European Commission

Joint Research Centre

The European Commission's in-house science service

www.jrc.ec.europa.eu

Serving society
Stimulating innovation
Supporting legislation

IE – Petten, The Netherlands
Institute for Energy

IRMM – Geel, Belgium
Institute for Reference Materials and Measurements

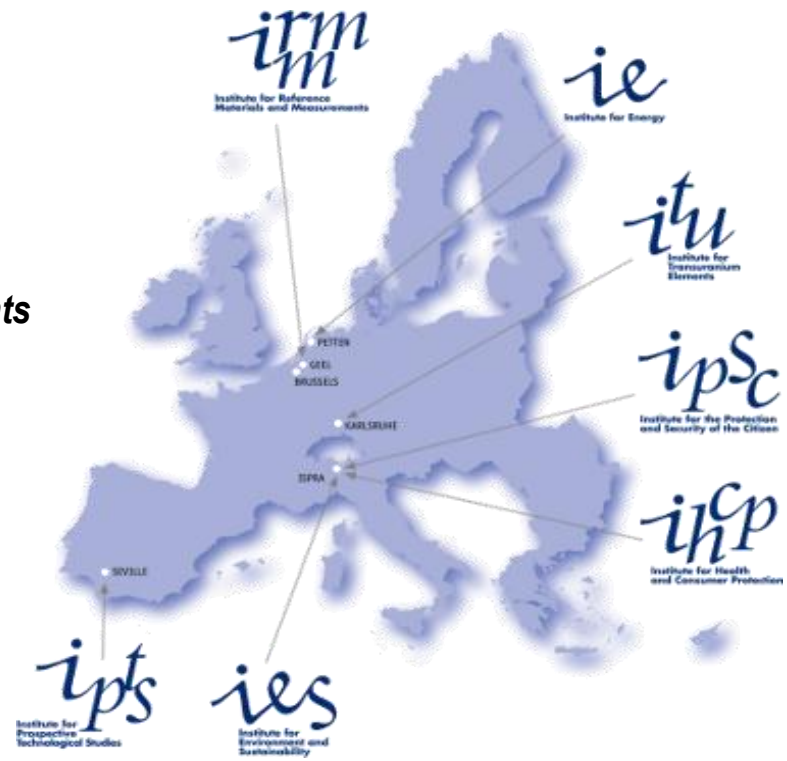
ITU – Karlsruhe, Germany
Institute for Transuranium Elements

IES/ IHCP/ IPSC – Ispra, Italy
Institute for Environment and Sustainability

Institute for Health and Consumer Protection

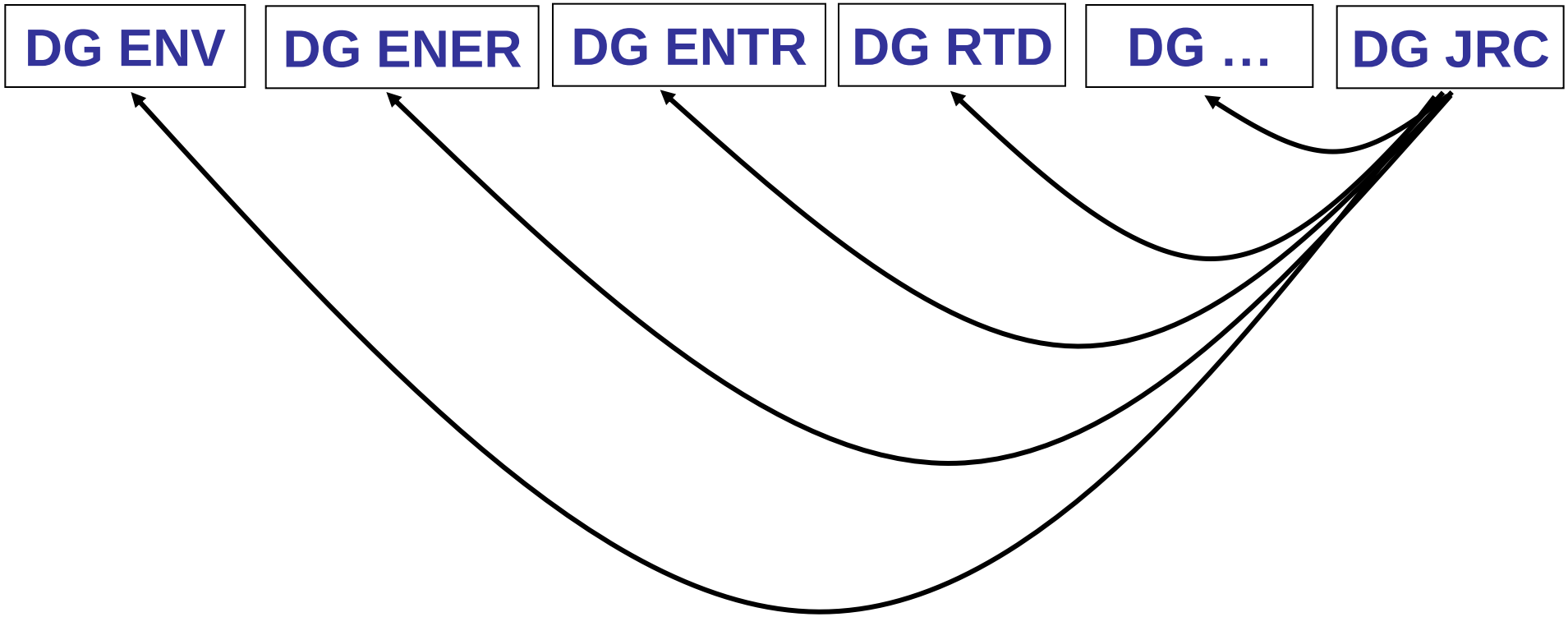
Institute for the Protection and Security of the Citizen

IPTS – Sevilla, Spain
Institute for Prospective Technological Studies



European Commission

Joint Research Centre in the context of the European Commission:



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Activities in support of Product Policy

IPTS supports the development and implementation of environmental product policies, amongst them the EU Ecolabel Regulation, the Green Public Procurement Communication, the Energy Related Products Directive and the Energy Labelling Directive.

This includes the techno-economic research as well as the operational management particularly of the stakeholder consultation.

Ecodesign for Commercial Refrigeration
ENER LOT 12

Hans Moons (JRC-IPTS)
Alejandro Villanueva (JRC-IPTS)
Oliver Wolf (JRC-IPTS)

Ewout Deurwaarder (DG Energy)

23 April 2013

Joint Research Centre

Introduction

Joint
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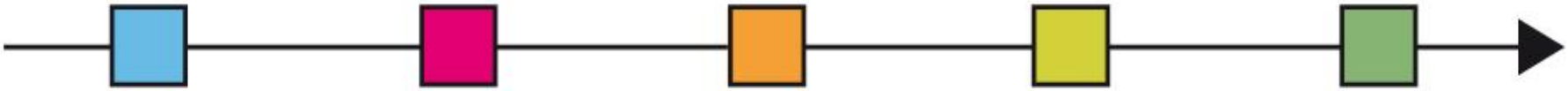
Ecodesign process



1. Product study completed

A study for each product group examines market data, technological status and other relevant issues.

When the study is completed, the Commission formulates a proposal (working document) taking the findings and recommendations of the study into account.

2. Consultation Forum and proposal

The proposal (working document) from the Commission is communicated to experts, stakeholders and Member States. These parties meet in the Eco-design Consultation Forum to discuss the proposal.

Based on the Consultation Forum and the impact assessments, the Commission formulates a draft regulation.

3. Draft regulation

When the Commission has formulated a draft regulation, it is submitted to the Eco-design Regulatory Committee, which is composed by one representative from each EU Member State.

4. Approved by Regulatory Committee

After the proposed regulation is adopted by a majority of the Regulatory Committee (the voting power of each Member State is weighted based largely on each state's population) it is sent to the European Parliament for scrutiny. It is also notified to the World Trade Organisation.

5. Final regulation

The regulation is formally adopted by the Commission and published in the Official Journal of the European Union (OJ) before it enters into force.

The most likely legal form of the implementation is "regulation", which means that it takes direct legal effect in all Member States.

Where we come from…

- BIO IS study 2007, Wuppertal Impact Assessment 2010
- Desk research
- Questionnaire (+ follow-up phone calls)
- Plant visits:
  - Efficold: beverage coolers
  - Bonnet-Névé: remote display cabinets
  - Koxka: remote and plug-in display cabinets
  - Coca-Cola: beverage coolers and vending machines
  - Jofemar: vending machines
  - Recilec: end-of-life treatment, recycling
  - Cemafroid: Test labs, expert in cold and refrigeration
- Back2back meetings:
  - Eurovent association
  - European Vending Association
- Background document

Where are we going to…

- Collect feedback (24 May 2013)
- Possible second questionnaire
- Next Technical Working Group meeting: end 2013
- Final technical report

Timing	2012		2013												2014	
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Steps and content																
Revision/udate preparatory work																
Establishment of TWG																
1st stakeholder meeting (kick-off)																
Collection/submission of TWG info																
First draft report preparation																
Second stakeholder meeting																
TWG comments																
Deliverables																
Website																
Revised/updated preparatory study																
First draft report																
Final technical report																

Introduction

Aim of today's meeting:

- Present status of knowledge
- Discuss openly
- Identify datagaps and where to find this data

How?

- Refresh info in background document (questions, comments)
- Discuss key issues
- Task-by-task, followed by wrap-up

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Scope and definitions

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Definition

A commercial refrigerated cabinet is a

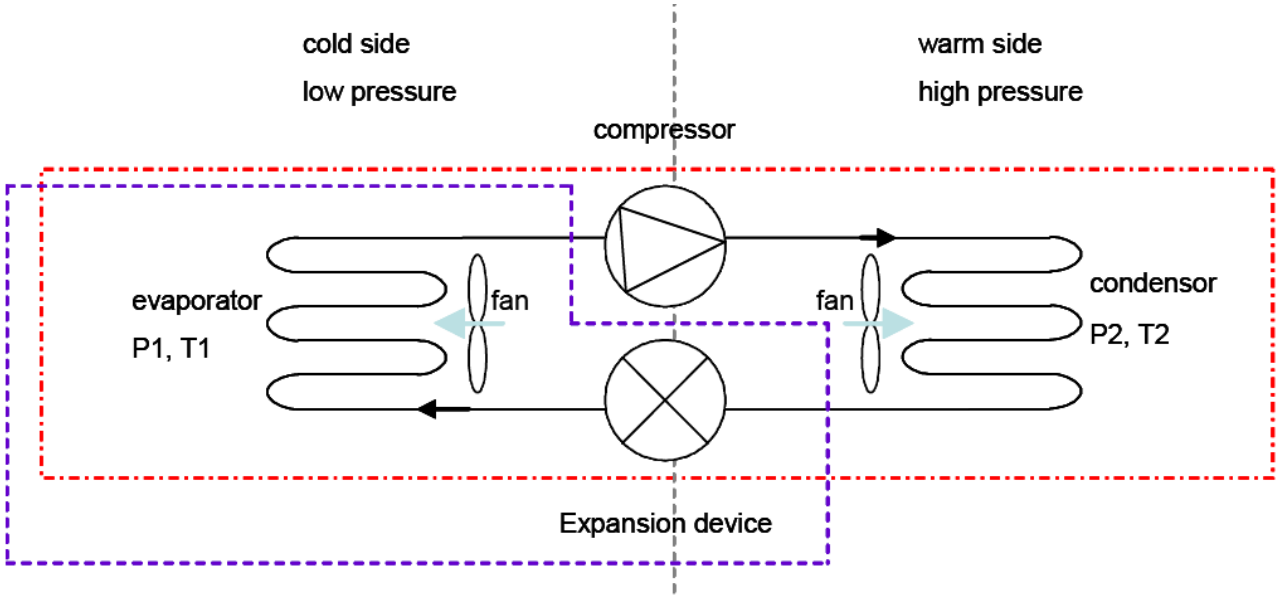
- refrigerated appliance
- intended for the storage and display for merchandising
- at specified temperatures below the ambient temperature, of chilled and/or frozen products[1]
- accessible directly through open sides or via one or more doors, and/or drawers
- designed for the use by commercial, institutional or industrial facilities

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

Scope and definition

- Plug-in display cabinets

- Remote display cabinets: remote cooling system (compressor and condensor) is NOT taken into account



Scope and definition

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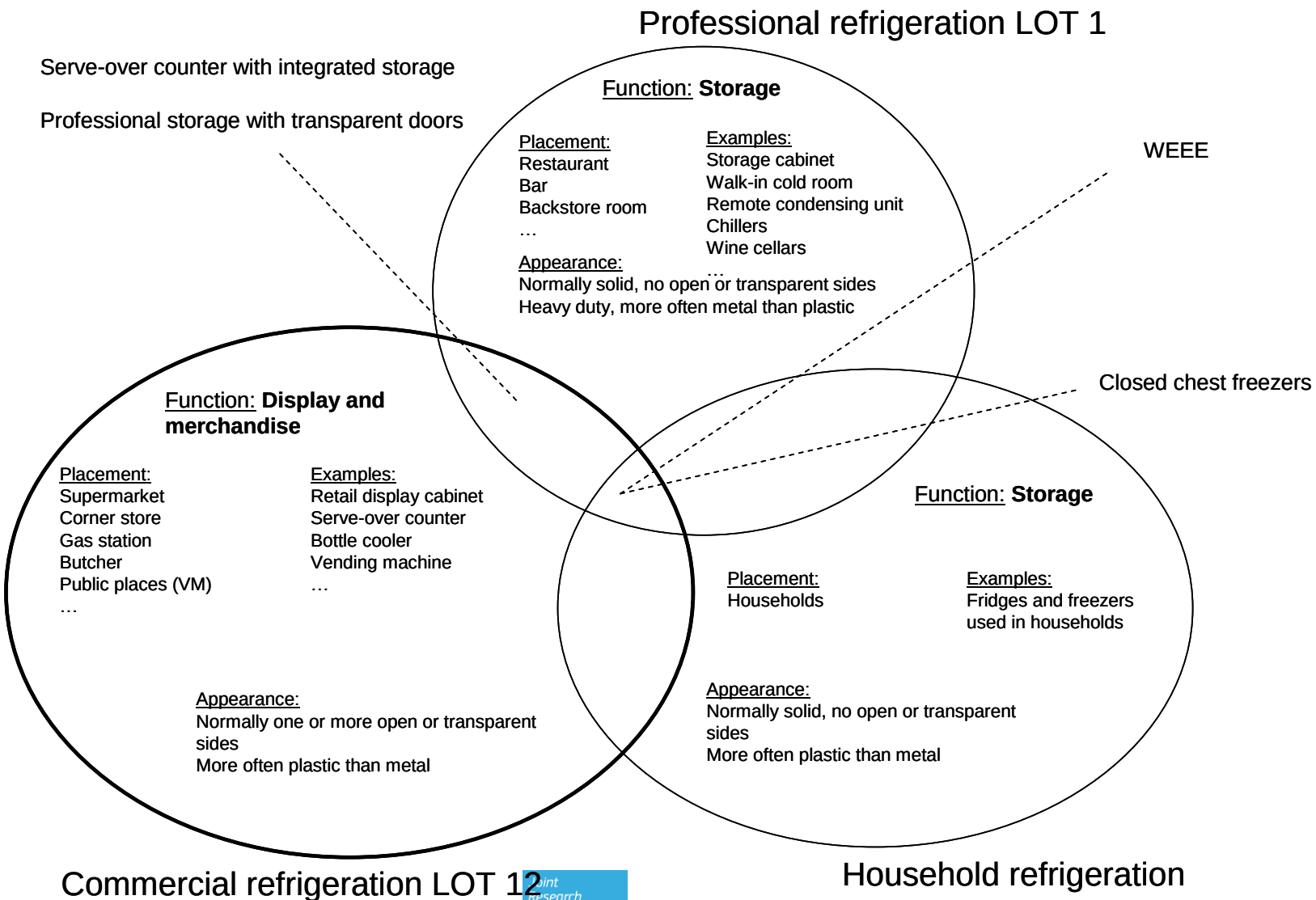
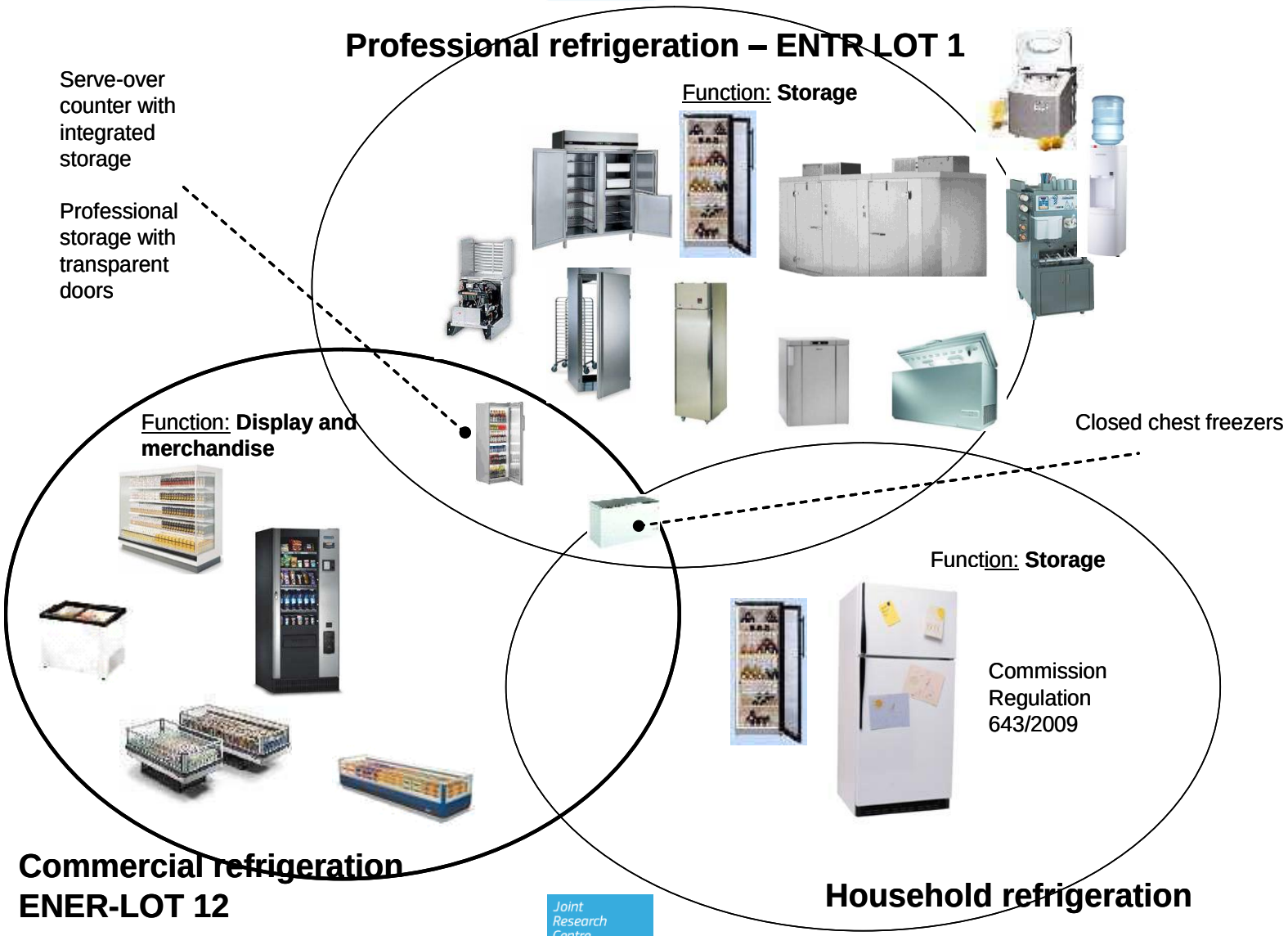
Scope


Professional refrigeration LOT 1
Serve-over counter with integrated storage
Professional storage with transparent doors
Function: Storage
Placement:
Restaurant
Bar
Backstore room
…
Examples:
Storage cabinet
Walk-in cold room
Remote condensing unit
Chillers
Wine cellars
…
Appearance:
Normally solid, no open or transparent sides
Heavy duty, more often metal than plastic
WEEE
Closed chest freezers
Function: Display and merchandise
Placement:
Supermarket
Corner store
Gas station
Butcher
Public places (VM)
…
Examples:
Retail display cabinet
Serve-over counter
Bottle cooler
Vending machine
…
Appearance:
Normally one or more open or transparent sides
More often plastic than metal
Function: Storage
Placement:
Households
Examples:
Fridges and freezers used in households
Appearance:
Normally solid, no open or transparent sides
More often plastic than metal
Commercial refrigeration LOT 12
Household refrigeration

Scope


Professional refrigeration – ENTR LOT 1
Function: Storage
Serve-over counter with integrated storage
Professional storage with transparent doors
Function: Display and merchandise
Closed chest freezers
Function: Storage
Commission Regulation 643/2009
Commercial refrigeration ENER-LOT 12
Household refrigeration

Excluded?

- closed chest freezers used for commercial purposes using product images
- minibars
- wine cellars
- 'production' devices such as ice-cream makers, ice-makers, chilled water dispensers
- gelato display cabinets

Questions

- Do you agree with the definition of commercial refrigeration proposed above?

- Are there any additional definitions that you find necessary?

- Do you agree with the scope proposed above? Are there any appliances that in your view should be included/excluded?

Standards and legislation

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Relevant EU legislation related to commercial refrigeration

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

Legislation

- F-gas regulation, update
- Safety regulations, ATEX and Pressure Equipment Directive
- End-of-Life, WEEE, Waste Shipment Regulation

Relevant standards for Lot 12 products

TYPE	STANDARD
International Standards	
Safety	ISO 5149:1993(2004): Mechanical refrigerating systems used for cooling and heating − safety requirements
	IEC 60335:2012 part 2-75: Household and similar electrical appliances − safety −: Particular requirements for commercial dispensing appliances and vending machines − part 2-89: particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor
Energy use	ISO 23953-2:2005/Amd 1:2012 refrigerated display cabinet − part 2: classification, requirements and test conditions
European Standards	
Safety	EN378 1:2008+A2:2012: Refrigerating systems and heat pumps – Safety and environmental requirements

Standards

Energy consumption

- ISO 23953, update
- EVA-EMP
- ASHRAE 32.1

Safety measures

- IEC 60335
- EN 378
- ISO 5149

Questions (safety)

- CO_2 and high pressure. Is there hard evidence that the high pressure can be a real safety concern? What is the exact (if any) legislative barrier for the use of CO_2 at high pressure?

- Hydrocarbons and flammability
  - 150g refrigerant charge limit. Only small-sized plug-ins feasible? Technical improvements to use HC for bigger plug-in appliances?
  - vending machines. Is it possible to separate product area from refrigerant area? How do others imply safe HC use in vending machines?

- Link between ATEX and standards. Is the 150g limit a guideline or legislation?

- Which standard/legislation limit the introduction of alternative refrigerants?

- Where could standards be changed? Are you aware of any change coming up?

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Questions (energy)

- Which products in the scope are not covered by ISO 23953 to measure energy consumption?

- Are presence detectors and other energy-saving options covered in the ISO 23953 standard, in EVA-EMP?

- Is testing the energy consumption at climate class 3 (25°C, 60%RH) appropriate?

- Could we also use ASHRAE 32.1 for vending machines (if EVA-EMP is not fully consolidated)?

Markets

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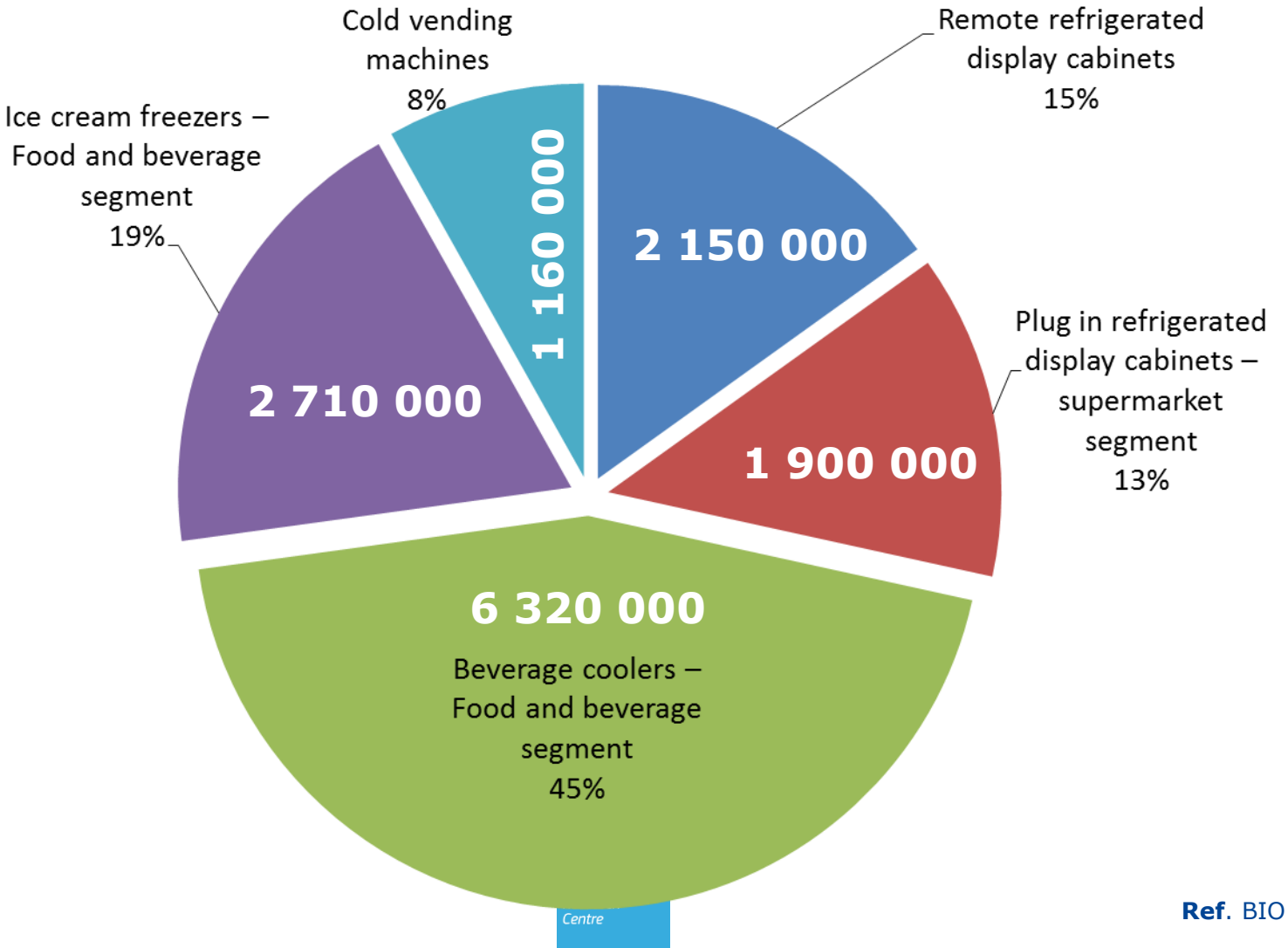
PRODCOM classifications used in Eurostat

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]

Breakdown level is not detailed enough

Detailed market data is necessary for the Impact Assessment

Stock estimates from industry



Ref. BIO IS, 2007

Remote display cabinets

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

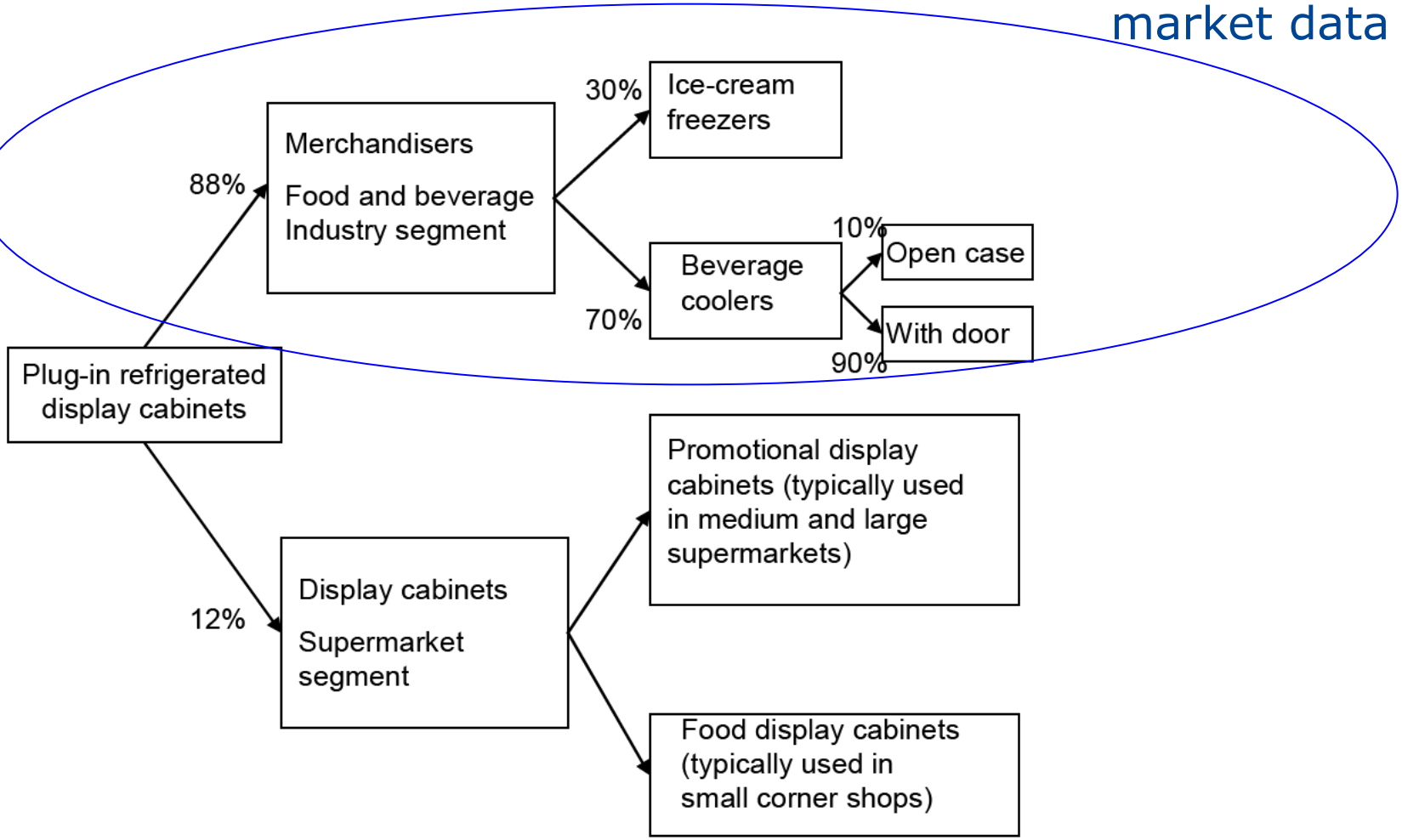
Ref. BIO IS, 2007. Eurovent Association

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

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

Plug-in display cabinets

no updated market data yet



Ref. BIO IS, 2007

Plug-in display cabinets supermarket segment

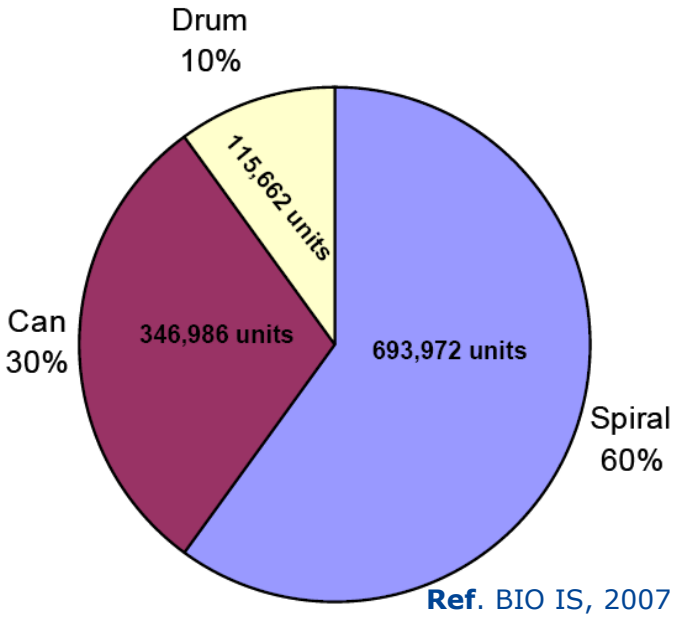
	Total sales units
2004	144 000
2005	154 000
2006	165 000
2007	176 500
2008	189 000
2009	202 000
2010	216 000

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

Product category	Eurovent classification	price	% of product category
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%

Ref. BIO IS, 2007. Eurovent Association

Vending machines



Ref. BIO IS, 2007

	Total machines, stock	
	2010	**2011**
Total market vending machines	3 786 572	3 778 026
Cold machines		693 986 (18%)
Snack machines		799 982 (21%)

Ref. European Vending Association

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

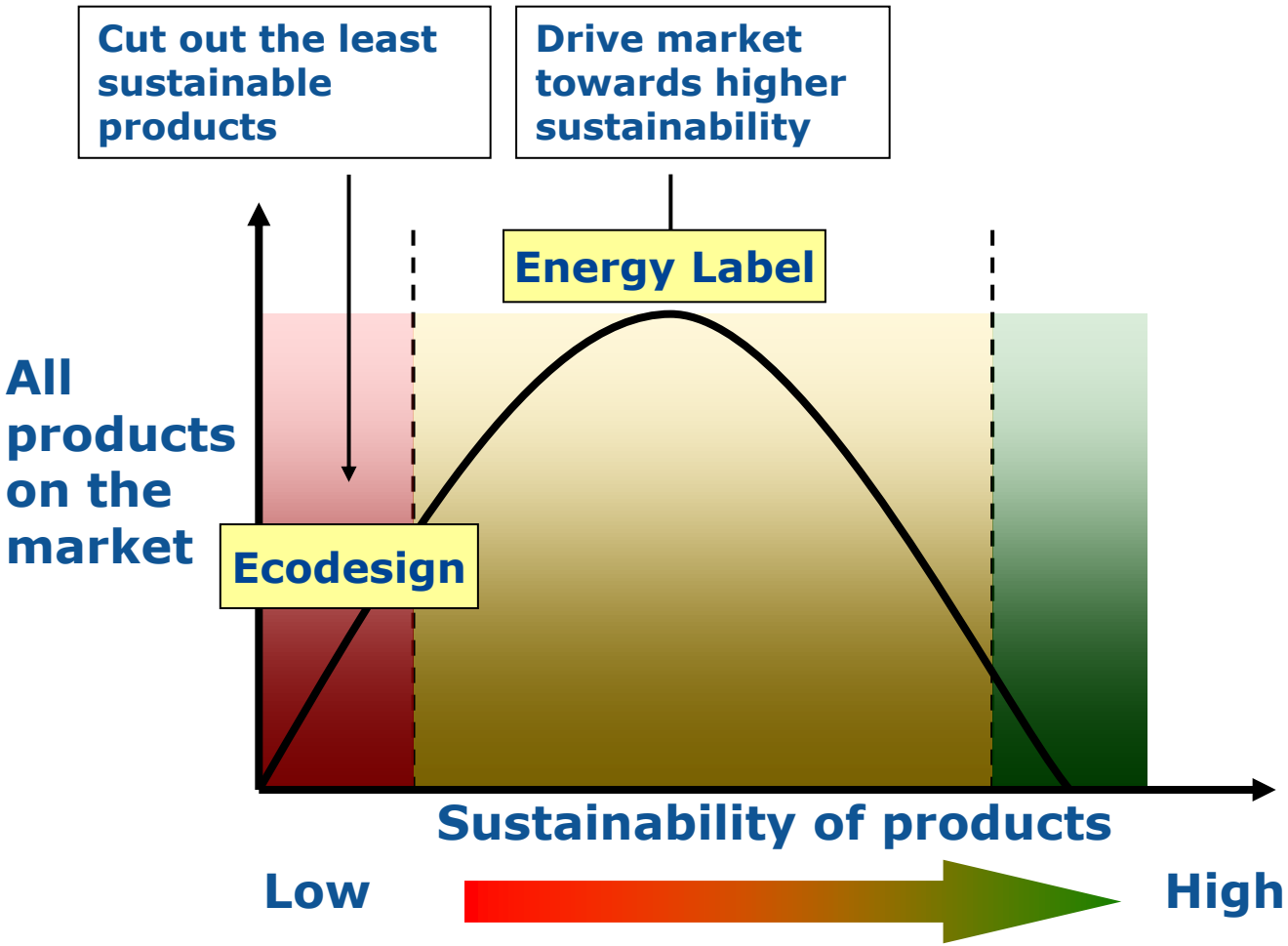
Ref. UK Market Transformation Programme, 2009

Questions

- Up-to-date market data (2006-2012)
  - remote cabinets
  - all plug-ins (supermarket, bottle coolers, ice-cream freezers , vending machines)
  - historical data 2005-2009 for vending machines
- Stocks and/or annual sales of the refrigerants used in the different main cabinet types
- Market share refrigerant used per cabinet group
- Future sales and stock figures, market forecast, guiding concepts

Technologies – Environment – Design

Energy


Cut out the least sustainable products
Drive market towards higher sustainability
Energy Label
All products on the market
Ecodesign
Sustainability of products
Low
High

Energy consumption

Define energy consumption

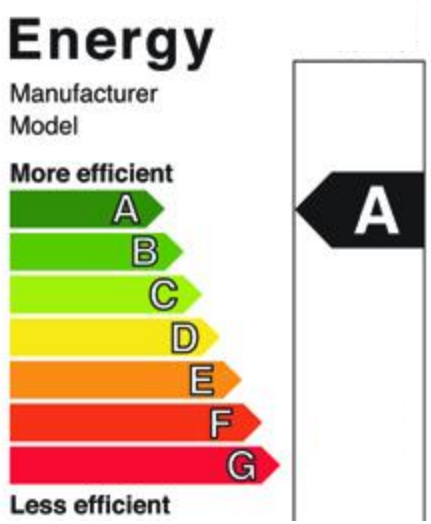
Discard the worst performing products from the EU market

Energy Efficiency Index (EEI)

EEI = (energy consumption / reference)

Measured, standard

To be defined



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Proposal

Wuppertal Institute (2010)

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

- Open

  $SEC = TEC / \text{Total Display Area}$

  $RSEC = [5.6 + VERT + L + 16 (T_a - T_{mc}) / T_{mc}]$

- Closed

  $SEC = TEC / \text{net volume of the appliance}$

  $RSEC = 1.8 \times [5.6 + VERT + L + 16 (T_a - T_{mc}) / T_{mc}]$

- Vending

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

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

Based on data from: Eurovent Certification program 2008, European Procool project, directly from manufacturers, EVA and Eurovent association

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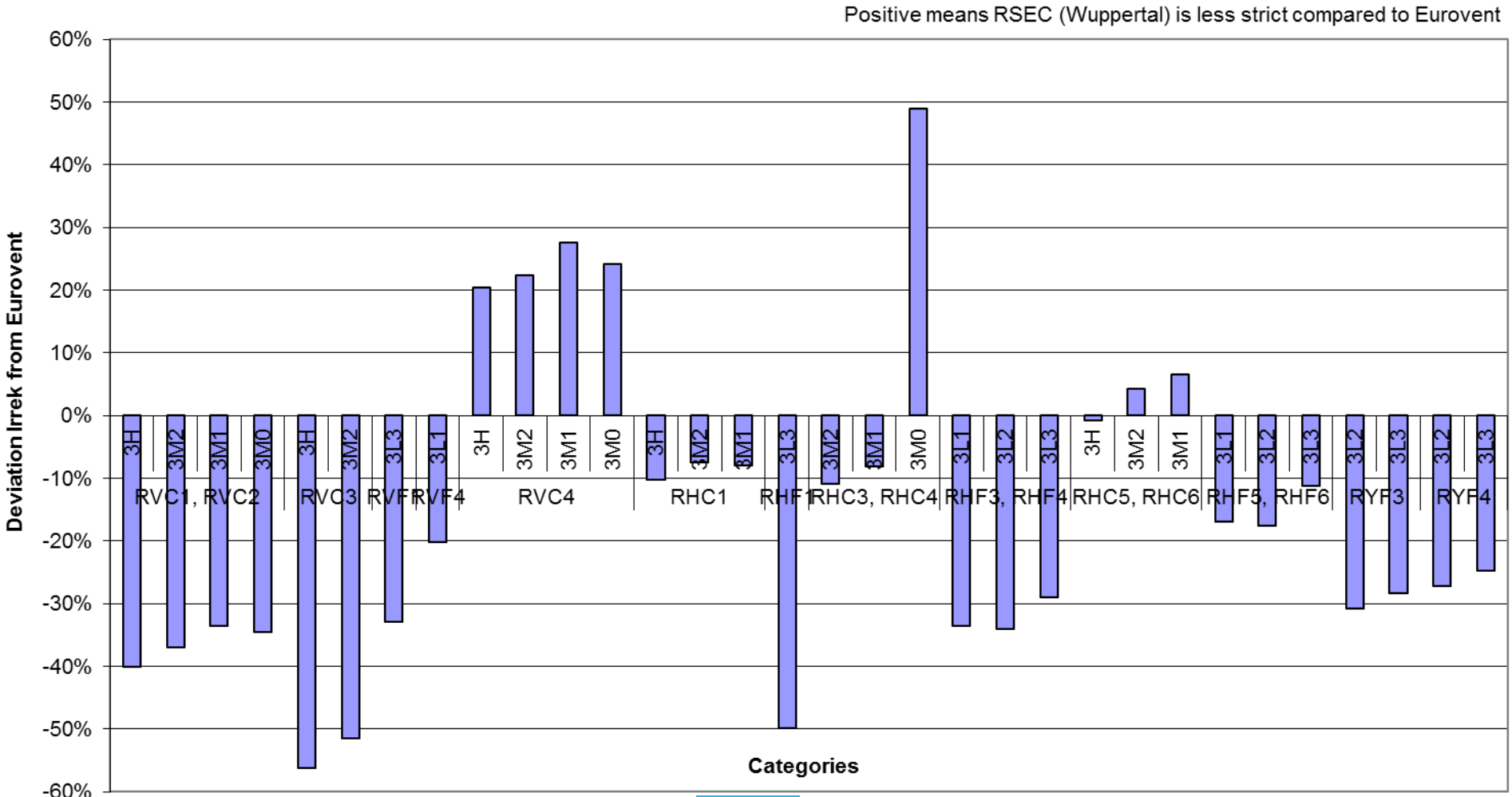
Ref. Impact Assessment, Wuppertal Institute, 2010

European Commission

Eurovent - Wuppertal
remote cabinets



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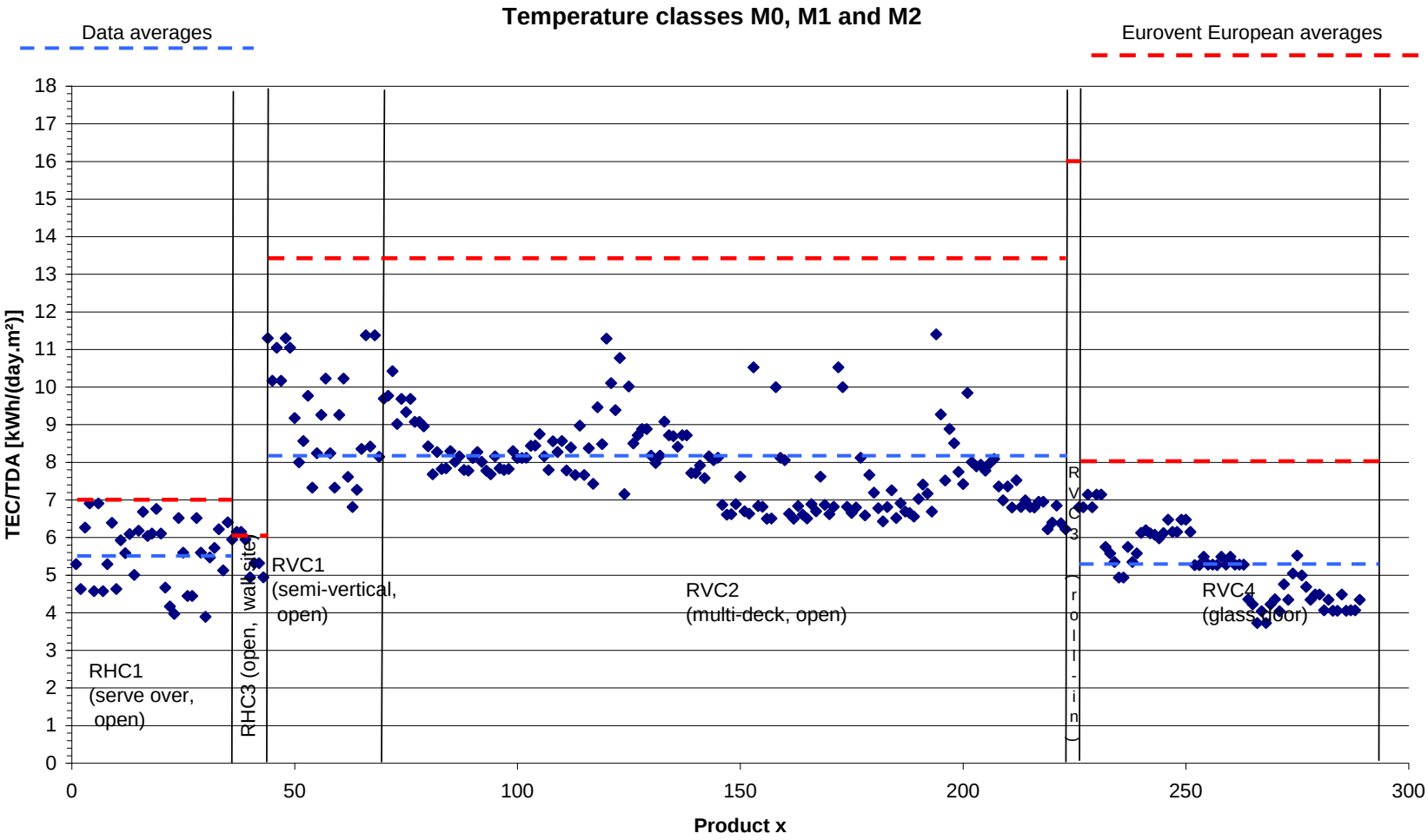
Ref. Eurovent Association and EPEE, Joint Industry Expert Group

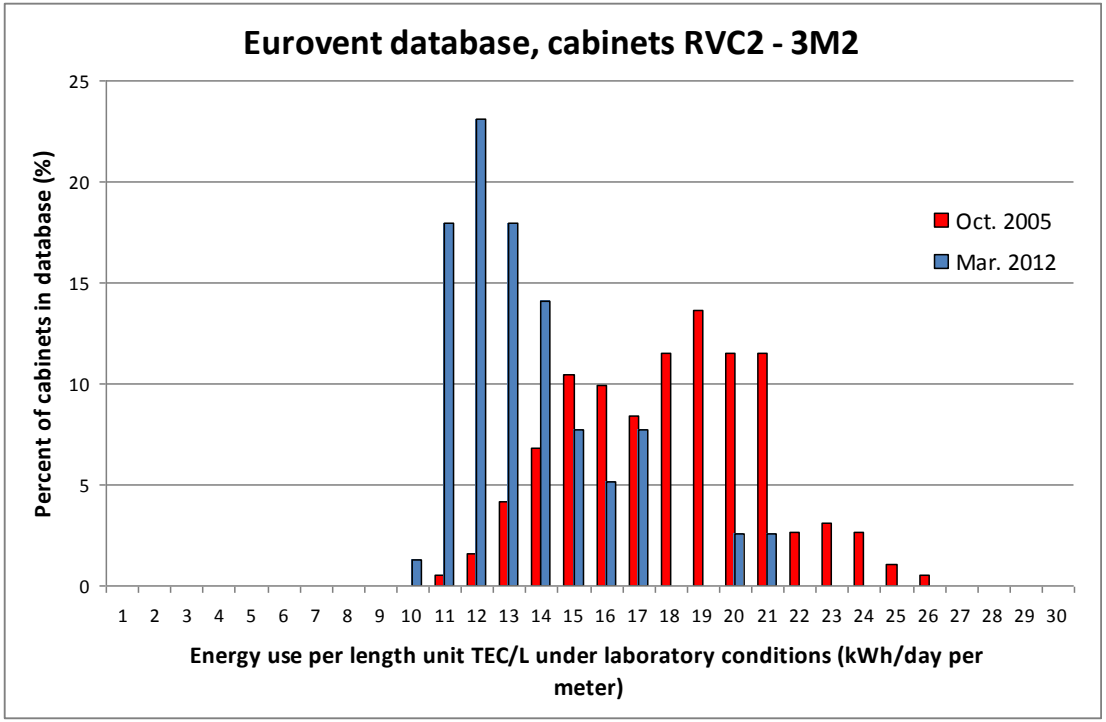
Remote cabinet data

Current Eurovent Certification Program database



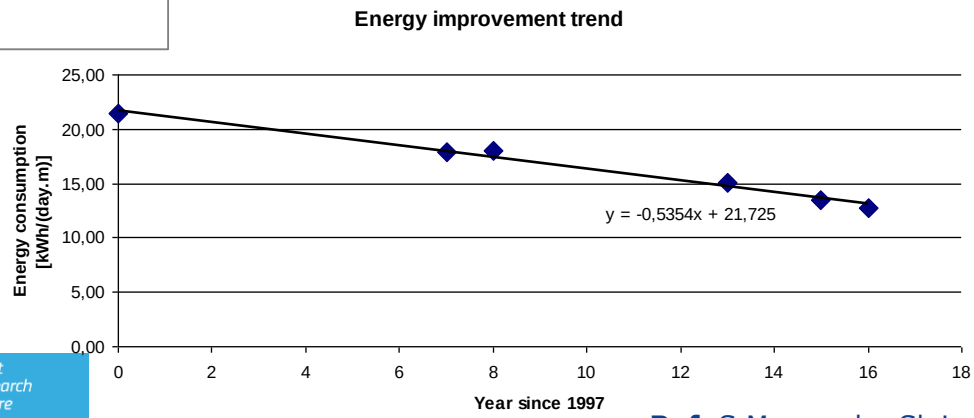
Historical trend

Remote cabinet



Significant reduction in energy consumption

RVC2, M2	kWh/(day.m²)
Eurovent data average	7,6
myCalc 2020 (conservative)	7,2
Current best Eurovent data	6,2
BAT 2016 (from IA 2010)	6,6
Eurovent average proposed	12,3



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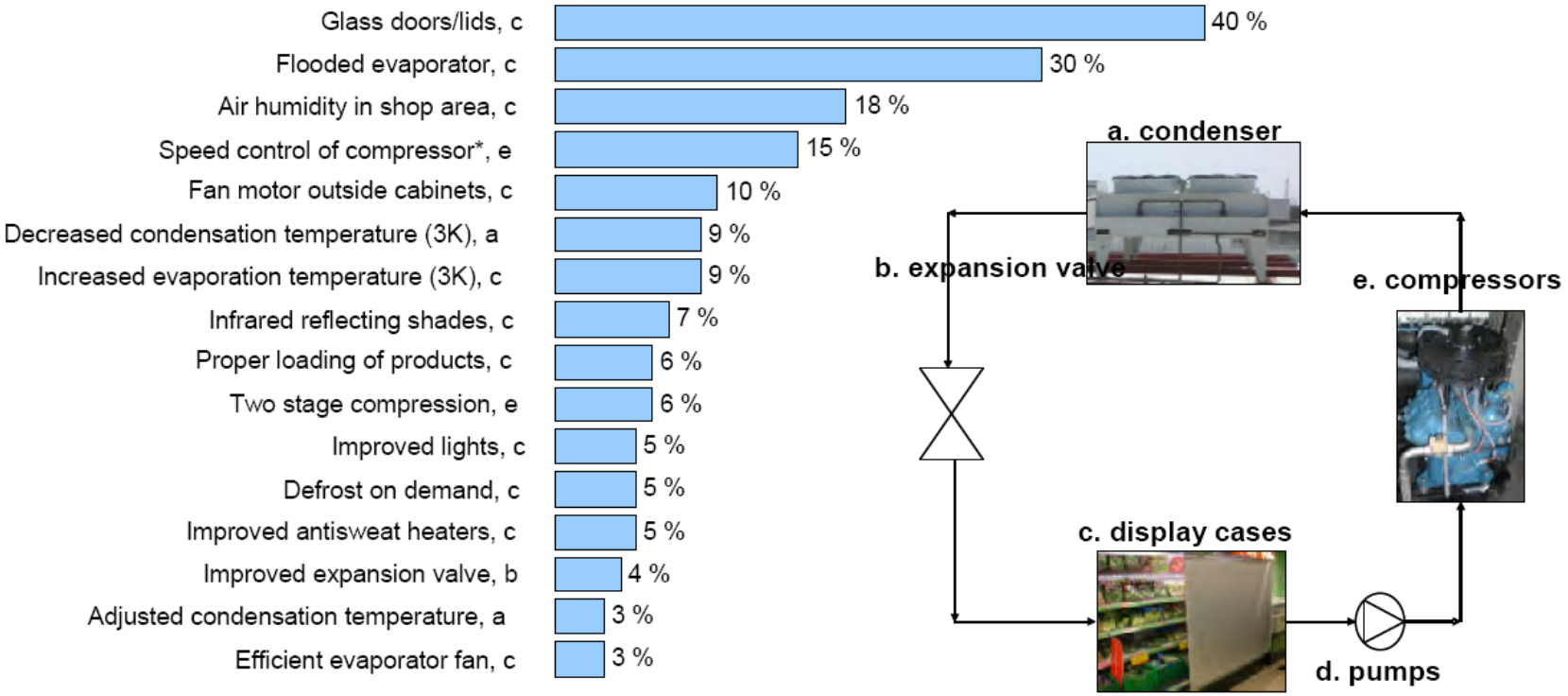
Ref. S.M. van der Sluis

Improvement options
display cabinets



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

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Ref. Pilot reference document on Best Environmental Management Practice in the Retail Trade Sector

Plug-in cabinet data

Plug-ins vs. remote, energy consumption

Remotes: TEC = REC + DEC

TEC = Total Energy Consumption
REC = Refrigeration Electrical energy Consumption
DEC = Direct Electrical energy Consumption (*e.g.* lighting, fans)

Plug-in: TEC = DEC = (REC + DEC)

DEC = direct (including refrigeration, so REC is included)

Only measured differently!

Plug-in cabinet data

Table 10-2: Performance thresholds for integral cabinets

temperature class	performance threshold
L1	(TEC)/(TDA)≤19.10 kWh/day/m^2
M0	(TEC)/(TDA) ≤14.70 kWh/day/m^2
M2	(TEC)/(TDA) ≤12.70 kWh/day/m^2
H2	(TEC)/(TDA) ≤9.2 kWh/day/m^2

Table 10-3: Performance thresholds for remote cabinets

temperature class	performance threshold
L1	(TEC) / (TDA) ≤23.50 kWh/day/m^2
L3	(TEC) / (TDA) ≤21.00 kWh/day/m^2
M0	(TEC) / (TDA) ≤11.75 kWh/day/m^2
M1	(TEC) / (TDA) ≤11.75 kWh/day/m^2
M2	(TEC) / (TDA) ≤10.85 kWh/day/m^2
H1	(TEC) / (TDA) ≤8.00 kWh/day/m^2
H2	(TEC) / (TDA) ≤9.20 kWh/day/m^2

Ref. ECA Technology criteria list (2006)

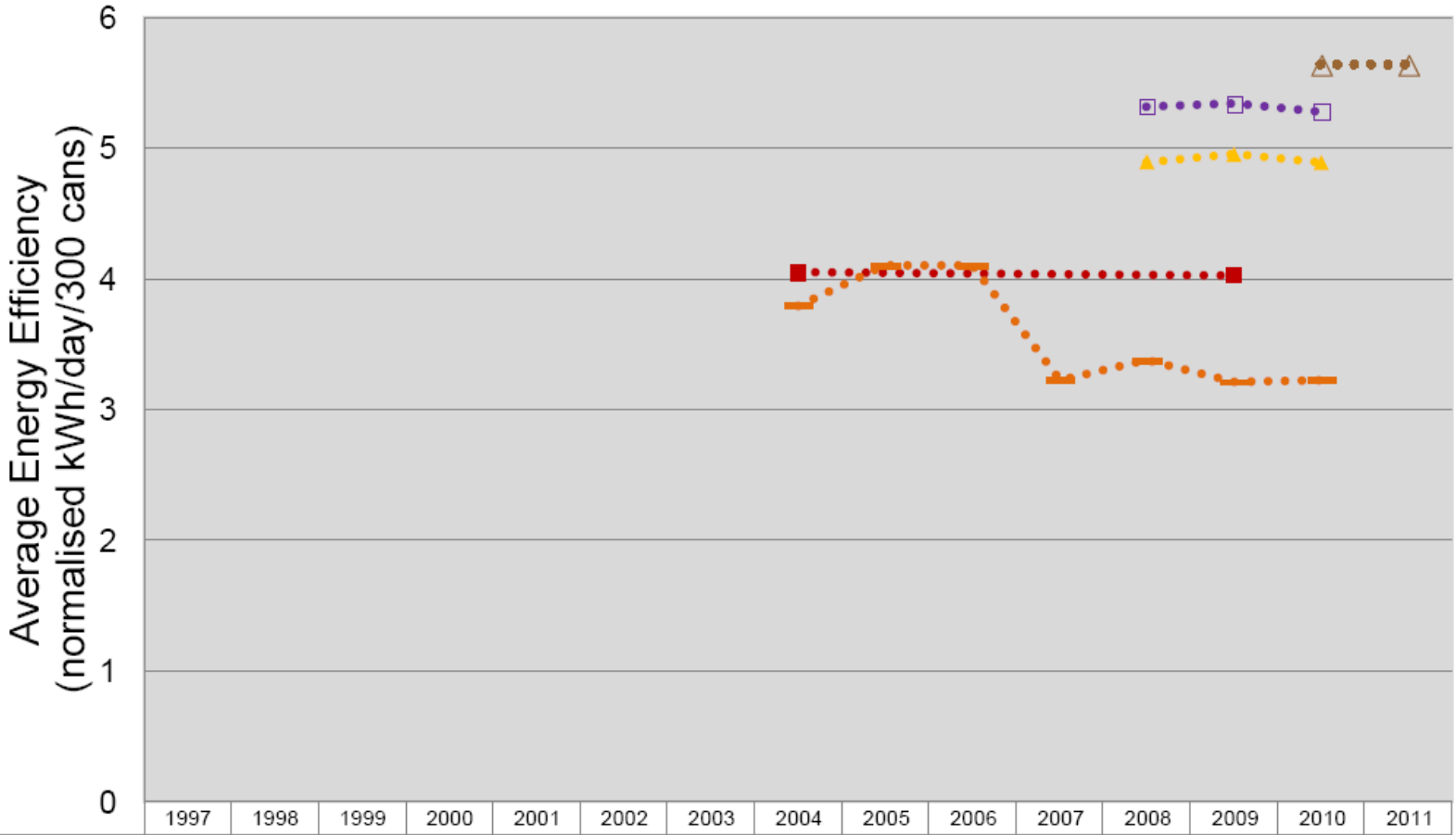
Vending machine data

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

Compare with other world regions, cfr. IEA 4E benchmarking study

Ref. Market Transformation Programme, BNCR VM0X: Cold Vending Machines
Government Standards Evidence Base 2009, Defra, UK

Vending machine



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Australia								4.04					4.02		
Canada												4.89	4.95	4.89	
USA CEC												5.32	5.33	5.28	
EU														5.63	5.63
USA ENERGY STAR								3.79	4.10	4.10	3.22	3.37	3.21	3.22	

Ref. Benchmarking report for refrigerated vending machines, IEA-4E, 2012

Improvement options
vending machines

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%

Ref. Market Transformation Programme, BNCR VM0X: Cold Vending Machines Government Standards Evidence Base 2009, Defra, UK

Questions

- What is your opinion on the energy efficiency index formula proposed by the Wuppertal Institute? Does such a formula cover all appliances defined in the scope, including ice-cream freezers, bottle coolers, etc.? Energy per volume, per Total Display Area, other?

- How could it be improved? Your proposal for MEPS? Implementing measure (one formula-fits-all, clustering of different cabinet types; per cabinet type, temperature class, other)?

Questions

- Please indicate which energy-saving measures are now standard compared to *e.g.* 10 years ago.

- Shall any generic recommendations be compulsory? Why (not)? (*e.g.* doors, LED, …)

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

- What is the 'low-hanging fruit'? What is the remaining room for improvement? How much energy can be saved extra at which cost?

- Which of the technological improvement options are a responsibility and choice of the manufacturer, and which are in the hands of the retailers and consumers?

Questions

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

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

- Manufacturers frequently argue lack of motivation of retailers for energy efficiency: is this still the case or is it changing?

Questions

- Most appliances use forced air convection for cooling. Which are the exceptions? Chest freezers? Any other chilling/freezing equipment? Is the reason for this that passive convection does not deliver sufficient chilling capacity?

- Are passive systems more/less efficient than the forced convection systems?

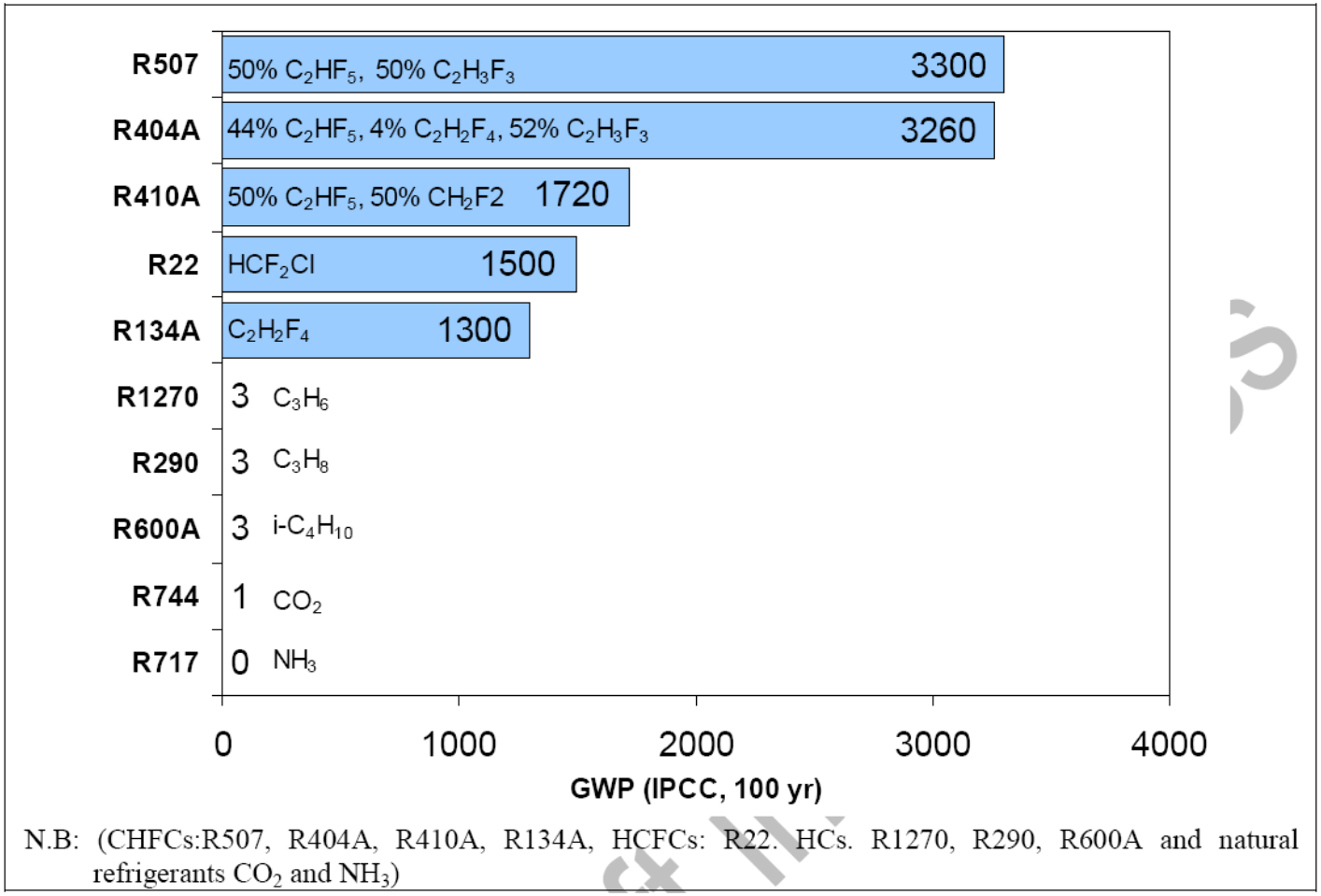
Questions

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

Technologies – Environment – Design

Refrigerants

Main concern, GWP

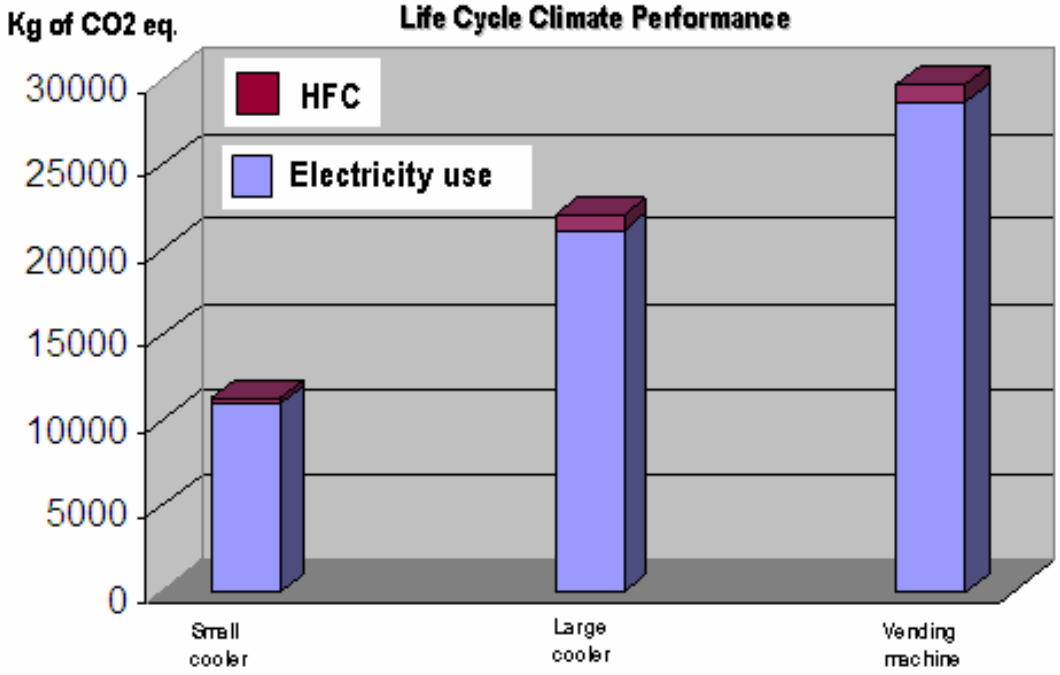


N.B: (CHFCs:R507, R404A, R410A, R134A, HCFCs: R22. HCs. R1270, R290, R600A and natural refrigerants CO_2 and NH_3)

Energy efficiency

Ref. Pilot reference document on Best Environmental Management Practice in the Retail Trade Sector

Refrigerants



Other refrigerants can have lower GWP AND better energy efficiency

Joint Research Centre

Ref. BIO IS, 2007

Pros & cons alternatives

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

Ref. BIO IS, 2007

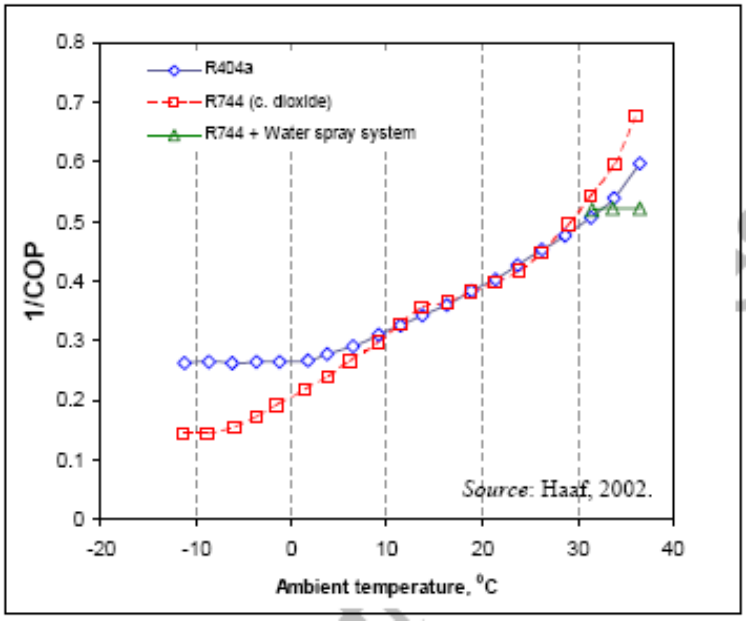
Refrigerants

Refrigerant	Drawbacks	Application
CO_2	Less efficient than HFCs at high ambient temperatures High pressures in the system High capital cost due to low mass production compressors	Remotes: used in several supermarkets Plug-ins: used in small quantity Vending machines: used in small quantity
Ammonia	Toxicity, leakages not permitted Flammability Limited charge permitted (150g)	Remotes: only usable in indirect systems Plug-ins: not suitable Vending machines: not suitable
Propane, propene	Flammability Limited charge permitted (150g-2.5kg) High installation cost in supermarkets?	Remotes: only usable in indirect systems Plug-ins: already used Vending machines: already used
Isobutane		
Unsaturated HFCs	New developments; properties and applications can differ for different products, benefits and drawbacks have to be studied	

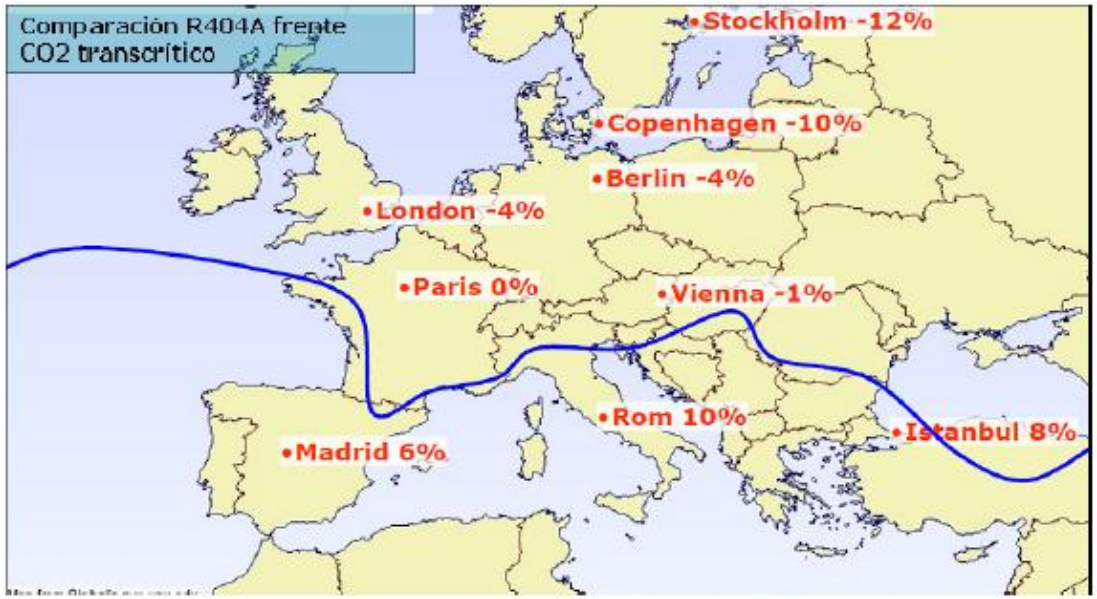
European Commission

CO_2 at high ambient temperature

Energy consumption of direct evaporation systems



Ref. Pilot reference document on Best Environmental Management Practice in the Retail Trade Sector



Ref. Danfoss S.A.

European Commission

Questions

- Efficiency comparison of refrigerants for the same cabinet type? Data available?

- More information about unsaturated HFCs (HFOs). Options, properties, drawbacks, applications, availability, cost, etc.

- Flammability/safety issues for hydrocarbons and CO_2. How to be solved (technically/legislation/standard)?

- How to solve CO_2 efficiency at ambient temperature >32°C? And the standard energy consumption measurement, climate class 3?

- CO_2 component availability? OK? If not, when expected?

- Bonus-malus system relating to the GWP of the refrigerant?

Joint Research Centre
Institute for Environment and Sustainability

"1st Technical Working Group Meeting on Ecodesign for Commercial Refrigeration "

End-of-Life analysis of Commercial refrigerators: hot-spots and potential requirements

F. Ardente, M. Calero, F. Mathieux

http://lct.jrc.ec.europa.eu/

Seville – 23rd April 2013

Outlines:

- Objective of the End-of-Life analysis.
- Description of the method for the assessment of the EoL and its application to commercial refrigerators.
- Analysis of End-of-Life scenarios and product's hot-spots for commercial refrigerators.
- Analysis of potential ecodesign requirements.
- Questions / Discussion.

Objective the analysis:

To investigate the End-of-Life (EoL) of commercial refrigerators and to explore the potential for Ecodesign measures for this phase.

Relevant EU legislation is the WEEE Directive (2012/19/UE): from 15 August 2018 all refrigeration appliances will be under the scope of WEEE. Until then, Member States have freedom of interpretation of the extents of the Directive (vending machines and household appliances are included).

The analysis has been based on a simplified 'Resource Efficiency Assessment of products - **REAPro' method** (JRC-IES and DG ENV).

The full description of the method, including applications to other case-studies (TV and washing machines), is provided in:

http://lct.jrc.ec.europa.eu/assessment/assessment/projects#d

Method:

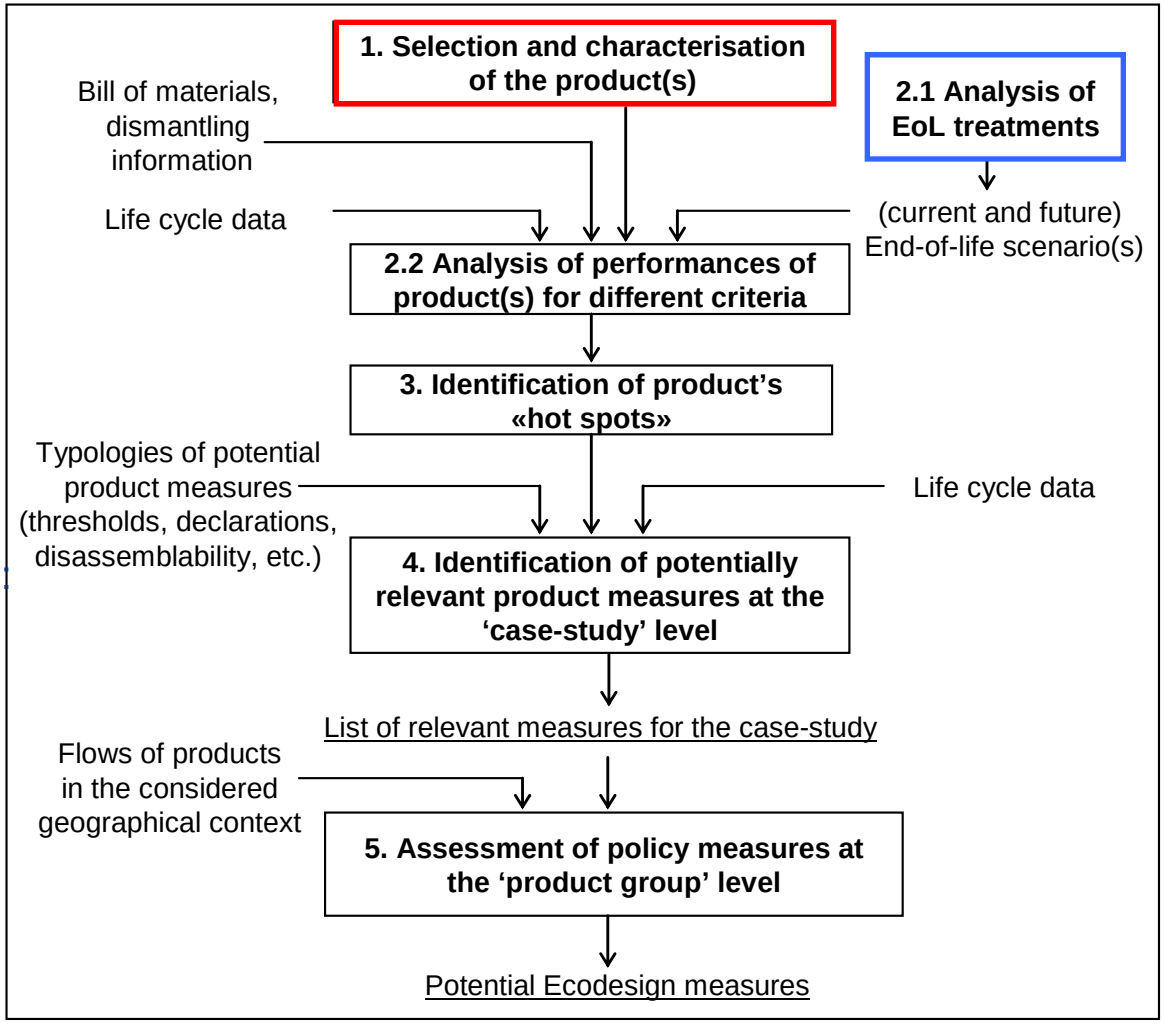
Method is composed by 5 steps:

Step 1. Characterization of the product(s):

- Analysis of materials & components
- Disassembly information (e.g. measurements of time for extraction of some components).
- Life cycle data.

Step 2.1 Analysis of EoL treatments:

- Visits to *various plants* for a representative overview of EoL treatments (e.g. dismantling / shredding based).
- Analysis of potential *risks/problems* based on observations and/or comments from recyclers (e.g. risks related to contaminations by hazardous substances).



Method:

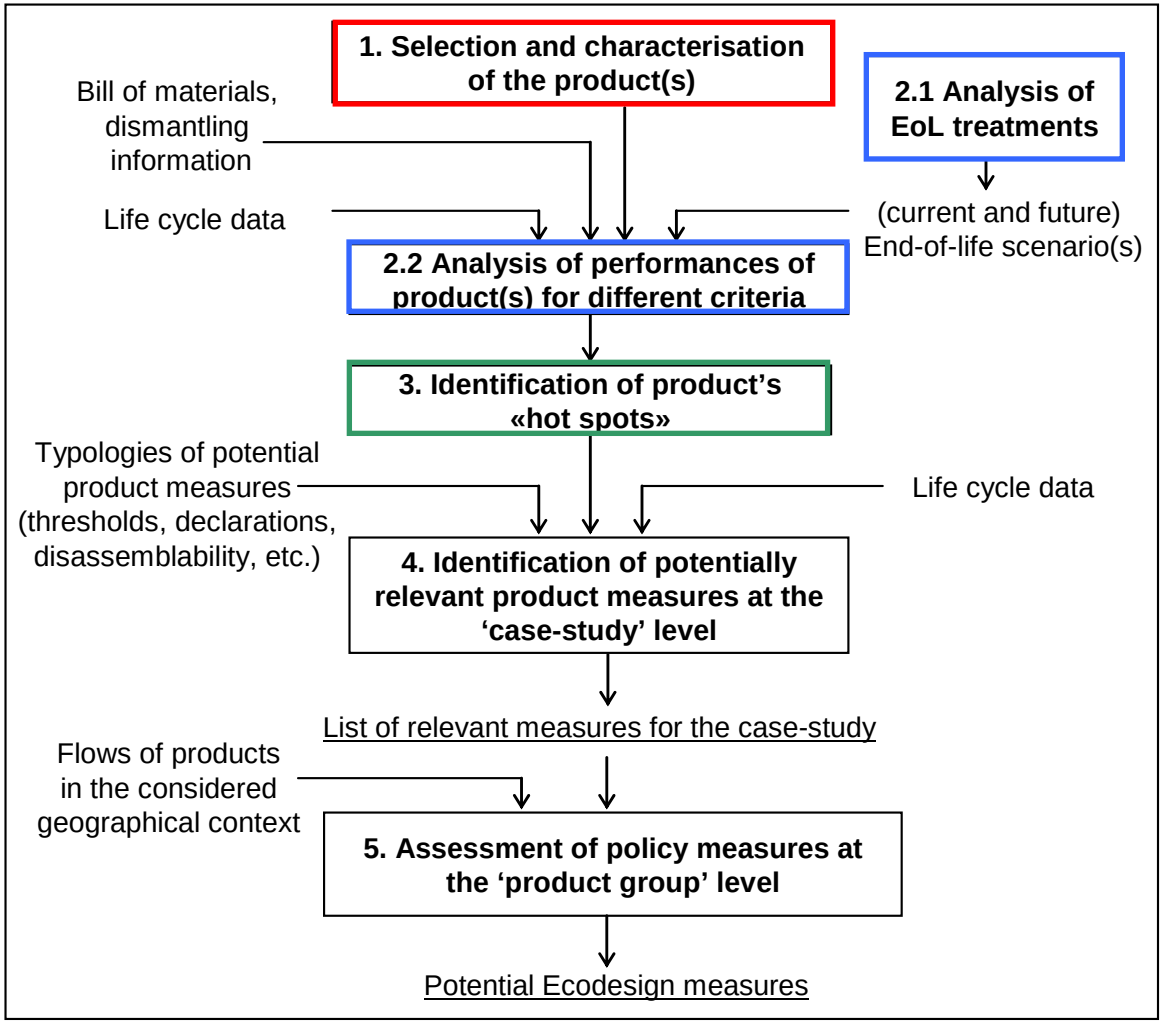
Method is composed by 5 steps:

Step 2.2 Analysis of product against a set of criteria:

- Cross comparison of literature review with on-site observations (e.g. precious metals in some electronics).
- Identification of better performing products (benchmark) (e.g. products with more recyclable plastics).

Step 3. Identification of 'hot spots': "components relevant at the EoL for some criteria"

- What components are currently landfilled / incinerated
- What components are responsible of relevant life cycle impacts for some categories
- How different treatments for some components can affect the quality / quantity of recyclable fractions?



Method:

Method is composed by 5 steps:

Identification of potential product's measures to improve product's EoL performances.

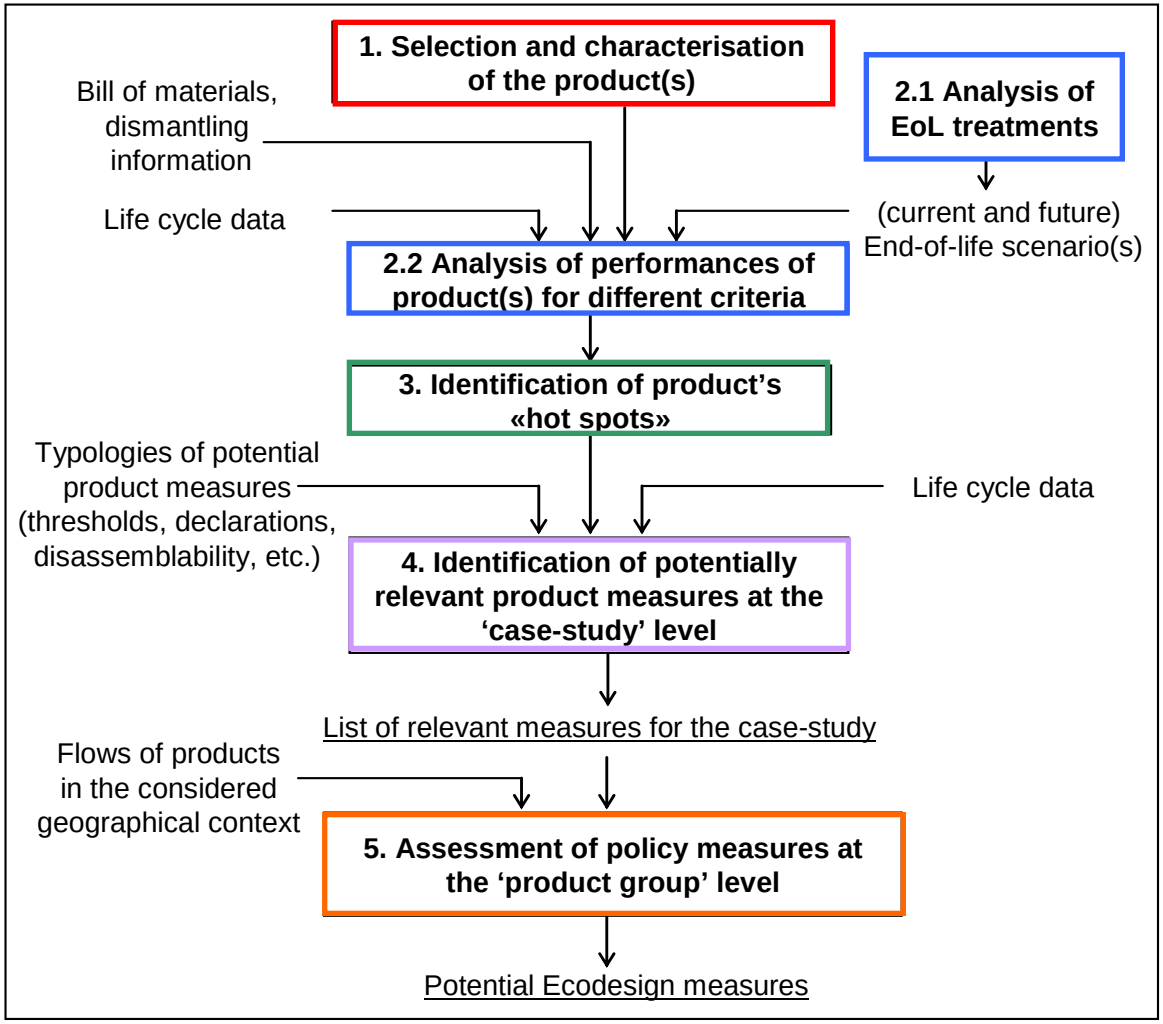
Step 4. at *case-study product* level

Step 5. at *product group* level

Identify/assess potential measures:

- from literature

- from stakeholders



Application to commercial refrigerators:

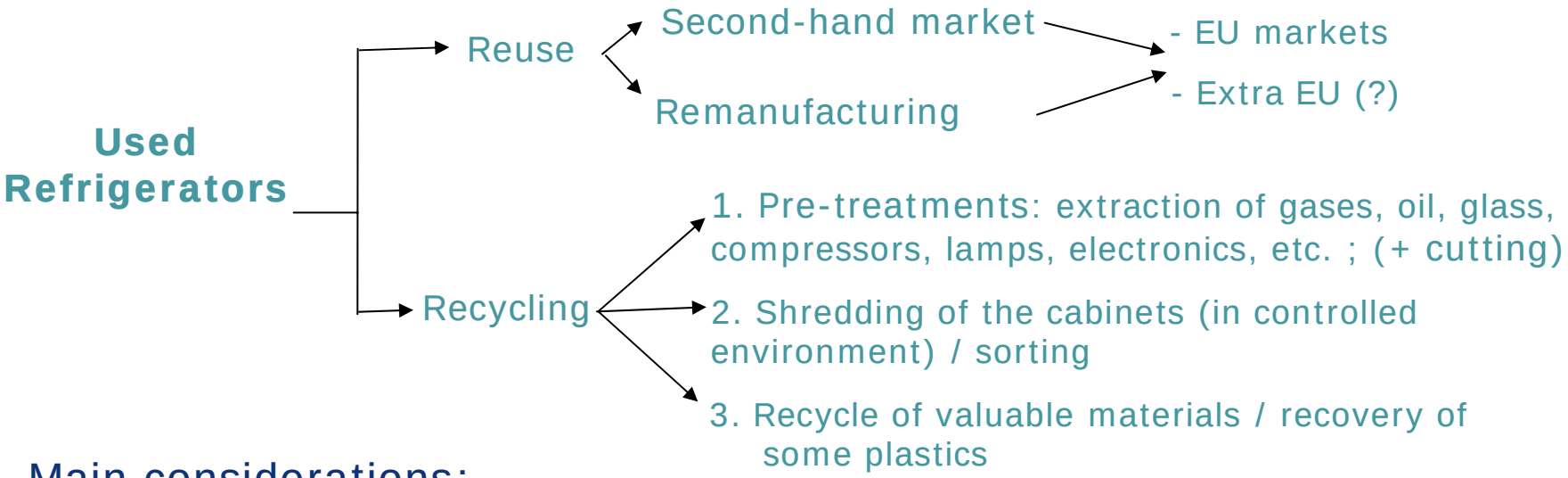
The **criteria used** for the qualitative analysis of commercial refrigerators include:

- Reusability / Recyclability / Energy Recoverability (in mass and environmental impacts).
- Use and management of hazardous substances.
- Durability (lifetime extension).
- Dematerialisation (reduced used of some polluting substances).

The analysis of the criteria undergoing for commercial refrigerators is supported by:

- Scientific and technical literature review on EoL treatments and environmental analysis of refrigerators and commercial refrigerators.
- Interviews/visits to companies dealing with the EoL treatments of commercial refrigerators, in order to identify representative EoL scenario(s) in the EU, including:
    - Recycling plant (visit to an Italian representative plant; identification of other EU representative plants)
    - Association of recyclers,
    - Take back schemes.

Current End-of-Life scenario



Main considerations:

- EoL treatments are similar to household refrigerators. Main differences related to:
  - problems related to the large dimensions.
  - presence of some additional components (e.g. large glass parts, electronics, lamps).
  - relevant incidence of second-hand market / remanufacturing / refurbishment

Current End-of-Life scenario

Reuse / remanufacturing:

Although few data available on flows and characteristics, there are evidences about its relevance:

- Specific characteristics that make products suitable for reuse/remanuf. (e.g. large devices with high value, high potential lifetime, producer's responsibility).
- Products generally substituted before the end of their wear out life for commercial reasons (e.g. fashion, changes of the needs of users).
- Some typologies of refrigerators (e.g. refrigerators for supermarkets) are largely under-represented in the waste flows of the interviewed recyclers.

Product's hot spots:

Reuse, remanufacturing

Potential problems/benefits

- Information needed about this phase (especially for some typologies as e.g. large supermarket refrigerators):
  - flows, exports?, treatment for reused/refurbished devices,
  - EoL treatments of reused/refurbished devices (including treatments outside EU?).
- Life extension of the product (including fashion issue?):
  - could bring environmental impacts benefits through the life-cycle (reduction of resource consumption and emissions in manufacturing phase; and waste reduction at EoL).
  - analysis needed to avoid loss in quality and energy efficiency.

Product's hot spots:

Recycling commercial refrigerators

- Dimension of devices complicates the waste collection, delivery and treatment in the plants (including risks of breakage of circuits and leakages of oils and refrigerant gases).
- Refrigerants and oils have to be carefully extracted to avoid dispersion to the environment. Treatment of these material is complex and impacting (5% of the installed refrigerant are estimated to be recycled).
- Glass parts and fluorescent lamps are difficult to be removed from the cabinets.
- Electronics (printed circuit boards, capacitors, switches, others): difficult to be removed and contain valuable materials.
- PUR insulating foams (currently landfilled) may contain polluting substances (CFC or hydrocarbons). Foams are separated after shredding or before (less common)

Exemplary structure of requirement:

Design for Extraction of the key components of the Comm. Refrigerators

*The time for the **extraction**[1] of **key components**[2] of the **commercial refrigerators**[3], performed by professional worker, shall not exceed **X**[4] seconds.*

1. To be measured according to a standardized procedure
2. These could include, among the others: glass parts (doors), lamps, batteries, electronics (e.g. printed circuit boards, capacitors, switches)
3. Requirements could be differentiated for different sub-categories of commercial refrigerators
4. To be defined according to on-site measurements.

Other potential requirements:

Other potential requirements could focus on:

- Dematerialisation: Thresholds on the use of refrigerant gases (e.g. per unit of cooling capacity), without affecting efficiency.
- Labelling of refrigerants (for separate collection and recycling)
- Substitutability of key components and availability of spare parts for lifetime extension (including remanufacturing/reuse options).
- Modularity and/or easy disconnection of product's parts (to simplify EoL management, especially transports and handling in the recycling plants).
- Measures to avoid accidental breakage of refrigerant circuits (shielding).
- Measures to reduce problems related to insulation materials (blowing gases, improve recyclability of these parts).
- Provision of relevant information (suggestions?)

Discussion:

- Is the presented analysis in line with your knowledge? (missing key issues? Suggested representative recycling plants? Potentially relevant references?).
- Could you please provide additional information about remanufacturing/reuse?
- How long do some pre-treatments require? (information on time for extraction of key components).
- Could you please provide information on quantity/typologies of refrigerant and product's efficiency in relationship with the cooling capacity (potential setting of thresholds for the amount refrigerants).
- Do you know additional hot spots for the EoL of commercial refrigerators?
- Do you suggest any additional potential measure (including relevant information to be provided).
- Will new materials hinder the EoL treatments? (e.g. new refrigerants, blowing gases used in the insulations, new electronics, etc.).
- ...?