $V = 500$ litre. As such, small ice-cream freezers for merchandising will fall under this category. They can have transparent or closed/opaque lids/doors.	Defining TEC in function of volume could be beneficial to include merchandisers with non-transparent doors (if not included under Household or Professional Refrigeration).	Segmentation for small ice-cream freezers is proposed. The limits at 500 litre and $1.1 \text{ m}^2$ are arbitrary estimates and should be discussed at the 2 <sup>nd</sup> TWG meeting.
Vending machines	Vending machines are technically different from display cabinets, <i>e.g.</i> they include vending systems, and often have a modular structure with only some parts refrigerated.	The measurement protocol is completely different from the ISO 23953 standard.	Segmentation for vending machines is proposed.
Solid/opaque door vs. transparent door	No consistent data available	Solid/opaque doors can be used for small ice-cream freezers and beverage coolers, where knowledge of the content is obtained via advertisement on the appliance. Certain vending machines, <i>e.g.</i> for beverage cans, usually use non-transparent doors.	No segmentation opaque door versus transparent door is proposed for display cabinets, beverage coolers and ice-cream freezers. For vending machines, segmentation could be an option.
Saving energy device or not	Such a device can save a considerable amount of energy (30-40%) for beverage coolers. This could also be very relevant if used in vending machines.	Not currently quantifiable following ISO 23953. Still unclear how to make its measurement and inclusion possible, in order to reward the appliances equipped with such a device.	Inclusion in MEPS or possible energy labelling should be discussed at 2 <sup>nd</sup> TWG.

The sections below explain in more detail the development of the equations proposed for each of the categories.

### 6.2.4 Standards, climate classes and temperature classes

Table 22 below summarises the data population available to estimate average energy consumption values, the climate class for the testing, and the testing protocol used.

**Table 22. Overview of data population, climate class for testing and testing protocol of different appliances**

	Data entries	climate class CC CC3 : (T = 25°C, RH = 65%) CC4: (T = 30°C, RH = 55%)	Measurement standard/protocol
Retail/supermarket display cabinet	Eurovent: 2623  ECA: 1430	CC3	Eurovent: ISO23953+A1:2012 (run method) or estimated  ECA: ISO23953:2005 (75% method)
Beverage cooler	Danish Technological Institute (DTI): 6  TopTen: 12  ProCool winner: 1   Beverage companies: confidential	DTI: CC3  TopTen: unknown  ProCool: CC4   Beverage companies: own climate classes not coincident with ISO23953	DTI: ISO 23953:2005  TopTen: unknown  ProCool: adapted ISO23953   Beverage company protocols and estimations for conversion to ISO23953
Artisan gelato ice-cream freezer	Assofoodtec/ACOMAG: 73	unknown	unknown, a new standard is under development.
Small ice-cream freezers	DTI: 4  TopTen: 18  ProCool winner: 1	DTI: CC3  TopTen: unknown  ProCool: CC4	DTI: ISO23953:2005  TopTen: unknown  ProCool: ISO23953

	Brand: confidential	Brand: CC4	Brand: ISO23953
Vending machines	EVA: 22	unknown	Unknown, still under development (EVA-EMP 3.0a) and not yet approved by CENELEC

Table 23 shows the temperature classification of refrigerated cabinets as defined in ISO 23953.

**Table 23. Temperature classification for display cabinets according to ISO 23953**

Class	Highest temperature, $\theta_{ah}$ , of warmest M-package colder than or equal to <sup>a</sup>	Lowest temperature, $\theta_b$ , of coldest M-package warmer than or equal to <sup>a</sup>	Lowest temperature, $\theta_{al}$ , of all M-package colder than or equal to <sup>a</sup>
	°C		
L1	-15	—	-18
L2	-12	—	-18
L3	-12	—	-15
M1	+5	-1	—
M2	+7	-1	—
H1	+10	+1	—
H2	+10	-1	—
S	Special classification		

<sup>a</sup> See Figure 28.

## 6.3 Supermarket display cabinets

### 6.3.1 Scope

Display cabinets are normally used in supermarkets or grocery stores. These can be plug-in appliances or connected to a remote refrigeration system. For remote refrigeration systems, only the cabinets and not the refrigeration units are included in the scope.

This section deals with energy use of display cabinets, including among others supermarket segment, serve-over counters and ice-cream freezers with  $V > 500$  litre.

### 6.3.2 Reference energy formula

It has been found that the display area (total display area, TDA, measured in  $m^2$ ) is the most frequently used variable for the physical characterisation of display cabinets, a consequence of their function as appliances that store and offer a maximum of visual

contact and easy access by customers. The use of the variable TDA is thus proposed. The reference total energy consumption (TEC) is expressed in kWh/year.

The multiplication factor  $C_2$  of TDA is defined by linear regression TEC vs. TDA, with  $C_1=0$  (*i.e.* passing through the origin (TDA = 0, TEC = 0)).

For the freezers, only data of closed cabinets has been used to define  $C_2$ . Most stakeholders, including manufacturers, retailers and Member States, agree that appliances for frozen products should be closed. As such, the reference energy consumption can be defined based on closed appliances only. For refrigerators, the reference energy consumption data is based on open as well as closed appliances.

In the Household and upcoming Professional Refrigeration Regulations, an off-set value is foreseen. The absence of a well-defined offset value resulting from regression analysis has led to the proposal to not have an offset value, similar to MEPS developed in Australia, for the supermarket display cabinet segment.

The proposed reference energy formulas are similar to the formulas provided in the domestic and professional refrigeration regulations, *i.e.* differentiating according to the set-up, vertical vs. horizontal, and the working temperature.

The proposed equations are presented below in Table 24. Following the conclusions from the segmentation options, and based on the available data, the equations are different for the different ISO 23953 temperature classes and basic set-up (vertical/horizontal). Figures with data points illustrating the regression lines are not disclosed (pending clearance of confidentiality). For freezers, only data for closed cabinets has been used.

**Table 24. Reference energy values proposed for supermarket display cabinets**

		Product temperature	TEC kWh/day	$C_2$ kWh/(day.m <sup>2</sup> )	TDA m <sup>2</sup>
Freezers	Vertical/combined (based on data from YF4, VF4, YM6)	L1	TEC =	19.4	TDA
		L2	TEC =	no data	TDA
		L3	TEC =		TDA
	Horizontal (based on data from HF5, HF6)	L1	TEC =	9.8	TDA
		L2	TEC =	9.0	TDA
		L3	TEC =		TDA
Refrigerators	Vertical/combined (based on data from VC1, VC2, VC3, VC4, YC4)	M1	TEC =	12.3	TDA
		M2	TEC =	10.0	TDA
		H	TEC =		TDA
	Horizontal (based on data from HC1, HC2, HC3, HC6, HC7)	M1	TEC =	5.4	TDA
		M2	TEC =	5.3	TDA
		H	TEC =		TDA

#### **L2 datasets:**

From the dataset, slight differences between L1 and L3 are noticed for vertical closed cabinets. No data for vertical closed cabinets working in the intermediate L2 temperature

class is available. Only 3 data points are available for open, vertical cabinets working at temperature class L2. For horizontal appliances, clearer differences are observed.

## **Q.6) REMAINING QUESTIONS**

### **Supermarket display cabinets**

**For vertical freezers working at L2, only three data points are available to determine the correlation equation. The equation of the neighbour categories L1 and L3, are obtained from much more populated datasets. Would you agree to obtain the equation for L2 RDCs, as a weighted average of the L1 and L3 values?**

**For which products is the temperature class L1, L2 or L3 used?**

**What is your opinion on defining the energy consumption for all freezers at temperature class L1, and for all fridges at M2?**

**In case you prefer to set an off-set constant ( $C_1 \neq 0$ ), could you please provide proposals based on data or logic reasoning?**

**In case you do not agree with the proposed values, please provide adequate information to support your opinion.**

Note that for freezers, the data collected on energy consumption stems only from closed appliances. If the dataset also included measurements from open appliances, the energy consumption figures would be higher.

The data presented, based on closed appliances, is kept and used as reference. The arguments for this are: firstly, that most appliances are currently closed, which explains why most data collected stems from this type of appliance and secondly, that a trend has been detected to the substitution of open freezers by closed freezers. However, the intended approach is to do not prescribe that the appliances shall be closed or open, as long as they meet minimum energy efficiency criteria still to be developed.

For refrigerators, datapoints for open as well as closed appliances have been used to define the reference energy consumption values. Stakeholders mention that some appliances, in particular those with a semi-vertical set-up, are difficult to manufacture in a closed set-up. These semi-vertical appliances are frequent in EU retailers today.

Further classification according to the more detailed set-up of the cabinet (semi-vertical, multi-deck, glass lid, glass door, etc.) aligned with the cabinet family classification in ISO 23953 would be complicated, merely because of the absence of sufficient data for each product family. Moreover, a multitude of different types and models, and possible future new designs, could complicate the legislation substantially and could cause loopholes for models not clearly described in the standard/legislation. The approach of no differentiation according to the detailed set-up has been widely supported by the stakeholders.

An exception for serve-over counters has been proposed, because of the small volume to TDA ratio. However, according to the available data, no significant differences are observed and segmentation is not necessary.

Table 25 compares the proposed energy consumption reference values with the threshold values for the ECA scheme, and the values used by Eurovent Certification.

**Table 25 ECA performance thresholds for refrigerated display cabinets**

Temp. Class	JRC proposal – TEC (kWh/(day.m <sup>2</sup> ))	ECA EEI performance threshold (kWh/(day.m <sup>2</sup> ))		Eurovent Certification scheme (averages for different cabinet types) (kWh/(day.m <sup>2</sup> ))
	Remote & Integral	Integral	Remote	Remote
L1	19.4 (vertical) 9.8 (horizontal)	<= 21.00	<= 23.50	28.5 (vertical) 13.5 (horizontal)
L3	18.5 (vertical) 7.4 (horizontal)	n/a	<= 21.00	29.0 (vertical) 15.5 (horizontal)
M0	12.3 (vertical) 5.4 (horizontal)	<= 12.50	<= 11.75	11.6
M1	12.3 (vertical) 5.4 (horizontal)	<= 12.20	<= 11.45	8.0
M2	10.0 (vertical) 5.3 (horizontal)	<= 11.60	<= 10.85	8.8
H1	7.6 (vertical) 4.6 (horizontal)	n/a	<= 8.00	7.7
H2	7.6 (vertical) 4.6 (horizontal)	<= 10.20	<= 9.20	7.7

Table 25 shows that the ECA scheme thresholds values are close to the reference energy consumption values proposed by the JRC, based on Eurovent's 2013 dataset. The values currently used for the Eurovent Certification Scheme are in some cases in line with the newly provided data, in other cases they deviate from it. As Eurovent Certification had defined their values as segmented for different models, in the table the average values are given for the different models in the same temperature class.

## 6.4 Artisan gelato ice-cream display cabinets

### 6.4.1 Scope

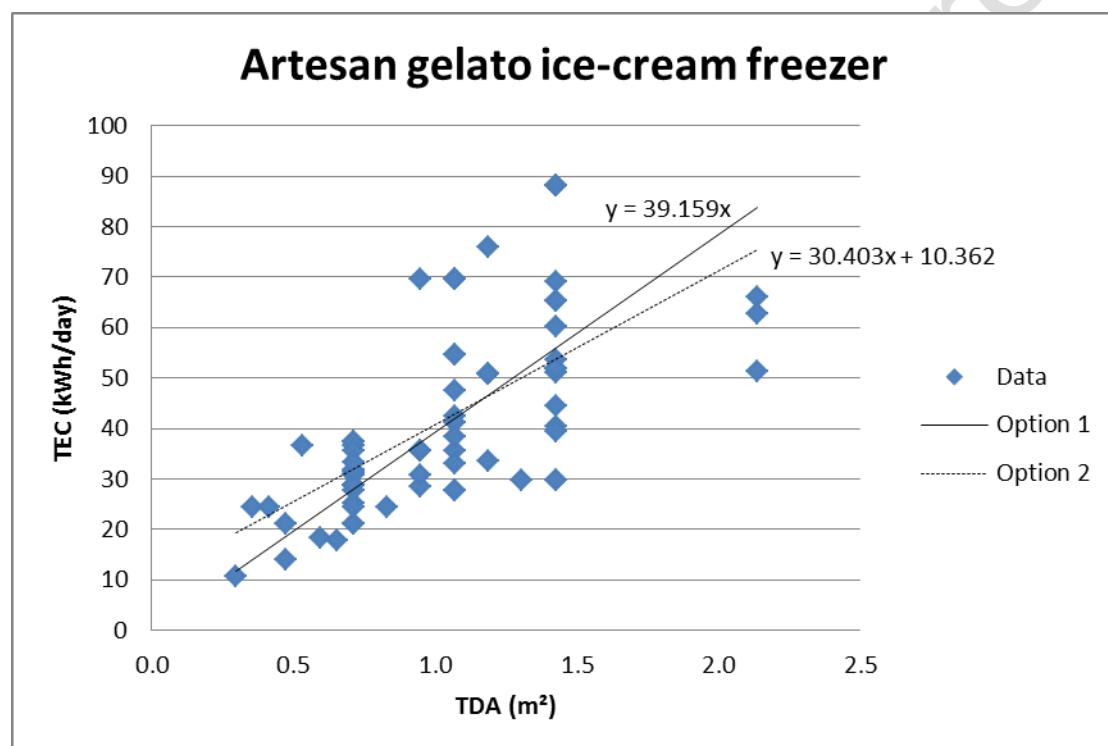
Artisan gelato ice-cream cabinets are especially designed to display and maintain the quality of 'home-made' ice-cream, which is usually high in sugar content, low in fat content. Because of their special function they differ from supermarket display cabinets. They work at different temperatures (-10°C) and the displayed products have different thermal characteristics. Technically, they have a controlled airflow, two evaporators and a defrost mechanism. The cabinet is designed to achieve the best display of the product using a heated double glass, and in general a solid structure.

Market data show that the share of artisan gelato display cabinets is about 3% of the total display cabinet market (supermarket + artisan).

#### 6.4.2 Reference energy formula

A new working group (N 5) for ‘Refrigerated display cabinets for artisan self-made gelato’ is established in CEN/TC 44. A first meeting is planned in December 2013. This means that currently no standard is available to define the energy consumption of these appliances.

Notwithstanding this, the association of gelato machines, shop fittings and equipment manufacturers (Assofoodtec/ACOMAG) has provided some data points, which are reproduced in Figure 14.



**Figure 14. Energy consumption of artisan gelato ice-cream display cabinets in function of TDA. Source: Assofoodtec/ACOMAG, 2013.**

From Figure 14 it can be seen that artisan gelato display cabinets consume much more energy than their horizontal supermarket counterparts with the same display area.

Table 26 shows the proposed reference energy consumption for artisanal gelato display cabinets.

**Table 26 Reference energy consumption proposal for artisanal gelato display cabinets.**

Artisanal gelato cabinets	TEC kWh/day	C <sub>1</sub> kWh/day	C <sub>2</sub> kWh/(day.m <sup>2</sup> )	TDA m <sup>2</sup>
<b>Option 1</b>	TEC =	0 +	39.2	TDA
<b>Option 2</b>	TEC =	10.4 +	30.4	TDA

For comparison, the reference energy consumption for horizontal supermarket freezers proposed is  $TEC = 9.8 \cdot TDA$ , exactly 25% of the value for gelato appliances ( $TEC = 39.2 \cdot TDA$ ) which actually operate at a higher temperature than supermarket cabinets.

Figure 14 also illustrates that there is a very large spread of energy use for gelato cabinets with the same TDA, indicating a large improvement potential for certain cabinet types.

## Q.7) REMAINING QUESTIONS

### Artisan gelato freezers

What is your opinion on treating artisan gelato ice-cream display cabinets as a different category?

In case you do not agree with the proposed reference energy consumption equations, please provide adequate information to support your opinion.

## 6.5 Ice-cream freezer ( $V < 500$ litre, $TDA < 1.1 \text{ m}^2$ )

### 6.5.1 Scope

An additional category, with own energy consumption data, is proposed for small ice-cream freezers.

Different types of small ice-cream freezers exist:

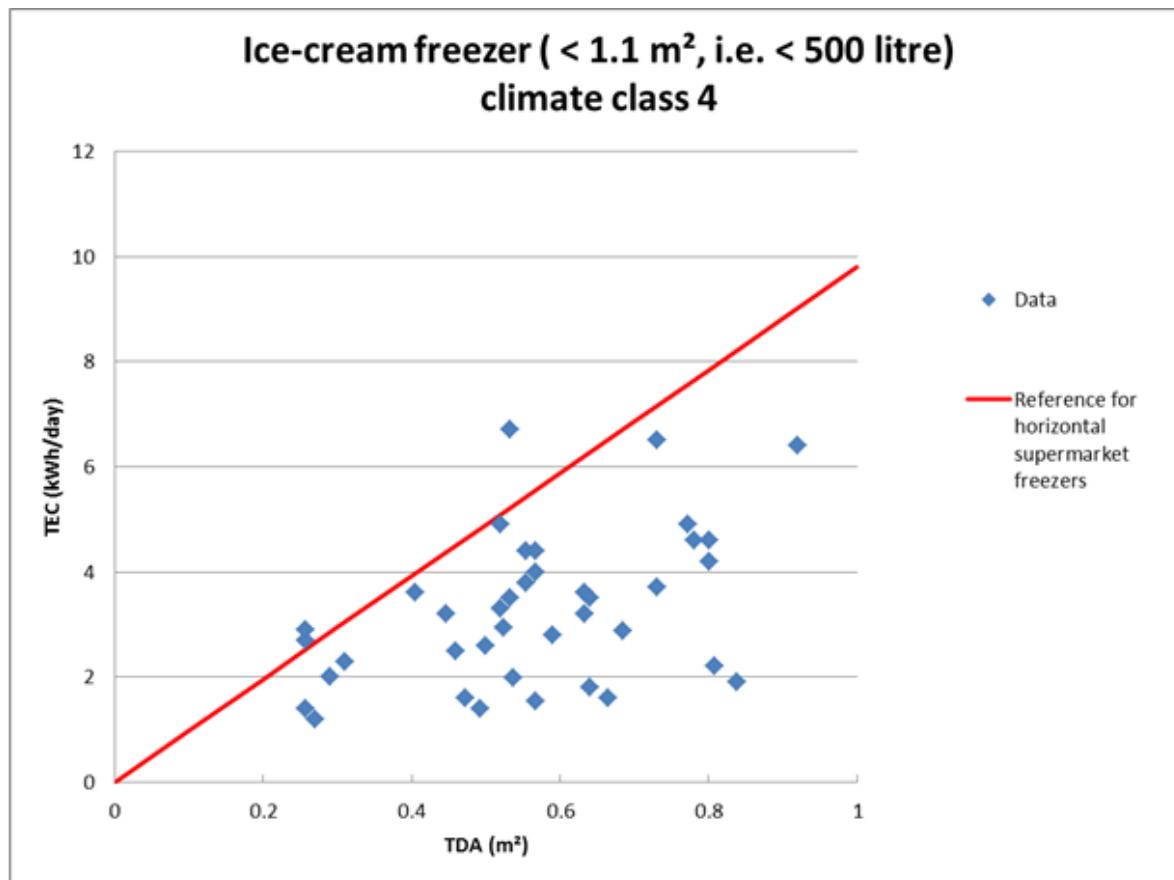
- a) Angle Top
- b) Flat Top
- c) Close Top



However, no further differentiation is proposed between these types of small ice-cream freezers.

In principle, these appliances could be classified as integral/plug-in, frozen, horizontal, closed cabinets (IVF4). However, differentiation is proposed based on a number of arguments. Most importantly, the net refrigerated volume is usually smaller for ice-cream freezers intended for merchandising, compared to their counterparts in the supermarket segment.

The (scarce) data that has been possible to collect shows a lower energy consumption compared to the supermarket segment counterparts (see Figure 15), which speaks in favour of a separate energy consumption equation, in order to reward appropriately energy efficiency merits.



**Figure 15. Data plot of energy consumption values for small ice-cream freezers. For reference, the line of average energy consumption for supermarket display cabinets (horizontal, frozen) is included (in red).**

A cut-off limit for the net refrigerated volume is proposed at  $V = 500$  litre, or equivalently a display area bigger than  $1.1\text{ m}^2$ . These volume and TDA are found as the trade-off upper limits for this type of appliance, that would ensure that manufacturers do not oversize the ice-cream freezers in order to use the more lenient energy consumption equation set for supermarket display cabinets (*e.g.* by making an appliance of 501 litres or TDA of 1.2  $\text{m}^2$ ).

### 6.5.2 Reference energy formula

Different approaches to the definition of the reference energy consumption equation are possible for ice-cream freezers. In short, three options are considered:

1. Based on the total display area (TDA), and part of the supermarket freezer categories described above.
2. An independent energy consumption equation based on the net refrigerated volume.

3. An independent energy consumption equation based on TDA.

***Option 1: Energy equation based on the Total Display Area, and part of the supermarket freezer categories described above.***

The equation that would apply would be (see Table 24):

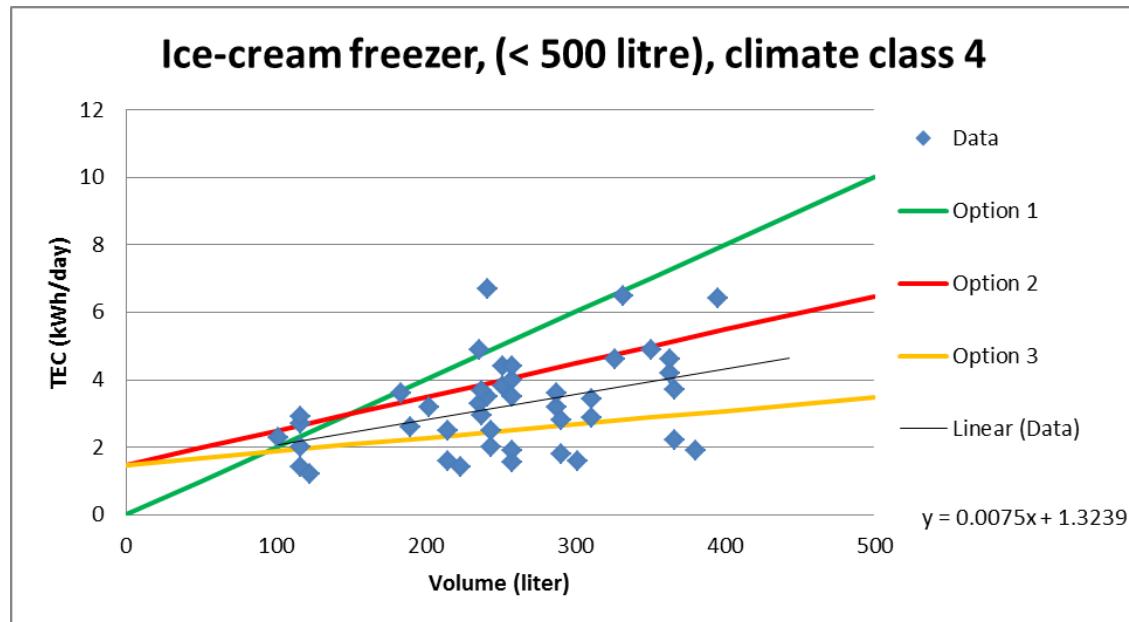
Supermarket display cabinet	Product temperature	TEC kWh/day	C <sub>2</sub> kWh/(day.m <sup>2</sup> )	TDA m <sup>2</sup>
Horizontal freezer (based on data from HF5, HF6)	L1	TEC =	9.8	TDA

The energy consumption of supermarket display cabinets is usually defined according to climate class 3 ( $T = 25^{\circ}\text{C}$ , RH = 60%). Small ice-cream freezers, however, tend to be used more outside in warmer climates. Climate class 4 ( $T = 30^{\circ}\text{C}$ , RH = 55%) could thus be more appropriate for small ice-cream freezers. As shown above, the use of this equation would overestimate the energy consumption of small ice-cream freezers.

***Option 2: Independent equation, based on net refrigerated volume***

Ice-cream freezers are usually closed, and therefore could have an energy consumption equation based on the net volume instead of on total display area. Indeed, most of the available data is expressed as energy consumption per unit of volume. Additionally, frequently ice-cream freezers for merchandising do not have a display area, and are equipped with a non-transparent door, often covered with advertisements. In such cases, the direct display function is judged unnecessary compared to the knowledge of the consumer – via advertisement on the cabinet's surfaces – of what the exclusive content of the cabinet is.

Figure 16 below depicts the data collected for ice-cream freezers and the proposed energy use equation based on volume derived from it.



**Figure 16.** Total energy consumption data per volume for small ice-cream freezers. Different reference options developed throughout stakeholder consultation are plotted as well, together with the linear regression.

Please note that due to the working conditions of ice cream cabinets, often in outdoor environments and hot climates, their energy use is tested customarily in climate class 4 ( $T = 30^\circ\text{C}$ , 55% RH) as compared to climate class 3 ( $T = 25^\circ\text{C}$ , 60% RH).

The reference energy consumption per unit of volume could be described using different approaches (Table 27):

**Table 27 Reference energy consumption for small ice-cream freezers per unit of volume**

Small ice-cream freezer	TEC kWh/day	$C_1$ kWh/day	$C_2$ kWh/(day.litre)	V litre
<b>Option 1</b>	TEC =	0 +	0.02	Volume
<b>Option 2</b>	TEC =	1.48 +	0.010	Volume
<b>Option 3</b>	TEC =	1.48 +	0.004	Volume
<b>JRC latest, volume</b>	TEC =	1.32 +	0.008	Volume

Throughout stakeholder consultation during the project, e.g. through questionnaires, different options to describe the reference energy consumption of these appliances have been obtained. JRC proposes the option of the linear regression of the data, which is an alternative between two options earlier proposed.

#### **Option 3: Independent equation, based on Total Display Area**

The freezers with one or more transparent sides have a display function which solid cabinets do not have. A means of addressing this is to base the energy accounting on TDA. However, as most data is recorded per display volume in these cabinets, a conversion factor volume to TDA would be needed.

Figure 17 presents the conversion factor development (regression after plotting the volume and TDA values of the data where both were provided). Figure 18 shows the resulting plot of energy consumption per display area, where all the reference lines of Figure 16 have been converted.

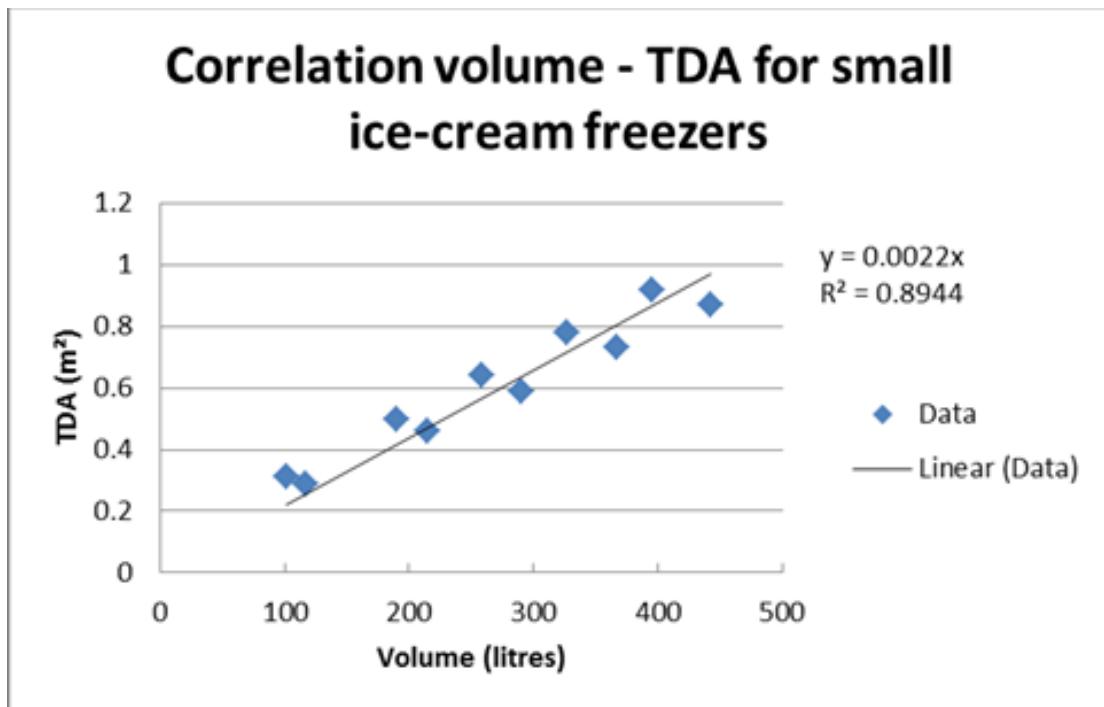
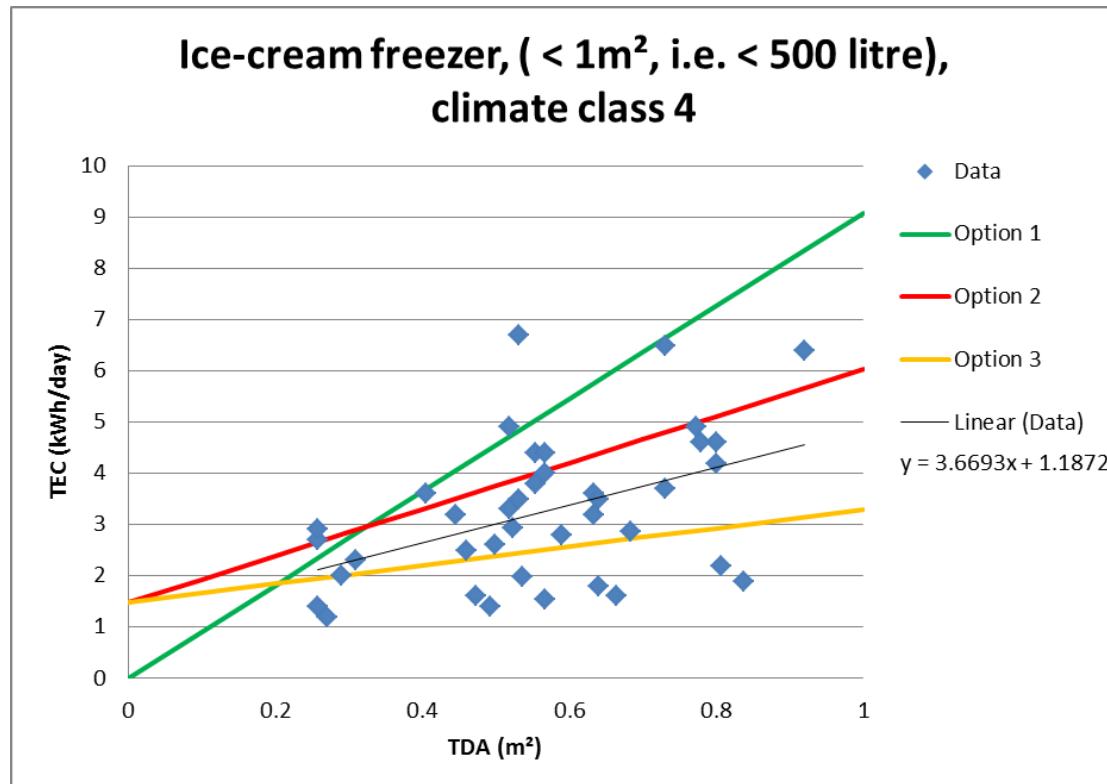


Figure 17. Linear regression fit of net refrigerated volume and TDA for small ice-cream freezers, used to determine the conversion factor volume/TDA.



**Figure 18.** Total energy consumption per total display area for small ice-cream freezers. Different reference options developed throughout stakeholder consultation are plotted as well, together with the linear regression.

The reference energy consumption per unit of display area could be described as follows (Table 28):

**Table 28.** Reference energy consumption for small ice-cream freezers per unit of display area

Small ice-cream freezer	TEC kWh/day	C <sub>1</sub> kWh/day	C <sub>2</sub> kWh/(day.m <sup>2</sup> )	TDA m <sup>2</sup>
JRC latest, TDA	TEC =	1.19 +	3.7	TDA

#### Summary

Table 29 below summarises pros and cons identified for the three options.

**Table 29.** Pros and Cons of three options to address the definition of energy consumption from small plug-in ice-cream freezers.

	Pros	Cons
Option 1. TDA, part of RDC family	Simplicity in resulting Regulation.	Normally different testing temperature (CC3 vs. CC4) of ice cream cabinets would make comparison difficult. No reward to lower energy consumption compared to most supermarket cabinets Not sufficient motivation for efficiency improvement.

Option 2. Volume, independent	No conversion mechanism needed. Most real data is expressed by volume. Most appliances are closed. Almost always the content of the cabinet is exclusively ice-cream from a single brand, so clear advertisement makes direct display unnecessary.	The freezers with display area are not rewarded for their additional display function, and would be penalised because of their worse energy performance compared to solid cabinets.
Option 3. TDA, independent	Addresses the display function directly	Solid freezers need to use a conversion mechanism

## Q.8) REMAINING QUESTIONS

### Ice-cream freezers

Which of the approaches above to define the average energy consumption formula for ice-cream freezers would you consider most suited? Per volume or per TDA? Which proposal do you think fits best the current market?

### Cut-off values

Would you agree that there is risk of circumventing or by-passing the energy consumption formula for ice-cream freezers using instead the horizontal supermarket freezer values? Or is such by-pass not feasible for technical/commercial reasons (if so, please specify these)?

In case there is such risk, which volume and/or TDA cut-off value would you propose? Are the V = 500 litre and TDA 1.1 m<sup>2</sup> adequate values in your view?

Alternatively, which means of avoiding by-passing the ice-cream energy values would you propose? Which other means could you propose to define these small-ice-cream freezers?

The climate class for ice-cream freezers could be determined at Climate Class 4 as they are frequently placed outside and most data is available for this climate class. What is your opinion on testing these appliances at climate class 4 (T= 30°C, RH = 55%), while other appliances probably will have to be tested at climate class 3 (T= 25°C, RH = 60%)? Could this be an extra burden for manufacturers?

## 6.6 Beverage coolers

### 6.6.1 Scope

Similarly to ice-cream freezers, an additional category with own energy consumption data is proposed for beverage coolers (BCs). In principle, these appliances could be classified as plug-in, chilled, vertical, closed cabinets (IVC4), following the categorisation of display cabinets from the supermarket segment. However, differentiation is proposed based on a number of arguments. Firstly, BCs could have other shapes for commercial reasons like bowls or cylinders. They are mostly glass-door refrigerators, sometimes with solid doors. Small impulse buyers can have an open structure. Secondly, data is usually

expressed in net refrigerated volume. Thirdly, the energy consumption is currently tested following protocols different from ISO 23953.

A number of additional features differentiate a beverage cooler from a supermarket display cabinet. One of these is that BCs are usually designed to quickly lower the temperature of products that have been inserted at ambient temperature, the so-called pull-down mechanism. This is in contrast with supermarket display cabinets, where products are perishable and therefore inserted at low temperature not to interrupt the cold chain. The cabinet is thus designed to keep the products cold, and not as much to cool them down. This has an effect on the design and sizing (normally overdimensioning) of the refrigeration components of beverage coolers, compared to supermarket cabinets of the same volume. Also the volume and display area are usually smaller than in supermarket cabinets. TDA of beverage coolers is usually below 2m<sup>2</sup>.

Moreover, beverage coolers are more and more equipped with energy saving devices that allow an increase of the working temperature for a certain period of time where activity is low. This goes beyond what is possible in supermarket cabinets containing perishable goods, which can also include such devices to reduce the cooling power (*e.g.* at night), but always maintaining a minimum temperature. These energy saving devices are shortly discussed in section 6.6.3.

### 6.6.2 Reference energy formula

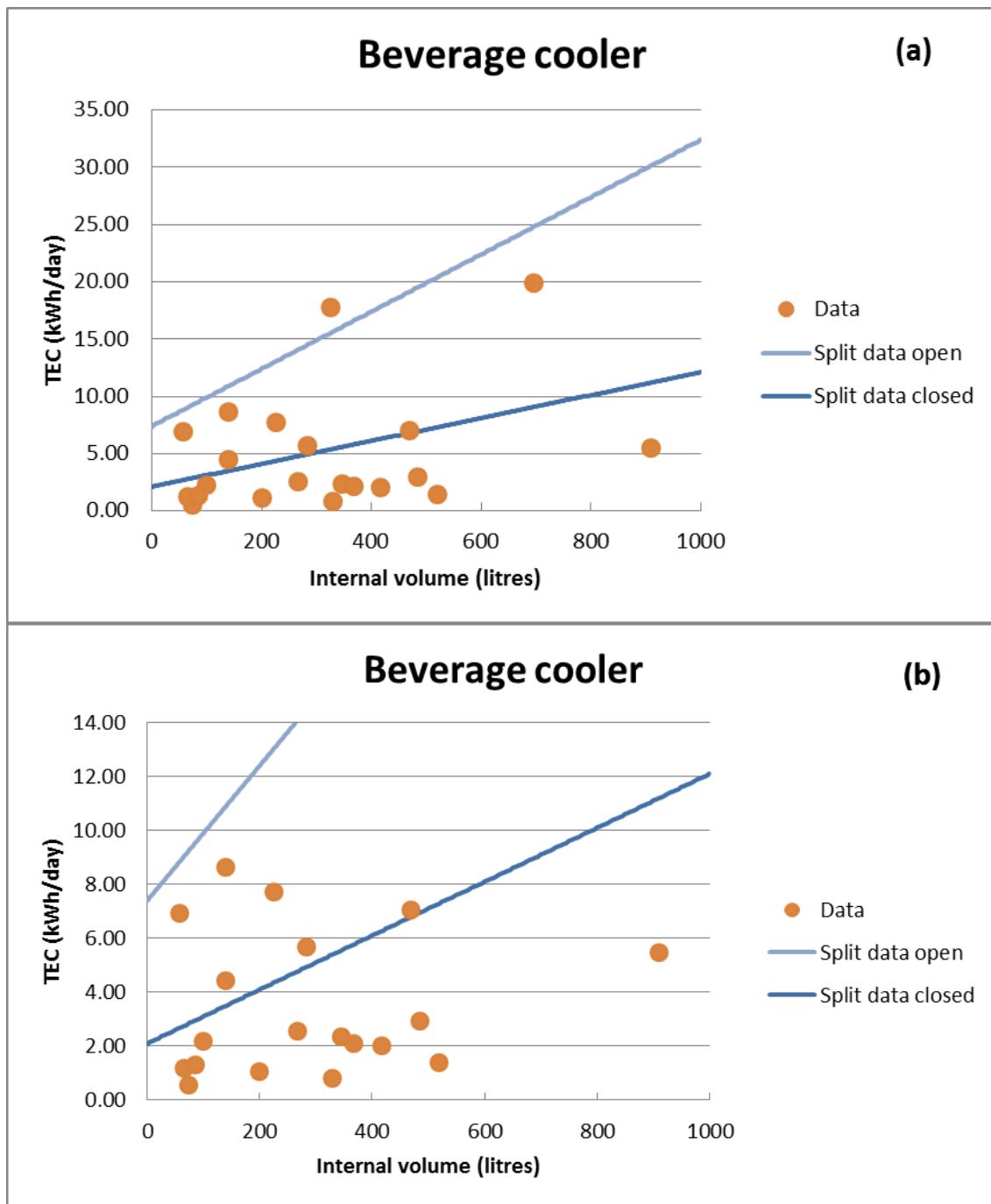
It is proposed to express the energy consumption per net refrigerated volume, as most data currently available is recorded using this reference. This simplifies additional inclusion of beverage coolers with solid/opaque doors (TDA = 0).

Table 30 shows reference energy consumption equations with a split between open and closed coolers.

**Table 30 Reference energy consumption equation proposals for beverage coolers.**

Beverage cooler	TEC kWh/day	C <sub>1</sub> kWh/day	C <sub>2</sub> kWh/(day.litre)	V litre
a. Split data: <b>closed BCs</b>	TEC =	2.1 +	0.010	Volume
b. Split data: <b>open BCs</b>	TEC =	7.4 +	0.025	Volume

Figure 19 below depicts the data available and the regression lines that obtained for open and closed coolers.



**Figure 19 (a) Linear regression of energy consumption equations for beverage coolers. In figure (b) the scale of the energy axis has been reduced for clarity.**

Figure 19 clearly illustrates that open beverage coolers consume much more energy than their closed counterparts.

On the question of proposing a segmentation of open and closed beverage coolers, stakeholders have reported not to oppose a gradual phase out of large open beverage coolers. However, some concerns are raised on making possible the use of smaller open coolers related to niche, short life marketing strategies (*e.g.* launching a new product and ‘impulse’ buying).

Should a MEPS be developed at a later stage of this project based on an energy formula for closed appliances, the survival of open coolers would be conditioned to a very good energy performance, similar to that of closed coolers. In the context of MEPS formulation, it will be important to know precisely the market share of these small, open beverage coolers, so the impact of the MEPS on them can be properly addressed.

Moreover, the energy consumption data available for open beverage coolers is scarce. In the absence of reliable energy consumption data and market share data, the alternative proposal will be to only use closed beverage cooler data, also for the open coolers. This may likely result in the outphasing of these open coolers.

## **Q.9) REMAINING QUESTIONS**

### **Beverage coolers**

**Would you support the technical characterisation of energy consumption of beverage coolers described above?**

**On which physical features, easy to be checked, could a beverage cooler be differentiated from a plug-in, vertical, closed supermarket display cabinet?**

**In order to improve the reliability of the underlying data for the proposal, stakeholders are invited to share with the JRC stock data of their BC fleets, for closed as well as for open beverage coolers. Stakeholders are also invited to provide energy consumption data for open beverage coolers, as the currently collected data are scarce.**

### ***Measurement challenges***

The proposed reference energy equation could be compared with similar equations for ENTR Lot 1 (professional refrigeration) and domestic refrigeration, both also using as reference the net refrigerated volume. Regarding the Household Refrigeration Regulation, bottle coolers could be compared with a domestic refrigerator with one or more fresh food storage compartments ( $T = 5^\circ\text{C}$ ), defined as category 1. In ENTR Lot 1 proposal, a bottle cooler could be compared with a vertical, chilled appliance (see section 8.3)

In both cases, the comparison is not on an equal basis, as the measurement protocols for energy consumption are different. In ENTR Lot 1 it will be based on a new standard, now under development. In domestic refrigeration it is based on ISO 8187, ISO 8561, and ISO 7371. As known, for commercial refrigeration it is described in ISO23953, and uses M-packages in the testing. However, most data available are not tested by any of the mentioned standards, but instead using specific test protocols developed by some of the largest beverage producers, and use actual beverages in the testing. These protocols deviate from the ISO23953 standard, and only in some cases correlation coefficients can be applied to estimate the equivalent consumption if *e.g.* ISO23953 was used. A few data points measured following ISO 23953 have been made available for this project.

Another issue related to the use of ISO 23953+A1:2012 for beverage coolers is in relation to appliances that work with static air instead of a forced air flow<sup>s</sup>. Stakeholders report

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<sup>s</sup> No exact numbers have been collected of the market share for these appliances. They are expected to be low. For horizontal appliances working with static air, such problems are not encountered.

that vertical static air devices are unlikely to meet the door opening requirements described in ISO23953+A1:2012, whilst maintaining the required temperatures. This could be problematic, as static air cabinets unable to maintain the required temperature would not qualify for an energy label nor meet Ecodesign requirements, if these were only based on the current version of ISO23953. It is thus necessary to exclude these appliances from the scope (and include them in the Household or Professional refrigeration Regulations), or accommodate them in some way in the regulation, describing a specific measurement protocol within ISO 23953 or out of it, as they are not necessarily less energy efficient than forced air flow appliances.

#### **Q.10) REMAINING QUESTIONS**

##### **Static beverage coolers**

**Do you have data of the market share of static beverage coolers compared to forced air flow beverage coolers that the JRC could use to assess the relevance of any efforts to include them?**

**What is your opinion on including these static air beverage coolers in the Household or Professional Refrigeration Regulation?**

#### **6.6.3 Energy management devices (EMD)**

Energy management devices are electronic control components that allow an appliance (cooler, vending machine or other) to run in low-energy/stand-by state for a certain time. It can steer lights and the working temperature. If the content is non-perishable, as is the case for canned beverages, a rise in the working temperature is possible, *e.g.* from 4°C to 10°C. The duration of such high temperature periods can be controlled by a presence detector, adapting it to the learned sequence of demand. According to stakeholders, an energy management device can save up to 35% of energy consumption.

Accounting for the presence of such (or a similar) device in the Ecodesign measures is not straightforward, as its performance cannot be detected by the ISO 23953 testing standard. Conversely, they are taken into account in the testing protocols developed by the beverage companies. When addressing this in a later phase of this project, several options may be possible. One is *e.g.* to adapt the standard and device mechanisms in the testing protocol to measure the effectiveness of these devices.

Another option may be to accept that their effect cannot be quantified with ISO 23953, but if alternative and recognised testing protocols (such as those developed by the beverage companies) are able to measure their effect, allow for a complementary communication of such benefits. This could be connected to a specific labelling on this issue (*e.g.* energy class A plus 10% if EMD activated). If not quantified, requirements on the EMD and what it must be able to deliver must be specified, as otherwise the label will have no credibility.

Some stakeholders have objected rewarding the use of EMD, as they argue this may be a short-cut to achieve the Ecodesign requirements minimum efficiency without necessarily taking action on other more fundamental technologies such as insulation, control of air

flows, or heat leak contention. With this in mind, care has to be taken that when MEPS are developed, EMDs could be rewarded, but should not influence the MEPS levels.

#### **Q.11) REMAINING QUESTIONS**

##### **EMDs and beverage coolers**

**Which options (as presented above, or other) for testing and rewarding the installation of EMDs in commercial cabinets would you see most feasible?**

## **6.7 Vending machines**

### **6.7.1 Scope**

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. Excluded are vending machines with combined heating and cooling parts, or food preparation

### **6.7.2 Reference energy consumption**

For defining the reference energy consumption of refrigerated vending machines, different options are possible:

1. Use and refine the formula developed in an earlier stage of the project by Wuppertal Institute.
2. Extrapolate to the EU the formula from another world region (e.g. USA, where the measurement method is similar to the one proposed by EVA and under revision by CENELEC).
3. Apply the energy labelling classes as proposed in the EVA-EMP 3.0a protocol and base MEPS on this.

#### ***Option 1: Formula developed earlier in the project.***

The formula earlier developed in the project was based on confidential data. It reads as follows.

For cold vending machines, to which the EVA-EMP 3.0a can be applied, 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/(m<sup>3</sup>.year) and recorded to two decimal places, as:

$$\text{RSEC} = [1,500 + 16 \times \text{EC}]$$

$$\text{with EC} = \sum_i V_i \times \frac{T_a - T_{mc_i}}{T_{mc_i}}$$

where

i = different compartments within a vending machine which are operated at different temperature levels T<sub>mc*i*</sub>, 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 dm<sup>3</sup>.

RSEC would in this case represent the reference energy consumption value.

Without recent data measurements, the validity of this formula cannot be assessed.

***Option 2: Based on extrapolation of data from e.g. USA.***

Different datasets could be used for the development of a reference energy consumption formula.

- Californian data can be downloaded from <http://www.appliances.energy.ca.gov/>. The Appliances Database contains listings for all appliances currently certified to the California Energy Commission as meeting currently applicable efficiency standards. The appliances listed there either meet USA federal efficiency standards or, where there are no federal efficiency standards, meet California's appliance efficiency standards.
- Another source of data is the USA Energy Star scheme for which data can be downloaded at <http://www.energystar.gov/productfinder/product/certified-vending-machines/>.

The SEAD report<sup>25</sup> indicates that not too much difference is expected between the USA (ASHRAE32.1:2010) measurement method and the EVA-EMP 3.0a protocol. This would allow using data available from the USA to develop a reference energy consumption formula. Care has to be taken as the machines in the EU and USA are known to have clear physical differences. A comparison shall focus on machines for the same product group, e.g. beverage cans.

***Option 3: Apply the energy labelling classes as proposed in the EVA-EMP 3.0a protocol***

EVA-EMP provides a measurement protocol together with a labelling system. This is now under revision by CENELEC. If it is approved by CENELEC it could serve as a basis for EU MEPS and possible EU labelling. However, the energy labelling system should be reliable and robust. The current lack of lack of recent data makes such assessment not possible.

As at the moment, EVA reports that energy consumption data is hardly available for European vending machines, beverage and food manufacturers could probably be an alternative source of data.

***Data***

If additional energy consumption data of European refrigerated vending machines could be obtained, all the above options could be explored, and additionally the same procedure as for the other commercial refrigeration appliances could be followed.

**Q.12) REMAINING QUESTIONS**

**Data on Vending Machines**

Please provide your opinion on the feasibility of the options presented above.

Beverage and food producers are especially encouraged to share data on energy consumption of vending machines with the JRC, so the assessment can be completed.

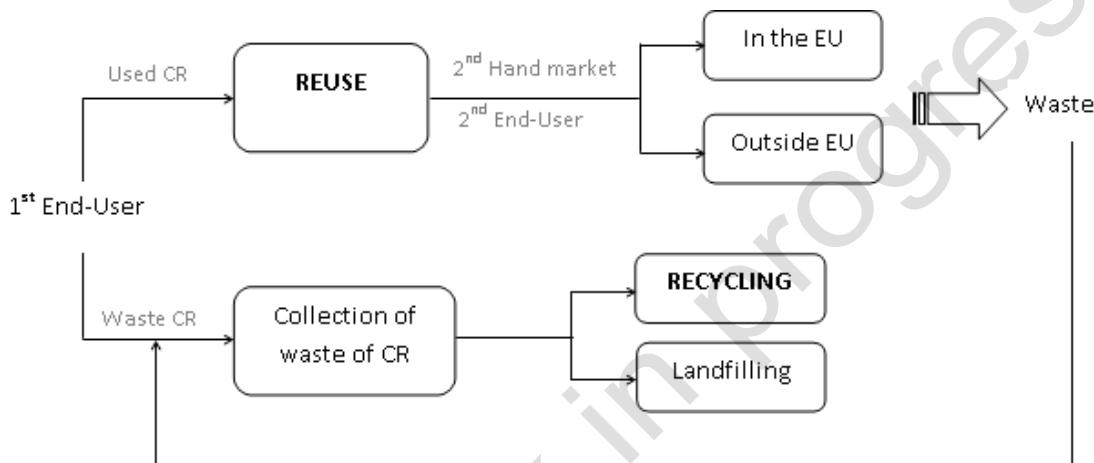
Draft - work in progress

## 7 END-OF-LIFE (EOL)

### 7.1 Data on end-of-life treatment of commercial refrigeration appliances

After the first use, the commercial refrigeration appliance becomes either a used device, which can be put again on the market, or a waste. Used commercial refrigeration appliances can be reused in the second hand market inside or outside the EU.

Regarding the waste of commercial refrigeration appliances, these are first collected and then sent to recycling or landfill (Figure 20).



**Figure 20. Overview of EoL flows of commercial refrigeration appliances**

From the current available data, it is difficult to estimate the flows of commercial refrigeration appliances that are reused inside/outside the EU or collected as waste and further recycled or landfilled. Although quantitative information of flows of commercial refrigeration appliances at their EoL is very limited, the next sections attempt to give an overview of these figures.

Regarding recycling data, in the absence of specific information, the following figures about the treatment of WEEE at the EoL have been analysed:

- WEEE Category 1 “Large household appliances”. Commercial appliances are likely to be classified within the scope of this WEEE category if they resemble household appliances. In addition household and non-household refrigerators are generally recycled together.
- WEEE Category 10 “Automatic dispensers”. Vending machines are the only type of commercial refrigeration appliances explicitly included in WEEE Directive.

Moreover, general figures of WEEE have been considered when information on Categories 1 and 10 were not available.

Please note in the next section that the data here presented are limited to available statistics and do not cover fully all categories of commercial refrigeration appliances.

### 7.1.1 Data about reuse and recycling flows of waste

No detailed data is available on the reuse of commercial refrigeration appliances or even on EEE. Although there are evidences of trades of used EEE, this is hardly documented and quantified.

The first constraint when looking for specific figures is that statistics do not differentiate between used and new goods. This fact complicates the reporting of products put in the second-hand market, either inside or outside the EU.

Regarding the trade of EEE to third countries, quantitative data of exports, either as used equipment or as a waste, is also very scarce.

European figures of products put in the market and waste of some types of commercial refrigeration appliances are available in EUROSTAT. These data are provided by member states according to the reporting requirements of WEEE Directive. In 2010, 60 655 tonnes of “Automatic dispensers” (Category 10 of the WEEE Directive) were put in the market while only 12.536 tonnes were collected. For Category 1 Large household appliances<sup>t</sup> 4 684 993 tonnes of products were put in the market in 2010 and only 1 556 141 were collected as waste<sup>u</sup>.

As seen above, statistical figures on products put on the market and on waste flows can hardly be compared, in order to ensure their robustness. This can be explained by the fact that commercial refrigeration appliances can be collected and treated by manufacturers and/or professional users, and not only by recyclers. The differences in the figures of collected waste compared with products put in the market can also be related to the time lag between the moment a product is put in the market and the time when it is discarded. However, these observed large discrepancies could also relate to the lack of official ways of reporting second-hand trades and to illegal shipments of waste<sup>59</sup>.

Table 31 shows the amounts in tonnes of the waste of automatic dispensers and large household appliances, and where these were treated. It is also observed that a small percentage of waste of these two groups of appliances is treated outside of the member state where the waste was generated.

**Table 31.** Destination of waste “Automatic dispensers” and “Large household appliances” (EUROSTAT)

<b>EUROSTAT data for 2010</b>	<b>Treated in the Member State</b>		<b>Treated in another Member State of the EU</b>		<b>Treated outside the EU</b>	
Automatic dispensers (t)	11 427	96%	451.5	3.8%	23.3	0.2%
Large household appliances (t)	1 311 421	95.3%	61 304	4.4%	3 359	0.2%

<sup>t</sup> Waste stream in which some commercial refrigerators might be present

<sup>u</sup> EUROSTAT, 2013 <http://appsso.eurostat.ec.europa.eu> (access 7<sup>th</sup> June 2013)

### 7.1.2 Additional information

Some additional information about waste flow of commercial refrigeration appliances has been derived by interviews of manufacturers and recyclers. Four recyclers observed that some typologies of commercial refrigeration appliances (*e.g.* large supermarket refrigerators) are under-represented in their waste flows. Manufacturers stated that a great number of commercial refrigeration appliances are fully or partially remanufactured<sup>v</sup>. However, more precise figures are not available.

Table 32 shows the recovery and recycling ratios for automatic dispensers and large household appliances. These rates have been calculated based on EUROSTAT data. Rates refer to the percentages of recycled/recovered mass versus tonnes of waste treated. The difference between recycling and recovery is related to energy recovery. The difference to 100% is disposal (landfilling and incineration without energy recovery).

**Table 32.** Recovery and recycling ratio for waste of automatic dispensers and large household appliance.

<b>EUROSTAT data for 2010</b>	<b>Recovery</b>	<b>Recycling</b>
Automatic dispensers	77.6%	72.1%
Large household appliances	88.3%	84.0%

Finally, regarding the EoL of refrigerants, only 5% of the installed refrigerants are estimated to be recycled each year<sup>66</sup>.

This section demonstrates that only scarce and incomplete statistical data are currently available on the fate of commercial refrigeration appliances at their end-of-life. However, the expertise of manufacturers and recyclers can help to have a good understanding of EoL treatments, as described in the following sections.

## 7.2 Technical and environmental analysis of end-of-life of commercial refrigeration appliances

The technological and environmental analysis of EoL of commercial refrigeration appliances has been carried out throughout literature review, communications with stakeholders (manufacturers and recyclers), interviews and visits to recyclers.

When the manufacturer sells a new commercial refrigeration appliance, the user utilizes it for a period of time which can coincide or not with the lifespan of the device. The used commercial refrigeration appliances could be reused; otherwise it will become a waste. Reuse and recycling technical features are explained in the next sections.

<sup>v</sup> This claim has been also repealed during the first technical working group meeting for commercial refrigerators (Seville, 23<sup>rd</sup> April 2013).

### 7.2.1 Re-use practices

Though few data are available on reuse, there are evidences about their relevance, as following detailed. Commercial refrigeration appliances have specific characteristics that make them suitable for reuse (e.g. large devices with a value frequently well above 1000€, average lifetime of 8-10 years but often more, etc.). In addition, according to feedback received by stakeholders, they are usually substituted before their technical life ends for commercial reasons (e.g. fashion, changes of the needs of users).

The product can be reused as originally conceived or with some modifications<sup>w</sup>. In the reuse of a product as conceived, minor modifications take place such as cleaning or correction of components in order to return the appliance to satisfactory working condition. It includes the direct resell/remarket, the refurbish/recondition and the repair of the devices.

The reuse of products with modifications includes remanufacturing and upgrade. Remanufacturing is to transform a used product into an as-new condition with the required warranty. According to the Centre for remanufacturing & Reuse of the UK, the remanufacturing process of Refrigeration Display Cabinets (RDC) shall include an initial inspection, the deconstruction, repair and resurfacing of cosmetic and functional components, inspection and replacement of fans, cooling coils and the controlling circuit and the re-assembly and a final inspection<sup>75</sup>.

Remanufacturing may also happen on the retailer's request, by manufacturing or maintenance companies. These companies operate a product-oriented service business model for extending life or upgrading these commercial refrigeration appliances

Regarding remanufacturing, from an environmental life cycle perspective, a study has shown that remanufacturing of WEEE is preferable in terms of material resource efficiency when compared with new products<sup>67</sup>. However, the remanufactured products can be potentially less energy efficient than new products, and in some, the replacement of old products can be beneficial for some environmental impact categories<sup>51,64</sup>.

Nevertheless, vending machines should be considered apart. According to the U.S. Environmental Protection Agency voluntary program 'Energy Star' "*Remanufactured vending machines represent a significant share of new machine placements*"<sup>x</sup>. The vending industry is unique in that vending machines once sold may continue to be refurbished, leased, and placed on several host site locations throughout their lifetimes. Many of the older machines can be retrofitted with high efficiency components and in the end perform at the same energy efficiency levels as brand new machines. For such reason, remanufactured vending machines can be awarded with the Energy Star label, similarly to new devices.

### 7.2.2 Recycling processes

Previous to the recycling process, storage, collection and transport of the waste take place. EoL transport can be environmental relevant for some life cycle impact categories, as particulate matter (BioIS, 2007) and economically relevant, as highlighted by

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<sup>w</sup> [www.rreuse.org](http://www.rreuse.org) (access: June 2013)

<sup>x</sup> [www.energystar.gov/index.cfm?c=archives.rebuilt\\_vending\\_spec](http://www.energystar.gov/index.cfm?c=archives.rebuilt_vending_spec)

interviewed recyclers. In addition, transport of commercial refrigeration appliances (especially those of large dimensions) can have some risks of leakages of refrigerant gases, due also to accidental breakages of the refrigeration circuit.

Once the refrigeration appliances arrive to the recycling plants, these are grouped into homogeneous batches in order to be optimized for the next treatments.

Recycling of commercial refrigeration appliances is similar to the one of household refrigerators, as shown by the analysis of five European recycling plants. Main differences are related to the large dimensions and the presence of some additional components (e.g. large glass parts, larger amount of electronics and lamps). Waste of commercial refrigeration appliances at the EoL is generally treated in the EU in the same recycling plants of household refrigerators.

It should be noted that this analysis on the technical aspects of recycling of commercial refrigeration appliances has been based on the observation of the treatments of old devices (5 years the newest) currently reaching the recycling plants. These commercial refrigeration appliances were generally designed and put in the market under different legislation requirements. Therefore, it is highlighted a possible mismatch on the characteristics of the appliances being recycled today and the ones currently commercialized (without for example, mercury switches or CFC).

The analysis of the current recycling practices in five recycling plants showed that recycling of commercial refrigeration appliances is usually done in 3 main steps:

- 1) pre-treatment (consisting in the manually dismantling of specific components containing potentially polluting substances);
- 2) shredding of the appliances;
- 3) mechanical sorting for recycling/recovery of various materials.

#### **7.2.2.1        Pre-treatment**

The pre-treatment of waste commercial refrigeration appliances is the only step where these products are treated differently than household refrigerators. The large dimensions of commercial refrigeration appliances (e.g. for some vending machines, supermarket refrigerators, freezers, etc.) represent a problem during the waste collection, delivery and treatment in the plants. Large refrigeration appliances are usually manually dismantled and/or mechanically cut in smaller pieces at the recycling plant in order to be treated by shredders.

In the case of large remote display cabinets (e.g. those used in supermarkets), some pre-treatments already occur on-site. Refrigerants and oils are extracted before uninstalling of the cabinets. Successively, waste is delivered to the recycling plant for further treatments.

Vending machines which are made of heavy and sturdy materials are also very difficult to dismantle and, in some cases depending on the technology owned by recyclers, vending machines has to be deprived of some hard materials (such as hard plastics or iron reinforcements) that cannot be put inside the shredders.

During the pre-treatment some components and materials are manually extracted/removed from the appliances. These include, first of all, refrigerant gases and oils in the

refrigeration circuit, and various components (as glass door, compressors, shelves, cables).

According to three interviewed recyclers, glass parts might be manually extracted from doors and other parts of the appliances since they can damage (for abrasion) the blades of the shredders.

Also electronic components (e.g. printed circuit board, capacitors, switches, thermostat, liquid crystal displays) and lighting systems (compact fluorescent lamps) are dismantled, when present.

### **7.2.2.2 Shredding**

This process takes place in one or several shredders that reduce the appliance in pieces of different sizes. In some cases, during the first shredding, suction of gases (CFC, HCF and hydrocarbons among others)<sup>y</sup> contained in insulation foams (mainly PUR) happens. The shredding is usually done in a closed chamber where the atmosphere is low in O<sub>2</sub> by injection of N<sub>2</sub>, to reduce the risks of explosions derived from the presence of hydrocarbons.

### **7.2.2.3 Sorting for recovery**

Separation of materials happens through different phases e.g. by magnets and eddy currents or density separators. From these treatments, metal fractions (ferrous and non-ferrous materials) and mixes of foam and recyclable plastics are sorted.

Main valuable materials for the recycling are: ferrous metals, non-ferrous metals (copper and aluminium), precious and valuable metals (from electronics, when present<sup>z</sup>), glass and some plastics (mainly PS and ABS).

Shredding residues, mainly constituted by not recyclable plastics (e.g. PUR dusts) are incinerated with energy recovery or landfilled.

Figure 21 shows an overview of the recycling/recovery processes of commercial refrigeration appliances.

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<sup>y</sup> The presence of CFC in current recycled commercial refrigerators should not be found in the devices manufactured today which will be recycled in the future.

<sup>z</sup> The EoL treatments of electronic components are mainly targeted to the recycling of precious metals (gold, silver, platinum and palladium) and of some other valuable metals (e.g. copper)<sup>52</sup>.

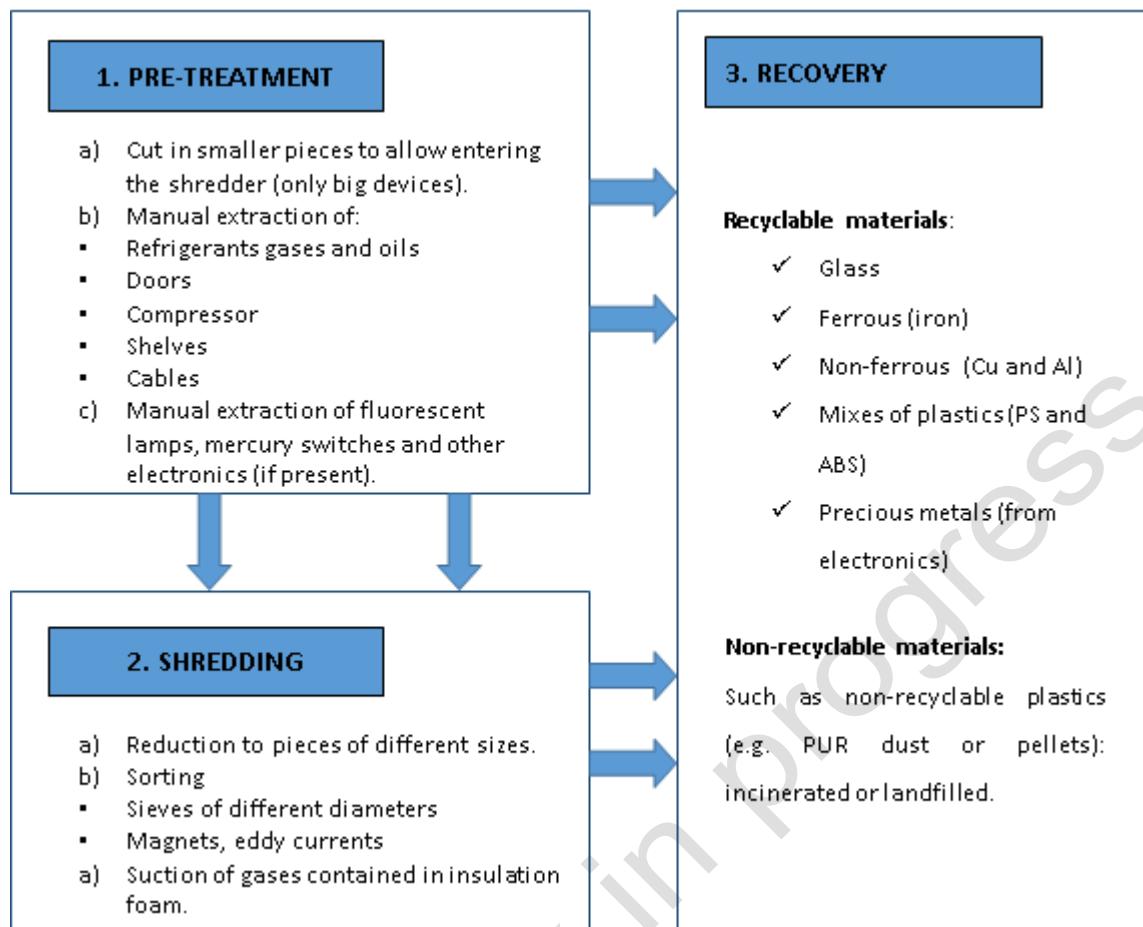


Figure 21. Summary of recycling/recovery processes of commercial refrigeration appliances.

## 7.3 End-of-Life hot spots and proposed strategies for EoL improvements

The EoL hot spots of the commercial refrigeration appliances have been identified according to the REA-Pro method, as detailed in the section 8.7, and based on the information presented in the previous sections. This analysis has been supported by feedback from stakeholders (recyclers and manufacturers) and information available in the scientific literature.

The identified hot spots are:

1. Durability of the products: lifetime of commercial refrigeration appliances influences life cycle impacts.
2. Large dimensions and composition of the devices: it represents a problem for some commercial refrigeration appliances during the waste collection, delivery and treatment in the recycling plants.
3. Presence of refrigerants and oils: pollutant substances, they have to be extracted/treated carefully to avoid dispersion into the environment.
4. Presence of components difficult to be treated as (when contained):
  - Glass components

- Fluorescent lamps
  - Electronic parts.
5. Treatment of insulation: low recyclability of PUR foams
  6. Treatment of foaming agents: commercial refrigeration appliances are generally treated in shredders with controlled atmosphere to avoid the dispersion of foaming agents in the environment and to reduce the risks of explosions (in the case of hydrocarbons).

The following sections analyse in detail the EoL hot spots and discuss improvement strategies and related potential Ecodesign measures.

### **7.3.1 Durability of the products**

The improvement of the durability of commercial refrigeration appliances can contribute to the reduction of environmental impacts for the production of new devices (due to the avoided use of materials and energy), and also to the reduction of impacts of EoL treatments. Extended lifetime can grant also a reduction of costs for users.

It is also highlighted that the extension lifetime of commercial refrigeration appliances can also delay the substitution with new products (potentially more energy efficient) and therefore can affect the overall energy consumption of the product during the use phase.

The lifetime can be extended via some strategies, such as:

- Minimum thresholds of the lifetime (measured according to standardized methods, when available);
- Design for substitution and/or repair of key components of commercial refrigeration appliances<sup>aa</sup>;
- Provision of information for users about maintenance/repairing.

Concerning the minimum threshold of lifetime, the main barrier to related potential ecodesign requirements is the current unavailability of suitable standards for this product group.

Concerning the reparability, it is difficult to enforce related Ecodesign requirements due to the high variability of the design in this product group, and the absence of available analysis of failure of these products. It is currently not possible to identify relevant critical components.

Concerning maintenance and reparation, all the relevant information is already provided by manufacturers to users.

Finally, it is noticed that in most cases commercial refrigeration appliances are replaced for specific commercial reason (e.g. aesthetics, requests of the client) before the end of their technical lifetime.

According to this analysis no requirement for durability is proposed.

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<sup>aa</sup> This strategy can include also the design of ‘modular’ components, e.g. component specifically designed to be easily extracted and, after minor interventions, to be used in other products (including new products).

### 7.3.2 Large dimension and composition of products

According to the interviewed recyclers, the large dimensions and composition of some commercial refrigeration appliances (especially large display cabinets and heavy and sturdy vending machines) can be responsible of high costs and problems during the waste collection, transport to the recycling plant and movement during the recycling processes.

The movement of large commercial refrigeration appliances can also cause safety problems (for workers) or environmental problems (e.g. due to the risk of accidental breakage of the refrigeration circuit during the transport).

However, it is not possible to univocally define when dimension of commercial refrigeration appliances represent a problem. Difficulties to treat waste are in fact related to the dimensions and capacity of utilized shredders and the related loading system<sup>bb</sup>. In some plants, large devices are cut and/or partially dismantled in order to be reduced in size before being shredded.

In order to simplify the movement and recycling of large commercial refrigeration appliances, recyclers could benefit of design for dismantling measures (including e.g. to avoid/reduce the use of welding on some thick metal parts, the use of standardized screws or the setting of thresholds of the time for dismantling).

Barriers on such measures have been highlighted by manufacturers due to the fact that the dimensions and the characteristics of commercial refrigeration appliances are generally designed according to specific requests of the clients. This implies a large variability of the design and makes difficult to identify, at the product group level, relevant components that should be targeted by design for dismantling measures (e.g. based on the time for dismantling). In addition, vending machines are also designed to be not easy dismantled, in order to avoid vandalism.

According to this analysis no requirement regarding the large dimension and composition of products is proposed.

### 7.3.3 Presence of refrigerants and oils to be extracted

The presence of refrigerants and oils in commercial refrigeration appliances is a relevant hot spot of EoL treatments. The recyclers have to extract them from the refrigeration circuit and properly treat them in order to avoid the dispersion of pollutants in the environment and in compliance with current environmental and safety legislation and standards (as detailed in the previous chapter on legislation)<sup>cc</sup>.

According to feedback from interviewed recyclers, potential strategies to improve the recycling of refrigerants could include:

<sup>bb</sup> In some cases, problems occur because commercial refrigerators are recycled in plants for the treatment of household refrigerators.

<sup>cc</sup> A recycler also underlined the problem of pressurized refrigeration circuits (operating over 4 bars), which should be recycled separately from other commercial refrigerators for safety reasons. According to their experience, several waste commercial refrigerators are missing the indication of the pressure of the circuit. However, this lack of information and labelling is assumed to be related to the current treatment of old commercial refrigerators, put into the market before the enforcement of the current legislation (Directive 97/23/EC).

- Dematerialization. This intends to reduce the overall amount of used refrigerants in the devices. On such purpose, there are some evidences in the literature about a continuous decreasing trend in the use of refrigerant in refrigeration appliances<sup>60, 68</sup>.
- Simplification of the extraction of the refrigerants and oils. This could be done with the installation of an extraction valve in the refrigeration circuit of plug-in refrigeration appliances<sup>dd ee</sup>.
- Measures to reduce the risk of accidental breakage of refrigeration circuits (especially during transport). This can include the strengthening/reinforcement of some critical parts of the refrigeration circuit.

However, some barriers have been observed about the enforcement of such strategies. Concerning the setting of potential thresholds for the use of refrigerant, this could affect the energy efficiency of the commercial refrigeration appliances. According to two interviewed manufacturers, the amount of refrigerant is already carefully dosed in order to optimize the energy performance of the refrigeration appliances. In addition, the use of refrigerant represents a cost for manufacturer (some per cent), and they already design refrigeration appliances in order to avoid any overdosing.

The installation of a valve for the extraction of refrigerants at the EoL has been criticized by interviewed manufacturers. Plug-in refrigeration appliances are, in some cases, designed to be “hermetically sealed” devices<sup>ff</sup>, trying to minimize any component that could cause leakages. This additional valve would therefore represent a critical component of the refrigeration appliance, and it could increase the risks of leakages of refrigerants during the operating time (which could also negatively affect the efficiency of the refrigeration appliance during the use phase).

According to manufacturers, measures to avoid accidental breakages are already adopted, as far as possible. In particular, concerning remote cabinets, these are generally planned to be standing in a place once installed. At the EoL, the refrigeration circuit of remote cabinets is emptied before any displacement. Concerning plug-in refrigeration appliances, they are designed in order to be moved during the operating life with minimum risks of breakages and leakages. Moreover, manufacturers argue that the breakage of the refrigeration circuit before the treatment in the recycling plant is generally related to improper handling of the waste at the EoL and this issue cannot be avoided by Ecodesign measures.

According to this analysis no requirement is proposed concerning the use of refrigerants and the design of the refrigeration circuit.

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<sup>dd</sup> The introduction of a standardized valve was proposed to avoid the punching of the circuit and sucking of air during the extraction of the refrigerant.

<sup>ee</sup> In remote display cabinets, the extraction of refrigerants take place during the uninstall of the plant, before its transport to the recycling plants.

<sup>ff</sup> ‘Hermetically sealed system’ means a system in which all refrigerant containing parts are made tight by welding, brazing or a similar permanent connection which may include capped valves and capped service ports that allow proper repair or disposal and which have a tested leakage rate of less than 3 grams per year under a pressure of at least a quarter of the maximum allowable pressure (EU Regulation 842/2006).

### 7.3.4 Presence of components difficult to treat

The analysis of EoL of commercial refrigeration appliances identified some components that are difficult to treat and that can hamper the recycling processes. These include:

- Glass components: in small and medium sized recycling plants glass has to be extracted before shredding because potentially damaging (abrasive) the shredder's blades. The extraction of glass (sometimes by its breaking) can also cause safety risks for workers.
- Fluorescent lamps: to be extracted due to the content of mercury, as required by the WEEE Directive<sup>gg</sup>.
- Electronic parts (printed circuit boards (PCB), capacitors, liquid crystal displays (LCD), switches and thermostats): potentially dangerous for the content of some hazardous substances, as required by the WEEE Directive<sup>hh</sup>.

The improvement of the extractability of these parts could contribute to simplify the manual treatments of waste before shredding. The easy extractability of such components would also increase the recovery yields for some materials (especially precious metals into electronics<sup>ii</sup>).

According to two interviewed manufacturers, glass and electronic components in vending machine and display cabinets are already designed to be easily extracted (e.g. for repairing). Sometimes the electronics are also grouped in a specific part of the product (e.g. the top) and sometimes kept intentionally away from the refrigeration circuit (due to safety reasons, when hydrocarbons are used as refrigerants).

Some difficulties related to the design for dismantling have been identified. Commercial refrigeration appliances are generally very variable (compared e.g. to households products) and designed according to specific requests of the client: this makes difficult to identify, at the product group level, some specific components that should be targeted by design for dismantling measures (e.g. based on the time for dismantling). Some glass components have a double glazing and can be difficult to be manually extracted. However, these components are intentionally sealed to reduce heat dispersions during the operating phase. Furthermore, glass and electronics are sometimes specifically designed to be not "easily" extracted (e.g. to avoid vandalism or robbery in vending machines).

Finally, according to comments received by stakeholder at the 1<sup>st</sup> TWG meeting current fluorescent lamps are progressively replaced by other systems (e.g. LED).

According to this analysis, there is a rationale for proposing to manufacturers of refrigeration appliances to adopt some simple design measures that avoid that recyclers have difficulties in meeting the requirements laid out in the WEEE Directive for the removal of certain (hazardous) components.

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<sup>gg</sup> Fluorescent lamps are still in use in new commercial refrigerators, but they are going to be progressively substituted by LED lighting systems.

<sup>hh</sup> PCB embodied in electric and electronic equipment (including refrigerators) can contain a number of hazardous substances, including arsenic, antimony, beryllium, brominated flame retardants, cadmium and lead (European Commission, 2008). Mercury is used in some lamps and certain electrical switches (although progressively avoided in new products). The separation of PCB, switches, compact fluorescent lamps, capacitors and LCD is required by the WEEE Directive (2012/19/EU).

<sup>ii</sup> PCB in electronics (including commercial refrigeration appliances) can contain several precious metals including: gold, silver, palladium, platinum.

The requirement could potentially include the following specific elements:

- *Design of the refrigerated cabinet so that the following electric and electronic components:*
  - ;printed circuit boards;
  - capacitors;
  - LCD
  - switches
  - compact fluorescent lamps
- when present, are easily identifiable and can be manually extracted for recycling. This can for instance be ensured avoiding that they are glued, welded, or fixed with rivets, but fixed exclusively with screws or clamps.*
- *for the point above, manufacturers shall provide to downstream users , upon request, technical evidence of manual removal, for instance through the provision of graphic information (a short technical folder, a sequence of pictures or a video) showing the steps of the manual dismantling, or a standardized product information datasheet (in line e.g. with IEC/TR 62635/2012) that identifies the above listed elements.*

### **Q.13) REMAINING QUESTIONS**

#### **Design for compliance with WEEE**

**What is your opinion about the proposal above on simple design actions to facilitate compliance with WEEE Directive?**

**Should you disagree with the proposal made above, please provide at the workshop 10 December 2013 or in written form no later than 20 Jan 2014 your alternative proposal, duly supported by data and evidence.**

### **7.3.5 Treatment of insulation foams**

The recycling of insulation foams (especially PUR) is hardly feasible<sup>76</sup> compared instead to other insulation materials (as e.g. polystyrene panels) that have a higher recyclability.

PUR foam needs to be separated during the shredding and some residuals could potentially contaminate other recyclable materials (e.g. metal fractions). Finally, PUR foams generally contain some gases used as foaming agent (see next section), which need to be separated and specifically treated (e.g. shredding into closed and controlled environments).

On the other hand, PUR allows high performance as thermal insulation, and therefore it brings life-cycle benefits during the use phase. It is also used as structural element in sandwich plates, reducing the thickness of the metal plates.

According to this analysis no requirement is proposed concerning the use of insulation foams.

### 7.3.6 Treatment of blowing agents in insulating foams

A criticality of the recycling of commercial refrigeration appliances is represented by the treatment of foaming agents in insulation foams. In the past decades CFC and HCFC were the main foaming agents used. However, after the phase out of these gases the current major replacement options are<sup>54</sup>: HFC, CO<sub>2</sub> and hydrocarbons.

Pentane and cyclopentane are currently the most used blowing agent for PUR foams<sup>54</sup>. These agents remain in the foam cells and also contribute to the thermal performance of insulation. On the other hand, some flammability risks associated with recycling of these foams have been detected. According to the UK Environmental Agency<sup>62</sup>, fridge insulation foam produced using a hydrocarbon blowing agent should be classified as ‘hazardous waste’ because highly flammable.

Recyclers are already aware of such risks of flammability. Safety procedures are generally implemented by recyclers, as the shredding and sorting of the foams in hermetically sealed plants with controlled atmosphere (low oxygen chambers filled with inert nitrogen gas).

Although limited, HFC are still in use as blowing agents for some commercial refrigeration appliance. However, according to an interviewed manufacturer, the shifting of the use of HFC to other blowing agents (as CO<sub>2</sub>) would not represent a problem (especially if this would happen in some years, allowing the manufacturer to implement the required technological changes in the plant). The avoided use of HFC as blowing agent could allow some environmental benefits in terms of 3% reduction of the GWP of the product<sup>ii</sup>.

According to this analysis, it is highlighted that the use of HFC in insulation foams of commercial refrigeration appliances is relevant in terms of life cycle impacts and it should be regulated and, potentially banned. However, there are evidences that this issue is currently under discussion within the review process of the regulation on fluorinated greenhouse gases<sup>55</sup>. Therefore, no requirement on this issue is proposed at this stage.

#### **Q.14) REMAINING QUESTIONS**

##### **HFC Ban**

**What is your opinion about the consequences of the potential ban of the use of HFC in insulation foams of commercial refrigeration appliances, as currently discussed in the F-gas regulation negotiations?**

**Should you disagree with the proposal made above, please provide at the workshop 10 December 2013 or in written form no later than 20 Jan 2014 your alternative proposal, duly supported by data and evidence.**

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<sup>ii</sup> Considering a content of HFC (245fa) of 10% in mass of the PUR (GIZ, 2008), 4.175 [kg] of PUR foam in a vending machine (BioIS, 2007), and a GWP factor for HFC-245fa of 950 [kg<sub>CO2eq</sub>/kg], it results that the foaming agent is responsible of about 400 [kg<sub>CO2eq</sub>]. This amount represents about 3% of the total life cycle GWP of a vending machine (13,622 [kg<sub>CO2eq</sub>] as calculated by (BioIS, 2007)).

As suggested by one stakeholder, also the preventive knowledge of the foaming agents embodied into insulation would be beneficial to the recycling treatments. Due to the risk of flammability, nitrogen is inflated in the shredding chamber during the treatment. However, as the type and amounts of foaming agent is generally not known before shredding, nitrogen is generally overdosed to avoid possible explosions. In addressing this risk, the preventive knowledge of the foaming agent used (*e.g.* via labelling of the type and quantity), could help the recyclers to optimize the flows of refrigeration appliances to be treated and the amount of nitrogen inflated.

According to interviewed manufacturers, the marking of the type of foaming agent would not represent a problem, as is currently practice in household refrigeration. In some cases, this is already done by manufacturers on a voluntary basis. On the other hand, the exact amount blowing agent used in the foams can be difficult to measure<sup>kk</sup>.

According to this analysis there is a technical rationale for proposing a requirement on the labelling of blowing agents. Such proposal could be formulated, for example, as:

*“Manufacturers shall include in the back plate of appliances a marking with the name of the blowing agent used in the insulation foam(s)”*

Such measure would be also easy and inexpensive to implement. A discussion with the TWG of the specific characteristics of such marking (size, location, exact content, language, potential risk phrases, etc.) may follow, in case this proposal is accepted.

#### **Q.15) REMAINING QUESTIONS**

##### **Blowing agent labelling**

**What is your opinion about the proposal above on marking of the blowing agent, to facilitate safer recycling of it?**

**Should you disagree with the proposal made above, please provide at the workshop 10 December 2013 or in written form no later than 20 Jan 2014 your alternative proposal, duly supported by data and evidence.**

## **7.4 Summary of potential EoL requirements for commercial refrigeration appliances**

The previous sections provided a presentation and a discussion of EoL hot spots of commercial refrigeration appliances and possible strategies for the improvement of treatments at EoL.

Based on this analysis a summary table is following presented with the proposed potential EoL requirements for commercial refrigeration appliances.

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<sup>kk</sup> This amount could be estimated on the basis of the volume of the insulation foam.

**Table 33. Analysis of EoL hot spots of commercial refrigeration appliances and potential improvement strategies**

Hot spot	Rationale	Possible strategy	Potential benefits	Potential problems / drawback	Potential Ecodesign requirement
1. Durability of the products	Improvement of lifetime of the products	Minimum lifetime measured according to standardized methods (when available)	Reduction of the impacts due to the avoided production of new devices and reduction of impact of EoL treatments	<ul style="list-style-type: none"> <li>- Potential negative effects on energy efficiency during the use.</li> <li>- Products generally replaced for commercial reasons before the end of their technical life.</li> <li>- No evidences of standards for the measurement of lifetime for commercial refrigeration appliances.</li> </ul>	No requirement proposed.
		Substitutability / reparability of key components and availability of spare parts.		<ul style="list-style-type: none"> <li>Difficulties for the verification of potential requirement on substitutability of spare parts.</li> </ul>	
		Provision of information about product maintenance/reparation		<ul style="list-style-type: none"> <li>All relevant information already provided to the users</li> </ul>	
2. Large dimension and composition of commercial refrigeration appliances	To simplify the dismantling of large device before the treatment in the shredders	Design for dismantling	Simplification of EoL treatments with reduction of costs and of risks (for e.g. workers and accidental breakage of the refrigeration circuits during the moving of large appliances).	<ul style="list-style-type: none"> <li>- Difficulty to identify design for dismantling measures relevant for the product group level.</li> <li>- Characteristics of commercial refrigeration appliances (including dimensions) are generally designed according to specific requests of clients</li> <li>- Vending machines are intentionally difficult to be dismantled to avoid vandalism.</li> </ul>	No requirement proposed.
3. Presence of refrigerants and oils	Reduction of the use of refrigerants (dematerialisation).	Maximum amount of refrigerant used per unit of power capacity.	Avoided masses of refrigerants to be produced and treated at the EoL	<ul style="list-style-type: none"> <li>Potentially affecting the performance of the commercial refrigeration appliances during operation.</li> </ul>	No requirement proposed.
	Simplification of the extraction of refrigerant and oils	Standard extraction valve for refrigerant	Easier recovery of refrigerants and oils (refrigerants and oils are not mixed with air during the extraction)	<ul style="list-style-type: none"> <li>- The installation of the valve would be technically difficult for 'hermetically sealed' refrigeration appliances.</li> <li>- The installation of the valve could cause leakages of refrigerant during the use phase.</li> </ul>	
	To reduce accidental breakages of refrigeration circuits	Strengthening and protecting the refrigeration circuit	Reduced risk of accidental releases of refrigerants	<ul style="list-style-type: none"> <li>- According to manufacturers, protections are already implemented when possible.</li> <li>- The design of heavy and sturdy products could also make the</li> </ul>	

Hot spot	Rationale	Possible strategy	Potential benefits	Potential problems / drawback	Potential Ecodesign requirement
				recycling more difficult.	
4. Presence of components difficult to be treated / recycled	To simplify manual pre-treatments of waste at the recycling plant.	Design for dismantling of some components (glass parts, lighting systems, and electronics)	Reduced risk of dispersion of hazardous substances (in electronics and fluorescent lamps). Reduced safety risks for workers (in the case of glass). Higher recovery yields for some relevant materials (in electronics). Reduced labour costs.	-Commercial refrigeration appliances are generally very variable and designed according to specific requests of the client. This makes difficult to identify strict design for dismantling measures valid at the product group level. -Some components are intentionally designed to be difficult to be dismantled for security reasons (e.g. in vending machines). -Compact fluorescent lamps will be in the future progressively replaced by LED systems.	Commercial refrigeration appliances shall be designed in order that the following electric and electronic components (printed circuit boards, capacitors, LCD, switches and compact fluorescent lamps, when present) are easy to be located and manually extracted for the recycling. Manufacturers shall provide, upon request, technical evidences for this, e.g. with the provision of a video showing the steps of the manual dismantling or the provision of a standardized product information datasheet (in line e.g. with IEC/TR 62635/2012).
5. Treatment of insulating foams	To improve the recyclability of insulation foams in commercial refrigeration appliances	Substitution of PUR foams with other insulation materials	Increase recyclability of commercial refrigeration appliances with benefits in term of waste minimisation.	Insulation is fundamental for energy efficiency of commercial refrigeration appliances, and currently PUR seems to grant the highest performances compared to other options.	No requirement proposed
6. Treatment of blowing agents in insulation foams	Some foaming agents used in PUR are greenhouse gases and have an impact on the GWP of commercial refrigeration appliances	Use of alternative foaming agents	Reduction of GWP of commercial refrigeration appliances (about 3% in vending machines, compared to the use of e.g. Pentane)	The potential ban of HFC in foams is currently under discussion in the policy debate on the restriction of fluorinated greenhouse gases.	No requirement proposed
	The preventive knowledge of the blowing agent used into insulations could help the recycling processes	Labelling of the type of foaming agent used into insulation foams.	Optimisation of the recycling processes into the shredders, with a reduction of the risks of flammability and the optimisation of the flows of nitrogen inflated.	It is difficult for manufacturers to measure the exact amount of foaming agent used in the product.	Manufacturers shall include in the back plate of appliances a marking with the name of the blowing agent used in the insulation foam(s)

**Q.16) REMAINING QUESTIONS**

**Generic EoL description**

Should you disagree with the description of EoL presented above, please provide at the workshop 10 December 2013 or in written form no later than 20 Jan 2014 your alternative proposal, duly supported by data and evidence.

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## 8 ANNEXES

### 8.1 Annex I - Legislation

#### 8.1.1 European national legislation<sup>ll</sup>

##### 8.1.1.1 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.

##### 8.1.1.2 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.

##### 8.1.1.3 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.<sup>mm</sup> This ban has had a huge impact on the systems implemented especially in supermarkets, where practically all new supermarkets are built with transcritical CO<sub>2</sub> 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.

##### 8.1.1.4 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.

##### 8.1.1.5 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

<sup>ll</sup> Taken from Shecco marketing report 2009, CO<sub>2</sub> commercial refrigeration – The European market 2009

<sup>mm</sup> 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

#### **8.1.1.6 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<sub>2</sub> 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;

#### **8.1.1.7 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.

#### **8.1.1.8 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 the draft law has passed into a formal law and/or if there was any modification.

### 8.1.1.9 Italy

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

## 8.1.2 Extra-EU legislation

### 8.1.2.1 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 8.2.2.

### 8.1.2.2 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.<sup>nn</sup>

From 1 October 2004<sup>oo</sup>, 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 (R2013). The values were reconfirmed in July 2013. 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

<sup>nn</sup> See <http://www.environment.gov.au/atmosphere/ozone/sgg/equivalentcarbonprice/calculator.html>

<sup>oo</sup> Taken from <http://www.energystar.gov.au/products-themes/refrigeration/commercial-refrigeration/meps/>

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.

See 8.2.4 for MEPS and ‘High Efficiency’ values.

#### **8.1.2.3 USA**

The MEPS for the USA can be found in 8.2.1. 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<sub>2</sub> 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.

#### **8.1.2.4 California**

For MEPS in California see 8.2.3.

#### **8.1.2.5 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 "pull-down" refrigerators – transparent door - 0.126V+ 3.51 maximum daily consumption in kWh/d) which does not figure in the Californian standard. (BIO IS study)

#### **8.1.2.6 South-Africa**

##### **SANS 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)

## 8.2 Annex II - Existing MEPS in other countries

### 8.2.1 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. Formulas and associated definitions described in this section relate to MEPS established for commercial refrigeration equipment specified in the Code of Federal Regulations 10 CFR 431.66<sup>pp</sup>. 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.

Concerning the MEPS for commercial refrigeration equipment defined by the Code of Federal Regulations 10 CFR 431.66 a distinction is made among a) refrigerators, freezers, and refrigerator-freezers with a self-contained condensing unit; b) refrigerators with a self-contained condensing unit designed for pull-down temperature applications and transparent doors; c) refrigerators, freezers, and refrigerator-freezers with a self-contained condensing unit and without doors; refrigerators, freezers, and refrigerator-freezers with a remote condensing unit; and commercial ice-cream freezers; d) refrigeration equipment with two or more compartments (*i.e.*, hybrid refrigerators, hybrid freezers, hybrid refrigerator-freezers, and non-hybrid refrigerator-freezers); e) other than hybrid equipment, refrigerators-freezers or wedge cases.

**Table 34. MEPS established under the US 10 CFR 431.66 for refrigerators, freezers, and refrigerator-freezers**

Equipment class <sup>2</sup>	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.

<sup>2</sup> 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

<sup>pp</sup> See <http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec431-66.pdf> for further information.

**Table 35. Equipment configuration definitions**

Equipment family	Description
Vertical Open (VOP) .....	Equipment without doors and an air-curtain angle $\geq 0$ degrees and $<10$ degrees from the vertical.
Semivertical Open (SVO) .....	Equipment without doors and an air-curtain angle $\geq 10$ degrees and $<80$ degrees from the vertical.
Horizontal Open (HZO) .....	Equipment without doors and an air-curtain angle $\geq 80$ 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 $\geq 45$ degrees.

Source: DOE 2009

Concerning the MEPS established under the US code 10 CFR 431.66 it can be notice that, strangely enough, this code seems to assume that in case of integrated refrigerators and freezers with either transparent or solid doors, the cabinet volume is the main parameter to be included in the formula for MEPS calculation, whereas this formula depends on the volume only for solid doors refrigerators in case of refrigeration equipment with remote condensing units or in case of refrigerating equipment with two or more compartments. For these last product categories the formula for MEPS calculation depends indeed on the cabinets TDA when transparent doors are mounted or when cabinets are without doors.

When the same refrigerator classes falling under the remote (RC) and self-contained (SC) are compared in Table 34 (*e.g.* when RC vertical open cabinets are compared with SC open cabinets) it results that the maximum daily consumption allowed to SC cabinets is about two times higher than for RC cabinets.

**Table 36. 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
		Semivertical Open .....	<32	VOP.RC.L
		Horizontal Open .....	≥32	SVO.RC.M
		Horizontal Open .....	<32	SVO.RC.L
		Vertical Closed Transparent .....	≥32	HZO.RC.M
		Vertical Closed Transparent .....	<32	HZO.RC.L
		Horizontal Closed Transparent .....	≥32	VCT.RC.M
		Horizontal Closed Transparent .....	<32	VCT.RC.L
		Vertical Closed Solid .....	≥32	HCT.RC.M
		Vertical Closed Solid .....	<32	HCT.RC.L
		Horizontal Closed Solid .....	≥32	VCS.RC.M
		Horizontal Closed Solid .....	<32	VCS.RC.L
Self-Contained Commercial Refrigerators, Commercial Freezers, and Commercial Refrigerator-Freezers without Doors.	Self-Contained .....	Service Over Counter .....	≥32	HCS.RC.M
		Service Over Counter .....	<32	HCS.RC.L
		Vertical Open .....	≥32	SOC.RC.M
		Vertical Open .....	<32	SOC.RC.L
		Semivertical Open .....	≥32	VOP.SC.M
		Semivertical Open .....	<32	VOP.SC.L
		Horizontal Open .....	≥32	SVO.SC.M
		Horizontal Open .....	<32	SVO.SC.L
		Vertical Open .....	≥32	HZO.SC.M
		Vertical Open .....	<32	HZO.SC.L
		Semivertical Open .....	* ≤ -5	VOP.RC.I
Commercial Ice-Cream Freezers .....	Remote .....	Semivertical Open .....	.....	SVO.RC.I
		Horizontal Open .....	.....	HZO.RC.I
		Vertical Open .....	.....	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
		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
Commercial Ice-Cream Freezers .....	Self-Contained .....	Vertical Closed Solid .....	.....	VCS.SC.I
		Horizontal Closed Solid .....	.....	HCS.SC.I
		Service Over Counter .....	.....	SOC.SC.I
		Vertical Open .....	.....	VOP.SC.I
		Semivertical Open .....	.....	SVO.SC.I
		Horizontal Open .....	.....	HZO.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

## 8.2.2 Canada

Three standards have been developed by the Canadian Standard Association (CSA) that are part of the country legislation and establish MPES on non-household refrigeration. These standards are the CAN/CSA-C827 for food service refrigerators and freezers, the CAN/CSA-C657 for commercial refrigerated display cabinets and the CAN/CSA-C804 for vending machines. The latest versions of these standards are the CAN/CSA-C827-10, the CAN/CSA-C657-12 and the CAN/CSA-C804-09 respectively published in 2010, 2012 and 2009. Their main characteristics are described in this section by referring to older versions<sup>qq</sup> as the general principles, the main parameters and the refrigerators categories considered in these standards have remained probably unchanged compared to the previous versions.

The standard CAN/C657 applies to open and closed refrigerated display cabinets that are intended for displaying and merchandising food products including canned and bottled beverages, ice (intended for human consumption), and other perishable merchandise (*e.g.* cut flowers). It prescribes a minimum energy performance standard and test methodology, with

<sup>qq</sup> The versions considered in this section are the CAN/CSA-C827-98, CAN/C657-04 and the CAN/CSA-C804-96.

reference to ASHRAE testing methods (ANSI/ASHRAE Standard 72 for open cabinets and ANSI/ASHRAE Standard 117). Moreover it provides definitions, classifications, and a method for determining specific daily energy consumption (SDEC) values and states minimum energy efficiency requirements for refrigerated display cabinets. It does not apply to self-contained cabinets as covered by C827.

SDEC is calculated according to the following formula:

$$\text{SDEC} = \text{EC} + \text{ERRS} (\text{kWh}/\text{m}/\text{day})$$

where:

EC = Daily energy consumption of the display cabinet

ERRS = Daily energy consumption of the remote refrigeration system.

Q = Total refrigeration load per unit length of refrigerated display cabinet measured in (Btu/h)/m (a value obtained by the tests),

EER = Energy Efficiency Ratio Btu/(Wh)

ERRS =  $(Q/\text{EER}) \times (24/1000)$  (kWh/m)/day

Notice that the reference dimensional unit used is the length of the cabinet, measured in metres.

The EER values considered for the R-404 refrigerant are reported in the table below.

**Table 37. Energy Efficiency Ratios for R-404 refrigerant defined under the CAN/C657**

Evaporating Temperature °C	EER Value Btu/(Wh)
-40.0	5.2
-35.0	5.9
-30.0	6.7
-25.0	7.6
-20.0	8.7
-15.0	9.9
-10.0	11.4
-5.0	13.3
0.0	15.6

Maximum SDEC values per cabinet unit of length are established in the standard for various cabinet types as indicated in the following table<sup>rr</sup>:

<sup>rr</sup> Reference: BIOIS Preparatory Study for Eco-design Requirements for of EuPs. Study performed for the European Commission DG TREN – Lot 12 – Professional Refrigerators and Freezers – December 2007

**Table 38. Maximum standard daily consumptions established under the CAN/C657**

Class	Product Temperature °C	Temperature	Open/Closed	Deck	Number of Air Curtains	Angle of Air Curtain from Vertical	MEPS 2004 SDEC [(kWh/m)/day]
1	5.0	medium	open	single/multi	1	0-30°	13.12
2	5.0	medium	open	single/multi	1	30-60°	9.51
3	5.0	medium	open	single/multi	1	60-90°	5.24
4	-17.8	low	open	multi	2 or 3	0-30°	30.84
5	-17.8	low	either	single	1	60-90°	15.10
6a	5.0	low/medium	closed	multi	single vent with glass		7.55
6b	-17.8	Same as 6a					20.01
7a	5.0	medium	closed	single/multi	glass	n/a	8.53
7b	5.0	Same as 7a, except with only a gravity coil (no fan coil)					3.28

The standard CAN/CSA-C827 applies to self-contained commercial refrigerators, refrigerator-freezers, and freezer cabinets that are intended for storage or holding food products and other perishable merchandise. It sets the maximum annual energy consumption for products, as shown in the following tables under the column named "standard efficiency"<sup>ss</sup>.

This standard uses a 2-tier approach for characterising the cabinets (standard/high efficiency). It sets high efficiency values to be achieved by products that can be commercialised as high efficiency units, as indicated in the same tables<sup>t</sup>.

**Table 39. Maximum annual energy consumption for solid door self-contained refrigerators under CAN/C827.**

Type	Annual Energy Consumption (AEC <sub>max</sub> ), 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

<sup>ss</sup> BIOIS Preparatory Study for Eco-design Requirements for of EuPs. Study performed for the European Commission DG TREN – Lot 12 – Professional Refrigerators and Freezers – December 2007

<sup>t</sup> Refrigerators and freezers volumes are supposed to be measured in ft<sup>3</sup> in these tables.

**Table 40. Maximum annual energy consumption for glass door refrigerators under CAN/C827.**

<b>Type</b>	<b>Annual Energy Consumption (AEC<sub>max</sub>), kWh/y</b>	
	<b>Standard efficiency</b>	<b>High efficiency</b>
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

**Table 41. Maximum annual energy consumption for solid doors freezers under CAN/C827.**

<b>Type</b>	<b>Annual Energy Consumption (AEC<sub>max</sub>), kWh/y</b>	
	<b>Standard efficiency</b>	<b>High efficiency</b>
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

**Table 42. Maximum annual energy consumption of glass doors freezers under CAN/C827.**

<b>Type</b>	<b>Annual Energy Consumption (AEC<sub>max</sub>), kWh/y</b>	
	<b>Standard efficiency</b>	<b>High efficiency</b>
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

**Table 43. Maximum annual energy consumption for solid doors refrigerators-freezers under CAN/C827<sup>uu</sup>**

<b>Type</b>	<b>Annual Energy Consumption (AEC<sub>max</sub>), kWh/y</b>	
	<b>Standard efficiency</b>	<b>High efficiency</b>
Reach-in	92 AV + 1900	84 AV + 1160

The standard CAN/CSA-C804 applies instead to self-contained vending machines that actively cool or heat, or both, the product to be vended. It applies in particular to vending machines that dispense:

- refrigerated post-mix soft drinks
- refrigerated packaged (e.g. canned and bottled) beverages
- hot products that have been stored in a cooled space
- cold products that have been stored in a cooled space
- bulk (i.e. non pre-packaged) hot beverages
- other types of vending machines.

The maximum daily energy consumption ( $Ed_{max}$ ) is expressed in function of the machine capacity measured in terms of number of cans, in terms of the vending machine internal temperature and machine type (e.g. packed beverage, post-mix beverage, chilled non-perishable food, etc.). For example in case of packed beverage vending machines an operating temperature of  $1 \pm 1$  °C is defined and the maximum daily consumption is calculated as:

<sup>uu</sup> AV = adjusted volume = refrigerator volume plus 1.63 the freezer volume

$$Ed_{\max} (\text{kWh/day}) = 8.66 + (0.009 \times C)$$

where:

C= vending capacity of 355mL cans<sup>vv</sup>.

The Canadian regulation implementing the MEPS above described has been amended in 2006 in case of self-contained refrigerators and freezers and vending machines. The amendment has led to the inclusion of the MEPS for reach-in refrigerators and freezers and vending machines as defined in the regulation in place in the state of California. Given a lack of statistical data the MEPS defined in California instead of MEPS defined under the CAN/CSA C827 have been applied in case of reach-in cabinets (including reach-in cabinets without doors specifically designed for the display and sale of bottled or canned beverages). The main parameter for the calculation of these MEPS is still the cabinet volume. In case of vending machines, the more stringent California MEPS have been applied since it has been verified that those defined within CAN/CSA-804 would have had a limited impact on the energy performance of the models existing in the market. The formula considered for vending machines MEPS calculation has remained the same excepting overall multiplications factors ranging between 0.55 and 0.45 that have been introduced to reduce  $Ed_{\max}$ .

As of April 12, 2012, all self-contained, commercial refrigeration equipment will be required to meet the regulatory requirements if their manufacturing process is completed on or after January 1, 2010. The daily energy consumption,  $E_{\text{daily}}$  (in kWh/day) shall not exceed the maximum levels specified below:

#### **Commercial Self-contained Refrigeration Energy Performance Standard**

<b>Product</b>	<b>Door or drawer type</b>	<b>Maximum daily energy consumption</b>
<b>Refrigerators</b>	Solid	0.00353V + 2.04
	Transparent not designed for pull-down temperature application	0.00424V + 3.34
	Transparent designed for pull-down temperature application	0.00445V + 3.51
<b>Refrigerator-freezers</b>	Solid	greater of either (0.00953 AV - 0.71) or 0.70
<b>Freezers</b>	Solid	0.01413V + 1.38
	Transparent	0.02649V + 4.10

V is the refrigerator volume measured in litres.

AV (adjusted volume) is equal to the refrigerator volume plus 1.63 times the freezer volume. Note that to be “transparent” the glass area must cover at least 75 % of the principal display face.

#### ***Comments and observations on the formulae for MEPS established in Canada***

<sup>vv</sup> C is the maximum quantity of product that is recommended by the manufacturer to be dispensed from one full loading of the machine.

The total display area has not been considered as a relevant parameter for the definition of MEPS in case of display cabinets and the maximum reference consumption has been established per unit of cabinets' length. The CAN/CAS C657 applied in this case seems to have been defined mainly for remote display cabinets and covers both cabinets with and without doors. The presence of air curtain and their inclination with respect the vertical axis has been assumed to make a relevant difference in terms of maximum energy consumption that can be attributed to cabinets, this maximum energy consumption being able to vary by a factor greater than two depending on this inclination. In case of self-contained refrigerated cabinets with doors covered by the standard CAN/CAS-C827, the cabinet volume is the main parameters considered for the calculation of MEPS. Noticeably, glass doors cabinets are attributed a maximum energy consumption which exactly doubles the maximum energy consumption attributed to solid doors cabinets. In case of vending machines, the machine capacity expressed in number of cans and its internal temperature are the main parameters considered for the definition of MEPS.

### 8.2.3 California

Specific MEPS are in force for commercial refrigerators sold or offered for sale in the state of California (US). These MEPS are generally set out based on ANSI/ASHRAE 117 energy measurement standard except that the loading doors have to remain closed and the food temperature used during the test has to be adjusted to new values. The table below summarizes the various MEPS values for the cabinet types addressed since March 2003<sup>ww</sup>. The appliance covered are reach-in cabinets that include but are not limited to ice cream cabinets, milk or beverage cabinets; milk, beverage, and ice cream cabinets. Preparation tables, refrigerated buffet and preparation tables, or work top tables are not covered.

<sup>ww</sup> BIOIS Preparatory Study for Eco-design Requirements for of EuPs. Study performed for the European Commission DG TREN – Lot 12 – Professional Refrigerators and Freezers – December 2007

**Table 44. MEPS in force in California for commercial refrigerators**

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 5.19ft <sup>3</sup> 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 5.19ft <sup>3</sup>	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+0.00 9x C)	0.55(8.66+0.00 9x C)
Refrigerated canned and bottled beverage vending machines when tested at 75°F ambient temperature	Not applicable			0.55(8.66+0.00 9x C)	0.55(8.66+0.00 9x C)
V=total volume (ft <sup>3</sup> ) AV=Adjusted Volume = 1.63xfrezer volume (ft <sup>3</sup> )+refrigerator volume(ft <sup>3</sup> ) C = rated capacity (number of 12 ounce cans)					

It may be worth noticing that the state of Washington has issued a regulation comprising minimum efficiency standards<sup>xx</sup> in January 2007. To verify the accordance of the appliances with these requirements, the products are tested with the California Energy Commission testing method. 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<sup>yy</sup>, the requirements which apply are the same as in California except for one category of appliance which does not figure in the Californian standard (reach-in cabinets, pass-through cabinets, and roll-in or roll-through cabinets that are "pull-down" refrigerators – transparent door). For this category MEPS (kWh/day) are calculated as 0.126V+ 3.51.

#### ***Comments and observations on the formulae for MEPS established in California***

Cabinets volume is the main parameter included in the formulae for MEPS calculation. The difference in the maximum daily energy consumption allowed for appliances with solid and transparent doors is very significant and often exceeds a factor two.

<sup>xx</sup> See <http://apps.leg.wa.gov/RCW/default.aspx?cite=19.260.040>

<sup>yy</sup> Reach-in cabinets, pass-through cabinets, and roll-in or roll-through cabinets that are refrigerators, Reach-in cabinets, pass-through cabinets, and roll-in or roll-through cabinets that are freezers, Reach-in cabinets that are refrigerator-freezers.

### 8.2.4 Australia and New-Zealand

Refrigerated display cabinets manufactured in or imported into Australia and New Zealand must comply with MEPS set out in the standard AS 1731.14-2003 (R2013). 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.

Like in Canada, 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. MEPS for commercial refrigeration are set out as total energy consumption per total display area (TEC/TDA) and are expressed in kWh/(m<sup>2</sup>.day) for various unit types. These MEPS do not apply to refrigerated vending machines, cabinets intended for use in catering and similar non-retail applications. Testing for MEPS is at climate class 3 (i.e. ambient dry bulb temperature at 25° C and relative humidity at 60%).

The methodology to measure the TDA is the same as that described in the EN ISO 23953. Also the methodology to test the cabinet total energy consumption (TEC) is identical to those defined within the EN ISO 23953, excepting for the test duration<sup>zz</sup>.

The tables below report the MEPS prescribed for remote cabinets and integral cabinets<sup>aaa</sup>.

**Table 45. MEPS prescribed for remote cabinets under the standard AS 1731.14-2003**

<sup>zz</sup> In EN ISO 23953:2005 it is stated that the cabinet should be run in empty for at least 2 hours whereas in AS 1732 it is stated that the cabinet should be run empty for at least 24 hours before being loaded. Likewise the stabilisation period prior to the start of a test is required to be only 4 hours in AS 1731 (as opposed to 24 hours in EN ISO 23953:2005). The door opening regime in AS 17321 for closed door cabinets is the same as in EN ISO 23953:2005 but the test duration is 48 hours and lighting is switched on 1 hour before the start of the test. In all tests (closed and open cabinets) the lighting is on continually during the test.

<sup>aaa</sup> Reference: Test Standards for Retail Cabinets Worldwide. Refrigeration Development and Testing Ltd; February 2013.

Type		Maximum energy consumption TEC/TDA (kWh/day/m <sup>2</sup> )	
		MEPS	High efficiency
RS 1—Unit shelves	High open multi-deck	12.55	8.37
RS 1—Lit shelves		17.76	10.66
RS 2—Unit shelves	Medium open multi-deck	12.73	8.49
RS 2—Lit shelves		16.98	11.32
RS 3—Unit shelves	Low open multi-deck	14.84	10.32
RS 3—Lit shelves		18.39	12.26
RS 4—Solid door	Self service and storage closed cabinet	No value	No value
RS 4—Glass door		9.73	6.77
RS 5—Solid door	Self service and storage closed cabinet-under counter	No value	No value
RS 5—Glass door		No value	No value
RS 6—Gravity coil	Flat glass-fronted—single deck	14.21	9.88
RS 6—Fan coil		14.16	9.85
RS 7—Gravity coil	Flat glass-fronted—2 tier or more	No value	No value
RS 7—Fan coil		14.79	9.86
RS 8—Gravity coil	Curved glass-fronted—single deck	12.25	8.52
RS 8—Fan coil		13.19	9.17
RS 9—Gravity coil	Curved glass-fronted—2 tier or more	No value	No value
RS 9—Fan coil		12.09	8.06
RS 10—High	Island/Walk around merchandiser	No value	No value
RS 10—Medium		No value	No value
RS 10—Low		18.67	12.99
RS 11	Medium open multi-deck	38.13	26.52
RS 12	Low open multi-deck	66.33	46.14
RS 13—Solid sided	Well-type, single width cabinet	19.48	12.99
RS 13—Glass sided		19.58	13.62
RS 14—Solid sided	Well-type, double width cabinet	15.49	11.45
RS 14—Glass sided		19.29	12.863
RS 15—Solid door	High self service and storage closed cabinet	No value	No value
RS 15—Glass door		37.08	27.41
RS 16—Solid door	Medium self service and storage closed cabinet	No value	No value
RS 16—Glass door		40.56	29.98
RS 17—Solid door	Low self service and storage closed cabinet	No value	No value
RS 17—Glass door		No value	No value
RS 18	Combination glass door over and well under	48.58	39.75
RS 19	High self service island closed cabinet	36.15	29.57
RS 20	Medium self service island closed cabinet	No value	No value

**Table 46. MEPS prescribed for integral cabinets under the standard AS 1731.14-2003<sup>bbb</sup>**<sup>bbb</sup> The classification adopted for integral display cabinets is identical to that defined under the EN ISO 23953

Type			Temperature class				Type			Temperature class			
			M1	M2	M1	M2				L1	L2	L1	L2
			MEPS		High efficiency					MEPS		High efficiency	
HC1	Serve-over counter		11.50	11.50	8.50	8.50	HF1	Serve-over counter		NV	NV	NV	NV
HC2	Serve-over counter with integrated storage		NV	NV	NV	NV	HF2			NV	NV	NV	NV
HC3	Open top wall site		NV	NV	NV	NV	HF3	Open top wall site		NV	NV	NV	NV
HC4	Open top island		15.50	15.50	11.40	11.40	HF4	Open top, island		26.50	26.50	19.50	19.50
HC5	Chilled, glass top, wall site		NV	NV	NV	NV	HF5	Glass top, wall site		NV	NV	NV	NV
HC6	Glass top, island		NV	NV	NV	NV	HF6	Glass top, island		8.00	8.00	5.90	5.90
VC1	Semi-vertical		37.50	28.00	27.60	20.60	VF1	Semi-vertical		NV	NV	NV	NV
VC2	Multi-deck		27.00	25.50	19.90	18.80	VF2	Multi-deck		NV	NV	NV	NV
VC3	Chilled, roll in		NV	NV	NV	NV	VF3			NV	NV	NV	NV
VC4	Glass and solid door	Solid door	17.00	17.50	7.30	7.30	VF4	Glass and solid door	Solid door	44.00	39.00	32.40	28.70
		Glass door	17.00	17.50	10.70	10.70			Glass door	44.00	39.00	32.40	28.70
YC1	Open top, open bottom		NV	NV	NV	NV	YF1	Open top, open bottom		NV	NV	NV	NV
YC2	Open top, closed bottom		NV	NV	NV	NV	YF2	Open top, closed bottom		NV	NV	NV	NV
YC3	Glass door top, open bottom		NV	NV	NV	NV	YF3	Glass door top, open bottom		NV	NV	NV	NV
YC4	Glass door top, closed bottom		NV	NV	NV	NV	YF4	Glass door top, closed bottom		NV	NV	NV	NV

NV=No value

C=chilled, F=frozen

### Comments and observations on the formulae for MEPS established in Australia/New Zealand

In case of remote cabinets lighting seems to make a significant difference on MEPS definition (at least for open multi-deck cabinets). The difference in the attributed energy consumption seems indeed to range between 25% and 40% for open multi-deck cabinets with lit and unlit shelves. Fan and gravity type coils for the coolant do not seem to make a big difference in the energy consumption attributed to remote cabinets, excepting for curved-glass fronted single deck cabinets for which the presence of one or the other coil type seems to determine an energy consumption difference around 8%. When it comes to integral cabinets for which a MEPS has been defined, M-packages temperature classes seem to make a difference in the MEPS defined only in case of multi-deck VC2 and semi-vertical VC1 cabinets. Strangely enough, solid doors are indicated in the table related to MEPS for integral VC4 and VF4 cabinets, although these cabinet types should in principle mount only glass doors<sup>ccc</sup>. However the presence of solid doors or glass doors does not seem to have made a difference in the MEPS defined for VC4 and VF4 cabinets in the Table 46 above reported.

<sup>ccc</sup> See classification of refrigerated display cabinets according to EN ISO 23953.

### 8.2.5      **Earlier versions of the EU commercial refrigeration reference formulas and MEPS**

The European Commission has performed preparatory and impact assessment studies for the implementation of eco-design requirements for commercial refrigerators<sup>ddd</sup>. Whereas the preparatory studies date back to December 2007, a first version of an impact assessment and of the formulae to be considered for the calculation of MEPS to be possibly implemented have been produced on July 2010. Based on new data available and further discussions with experts and commercial refrigerators manufacturers, the research institute in charge of performing the impact assessment<sup>eee</sup> produced new formulae for MEPS calculation in March 2011. The first and second version of the formulae proposed for MEPS calculation are briefly described below.

#### **First version of the formulae for MEPS calculation proposed on July 2010:**

The first proposal concerning possible formulae for MEPS implemented was based on a definition of an energy efficiency index (EEI) calculated as:

$$\text{EEI} = \text{SEC} / \text{RSEC} \times 100$$

with the Specific Energy Consumption SEC and the Reference Specific Energy Consumption (RSEC) defined separately for **three** types of product groups as follows:

**1. For remote open appliances**, to which EN ISO 23953 can be applied (or a similar further developed norm):

SEC is calculated in kWh/m<sup>2</sup>/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 multiplied by 365, and TDA is the total display area.

RSEC is calculated in kWh/m<sup>2</sup>/year and recorded to two decimal places, as:

$$\text{RSEC} = [5.6 + \text{VERT} + L + 16 (\text{Ta} - \text{Tmc}) / \text{Tmc}] \times 365$$

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/(m<sup>2</sup>\*day),

L is the additional electricity allowed for lighting of shelves, which is set here at 1.3 kWh/(m<sup>2</sup>\*day), following a recommendation by Eurovent to take into account at least 1.25 kWh/(m<sup>2</sup>\*day) for lighting of a multi-deck cabinet with five roughs of lighted shelves, but which could also be formulated as a function of luminous flux or luminous energy,

Ta = θ<sub>ambient</sub> + 273.15, with θ<sub>ambient</sub> = 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.

<sup>ddd</sup> See <http://www.ecofreezercom.org/> for further information on the preparatory studies.

<sup>eee</sup> The institute that performed the impact assessment study is the Wuppertal Institute for Climate, Environment and Energy.

$T_{mc} = \theta_{mc} + 273.15$ , with  $\theta_{mc}$  as the arithmetic mean temperatures of all M-packages for the test period [in °Celsius].

2. 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/m<sup>3</sup>/year and recorded to two decimal places, as:

$$RSEC = [1,500 + 16 \times EC]$$

$$\text{With } EC = \sum_i V_i \times \frac{(Ta - T_{mci})}{T_{mci}}$$

Where:

i = different compartments within a vending machine which are operated at different temperature levels  $T_{mci}$ , 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 dm<sup>3</sup>

3. For other (closed) appliances, SEC is calculated in kWh/m<sup>3</sup>/year and recorded to two decimal places, as  $SEC = TEC / \text{net volume of the appliance}$ , and with RSEC calculated in kWh/m<sup>3</sup>/year and recorded to two decimal places, as:

$$RSEC = 1.8 \times [5.6 + VERT + L + 16 (Ta - Tmc) / Tmc] \times 365$$

Where 1.8 would be a 'closed appliance' factor

#### **Second version of the formulae for MEPS calculation proposed in March 2011:**

A slightly changed approach has been proposed by the Wuppertal Institute after further discussions with experts and based on new data made available by manufacturers on March 2011. A same formula has been proposed for all commercial refrigerators and freezers for which EN ISO 23953 can be applied (i.e. for plug-in and remote cabinets, closed and open ones), whereas a different formula has been proposed for vending machines for which the EVA-EMP test protocol can be applied. The two formulae are supposed to be used for the calculation of the usual appliance energy efficiency index (EEI) defined as follows:

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

In case of all refrigerators and freezers for which the EN ISO 23953 can be applied (1 and 3), the following formulae have been proposed for SEC and RSEC calculation:

$SEC = TEC / (consumption metered in test room according to EN ISO 23953 with or without lighting and at climate class 3) / TDA$

$$RSEC = [4.1 + VERT + L + 56 \times T\_VERT \times ((Ta - Tm) / Tm - 0.05)] \times REFRIG \times 365$$

with:

$\text{VERT} = 1.5 \text{ kWh/m}^2/\text{day}$  for vertical or semi-vertical appliances, 0 for horizontal ones,

$T_{\text{VERT}} = 2.7$  for vertical or semi-vertical appliances, 1 for horizontal ones,

$L = 1.3 \text{ kWh/m}^2/\text{day}$  for lighting if lighting is included in SEC,

$T_a = 25 + 273.15$  (ambient temperature of test room; climate class 3) [ $^{\circ}\text{Kelvin}$ ],

$T_m = \theta_{mc} + 273.15$ , with  $\theta_{mc}$  = average upper value of the M-package temperature class as defined

in ISO 23953: warmest M-package for the M-package temperature class [ $^{\circ}\text{Celsius}$ ].

$\text{REFRIG} = \text{option a): } 1.0; \text{ option b): } 1.05 \text{ for refrigerants with } \text{GWP} < 20; 1.03 \text{ for refrigerants with } 20 < \text{GWP} < 800; 1.02 \text{ for refrigerants with } 800 < \text{GWP} < 1,500 \text{ and } 1.0 \text{ for other refrigerants.}$

In case of vending machines, for which the EVA-EMP test method can be applied, the formulae considered were instead the following ones:

$\text{SEC} = \text{metered consumption at „idle state“ for 24 h, multiplied by 365}$

$$\text{RSEC} = [1,500 + 16 \times \text{EC}] \times \text{REFRIG}$$

$$\text{with EC} = \sum_i V_i \times \frac{(T_a - T_{mci})}{T_{mci}}$$

where:

$i$  = different compartments of the vending machine with different temperature levels  $T_{mc}$

$V_i$  = Volume of the respective compartment, metered in  $\text{dm}^3$

## 8.2.6 Summary on existing formulae for MEPS calculation on refrigeration

The table below reports a summary of the metrics adopted to set MEPS for refrigerators in the geographical areas covered in the previous sections of this document.

Table 47: Summary of the metrics adopted to set MEPS in various geographical areas

	Remote refrigerated display cabinets			Plug-in cabinets			Cold vending machines
	Without door	Transp. door	Solid Door	Without door	Transp. door	Solid Door	
<b>US</b>	a·TDA+b	a·TDA+b	a·V+b	a·TDA+b	a·TDA+b	a·V+b	Not covered
<b>US Energy Star</b>	Not covered	Not covered	Not covered	Not covered	a·V+b	a·V+b	x·C+y
<b>Canada</b>	TEC/L	TEC/L	TEC/L	TEC/L	a·V+b	a·V+b	x·C+y
<b>Australia/NZ</b>	TEC/TDA	TEC/TDA	TEC/TDA	TEC/TDA	TEC/TDA	TEC/TDA	

<b>California</b>	None	None	None	None	a·V+b	a·V+b	x·C+y
<b>EU household</b>	Not applicable	a·V+b	Not applicable				
<b>EU professional</b>	Not covered	Not covered	Not covered	Not covered	?	a·V+b	Not applicable

Clearly, not all the differences among the various approaches adopted could be summarised in this table. For example it could not be possible to indicate whether a segmentation with respect to cabinet types (e.g. multi-deck, roll-in; serve-over counter, semi-vertical, cabinets etc.) or with respect to product temperature classes is considered. Nevertheless, this table shows already a large variability in the metrics adopted in the different countries and geographical areas. Concerning refrigerators different from vending machines, a first differentiation can be done between formulae where MEPS are established per unit of cabinet length or per unit of cabinet display area (e.g. in Canada and in Australia/New Zealand MEPS are established in terms of kWh/m/day and kWh/m<sup>2</sup>/day respectively) and countries or regions where MEPS are established in absolute terms (kWh/day or kWh/year). This difference is quite relevant because, where MEPs are not established per unit of length, per unit of display area, or per unit of volume, these MEPS results from formulae typically depending on parameters like volume or total display area and are probably more finely tuned to the existing products market segmentation. On the contrary, where MEPS are established per unit of length, per unit of display area or per unit of volume, these MEPS are typically assumed to be constant over different product lengths, product display areas or product volumes (i.e. a same MEPS expressed e.g. in terms of kWh/m/day, kWh/m<sup>2</sup>/day or kWh/m<sup>3</sup>/day is respectively applied over cabinets of any length, display area or volume).

A second consideration that can be done is that the (net) volume seems to be the preferred variable for the calculation of MEPS in case of refrigerators with doors, whereas the TDA (or the cabinets' length L) is preferred in case of cabinets without doors. However, in some countries the TDA is considered also in case of MEPS for cabinets with doors.

A third consideration relates to the fact that MEPS established in the geographical areas considered tend to differentiate among the energy consumption of cabinets with solid doors and transparent doors, as well as between the energy consumption of cabinets without doors and with doors and between cabinets with a remote condensing unit and integrated cabinets.

In case of cold vending machines displaying perishable food or snacks and beverages, the trend seems to be that of considering the energy consumption for a specific refrigerated volume and the product temperature range. For beverage vending machines, the energy consumption is expressed as a function of the number of cans it can hold. However it has to be mentioned that, compared to the number of cans/bottles that can be held, machines volume seems in general a much better parameter to be included in the formula for the calculation of RSEC for the reasons already mentioned in the previous paragraph.

## FINAL CONSIDERATIONS ON THE EARLIER FORMULAE SO FAR PROPOSED FOR MEPS OF EU COMMERCIAL REFRIGERATORS

As already pointed out, the parameters and the associated values included in the last version of the formula proposed by the Wuppertal Institute for commercial refrigerators other than vending machines have been calculated by performing linear regressions whereby SEC=TEC/TDA has been considered as the dependent variable and the coefficient (Ta-

$T_m/Tm$  as the independent one. The choice of  $(Ta-Tm)/Tm$  as the independent variable for the linear regression differs from that of formulae developed in the not European countries. In these countries the approach adopted seems to have rather been that of grouping products with different operating temperatures under different classes and of performing linear regressions within each class. The approach adopted by the Wuppertal Institute, however, is not completely new, as a similar one has been followed for example in case of the calculation formula developed in Europe for MEPS on household refrigerators. In this case MEPS have been indeed parameterized in terms of a thermodynamic factor included in the formula for the calculation of the equivalent volume  $V_{eq}$ .

The reasons for the choice of TEC/TDA (instead of TEC) as the dependent variable and of  $(Ta-Tm)/Tm$  (instead of TDA in the different classes corresponding to the different refrigerators operating temperatures) as the independent variable for the regression analysis might deserve further investigations<sup>fff</sup>.

Another point that may deserve attention concerns the choice of the *highest* temperature of the *warmest* M-package for the definition of  $T_m$  in the formulae proposed. This choice has probably been caused by the fact that the highest temperature of the warmest M-package is the only information made available by the manufacturers in the database used. In order to test the sensibility to this definition of the performed calculations, it has been instead assumed that  $T_m$  could be, probably more realistically, defined as follows:

For refrigerators whose M-package temperature class is L1, L2 or L3<sup>ggg</sup>:

$T_m = \text{average}$  between the *highest* temperature and the *lowest* temperature that can be achieved respectively by the *warmest* and *coldest* M-packages under the refrigerator temperature class;

For refrigerators whose M-package temperature class is M0, M1, M2, H1, H2:

$T_m = \text{average}$  between the *highest* and *lowest* temperature that can be achieved by the *warmest* M-packages under the refrigerator temperature class.

The relative difference between the RSEC values resulting from linear regressions performed based on this alternative definition of  $T_m$  and the ones resulting from the Wuppertal Institute formula is compared in the table below for some M-package temperature classes.

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<sup>fff</sup> Notice however that the number of classes that could be defined based on the temperature  $T_m$  is only 6 (i.e. the class corresponding to products with the warmest M- package at 10 °C, 7 °C, 5 °C, 4 °C, -12 °C, -15 °C respectively). Notice also that a grouping of the classes with  $T_m = 5$  °C and  $T_m=4$  °C would have determined the creation of 5 classes. The database provided by the Wuppertal institute indicates that the number of models of remote cabinets falling under each of these classes would be 328, 296, 299, 122 and 100 respectively.

<sup>ggg</sup> See the M-package temperature classes as defined in the EN ISO 23953

**Table 48. Variation of RSEC value as resulting from an alternative definition of Tm**

M-package temperature class	RSEC Variation (%)	
	Vertical Cabinets	Horizontal Cabinets
L1	-6%	-2%
L2	-1%	1%
M0	-8%	-1%
M1	-5%	1%
M2	1%	5%
H1	6%	8%

The values in the table above indicate that the variation in the RSEC values induced by the proposed alternative definition is not completely negligible (especially in case of class M0 vertical cabinets and class H1 horizontal cabinets)<sup>hhh</sup>. The introduction of this uncertainty level could be perhaps avoided if the statistical sample available would have been segmented with respect to the different possible M-package temperature classes and linear regressions with respect to cabinets' volume or cabinets TDA would have been performed in each class as previously suggested. This would make the definition of Tm unnecessary. However the feasibility of this approach should be tested in practice on the data presently available.

Concerning the choice of the TDA instead of the net volume in the definition of SEC, the document whereby the new formulae have been proposed by the Wuppertal Institute mentions that the formula initially proposed for closed cabinets (other than vending machines) and defining  $SEC=TEC/\text{net volume}$  has been abandoned because the discussions held with manufacturers highlighted the higher costs of product tests in case the net volume would have to be measured. Manufacturers have indeed claimed that while the measurement of volume in the test laboratory could take up to one day, measurement of TDA just takes about half an hour. This choice however might cause, especially in case of closed cabinets, that the RSEC value associated to a cabinet of given TDA and the resulting EEI value do not reflect with sufficient accuracy the energy performances of this cabinet compared to the market average.

Finally, concerning vending machines, as already mentioned, it is quite difficult to comment on the RSEC values resulting from the proposed formula because of the different parameterization of machines capacities typically adopted in the energy consumption estimates available in the literature. However the choice of the machines volume as a parameter to measure their capacity seems in general to have to be preferred compared to the one typically adopted for beverage and snack/drink vending machines (i.e. number of bottles/cans that can be held in the machine). The inclusion of the thermodynamic factor  $(T_a - T_m)/T_m$  in the formula for RSEC seems to be able to reflect energy consumption differences due to different ambient temperatures (e.g. in case of outdoor and indoor vending machines) or different machines operating temperatures.

<sup>hhh</sup> The values reported in the table above are calculated by neglecting the energy consumption due to lighting.

Unfortunately, the absence of energy consumption data does not allow to establish whether additional segmentations (e.g. due to machines with glass and opaque fronts or with respect to machines operating temperatures) could be considered in the formula.

Draft - work in progress

## 8.3 Annex III - EU MEPS for Professional and Household Refrigeration

### 8.3.1 Professional Refrigeration

A draft of a regulation implementing the Directive 2009/125/EC with regard to eco-design requirements for professional storage cabinets, blast cabinets, condensing units and process chillers has been produced by the European Commission and is the object of an inter-service consultation while this report is being written. This draft includes a definition of a method for calculating the energy efficiency index (EEI) of professional refrigerated storage cabinets and MEPS for these product types defined based on this index.

In the draft regulation ‘professional storage cabinet’ means an insulated refrigeration product integrating one or more compartments accessible via one or more doors or drawers, capable of continuously maintaining the temperature of foodstuffs within prescribed limits at chilled or frozen operating temperature, using a vapour compression cycle, and intended for the storage of foodstuff in non household environments but not for the display to and access by customers.

This draft regulation is supposed to not be applied to:

- professional storage cabinets that are primarily powered by energy sources other than electricity;
- professional storage cabinets operating with a remote condensing unit;
- open cabinets, when their openness is a fundamental requirement for their primary functionality, such as open top preparation tables and saladettes;
- Cabinets specifically designed for carrying out food processing through, for example, heating in addition to foodstuffs refrigeration or storage of refrigerated or frozen foodstuffs such as bakery cabinets that chill, heat and humidify.
- Cabinets specifically designed only for the purpose of thawing frozen foodstuff in a controlled manner;
- Serve-over counters and other similar forms of cabinet primarily intended for display and sale of foodstuffs in addition to refrigeration and storage;
- Cabinets specifically designed for the storage of medicines and scientific samples;

Moreover in the draft regulation it is mentioned that a professional storage cabinet may include one or more partially or wholly transparent door(s) and/or drawers(s), as long as the total transparent area of the cabinet door(s) and/or drawers(s) is not more than 80% of the total door/drawer area

For the calculation of the Energy Efficiency Index (EEI) of a professional storage cabinet model, the Annual Energy Consumption of the cabinet is compared to its Standard Annual Energy Consumption.

The Energy Efficiency Index (EEI) is calculated as:

$$\text{EEI} = (\text{AEC}/\text{SAEC}) \times 100$$

Where:

$$\text{AEC} = \text{E}24\text{h} \times 365$$

With AEC = Annual Energy Consumption of the cabinet in kWh/year

E24h = energy consumption of the cabinet over 24 hours

And

$$SAEC = M \times Vn + N$$

With SAEC = Standard Annual Energy Consumption of the cabinet in kWh/year

Vn = net volume of the appliance, which is the sum of net volumes of all compartments of the cabinet.

M and N defined are given in the following Table.

**Table 49. Proposed coefficients for the calculation of the Standard Annual Energy Consumption of EU professional refrigerators**

<b>M and N coefficient values</b>		
Category	Value for M	Value for N
Vertical Chilled	1.643	609
Vertical Frozen	4.928	1472
Counter Chilled	2.555	1790
Counter Frozen	5.840	2380

For refrigerators-freezers, the net volume is replaced by the adjusted net volume:

$$Va = Vn,ref + Vn,frz \times 1.92$$

Where:

Vn,ref is the sum of the net volume of all chilled compartments in litres

Vn,frz is the sum of the net volumes of all freezer compartments in litres

The factor 1.92 is from a standard thermodynamic ratio which provides the volume of chilled compartment that consumes the same energy as a unit volume of the frozen compartment. It is calculated from the equation:

$$(30 - (-18)) / (30 - 5)$$

in which the ambient temperature is 30°C, the average frozen compartment temperature during test is -18°C and the average chilled compartment temperature during test is 5°C.

For establishing the values of annual energy consumption and Energy Efficiency Index for professional storage cabinets, measurements have to be done using the following conditions:

- i) The temperature of test packages has to be comprised between -1°C and 5°C for chilled cabinets and lower than -15°C for frozen cabinets

- ii) The ambient conditions have to correspond to climate class 4 as detailed in following table, except for light-duty cabinets which have to be tested in ambient conditions corresponding to climate class 3.
- iii) If one or several compartment(s) is/are multi-use, it/they has/have been tested at the lowest operating temperature at which it/they can be used

**Table 50. Ambient conditions defining climate classes 3, 4 and 5 in the draft regulation setting eco-design requirements for EU professional refrigerators**

<b>Ambient conditions of the climate classes 3, 4 and 5</b>				
Test room climate class	Dry bulb temperature, °C	Relative humidity, %	Dew point, °C	Water vapour mass in dry air, g/kg
3	25	60	16.7	12.0
4	30	55	20.0	14.8
5	40	40	23.9	18.8

***Comments and observations on the formulae for MEPS proposed for EU professional refrigeration (EU- ENTR Lot 1)***

In the draft regulation it is mentioned that all tests aiming to measure cabinets' energy consumption have to be performed under the climate class 4, excepting of light-duty cabinets for which the ambient conditions must correspond to those of the climate class 3. The updated version of the regulation (to be presented once the interservice consultation will be closed) will contain the necessary adjustment factors for light duty cabinets. As from the draft regulation, in case of heavy duty cabinets (which means, by definition, that they are working under ambient conditions corresponding to climate class 5), these product types will have to be tested under climate class 4.

The formula proposed for MEPS calculation depends on the cabinet net volume as the TDA cannot be defined or is not a relevant parameter for the service supplied by this product type.

### **8.3.2 Household refrigeration**

MEPS for EU household refrigeration are established in the European Commission Regulation N.643/2009 implementing Directive 2005/32/EC with regard to eco-design requirements for household refrigerating appliances. This regulation classifies household refrigerating appliance in 10 categories (e.g. refrigerators with a 1-star compartment, with a 2-star compartment, with a 3-star compartment, refrigerator-freezers, upright freezers, horizontal freezers, etc.) and defines the compartment composition relevant for its application for each of these categories. Moreover it defines four climate classes (SN – extended temperate, N-temperate, ST-subtropical, T-tropical) depending on the ambient average temperature household refrigerating appliances are designed to work at. For each appliance compartment the storage temperature and permitted temperature deviations (during the defrost cycle) are also defined.

Minimum energy performance requirements are established by setting the maximum values allowed for the energy efficiency index (EEI) of household refrigerating appliances. This index is defined as:

$$\text{EEI} = (\text{AEC} / \text{SAEC}) \times 100$$

where:

- AEC = Annual Energy Consumption of the household refrigerating appliance
  - SAEC = Standard Annual Energy Consumption of the household refrigerating appliance.
- The Annual Energy Consumption (AEC) is calculated in kWh/year, and rounded to two decimal, by multiplying by 365 the daily energy consumption of the household refrigerating appliance (in kWh/24h) and rounded to three decimal places.

The Standard Annual Energy Consumption (SAEC) is calculated in kWh/year and rounded to two decimal places, as:

$$SAEC = V_{eq} \times M + N + CH$$

where:

- $V_{eq}$  is the equivalent volume of the household refrigerating appliance EN 23.7.2009 Official Journal of the European Union L 191/65

The equivalent volume  $V_{eq}$  is calculated in litres and rounded to the nearest integer as:

$$V_{eq} = \left[ \sum_{c=1}^{n} \left( V_c \times \frac{(25-T_c)}{20} \times FF_c \right) \right] \times CC \times BI$$

where:

- n is the number of compartments ;
- $V_c$  is the storage volume of the compartment(s);
- $T_c$  is the nominal temperature of the compartment(s) as set in the regulation;
- $(25 - T_c)/20$  is a thermodynamic factor;
- $FF_c$  (frost-free),  $CC$  (climate class) and  $BI$  (built-in) are volume correction factors set out in the regulation for frost-free frozen-food storage compartments, tropical and subtropical climate class appliances<sup>61</sup> and built-in appliances respectively.

The thermodynamic correction factor  $(25 - T_c)/20$  is the temperature difference between the nominal temperature of a compartment  $T_c$  and the ambient temperature under standard test conditions at + 25°C, expressed as a ratio of the same difference for a fresh-food compartment at + 5 °C.

- $CH$  is equal to 50 kWh/year for household refrigerating appliances with a chill compartment with a storage volume of at least 15 litres
- the  $M$  and  $N$  values are given in table below for each household refrigerating appliance category.

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<sup>61</sup> If a refrigerating appliance is classified in more than one climate class, the climate class with the highest correction factor is used for the calculation of the equivalent volume.

Category	M	N
1	0,233	245
2	0,233	245
3	0,233	245
4	0,643	191
5	0,45	245
6	0,777	303
7	0,777	303
8	0,539	315
9	0,472	286
10	*	*

With the categories defined in the table below.

Category	Designation
1	Refrigerator with one or more fresh-food storage compartments
2	Refrigerator-cellar, cellar and wine storage appliances
3	Refrigerator-chiller and refrigerator with a 0-star compartment
4	Refrigerator with a 1-star compartment
5	Refrigerator with a 2-star compartment
6	Refrigerator with a 3-star compartment
7	Refrigerator-freezer
8	Upright freezer
9	Chest freezer
10	Multi-use and other refrigerating appliances

#### *Comments and observations on the formulae for MEPS established in the EU for household refrigerators*

The main parameters considered in the formula for MEPS calculation are the appliance volume and the nominal temperature of compartments. Multiplicative adjustment factors have been introduced for appliances with frost-free solutions, belonging to tropical and subtropical climate classes and built-in. All these factors reward these appliances with a 20% higher  $V_{eq}$  resulting in a lower energy efficiency index. Appliances reference energy consumption is also increased by 50 kWh/year because of the possible presence of a chill compartment. Finally appliances reference energy consumption has been assumed to depend linearly on  $V_{eq}$ .

The probably very high statistics available has allowed establishing different reference consumptions for ten different household refrigerating appliance categories. The very different operating temperatures of each category or of each appliance compartment within each category has made the introduction of thermodynamic correction factor necessary in order to duly take the associated variations in the energy consumption into account.

## 8.4 Annex IV - Markets

**Table 51 Eurovent 2010 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
<b>Aus</b>	5524	5661	5936	6066	4024	4068	4032
<b>Bel</b>	6291	3822	3940	4050	3369	3483	3639
<b>Cypr</b>	346	394	470	558	900	975	300
<b>CZ</b>	4253	4497	4672	4770	2350	2433	2325
<b>DK</b>	6256	3361	3642	3865	3035	3158	2705
<b>Eire</b>	5546	2654	2941	3132	3234	3300	3196
<b>Esto</b>	1597	705	809	955	820	878	667
<b>Fin</b>	9761	4187	4494	4672	4068	4160	3897
<b>Fra</b>	31445	31144	31817	32109	32026	32411	32195
<b>Ger</b>	45546	45766	46174	46770	43705	44077	36283
<b>Gree</b>	3101	3373	3756	3960	3133	3317	3800
<b>Hung</b>	9083	9892	10802	11350	3460	3660	4190
<b>Ital</b>	26228	26482	26938	27404	26219	26328	26172
<b>Latvia</b>	813	475	589	649	725	800	417
<b>Lithu</b>	1103	774	898	953	1083	1145	510
<b>Lux</b>	892	884	892	919	1215	1258	1509
<b>Malta</b>	124	135	145	165	165	215	30
<b>NL</b>	8948	6595	6887	7193	6288	6477	4664
<b>Pol</b>	11019	10071	10935	11493	11429	11946	9274
<b>Port</b>	4679	4908	5089	5347	5092	5238	3445
<b>Slova</b>	3012	3100	3206	3302	1367	1567	1150
<b>Slove</b>	1590	1787	1962	2229	1550	1775	850
<b>Spain</b>	18317	19140	19533	19924	18214	18693	15210
<b>Swed</b>	7783	5738	6264	6501	5843	6000	5064
<b>UK</b>	39463	26000	26714	27483	25650	26100	20433
<b>Total</b>	<b>225 884</b>	<b>231 400</b>	<b>239 073</b>	<b>245 255</b>	<b>219 723</b>	<b>224 395</b>	<b>196 488</b>

## 8.4.1 Generic economic data based on Eurostat statistics and Prodcom

### 8.4.1.1 Inside EU27

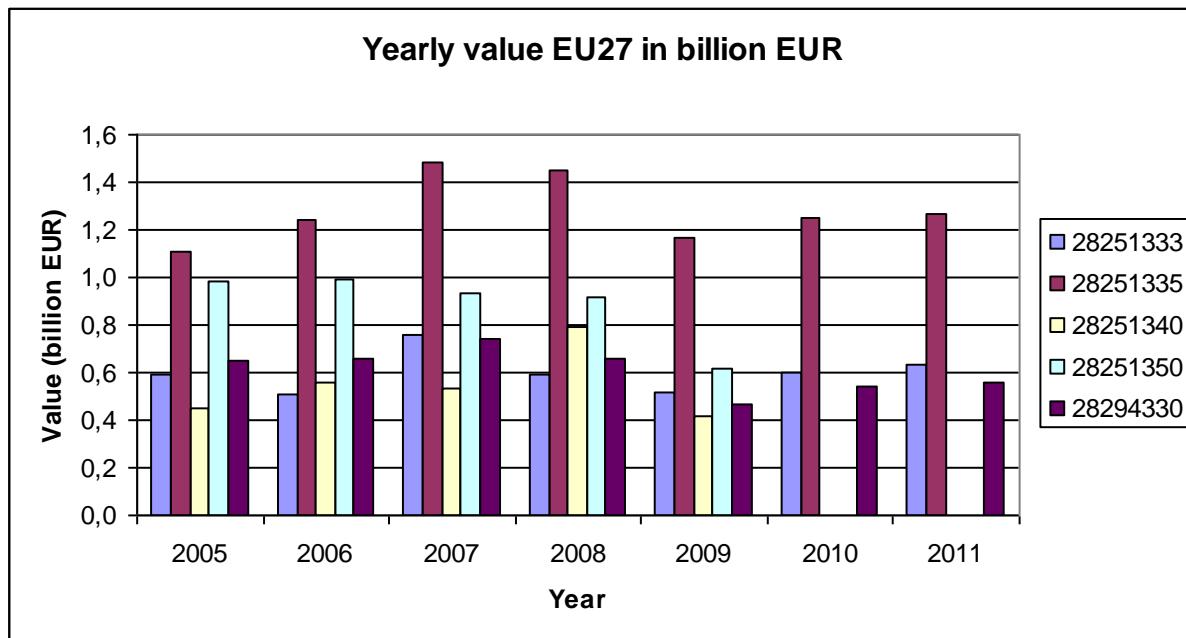
**Table 52 PRODCOM categories relevant for this project**

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 incorporating 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***

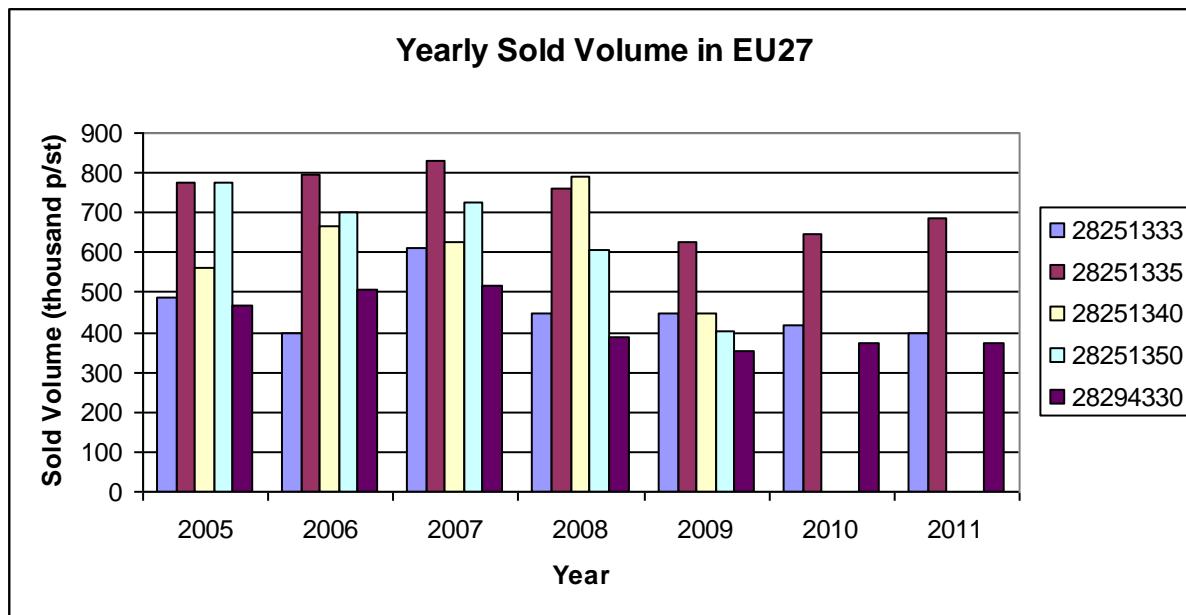
Yearly production of different product groups in euro from Prodcom database (Nace Rev. 2). No data available for group 28251340 and 28251350 for 2010 and 2011.

**Figure 22 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  
Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator (excluding for frozen food storage)
- 28251335      Deep-freezing refrigerating furniture (excluding chest freezers of a capacity <= 800 litres, upright freezers of a capacity <= 900 litres)
- 28251340      Refrigerating furniture (excluding for deep-freezing, show-cases and counters incorporating a refrigerating unit or evaporator)
- 28251350      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

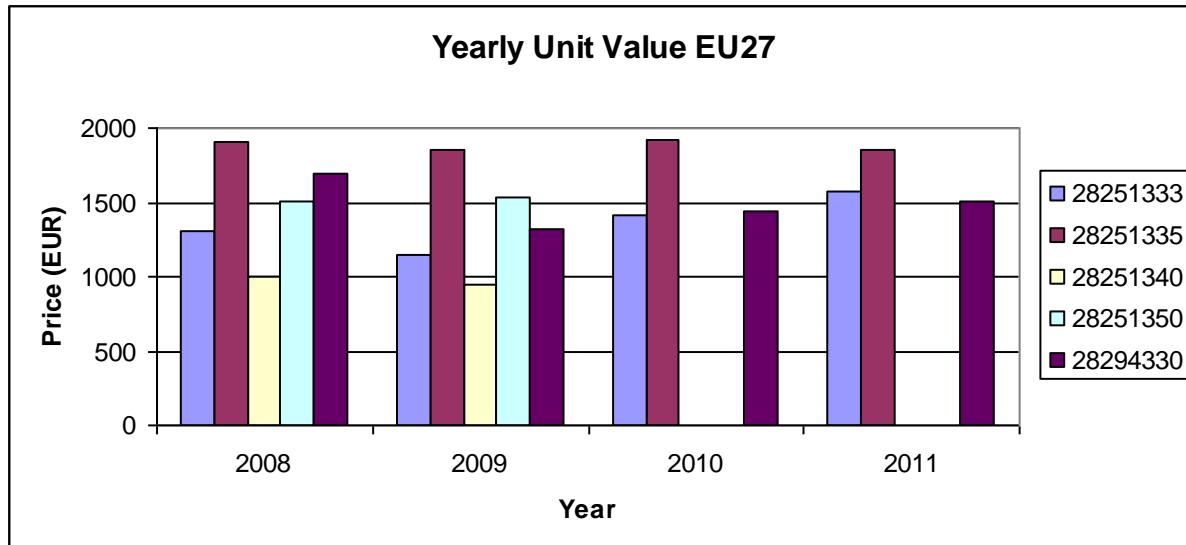


**Figure 23 Yearly sold volume in the EU27 of the selected product groups**

- 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 24 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

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

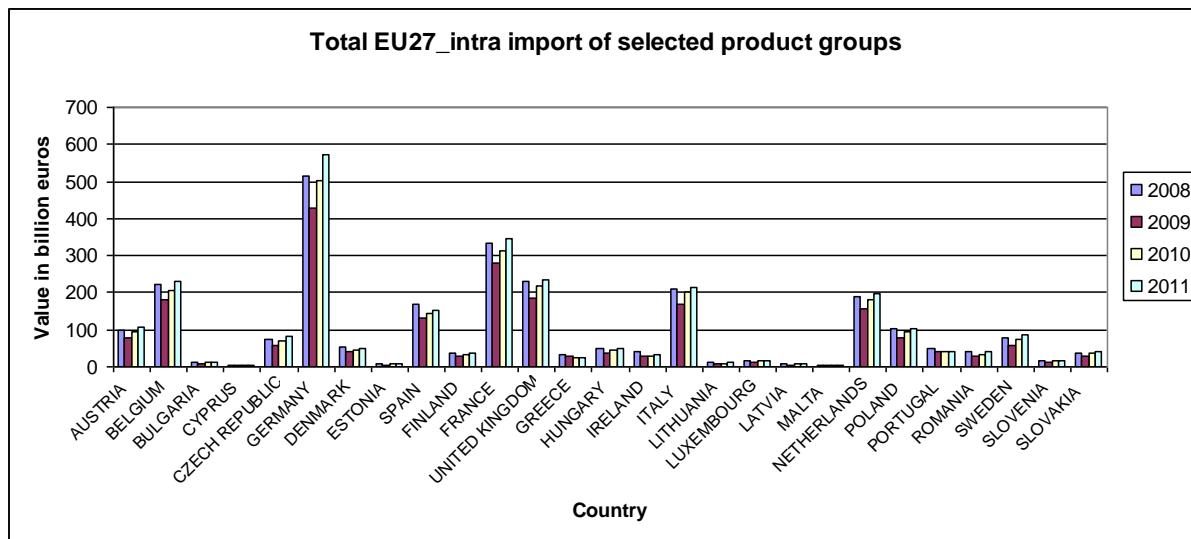


Figure 25 Total EU27 import of the selected product groups inside the EU27

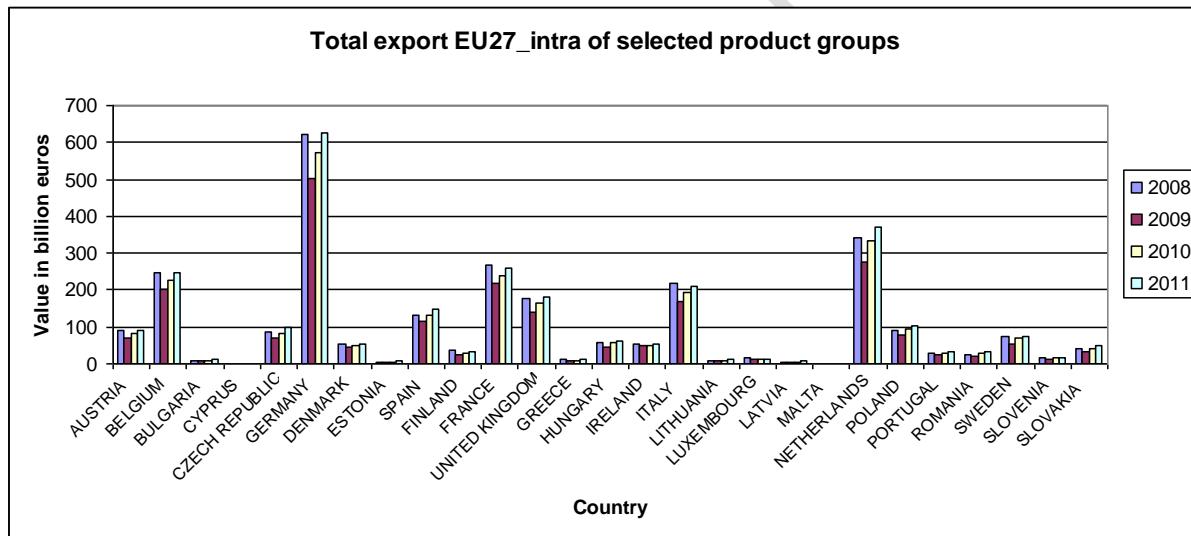
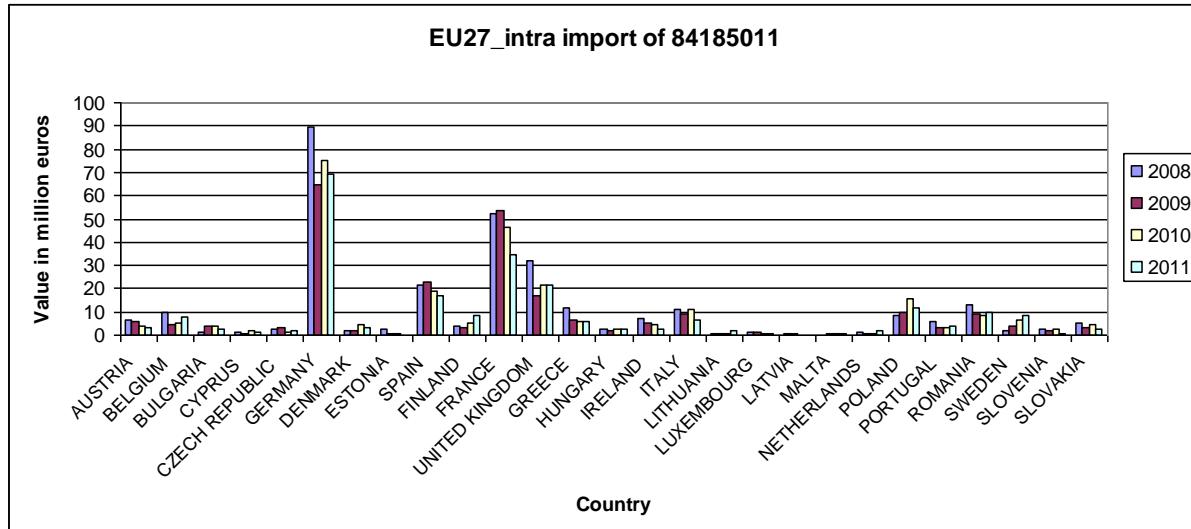


Figure 26 Total EU27 export of the selected product groups inside the EU27

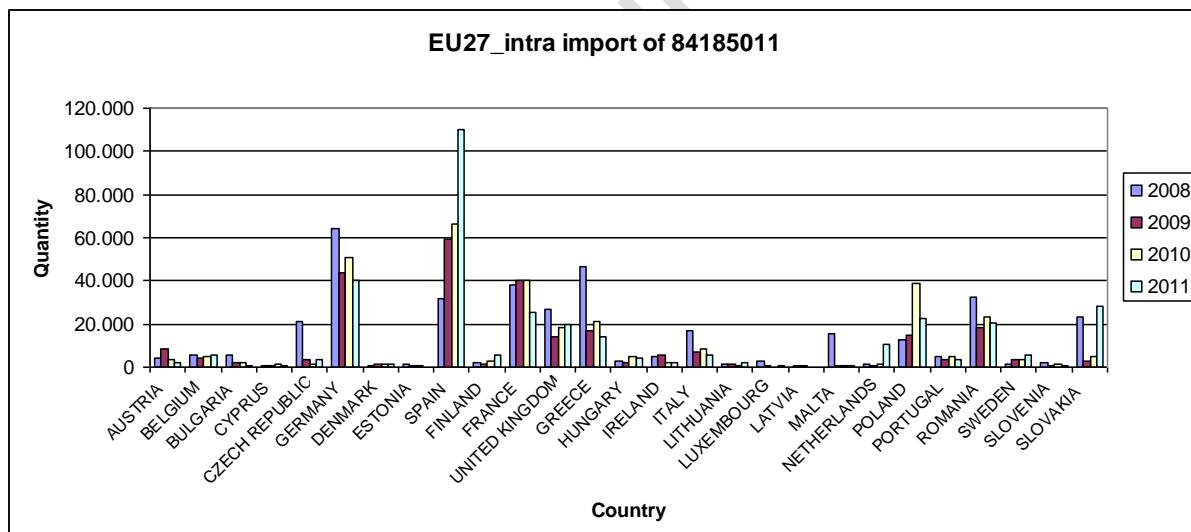
Per product group

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.

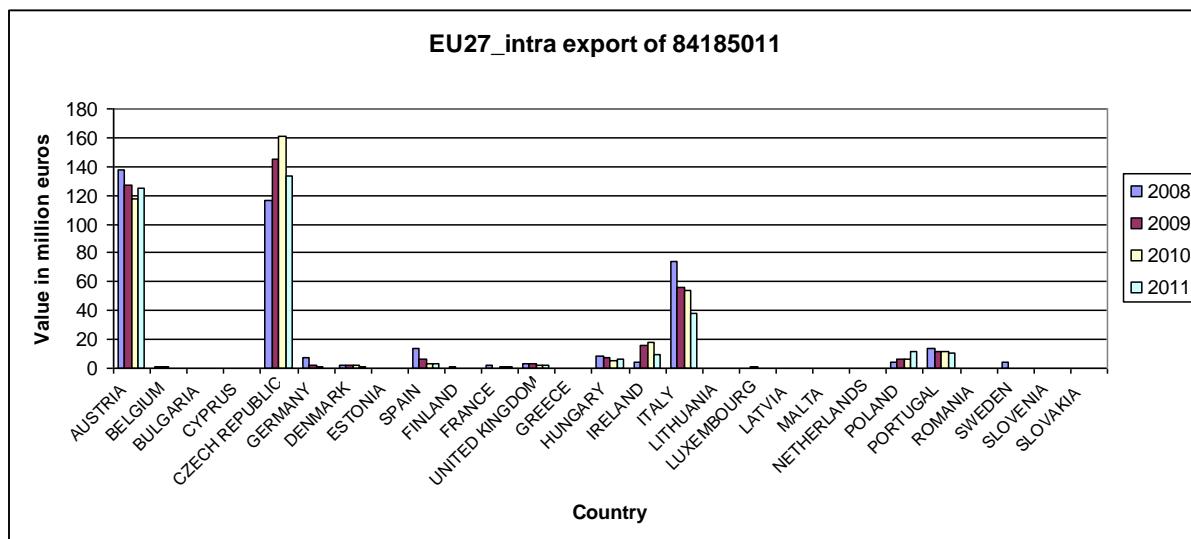
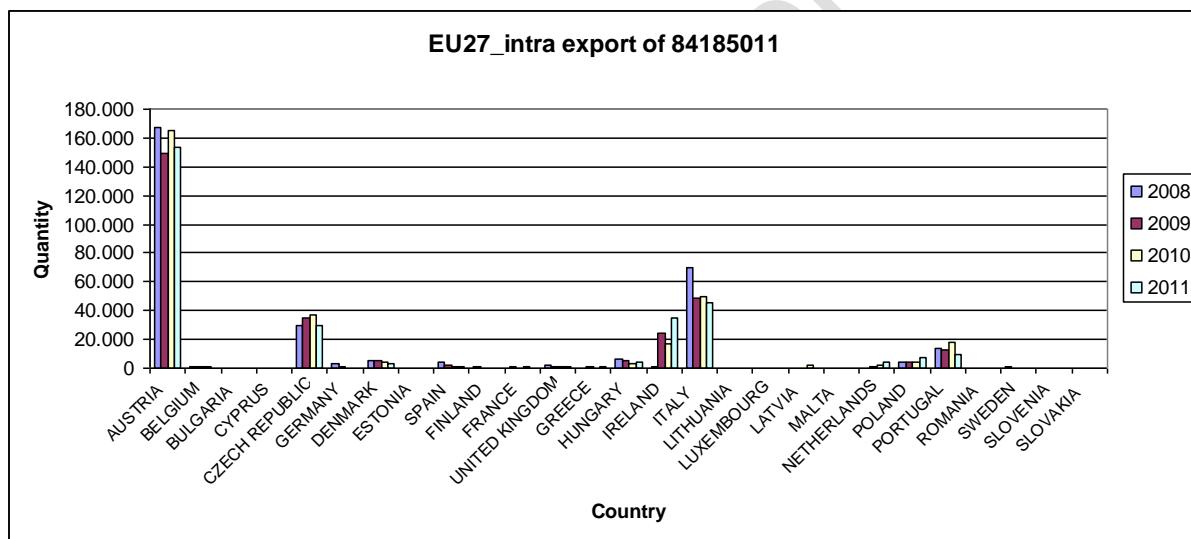
**EU27 import inside EU27**



**Figure 27 Value of EU27 import of product group 84185011 inside the EU27**



**Figure 28 Quantity of EU27 import of product group 84185011 inside the EU27**

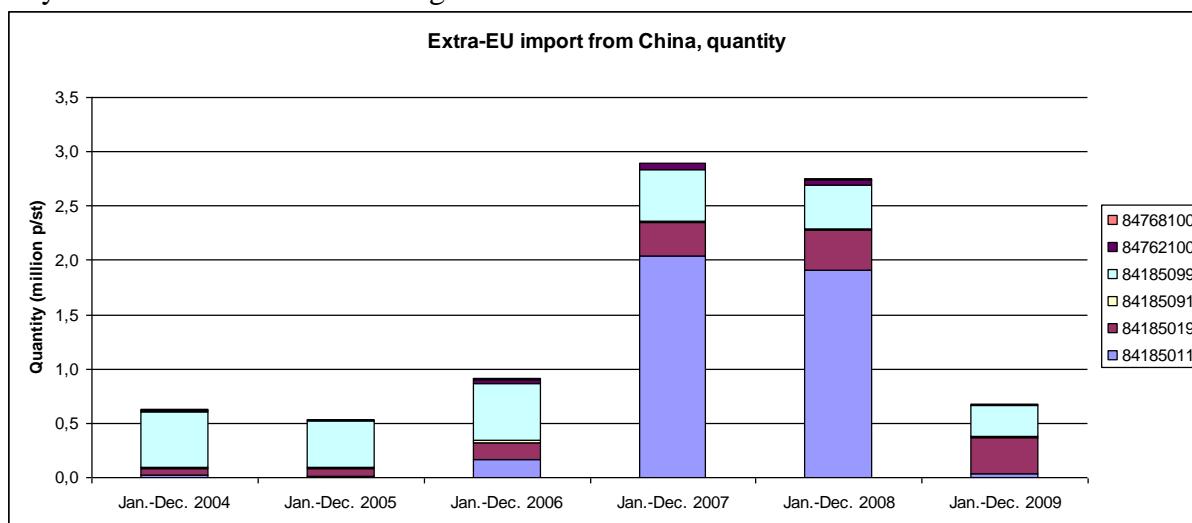
**EU27 export inside EU27 of 84185011****Figure 29 Value of EU27 export of product group 84185011 inside the EU27****Figure 30 Quantity of EU27 export of product group 84185011 inside the EU27**

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 on-going regarding the values for 2007 and 2008 as they look overestimated at first sight.

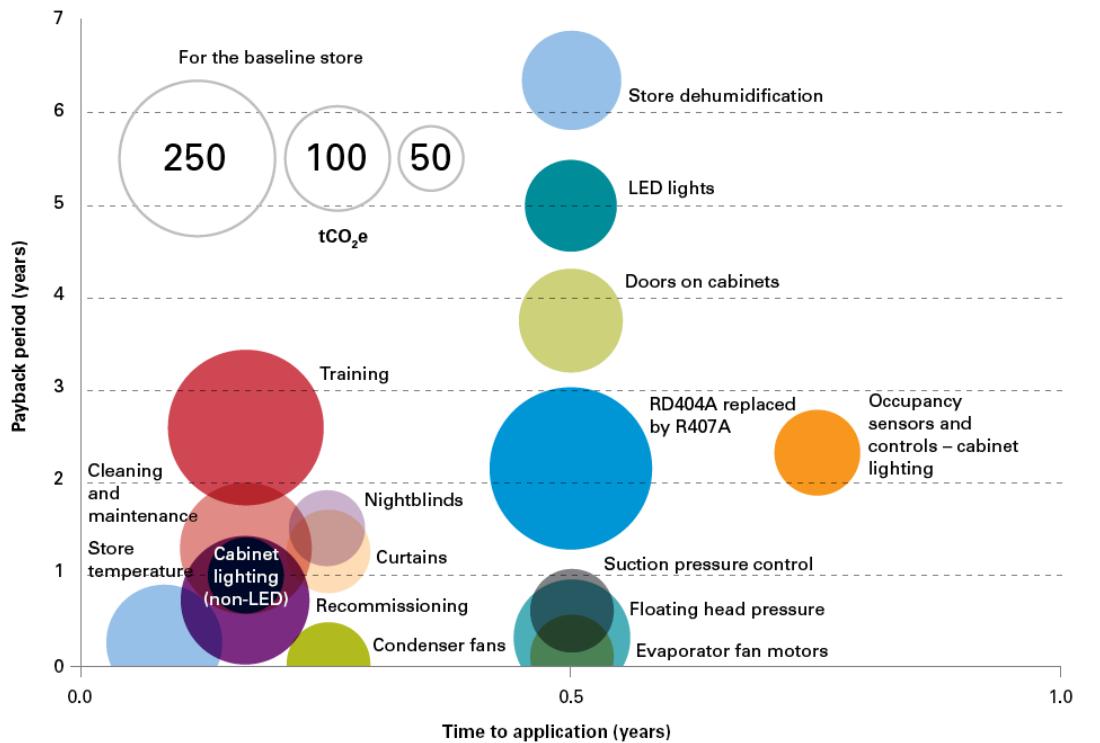


**Figure 31 Quantity of EU27 import from China for the selected product groups.**

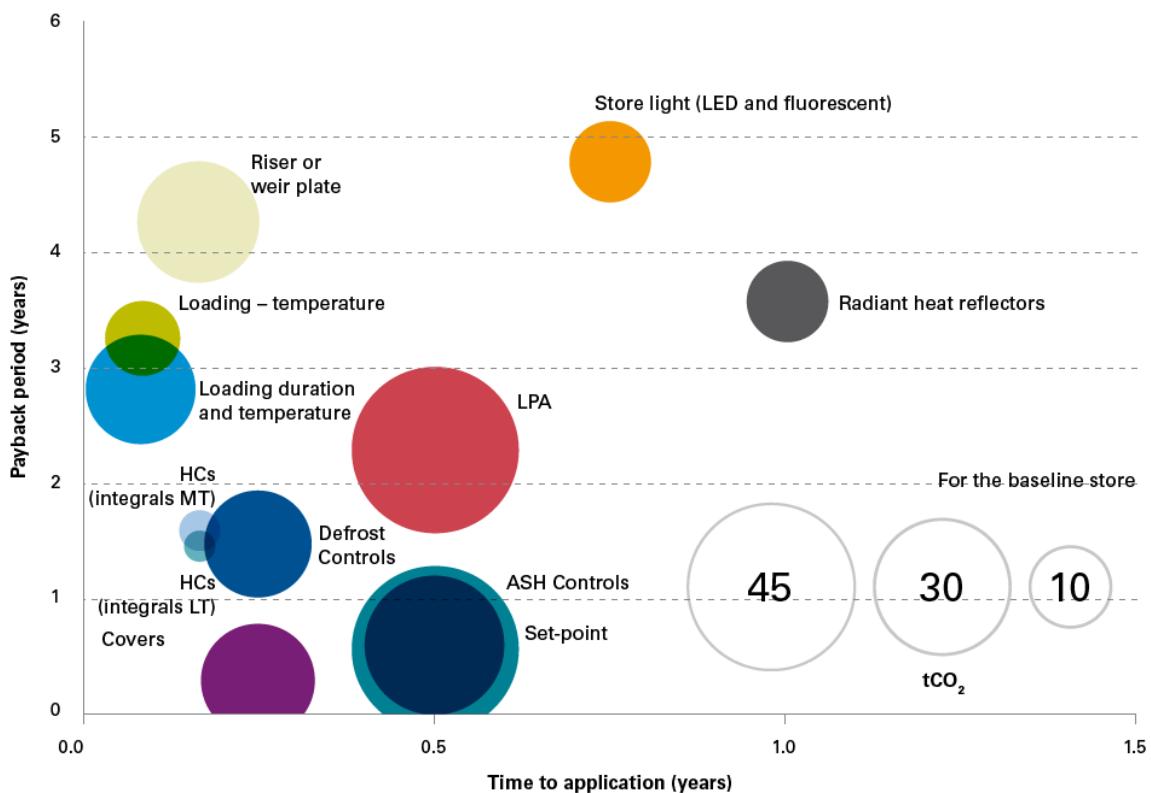
Selected product groups:

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]

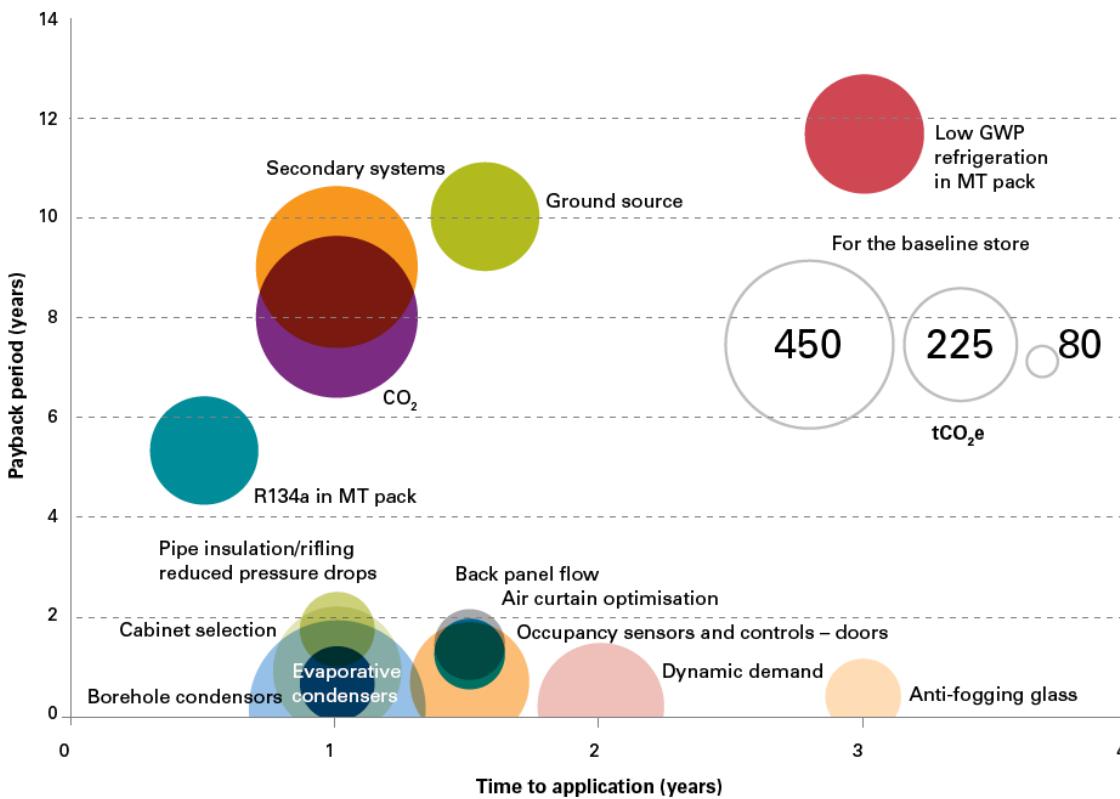
## 8.5 Annex V – Technologies



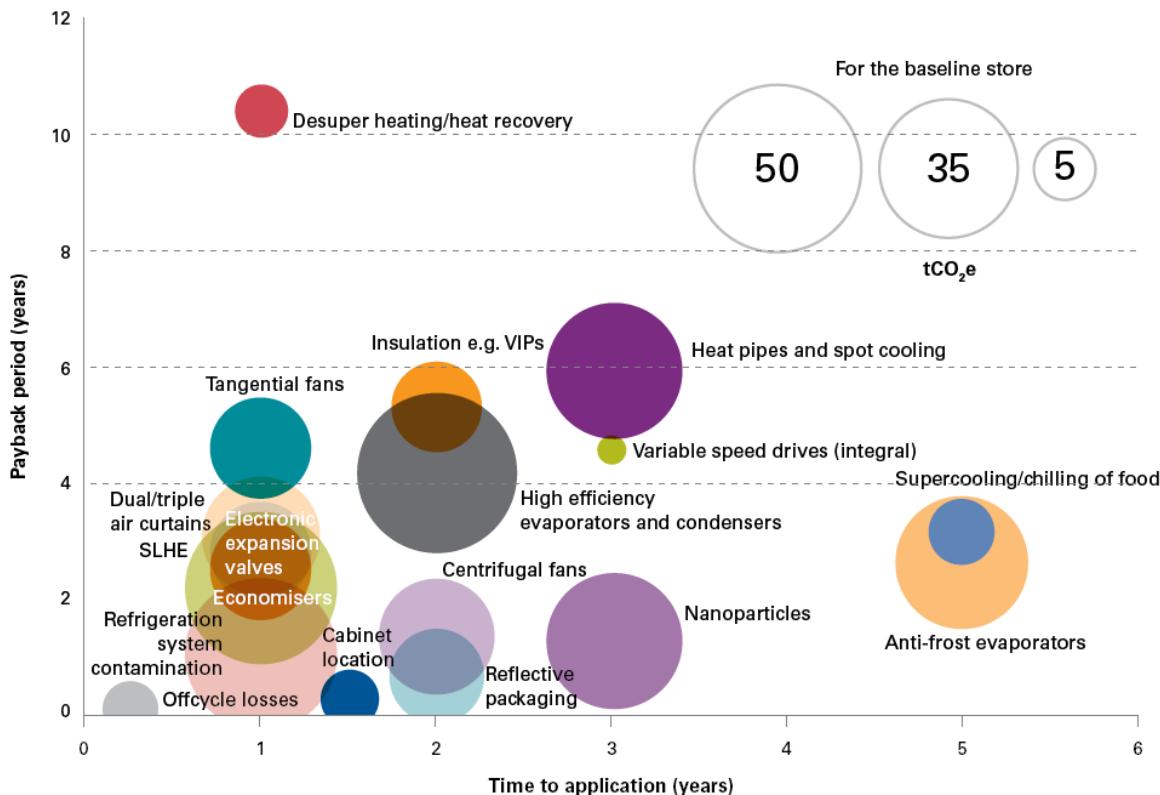
**Figure 32 Technologies that can be retrofitted with potential to save > 50tCO<sub>2</sub>e pa  
(Taken from Carbon Trust's Refrigeration Road Map<sup>15</sup>)**



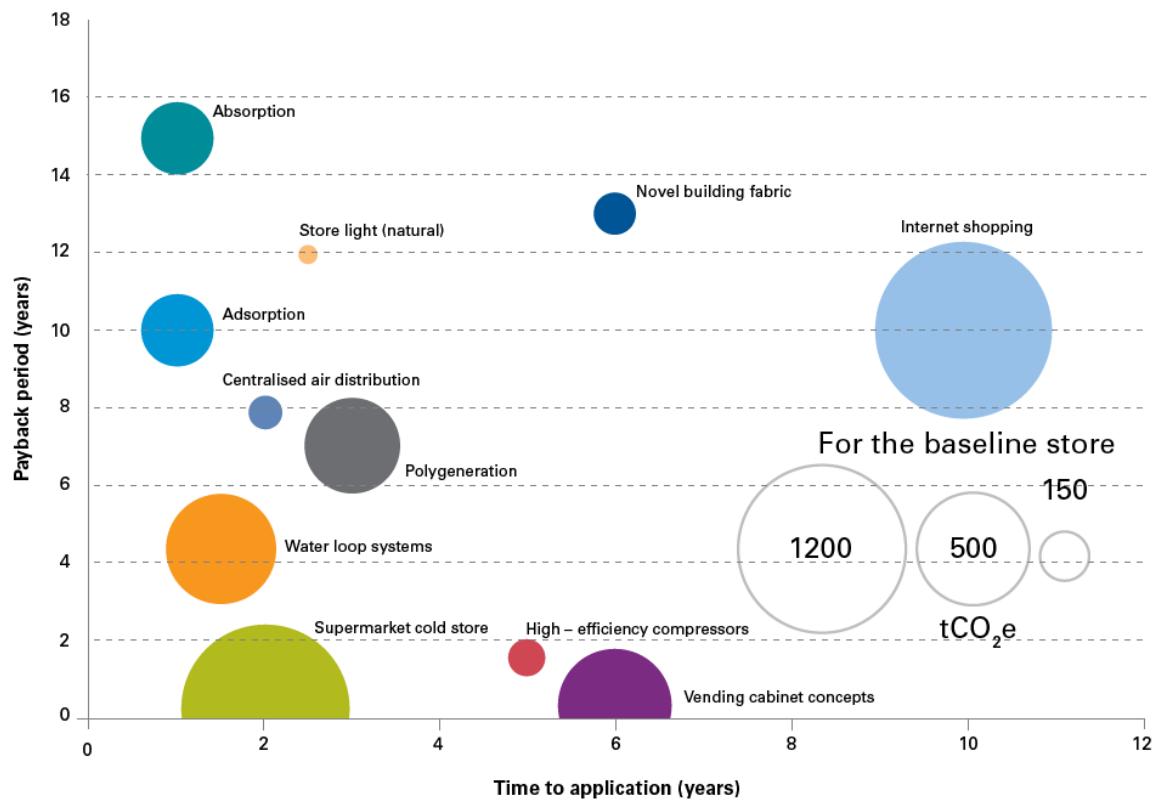
**Figure 33 Technologies that can be retrofitted with potential to save < 50tCO<sub>2</sub>e pa  
(Taken from Carbon Trust's Refrigeration Road Map<sup>15</sup>)**



**Figure 34 Technologies that are available during a store refit with potential to save > 50tCO<sub>2</sub>e pa (Taken from Carbon Trust's Refrigeration Road Map<sup>15</sup>)**



**Figure 35 Technologies that are available during a store refit with potential to save < 50tCO<sub>2</sub>e pa (Taken from Carbon Trust's Refrigeration Road Map<sup>15</sup>)**



**Figure 36 Technologies that are available when designing a new store/retail concept**  
(Taken from Carbon Trust's Refrigeration Road Map<sup>15</sup>)

**Table 53 Average energy efficiency levels for refrigerated display cases (Class 3 performance data), UK Market Transformation Program Policy scenario<sup>34</sup>**

<b>Remote Display Cases</b>						
Temp Class	<b>Energy Consumption (kWh/m<sup>2</sup>/day)</b>					
	M0	M1	M2	H1	H2	L1
<b>2009</b>	15.18	13.30	11.61	9.67	9.82	22.00
<b>2010</b>	14.33	12.57	10.84	9.05	9.18	21.14
<b>2011</b>	13.48	11.83	10.07	8.42	8.54	20.28
<b>2012</b>	12.64	11.10	9.31	7.80	7.89	19.42
<b>2025</b>	10.02	8.78	7.66	6.38	6.48	19.30
<b>2030</b>	10.02	8.78	7.66	6.38	6.48	19.30
<b>Plug-in Display Cases</b>						
Temp Class	<b>Energy Consumption (kWh/m<sup>2</sup>/day)</b>					
	M0	M2	H2	L1		
<b>2009</b>	14.17	15.69	13.79	24.06		
<b>2010</b>	13.37	14.14	12.70	22.75		

## 8.6 Annex VI - Developments in the update of the F-gas Regulation

In 2012, the European Commission made a proposal<sup>17</sup> 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.<sup>18</sup> The Rapporteur's recommendations were discussed by the ENVI Committee, the parliamentary committee for Environment, Public Health and Food Safety and are now under discussion in a triilogue between the European Commission, the European Parliament and the European Council.

Table 54 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, small ice-cream freezers as well as vending machines).

**Table 54 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

### 8.6.1 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 55).

**Table 55 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.

#### 8.6.1.1 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 <sub>2</sub> emissions	(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 <sub>2</sub> emissions resulting from their energy

<p>resulting from their energy consumption.</p> <p><b><i>Equipment containing fluorinated greenhouse gases should thus be allowed if their overall greenhouse gas emissions are 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)</i></b></p>	<p>consumption.</p>
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#### Amendment 24

##### Proposal for a regulation

Article 9 – paragraph 2 Text proposed by the Commission	Amendment
<p><b><i>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<sub>2</sub> emissions would be lower than that from equivalent equipment which meets relevant Ecodesign requirements and does not contain hydrofluorocarbons.</i></b></p>	<p><b><i>Deleted</i></b></p>
<p><i>Justification</i></p> <p>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.</p>	

#### 8.6.1.2 Rapporteur amendments related to a ban on certain refrigerants

##### Amendment 44

##### Proposal for a regulation

ANNEX III – table – line 10 a (new)	Amendment
	<p><b><i>10a. Refrigeration equipment that contains fluorinated greenhouse gases with GWP of 2150 or more</i></b></p> <p><b><i>1 January 2015</i></b></p>
<p><i>Justification</i></p> <p>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.</p>	

**Amendment 47****Proposal for a regulation**

<b>ANNEX III – table – line 11 – part one</b>		
<i>Text proposed by the Commission</i>		
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 <b>2500</b> or more	<b><i>1 January 2017</i></b>
<i>Amendment</i>		
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 <b>2150</b> or more	<b><i>1 January 2015</i></b>

**Amendment 48****Proposal for a regulation**

<b>ANNEX III – table – line 11 – part two</b>		
<i>Text proposed by the Commission</i>		
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 <b>with GWP of 150 or more</b>	<b><i>1 January 2020</i></b>
<i>Amendment</i>		
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	<b><i>1 January 2018</i></b>

## 8.7 Annex VII - The REAPro method

The analysis of potential EoL Ecodesign measures of commercial refrigeration appliances has been based on a qualitative application of the ‘Resource Efficiency Assessment of products - REAPro’ method (Ardente and Mathieu, 2012). This method aims at the identification and assessment of measures to improve the resource efficiency of products at the EoL. The REAPro method applied in this analysis is composed of 5 steps:

Step 1. Characterization of the products: This step includes the analysis of materials and components of the target products.

Step 2. Assessment of the product group against the selected criteria. This is further subdivided in:

### 2.1) Definition of EoL scenario(s):

The EoL practices are analysed, using literature review, interviews of recyclers and visits of representative recycling plants, in order to have an overview of EoL treatments (e.g. dismantling / shredding based). In addition, potential risks and problems based on observations and/or comments and/or data from recyclers (e.g. risks related to contaminations by hazardous substances, extraction of key components) are analysed.

### 2.2) Analysis of product performance against the following set of criteria:

The criteria used for the qualitative analysis of commercial refrigeration appliances include:

- Reusability / Recyclability / Energy Recoverability (in terms of mass and environmental impacts).
- Use and management of hazardous substances.
- Durability (lifetime extension).
- Dematerialization (reduced use of substances).

The on-site observations are crossed compared with the literature review (e.g. identification of priority materials, as precious metals in some electronics).

Step 3. Identification of product’s ‘hot spots’: components relevant for some criteria and for the considered EoL processes”. In this step it is studied:

- What components are currently landfilled/incinerated.
- What components are responsible of relevant life cycle impacts for some categories.
- How different materials / components could affect the quality / quantity of recyclable fractions.
- What components are covered by current legislation.

Steps 4 and 5 deal with the identification of potential measures to improve product’s EoL performances. Specifically, Step 4 applies at the case-study product level and Step 5 at product group level.

Finally, potential Ecodesign improving measures are identified and assessed based on information from previous steps, including: interviews and visits to companies dealing with EoL treatments, literature (scientific and technical reviews on EoL treatments and environmental analysis, take back schemes, etc.) and feedback from stakeholders.

## 8.8 Annex VIII – Definitions

Taken directly from existing EU legislation texts and could later be used for the Commercial Refrigeration Regulation:

- *absorption-type refrigerating appliance*: means a refrigerating appliance in which refrigeration is effected by an absorption process using heat as the energy source;
- *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;
- *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;
- *cellar*: means a refrigerating appliance where only one or more cellar compartments are present;
- *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;
- *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;
- *compartments*: means any of the compartments listed in points below:
  - 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;
  - fresh-food storage compartment: means a compartment designed for the storage of unfrozen foodstuffs, which may itself be divided into sub-compartments;
  - frozen-food storage compartment means a low-temperature compartment intended specifically for the storage of frozen foodstuffs and classified according to temperature as follows:
  - ice-making compartment: means a low-temperature compartment intended specifically for the freezing and storage of ice;
  - 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:
  - ‘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;
  - ‘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;
- ‘one-star compartment’: a frozen-food storage compartment in which the temperature is not warmer than – 6 °C;
  - ‘three-star compartment’: a frozen-food storage compartment in which the temperature is not warmer than – 18 °C;
  - ‘two-star compartment’: a frozen-food storage compartment in which the temperature is not warmer than – 12 °C;
  - 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;
  - 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;
- *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;
  - *Compression-type refrigerating appliance*: means a refrigerating appliance in which refrigeration is effected by means of a motor-driven compressor;
  - *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;
  - *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;
  - *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;
  - *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;
  - *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;
  - *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;
  - *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;

- *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.
- *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.
- *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;
- *Foodstuffs*: means food, ingredients, beverages, including wine, and other items primarily intended for consumption which require refrigeration at specified temperatures;
- *Frost-free compartment*: means any compartment defrosted by a frost-free system;
- *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;
- *Frozen-food storage cabinet*: means a refrigerating appliance with one or more compartments suitable for the storage of frozen foodstuffs;
- *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;
- *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.
- *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 );
- *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;
- *Implementing measure*: means measure adopted pursuant to a Directive laying down e.g. specific Ecodesign requirements for defined products or for environmental aspects thereof;
- *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;
- *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;
- *Life cycle*: means the consecutive and interlinked stages of a product from raw material use to final disposal;

- *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;
- *Materials*: means all materials used during the life cycle of a product;
- *Multi-use appliance*: means a refrigerating appliance that has no compartment other than one or more multi-use compartments;
- *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;
- *Other-type refrigerating appliances*: means a refrigerating appliance in which refrigeration is effected by any other technology or process than compression or absorption-types;
- *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;
- *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;
- *Putting into service*: means the first use of a product for its intended purpose by an end-user in the Community;
- *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 );
- *Recycling*: means the reprocessing in a production process of waste materials for the original purpose or for other purposes but excluding energy recovery;
- *Refrigerator*: means a refrigerating appliance intended for the preservation of foodstuffs with at least one compartment suitable for the storage of fresh food and/or beverages, including wine;
- *Refrigerator-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;
- *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;
- *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);
- *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;

- *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;
- *Top-opening type or chest type*: means a refrigerating appliance with its compartment(s) accessible from the top of the appliance;
- *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;
- *upright type*: means a refrigerating appliance with its compartment(s) accessible from the front of the appliance;
- *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;
- *Wine storage appliance*: means a refrigerating appliance that has no compartment other than one or more wine storage compartments;

## 8.9 Annex IX – Classification for refrigerated display cabinets

Designation of refrigerated display cabinet families,  
Annex A of ISO 239553-1:2005+A1:2012, informative)

Application	Temperature positive		Temperature negative	
	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
R Remote condensing unit	V Vertical			
I Incorporated condensing unit	Y Combined			
A Assisted service	C Chilled			
S Self service	F Frozen			
H Horizontal	M Multi-temperature			
General classification can be used as follows: HC1, VF1, YM5. When necessary, the classification can be more precise for example, RHC1A, IVF1S				
NOTE Serve-over counters are primarily in assisted service but can be in self-service. Chilled multi-deck cabinets are primarily in self-service but can be in assisted service.				

## 9 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 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.merp.eu](http://www.merp.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.
  - 13. Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (recast).
  - 14. Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste.
  - 15. Refrigeration Road Map, Carbon Trust, the Institute of Refrigeration and the British Refrigeration Association, March 2012, UK (CTG021).  
[http://www.carbontrust.com/media/147175/j7924\\_ctg021\\_refrigeration\\_road\\_map\\_aw.pdf](http://www.carbontrust.com/media/147175/j7924_ctg021_refrigeration_road_map_aw.pdf)
  - 16. Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases.
  - 17. Proposal for a Regulation of the European Parliament and of the Council on fluorinated greenhouse gases [http://ec.europa.eu/clima/policies/f-gas/legislation/docs/com\\_2012\\_643\\_en.pdf](http://ec.europa.eu/clima/policies/f-gas/legislation/docs/com_2012_643_en.pdf)
  - 18. <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-%2F%2FEP%2F%2FNONGML%2BCOMP%2BPE-506.101%2B01%2BDOC%2BPDF%2BV0%2F%2FEN>
  - 19. Regulation (EC) No 1005/2009 of the European parliament and of the Council of 16 September 2009 on substances that deplete the ozone layer (recast).
  - 20. Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 relating to emissions from air-conditioning systems in motor vehicles and amending Council Directive 70/156/EEC.
  - 21. Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment.
  - 22. Wees, R.M.M. van de, Kastele, R.M., Ham, J.M., Tests of CO<sub>2</sub> refrigeration equipment, TNO 2012 R10776, Utrecht, November 2012.
  - 23. Wees, R.M.M. van, Wissink, E.B., Ham, J.M., Qualitative risk assessment for cold drink equipment with carbon dioxide as refrigerant, TNO 2012 R10916, Utrecht, November 2012.
  - 24. Test standards for retail cabinets Worldwide, Refrigeration Developments and Testing Ltd., 2013.
  - 25. Technical Evaluation of National and Regional Test Methods for Commercial Refrigeration Products, CLASP on behalf of the SEAD Initiative, August 2013.
  - 26. Benchmarking report for refrigerated vending machines, International Energy Agency Implementing Agreement for a Co-operating Programme on Efficient Electrical End-Use Equipment (4E), 2012.
  - 27. Market Transformation Programme, BNCR VM0X: Cold Vending Machines Government Standards Evidence Base 2009, Defra, UK, <http://efficient-products.defra.gov.uk>
  - 28. Watkins, R., Tassou, S., Life cycle analysis of the environmental impact of different cabinet designs, 13th World Congress of Food Science & Technology, IUFoST World Congress, 2006, DOI: 10.1051/IUFoST:20060701.
  - 29. JRC Scientific and Policy Report on Best Environmental Management Practice in the Retail Trade Sector, June 2013, H. Schönberger, J.L. Galvez Martos, D. Styles, <http://susproc.jrc.ec.europa.eu/activities/emas/documents/RetailTradeSector.pdf>

30. The Enhanced Capital Allowance (ECA) Scheme is a key part of the UK Government's programme to manage climate change. It provides businesses with enhanced tax relief for investments in equipment that meets published energy-saving criteria. <https://etl.decc.gov.uk/etl/site.html>
31. Benchmarking report for retail display cabinets, International Energy Agency Implementing Agreement for a Co-operating Programme on Efficient Electrical End-Use Equipment (4E), 2012.
32. Sietze van der Sluis, Saint Trofee, The Netherlands, personal communication.
33. Coca-Cola, personal communication.
34. Market Transformation Programme, BNCR RDC0X: Refrigerated Display Cases Government Standards Evidence Base 2009, Defra, UK, <http://efficient-products.defra.gov.uk>
35. Rhiemeier, J.M., Harnisch, J., Ters, C., Kauffeld, M., Leisewitz, A., Comparative assessment of the climate relevance of supermarket refrigeration systems and equipment, Research Report 20644.00 UBA-FB 001180/e, [www.umweltbundesamt.de](http://www.umweltbundesamt.de)
36. Commission Regulation (EU) No 206/2012 of 6 March 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to Ecodesign requirements for air conditioners and comfort fans.
37. TCGF Board Resolution on Sustainable Refrigeration  
[http://sustainability.mycgforum.com/images/sustainability-pic/board\\_resolutions\\_on\\_deforestation\\_and\\_refrigeration.pdf](http://sustainability.mycgforum.com/images/sustainability-pic/board_resolutions_on_deforestation_and_refrigeration.pdf)
38. <http://www.eia-international.org/chilling-facts-v>
39. Walsh, B.; Parker, D.; Pearson, J. Centre for remanufacturing & Reuse (CRR). Report on the remanufacturing of refrigerated display cabinets. June 2009.
40. Kauffeld, M., Availability of low GWP alternatives to HFCs: feasibility of an early phase-out of HFCs by 2020, Environmental Investigation Agency, 2012
41. Cemafroid, France, personal communication
42. <http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/atex/>
43. Articles about the use of hydrocarbon refrigerants, originally published in ACR Today  
[http://www.coolconcerns.co.uk/HC\\_design.pdf](http://www.coolconcerns.co.uk/HC_design.pdf)
44. Fricke, B.A., Becker, B.R., Glass Doored versus Open Vertical Display Cases: Energy and Sales, IEA Heat Pump Centre Newsletter, Volume 28, No. 4/2010, p. 31.
45. Lindberg, U.M., Axell, M., Fahlaen, P., Fransson, N., Supermarkets, Indoor Climate and Energy Efficiency – Field Measurements Before and After Installation of Doors on Refrigerated Cases, 2008, International Refrigeration and Air Conditioning Conference. Paper 879. <http://docs.lib.psu.edu/iracc/879>
46. Performance of retail and commercial refrigeration systems, J.A. Evans, M.V.L. Swain, 1<sup>st</sup> IIR International Cold Chain Conference, Cambridge, UK, 2010.
47. The WEEE Directive states that waste of electrical and electronic equipment (WEEE) should be appropriately separately collected and transported for preparing for re-use, recycling and the appropriate extraction/treatment of hazardous substances. In particular, this Directive establishes some minimum recovery targets as: starting from 15 August of 2015, WEEE falling within category 1 (large household appliances) and 10 (automated dispensers) shall be 85 % recovered, and 80 % shall be prepared for re-use and recycled.
48. This Directive sets up maximum concentration values tolerated by weight in homogeneous materials such as for lead (0,1%), mercury (0,1 %), cadmium (0,01 %), hexavalent chromium (0,1 %), among others. Annex I of RoHs Directive on Categories of EEE covered includes “Category 11. Other EEE not covered by any of

- the categories above". Cabinets not currently under the scope of WEEE would thus also be under the scope of the RoHS Directive.
49. F. Ardente, F. Mathieu. Refined methods and Guidance documents for the calculation of indices concerning Reusability/Recyclability/Recoverability, Recycled content, Use of Priority Resources, Use of Hazardous substances, Durability. JRC Technical Report n. 3 of the project "Integration of resource efficiency and waste management criteria in European product policies - Second phase". September 2012. (<http://lct.jrc.ec.europa.eu/assessment/assessment/projects#d>)
  50. BioIS. 2007. Preparatory studies for Ecodesign requirements of EuPs. Lot 12. Commercial refrigerators and freezers. Final Report – 2007.
  51. A., Boustan, S., Sahni, T., Gutowsky, S., Graves, 2010. Appliance remanufacturing and energy savings. Proceedings of the 2010 IEEE (Institute of Electrical and Electronics Engineers) International Symposium on Sustainable Systems & Technology, 2010. 1-6.
  52. P. Chancerel, C. E.M. Meskers, C. Hageluken, and V. S. Rotter. Assessment of Precious Metal Flows During Preprocessing of Waste Electrical and Electronic Equipment. Journal of Industrial Ecology. Volume 13, Number 5.
  53. Decision C(2001)107/Final of the OECD Council concerning the revision of Decision C(92)39/Final on the control of transboundary movements of wastes destined for recovery operations
  54. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). 2008. Programme Proklima. Natural Refrigerants Sustainable Ozone- and Climate-Friendly Alternatives to HCFCs. July 2008.
  55. <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-%2F%2FEP%2F%2FNONGML%2BREPORT%2BA7-2013-0240%2B0%2BDOC%2BPDF%2BV0%2F%2FEN>
  56. Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment.
  57. Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS).
  58. Directive 2012/19/EU of the European parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE)
  59. European Environment Agency (EEA). 2009. Waste without borders in the EU? Transboundary shipments of waste. EEA report No 1/2009 ([www.eea.europa.eu/publications/waste-without-borders-in-the-eu-transboundary-shipments-of-waste](http://www.eea.europa.eu/publications/waste-without-borders-in-the-eu-transboundary-shipments-of-waste))
  60. EMERSON. 2010. Refrigerant Choices for Commercial Refrigeration. EMERSON, Climate Technologies –Finding the right balance. ([http://www.emersonclimate.com/europe/Documents/Resources/TGE124\\_Refrigerant\\_Report\\_EN\\_1009.pdf](http://www.emersonclimate.com/europe/Documents/Resources/TGE124_Refrigerant_Report_EN_1009.pdf) ; access September 2013).
  61. EN 50574:2012: Collection, logistics & treatment requirements for end-of-life household appliances containing volatile fluorocarbons or volatile hydrocarbons.
  62. Environment Agency (UK). 2012. Flammability of fridge insulation foam produced with a hydrocarbon blowing agent. Version 1.0. December 2012 (<https://publications.environment-agency.gov.uk/skeleton/publications/ViewPublication.aspx?id=c6d5322c-1e26-4ccda-ace9-48421a8ea089> ; access: October 2013)
  63. European Commission. 2008. Commission Staff Working Paper accompanying the Proposal for a Directive of the European Parliament and of the Council on waste

- electrical and electronic equipment (WEEE) (recast). Impact Assessment. Brussels, 3.12.2008. SEC(2008) 2933.
64. EUROSTAT, 2010. (<http://www.eea.europa.eu/data-and-maps/indicators/waste-electrical-and-electronic-equipment/assessment-1>, access June 2013).
65. International Electrotechnical Commission (IEC). 2012. Technical Report IEC/TR 62635 Ed.1.0. "End of Life recyclability calculation for electrical and electronic equipment". June 2012.
66. IPPC-TEAP Special report. Safeguarding the ozone layer and the global climate system. Chapter 4: Refrigeration. 2004.
67. M., Lindahl, E., Sundin, J., Ostlin, 2006. Environmental issues within the remanufacturing industry. Proceedings of 13th CIRP International Conference on Life Cycle Engineering. 447-452. ISBN: 90-5682-712-X, 978-9-05682-712-0. Belgium, May 31st – June 2nd, 2006. (<http://liu.diva-portal.org/smash/get/diva2:256350/FULLTEXT01>, access: June 2013)
68. K. Nakano, R. Aoki, H. Yagita, N. Narita. 2007. Evaluating the Reduction in Green House Gas Emissions Achieved by the Implementation of the Household Appliance Recycling in Japan. Int J LCA 12 (5) 289 – 298.
69. RAL-GZ 728 Quality Assurance and Test Specification for the Demanufacture of Refrigeration Equipment. RAL Deutsches Institut fur Gutesicherung. September 2007.
70. Regulation EC 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases.
71. IPPC 2001  
[http://www.grida.no/publications/other/ipcc\\_tar/?src=/climate/ipcc\\_tar/wg3/144.htm](http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg3/144.htm) (access: September 2013)
72. Regulation (EC) No 1013/2006 UE of the European Parliament and of the Council of 14 June 2006 on shipments of waste
73. Regulation (EC) No 1494/2007 of 17 December 2007 establishing, pursuant to Regulation (EC) No 842/2006 of the European Parliament and of the Council, the form of labels and additional labelling requirements as regards products and equipment containing certain fluorinated greenhouse gases
74. Regulation EC 1005/2009 of the European Parliament and of the Council of 16 September 2009 on substances that deplete the ozone layer.
75. B., Walsh, D., Parker, J., Pearson. 2009. Centre for remanufacturing & Reuse (CRR). Report on the remanufacturing of refrigerated display cabinets. June 2009.
76. R. Zevenhoven. 2004. Treatment and disposal of polyurethane wastes: options for recovery and recycling. Helsinki University of Technology. Report TKK-ENY-19. June 2004. (<http://users.abo.fi/rzevenho/tkk-eny-19.pdf> accessed July 2013).

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