



D2.1: PROFESSIONAL COLD PRODUCT CATEGORY DEFINITIONS AND SAVING POTENTIALS.

WP2: Status quo and monitoring of market development

Task 2.1: Assessment of the current market situation

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INTRODUCTION

A specific objective of the ProCold project is to ensure more energy efficient professional cold products enter the EU market and increase their market shares, thereby contributing to the EU's energy efficiency goals and policies. This is why we started this project by assessing and defining exactly which product types we will be focusing on and what the saving potentials are (WP2 Deliverable D2.1).

For more information see the website www.topten.eu/pro-cold which displays lists of highly efficient products using exclusively green refrigerants. Other important reports and documents that concern typology and saving potentials of refrigerated cabinets are:

- D2.3: Overview of relevant legislation and policies
- D2.6: Good practice brochures
- Final and draft EU regulations regarding refrigeration products as well as related preparatory and impact assessment studies (References [1] to [6])
- Harmonised test standards

Very inefficient compared to household refrigerators

There are 12 times less plug-in commercial and professional refrigerated cabinets in the EU (25 million units) than there are household refrigerators and freezers (304 million units [1]). Their energy consumption, however, is half of that compared to household products (commercial / professional: 43 TWh/year, household: 84 TWh/year [1]). Size and cooling capacity notwithstanding, the main reason commercial and professional cabinets use much more energy is that they are not energy efficient. Household refrigerating appliances have improved tremendously over the past 20 years thanks to the EU energy label and ecodesign requirements. In 1995, when the EU energy label for household refrigerating appliances was introduced, class G products were common. At present no refrigerator or freezer worse than class A+ can be introduced to the market¹. Energy consumption was successfully reduced by more than 70% (for models with same size) in 20 years. The best products in class A+++ are twice as efficient as A+.

Best products save 50% easily

Energy consumption of plug-in commercial and professional refrigerated cabinets can easily be halved with best-available-technology products. In fact, product comparison discussed on page 16 ff. of this report shows that as a general rule: Typical products with doors use twice as much energy as best models; open products use 6 times more energy than best models with doors.

¹ Exemptions are wine storage appliances, absorption-type and thermoelectric products

Cutting today's total energy consumption by 50% would bring energy savings of 15 TWh/year and save 3 billion Euros in electricity costs (at an electricity rate of 0.2 Euro/kWh).

Lack of information as main problem

The biggest barrier for both manufacturers and buyers of commercial / professional refrigerated cabinets is that no standardised product information is available to compare the energy costs of different models. Energy consumption values are only found sporadically in catalogues and not suited for comparison because testing conditions are unknown. Figure 1 shows standardised energy consumption values compared to catalogue data for the same models. It becomes clear that energy consumption values declared in catalogues are typically lower than standardised energy consumption. An individual manufacturer has little incentive to declare standardised data because the values would be considerably higher. Mandatory product information and EU energy labels are therefore essential.

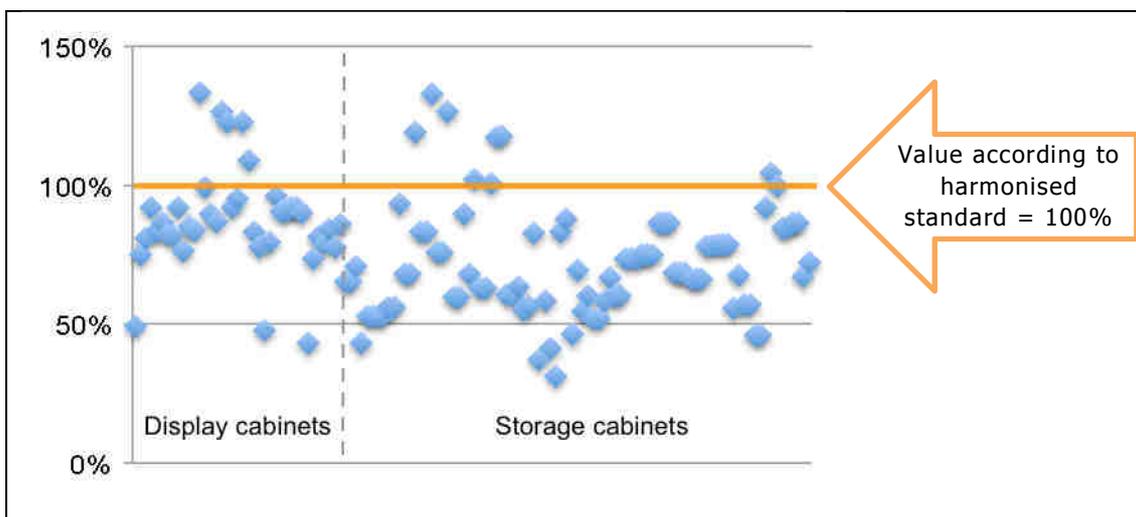


Figure 1: Energy consumption values from catalogues in relation to data according to harmonised standards (source: manufacturers' declaration for both catalogue and standard data, 124 models, study by Topten Switzerland, 2015)

EU legislation

Professional / commercial refrigerators and freezers are covered by several different EU regulations. The recently published labelling regulation No 2015/1094 concerns professional refrigerated storage cabinets [2]. It is accompanied by the Ecodesign regulation No 2015/1095 that sets requirements for professional refrigerated storage cabinets, blast cabinets, condensing units and process chillers [3].

The process of introducing Ecodesign (and possibly labelling) regulations for refrigerated commercial display cabinets is on-going. Working documents were discussed in a Consultation Forum in June 2014. New working documents should be circulated for Interservice Consultation later this year [4] [5]. Five main product types are defined: display cabinets of the supermarket segment, beverage coolers, small ice cream freezers, soft scoop ice cream freezers and refrigerated vending machines.

Some types of professional / commercial equipment could also be covered by the Ecodesign and labelling regulations for household refrigerating appliances because they are technically closer to products intended for domestic use [6] [7]. Household products are typically static-air cabinets (no ventilator that forces air circulation) and need less strict control of inside temperatures compared to professional equipment. This makes wine storage appliances, minibars and other static-air cabinets technically equivalent to household products. The differences are only in

the design, the size and in the common use of glass doors. It is already the case that some manufacturers provide the energy label for minibars and wine storage appliances even if they are intended for professional purposes and therefore strictly speaking not in the scope of the regulation. A revision of the Ecodesign regulation for household refrigerating appliances is going on this year. This offers the chance to include all minibars and wine storage appliances no matter if intended for professional or non-professional purposes.

Another important EU regulation for commercial/professional products is the recently revised F-gas regulation (No 517/2014) [8]. It will phase-out today's common refrigerants like R404A and R134a by 2020 and 2022 because they have very high global warming potential.

TYOLOGY

Beverage coolers and ice cream freezers



- Procured in large numbers by food and beverage industry and branded; loaned or leased to retailers, kiosks, take-aways, canteens, sport facilities etc.
- Electricity costs are paid by user, not by owner
- Procurers' motives for energy efficiency: meeting environmental targets, bringing cost reduction to customers, distinguishing as green company
- EU regulations in progress, Interservice Consultation coming up in autumn 2015 (new working documents will be circulated)
- EU energy label: planned from 1 January 2017 (no version with A+++ is foreseen)
- Models on www.topten.eu:

Sub-category	Efficient models	Inefficient model (EU base case)
Beverage coolers	A, B	D
Ice cream freezers	A, B	G

- No soft scoop ice cream freezers (yet)
- EU minimum requirements:

1 January 2017	EEI < 150
1 January 2019	EEI < 130
1 January 2021	EEI < 110
- A number of specific products are excluded from the scope of the EU regulations:
 - Absorption and thermoelectric based products (e.g. common minibars)
 - Refrigerated aquaria and water tanks
 - Wine storage appliances
 - Built-in cabinets
 - Vertical static-air cabinets
- Minibars, wine storage appliances, vertical static-air cabinets: currently falling into a gap between the scopes of EU regulations for professional / commercial and household products. At the discretion of manufacturers and dealers to omit product information for products intended for professional use. It will be ProCold's effort to find a way to close

this gap (for example by supporting the inclusion in the scope of the household ecodesign regulation which is currently being revised).

- Harmonised test standard available? Yes,
 - prEN 16902 for beverage coolers (draft to be published soon)
 - prEN 16901 for ice cream freezers (draft to be published soon)
 - prEN 16838:2015 for soft scoop ice cream freezers (draft to be published soon)

Details on beverage coolers:

- Central feature of beverage coolers is the capacity to “pull down” temperatures within maximum 4 hours after a refill with room-temperature cans (definition as in the prEN 16902 standard).
- Since beverages do not go bad the cooler can be switched off after opening hours. Energy management systems (so-called EMS or EMD for energy management device) can learn opening hours, or be triggered by door openings, and do this automatically. Saving potential: 15-45%. For example Coca-Cola and Heineken already use this technology. See ProCold factsheet on smart controls for beverage coolers and vending machines [10].

Details on ice cream freezers:

- The definition as in the prEN 16901 standard only comprises the most common form: chest freezers with lid and maximum 600 litres net volume. Vertical freezers and open freezers are classified as refrigerated commercial display cabinets (see next chapter), even if they are intended for selling ice cream.
- Soft scoop ice cream freezers are typically operated at -10°C (warmer than other ice cream freezers). Stock and sales are negligible compared to other ice cream freezers. Nonetheless the EU energy label will give the ProCold team a base to work with this product category. EU data shows differences in energy efficiency of factor 2-3.

Refrigerated commercial display cabinets



- This category comprises all cabinet forms that are not beverage coolers, ice cream freezers (according to definition in previous chapter) or vending machines. Typical use is in supermarkets, retail, canteens, bakeries etc. They can be self-service cabinets (direct access for customers) or serve-over counters, vitrines etc. where employees will access the foodstuffs.
- Some definitions from EU regulation drafts:
 - „Multi-temperature cabinet“ means a cabinet including at least one compartment exclusively intended for use as refrigerator, and at least one compartment exclusively intended for use as freezer

- „Multi-use“ means that a cabinet or compartment can be set to either chilled or frozen temperatures
- For display cabinets „combined cabinet“ means a cabinet which combines display and opening directions from a vertical, a horizontal or a semi-vertical cabinet. Not to be confused with the definition for professional refrigerated storage cabinets where „combined cabinet“ means a cabinet including two or more compartments with different temperatures for the refrigeration and storage of foodstuffs.
- Same EU regulations as for beverage coolers and ice cream freezers above: in progress, Interservice Consultation coming up in autumn 2015 (new working documents will be circulated)
- It is planned that the EU regulations will cover remote and plug-in cabinets.
- EU energy label: planned from 1 January 2017 (no version with A+++ is foreseen)
- EU minimum requirements and exclusions from scope see above
- Models on www.topten.eu:

Sub-category	Efficient models	Inefficient model
Horizontal frozen and multi-use	B	C

- No vertical chilled, vertical frozen or horizontal frozen cabinets (yet)
- No serve-over cabinets or vitrines (yet)
- Harmonised test standard available? Yes, EN ISO 23953-2:2005/A1:2012 and revised draft FprEN ISO 23953-2

Refrigerated vending machines



- Only for refrigerated foodstuffs. Does not include vending machines for coffee and other hot beverages or microwave-equipped vending machines.
- Same EU regulations as for beverage coolers, ice cream freezers and refrigerated commercial display cabinets above: in progress, Interservice Consultation coming up in autumn 2015 (new working documents will be circulated)
- EU energy label: planned from 1 January 2017 (no version with A+++ is foreseen)
- EU minimum requirements and exclusions from scope see above
- Models on www.topten.eu: none (yet)
- Harmonised test standard available? Will be available the latest by June 2016, developed by CENELEC based on industry standard used in EVA's (European Vending Association) voluntary labelling scheme.

Professional refrigerated storage cabinets



- Intended for use in professional kitchens, they meet high demands regarding food hygiene (temperature monitoring, stainless steel surfaces) and they function well in high ambient temperatures of 30°C. They are typically forced-air cabinets, however there are static-air cabinets as well (unknown market share, but expected to be much smaller compared to forced-air). The EU regulations exempt static-air cabinets; this creates a gap in the scopes of EU regulations.
- There are three climate classes for the energy consumption test defining ambient temperature and relative humidity for the testing chamber (EU regulation 2015/1095):

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

These are something else than the climate classes SN, N, ST, T that you might be familiar with from household refrigerators and freezers. Normal professional refrigerated storage cabinets are tested at climate class 4 (30°C, 55% relative humidity). There is an additional category called "light-duty" cabinets. They are not suited for (cannot operate in) climate class 4 conditions and are tested at climate class 3 (25°C, 60% relative humidity) and energy consumption is multiplied by a factor of 1.2 (chilled) or 1.1 (frozen). Manufacturers also have the option to declare a cabinet as "heavy-duty" which means it is suited for and tested in climate class 5 (40°C, 40% relative humidity).

- EU energy label: mandatory from 1 July 2016 (from 1 July 2019 version with A+++)
- Models on www.topten.eu:

Sub-category	Efficient models	Inefficient model (EU base case)
Storage Counter Refrigerators	A, B	C
Storage Refrigerators 1-door	A, B, C, D	G
Storage Refrigerators 2-doors	C, D	G
Storage Counter Freezers	A, B	C
Storage Freezers 1-door	A, B, C, D	G
Storage Freezers 2-doors	D	G
Storage Refrigerator-Freezers	D	G

- No light-duty cabinets (yet), they could come in all seven sub-categories above
- There are currently no A+ or better models available because the label classes have been tightened several times during the design process in order to account for updated product data. The calculation method of the EEI was not updated (very few product data was available to derive the method in the first place). For counter cabinets the EEI calculation leads to rather favourable energy classes (EU base case = class C), while for vertical cabinets (1-door, 2-door) the whole range of classes is covered and for some types like vertical freezers it is even a challenge to reach class D or better.
- EU minimum requirements:

1 July 2016	EEI < 115	G or better
1 January 2018	EEI < 95	F or better
1 July 2019	EEI < 85	E or better

- A number of specific products are excluded from the scope of the EU regulations:
 - remote cabinets
 - saladettes
 - refrigerator-freezers
 - static-air cabinets
 - built-in cabinets
 - roll-in and pass-through cabinets
 - chest freezers
- Refrigerator-freezers: mandatory product information (kWh/24h) was fortunately included in the EU ecodesign regulation; this gives the ProCold team a base to work with this product category.
- Static-air cabinets, chest freezers: currently falling into a gap between the scopes of EU regulations for professional / commercial and household products. At the discretion of manufacturers and dealers to omit product information for products intended for professional use. It will be ProCold's effort to find a way to close this gap (for example by supporting the inclusion in the scope of the household ecodesign regulation which is currently being revised).
- Harmonised test standard available? Yes, prEN 16825 (draft)

Plug-in blast cabinets



- Intended to rapidly cool hot foodstuffs to below 10 °C in the case of chilling and below –18 °C in the case of freezing
- EU energy label: none
- Models on www.topten.eu: none (yet)
- EU minimum requirements: none
- Mandatory product information (full load capacity in kg, standard temperature cycle, kWh/kg, refrigerant) was fortunately included in the EU ecodesign regulation; this gives the ProCold team a base to work with this product category.
- Harmonised test standard available? Needs to be researched.

Minibars



- Used primarily in 4- and 5-star hotels but also for camping and boating
- There are three technologies:
 - Compression-type: common technology used in most household and professional products, by far the most energy efficient technology, at the moment products with climate-damaging and climate-friendly refrigerants are offered, compressors make noise, therefore installed with presence sensors or timer when used for minibars in hotels, sometimes with eutectic plates (= cold storage) for long running time without compressor
 - Absorption-type: silent, inefficient, works with ammonia as refrigerant which has global warming potential of 0 (= climate-friendly), used in most minibars.
 - Thermoelectric, also called Peltier-type: silent, medium efficient, energy efficiency decreases strongly at ambient temperatures around 25-30°C, growing shares in minibar market.
- Biggest saving potentials for hotels would be to provide a central vending machine or refrigerator on the corridor instead of minibars in each room
- Minibars and wine storage appliances intended for professional purposes are currently falling into a gap between the scopes of EU regulations for professional / commercial and household products. It is at the discretion of manufacturers and dealers to apply labelling and Ecodesign requirements, or to omit product information. It will be ProCold's effort to find a way to close this gap (for example by supporting the inclusion in the scope of the household ecodesign regulation which is currently being revised).
- The European Commission communicated this possibility in the Consultation Forum regarding refrigerated commercial display cabinets on 2 July 2014. Excerpt from minutes: "Concerning wine coolers and minibars, the Commission considered that both types should be under the scope of the household cold appliances regulation regardless of whether the intended use is domestic or commercial. Vertical static air cabinets are normally not used for commercial purposes as they cannot withstand the opening regime typical for such cabinets and represent a very minor share of the market. Built-in cabinets should be further explored in particular as regards the appropriateness of information requirements."
- Current EU Ecodesign requirements for household products (EU regulation No 643/2009), not mandatory for professional products(!):
 - $EEI < 42$ for compression-type products (min. class A+)
 - $EEI < 110$ for absorption-type and thermoelectric products (min. class D), relatively recent: since July 2015

- Wine storage appliances are exempt
- Models on www.topten.eu:

Sub-category	Efficient models	Inefficient model
Minibars	A+++, A++, A+	D

Wine storage appliances



- Professional and household wine storage appliances are technically the same. They are mostly compressor-type cabinets and some electrothermal (Peltier) models exist. There are some differences in the design: professional products are typically larger, often have glass-doors, sometimes a compartment for bottles to stand up (for sale by the glass) and are inclined to elegant design.
- EU regulations see above under minibars (same situation), at the discretion of manufacturers and dealers to apply the regulations to products intended for professional purposes
- EU minimum energy efficiency requirements: wine storage appliances (even if only household products are considered) are in any case exempt from the minimum Ecodesign requirements in EU regulation No 643/2009.
- Models on www.topten.eu:

Sub-category	Efficient models	Inefficient model
One temperature zone	A+	G
Multi temperature zones	A	C

Professional / commercial static-air cabinets



- Professional static-air storage cabinets and commercial vertical static-air display cabinets² are currently falling into a gap between the scopes of EU regulations for professional / commercial and household products. It is at the discretion of manufacturers and dealers to omit product information. It will be ProCold's effort to find a way to close this gap (for example by supporting the inclusion in the scope of the household ecodesign regulation which is currently being revised).
- The European Commission did not communicate at the Consultation Forum regarding refrigerated commercial display cabinets on 2 July 2014 that static-air cabinets would likely be included in the household ecodesign regulation. **Therefore ProCold should ideally provide some evidence of this gap in the legislation, in order to call for a closing of the gap (research on static-air cabinets that are marketed without EU energy label for professional and commercial purposes).**
- One example is shown in Figure 2 below: the professional static-air chest freezer marketed in Switzerland uses 5 times more energy than household chest freezers (minimum requirement in Switzerland is A++ instead of A+ like in the EU). Its calculated EEI with declared energy and volume values is 166 (= class G). Businesses buying such a professional freezer are probably not aware that it costs over 6'000 Euros in energy costs over 15 years of use (at 20 cents/kWh).

² For display cabinets, horizontal or chest static-air cabinets are included while vertical static-air cabinets are excluded. For storage cabinets all static-air cabinets are excluded.

vergleichen						
Marke	Bauknecht	Siemens	Liebherr	Liebherr		UDD 600 BK
Modell	GT 2760	GC33MAW40	GTP 3656	GTP 4656		1340
Kaufpreis (Fr.)	1'390	1'900	2'190	2'390	1'560	6132
Stromkosten (Fr. in 15 J.)	408	408	456	525	633	646
Nutzzinhalt (Liter)	274	274	331	419	292	
Höhe (cm)	91.6	91.6	91.9	91.7	86.8	
Breite (cm)	140.5	140.5	137.3	164.7	132.5	
Tiefe (cm)	69.8	74.3	80.8	80.8	66.5	
Standort (°C)	10-43	10-43	10-43	10-43	10-43	
Effizienzklasse	A+++	A+++	A+++	A+++	A++	G
Effizienz-Index	21.9%	21.9%	22.0%	22.0%	32.9%	166.2%
Energie (kWh/Jahr)	136	136	152	175	211	2044

Figure 2: Left: household freezers on www.topten.ch, right: professional freezer marketed in Switzerland and its calculated EEI with declared energy and volume values

Ice machines



- Plug-in ice machines produce between few kg to a ton of ice per day. Various shapes of ice are produced like cubes, fingers, flakes etc. Ice machines are typically used in bars, fisheries, for fruit transports, for breakfast buffets, in hotels and hospitals.
- Not covered by EU ecodesign or labelling regulations
- There are ice machines that are cooled with water and with air. Water-cooled machines use much more energy than air-cooled ones. Climate-friendly refrigerants are currently only used in remote ice machines that are connected to a central cooling unit.
- The ProCold team should further study ice machines so that efficiency potentials and procurement guidelines can be communicated and best products can be promoted.
- Harmonised test standard available?

Cold water dispensers



- Used in many offices and good subject for procurers, could be interesting for ProCold.
- Research needed on market and energy efficiency potential.

Beverage tapping machines



- Beverage tapping machines are basically plug-in products to which the pipes and the tap are installed individually.
- They can be supplied by international beverage and brewer companies like Coca-Cola or Carlsberg, but also by more local specialised companies. Manufacturers are for example Manitowoc, Cornelius, Hertig and Hartek.
- The ProCold team should investigate if efficiency potentials, green refrigerants and procurement guidelines could be communicated and best products could be promoted.
- Not covered by EU ecodesign or labelling regulations
- No harmonised test standard is available

Other products

There are other types of plug-in professional / commercial refrigerated cabinets that are little studied, have small market shares and depending on their technical features can be complex to test and compare amongst each other.

These are for example machines for making and processing food like ice cream makers, milk-shake machines etc., trash coolers and refrigerators and freezers for laboratories and medicines.

Summary of products that ProCold will work on

Product Category	Covered by EU regulation	Harmonised test standard published	Topten product list	ProCold activities
Plug-in refrigerated display cabinets	✓	Latest by June 2016	So far only horizontal frozen and horizontal multi-use, shall be extended to vertical and chilled types	✓
Beverage coolers	✓	Latest by June 2016	✓	✓
Ice cream freezers	✓	Latest by June 2016	✓	✓
Soft scoop ice cream freezers	✓	Latest by June 2016	No	Maybe (argument for: EU energy label will be available at some point, argument against: very small stock in the EU)
Refrigerated vending machines	✓	Latest by June 2016	Foreseen when standard is published	✓
Refrigerated storage cabinets	✓	✓	✓	✓

Plug-in blast cabinets	✓	Needs to be researched	Foreseen when product information is mandatory (1 July 2016)	✓
Minibars	Falls in gap of the scopes between commercial and household products	✓	✓	Policy: support coverage by EU regulation for household appliances
Wine storage appliances	Falls in gap of the scopes between commercial and household products	✓	✓	Policy: support coverage by EU regulation for household appliances
Static refrigerated cabinets for commercial/professional use	✓	✓	✓	✓
Ice machines	No	Needs to be researched	If possible	Topten list: if test standard or ENAK test specifications can be used
Cold water dispensers	No	Needs to be researched	If possible	Topten list: if test standard or other test specifications can be used
Beverage tapping machines	No	No	If possible	Topten list: if ENAK test specifications can be used
Other products	No	No	No	No

OVERVIEW PRODUCT CATEGORIES, SALES, STOCK, CONSUMPTION

Table 1 gives an overview of the product categories' stock and energy consumption. Estimates for stock and total energy consumption in the EU are given for the year 2016 where trend estimates were available (2016 being the central year for the ProCold project).

Product Category	Stock EU (million units)	Total Annual Energy Consumption EU (TWh)
Plug-in refrigerated display cabinets ³	1.3	6.5
Beverage coolers	7.3	16.3
Ice cream freezers	3.1	4.5
Refrigerated vending machines	1.3	3.0
Refrigerated storage cabinets	3.2	6.9
Plug-in blast cabinets ⁴	1.7	5.8
Minibars	3.4	unknown
Wine storage appliances	1.7	unknown
Static refrigerated cabinets for commercial/professional use	unknown	unknown
Ice machines	1.3	unknown
Cold water dispensers	unknown	unknown
Beverage tapping machines	0.6	unknown
Other products	unknown	unknown
Total plug-in commercial/ professional products	>25	>43
Total household refrigerators and freezers	304	84

Table 1: Overview of product categories, EU stock and total energy consumption

Strong reliability: data for the four types of commercial refrigerated display cabinets are from JRC's preparatory study update [4]; data for refrigerated storage cabinets and plug-in blast cabinets is from Bio Intelligence Service's preparatory study for Lot 1 [9]. Trend estimates are available for all of them and values are extrapolated for the year 2016.

Medium reliability: data for wine storage appliances is from VHK and ARMINES's interim report on household refrigeration [1]; stock data for minibars, ice machines and beverage tapping machines is extrapolated to the EU from estimates for Switzerland from a report by Bush Energie for the Swiss Federal Office of Energy [11]. No trend estimates are available.

³ Remote refrigerated display cabinets: 2.7 million units, 42.2 TWh

⁴ Remote blast cabinets: 1.7 million units, 5.8 TWh. For other product categories the share of remote cabinets is negligibly small.

Table 2 shows the sales for six main product categories in the EU and in the combined regions of all ProCold partners. These numbers are used to estimate the minimal savings that shall be brought by the ProCold project. ProCold aims to trigger more than 30'000 additional BAT sales (BAT meaning energy efficient products with climate-friendly refrigerant). The biggest number of optimized procurement shall be achieved by working together with the beverage industry (11'000 additional units that meet the ProCold criteria).

Product group	Sales EU 2015	Sales EU 2016	Sales EU 2017	Sales EU 2015-2017	Sales Project 2015-2017	0.8% of Sales Project	0.15% of Sales rest of EU	Additional BAT sales due to Project
	units	units	units	units	units	units	units	units
Plug-in refrigerated display cabinets ⁵	218'604	219'129	219'655	657'389	324'823	2'599	246	2'845
Beverage coolers	872'409	879'039	885'720	2'637'168	1'303'054	10'424	989	11'413
Ice cream freezers	373'549	377'074	379'422	1'130'044	558'368	4'467	424	4'891
Refrigerated vending machines	163'502	159'716	155'877	479'095	236'726	1'894	180	2'073
Refrigerated storage cabinets	424'521	427'663	430'805	1'282'989	633'939	5'072	481	5'553
Minibars	344'586	347'205	349'844	1'041'635	514'684	4'117	391	4'508
Wine storage appliances	180'000	181'368	182'746	544'114	268'853	2'151	204	2'355
Sum				7'228'321	3'571'594			33'638
				100%	49%			0.5%

Table 2: Sales of seven product categories in the EU and target of the ProCold project (table from Grant Agreement updated with data for wine storage appliances)

SAVING POTENTIALS

The calculation of the saving potentials has been updated since the Grant application. New potentials have been included for minibars⁶ and wine storage appliances⁷. Table 3 shows the updated saving potentials per product category. They were calculated based on the specifications in Table 4. For other product categories like plug-in blast cabinets, ice machines, cold water dispensers etc. further researched would be needed to identify reference and BAT specifications and to calculate saving potentials. Whether they can be included in ProCold's activities depends on the availability of test standards and the support from manufacturers in publishing and evaluating product data for comparison of energy efficiency performance.

⁵ including supermarket, serve-over and self-service cabinets

⁶ BAT loosened from A+++ to A+ in order to consider thermoelectric minibars too and not only compression-type ones

⁷ Included into the ProCold project as new product category

Product category	Energy savings BAT vs. Ref. for a single product	Energy savings if EU stock was replaced with best products ⁸
	kWh/ operation phase	TWh/year
Plug-in refrigerated display cabinets	29'025	4.7
Beverage coolers	10'950	10.0
Ice cream freezers	6'340	2.5
Refrigerated vending machines	11'821	1.8
Refrigerated storage cabinets	10'615	4.2
Minibars	1'475	0.5
Wine storage appliances	1'312	0.2
Sum		23.9

Table 3: Calculation of saving potentials per product category

Product category	Reference models		Energy efficiency index		Annual energy consumption		Saving potential	Operation phase
	Net Volume	Total Display Area	Ref.	BAT	Ref.	BAT		
	litres	m2			kWh/ year	kWh/ year	years	
Plug-in refrigerated display cabinets		1.4	100	50	7'256	3'628	50%	8
Beverage coolers	500		100	50	2'738	1'369	50%	8
Ice cream freezers	291		100	40	1'321	528	60%	8
Refrigerated vending machines	750		100	40	2'318	927	60%	8.5
Refrigerated storage cabinets	450		100	47.5	2'519	1'192	53%	8
Minibars	40		100	42	254	107	58%	10
Wine storage appliances	200		100	55	292	160	45%	10

Table 4: Specifications of reference and BAT models
(table from Grant Agreement updated for minibars and wine storage appliances)

Comparison of real products

The ProCold project team researches and compares real product data and communicates the findings. Figure 3 shows an excerpt from the ProCold brochure where an open beverage cooler is compared with a product with glass door and with a BAT product with glass door. The comparisons are based on energy consumption data according to harmonised standards, provided by manufacturers, UK's Energy Technology List (<https://www.gov.uk/energy-technology-list>) or Australia's Energy Rating Program (<http://www.energyrating.gov.au>), researched by Topten Switzerland. Another example is given with ice cream freezers.

⁸ Multiplication of energy savings per single product times the EU stock from Table 1

Based on these product comparisons, the following rules of thumb were found:

- Closed cabinets use three times less energy than open cabinets.
- BAT products use two times less energy than typical closed cabinets, and 6 times less than open products.

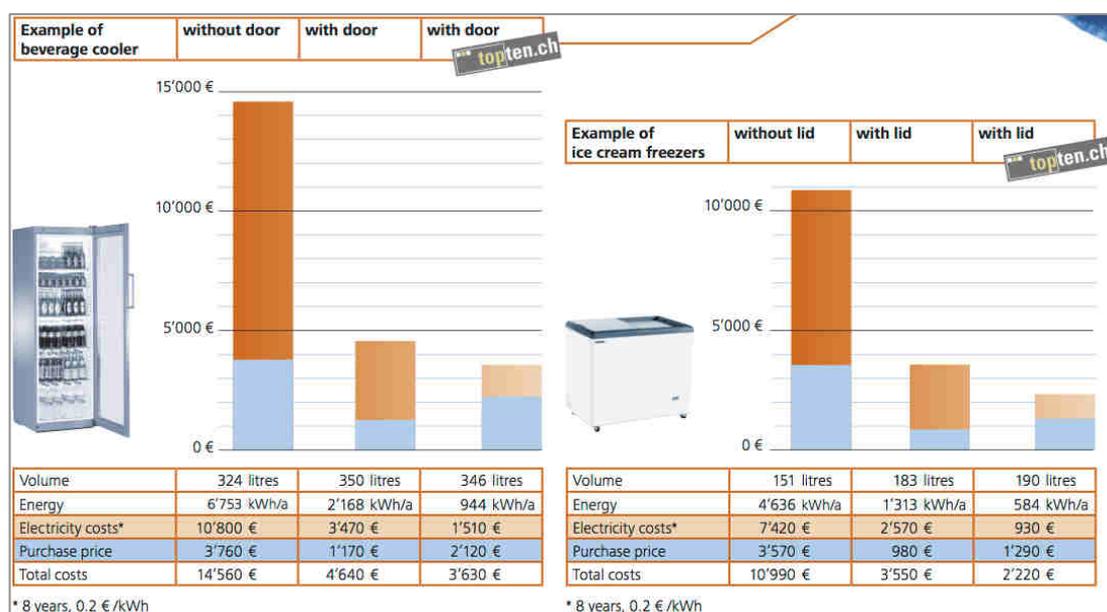


Figure 3: Comparison of real products based on energy consumption data according to harmonised standards (excerpt of ProCold brochure for retailers) [10]

JRC preparatory study update: improvement options for commercial refrigeration

Comprehensive information on saving potentials and improvement options for refrigerated display cabinets is collected in the preparatory study update by the European Commission Joint Research Centre (JRC, 2014) [4].

Life cycle costs are reported for base case models and several combinations of technological improvement options (9.7 Annex VII of the report). The result is that investment in energy efficient technology is always cheaper. For all five product types considered (remote vertical chilled cabinet, remote horizontal frozen cabinet, beverage cooler, ice cream freezers, refrigerated vending machine) life cycle costs were lowest when all improvement options were employed combined.

The saving potentials allocated to specific technological improvement options when used on their own are shown in Table 5. Main message: closing open cabinets is the single most effective improvement option. Energy consumption of vertical chilled cabinets can be reduced by 40%, of horizontal frozen cabinets by 37%.

LED	5-20%
Electronic fan / ECM fan	5-20%
Optimized air curtain	10%
Night curtain	18-26%
Glass door / glass lid	37-40%
Energy management device (EMD) for beverage coolers	26%
High efficiency compressor / variable speed compressor	5-20%
Anti-sweat heater location for vending machines	18%
Electronic thermostat	6%
Anti-sweat heaters control	6%
Increasing heat exchanger surface for ice cream freezers	4%

Table 5: Overview of saving potentials for specific improvement options [4]

REFRIGERANTS

The HFCs (hydrofluorocarbons) R134a and R404A are still the most commonly used refrigerants in professional / commercial cabinets. They are climate-damaging because they are strong greenhouse gasses and will be replaced by green refrigerants in the next 7 years (the phase-out is regulated in the EU F-gas regulation). Products with green refrigerants (the most common ones are R600a and R290) are currently available for all cabinet types in all sizes. The only exception is large, 2.5 meter, open plug-in cabinets because their cooling capacity is too high⁹; they can use green refrigerants when fitted with glass doors and thus improve cooling capacity.

So far the professional market has failed to follow the market for household refrigerating appliances in which green refrigerants have become common long ago and are now mandatory due to the F-gas regulation since January 2015 [8]. Positive exception is the German manufacturer Liebherr who has completely switched already and uses exclusively green refrigerants.

Experiences with the rebate programme in Switzerland and interviews with Swiss industry experts lead to the conclusion that the main barrier for green refrigerants is not lack of awareness or training for professionals but instead the additional effort and expense that come along with the switch to green refrigerants. Professionals need to transport additional gear for maintenance (gas containers, manometer, specific tools) and invest in an expensive precision balance (R290 and R600a must be filled precisely to the gram). This extra effort and expense leads to a situation where many professionals do not recommend and offer products with green refrigerants to their customers.

The refrigeration sector has already once undergone a change to more environmental-friendly refrigerants: in the 90ies CFCs (chlorofluorocarbons) that deplete the ozone layer were banned internationally following the Montreal Protocol. Old CFCs were replaced by HFCs, for example R12 with R134a, R502 with R404A. The HFCs R134a and R404A are still commonly used in professional / commercial refrigerated cabinets. They have zero ozone depletion potential, but they are very strong greenhouse gases. Green or climate-friendly refrigerants means they have a global warming potential (GWP) below 150. See Table 7 for common refrigerants and their GWP values.

With the new F-gas regulation [8], the EU decided to phase out climate-damaging refrigerants in commercial refrigerators and freezers by 2022 (see Table 6). The coming ban of climate-damaging refrigerants is essential to overcome the barrier that currently impedes widespread uptake of green refrigerants in commercial/professional refrigerated cabinets.

10. Domestic refrigerators and freezers that contain HFCs with GWP of 150 or more		1 January 2015
11. Refrigerators and freezers for commercial use (hermetically sealed equipment)	that contain HFCs with GWP of 2 500 or more	1 January 2020
	that contain HFCs with GWP of 150 or more	1 January 2022

Table 6: Prohibitions for placing on the market in the f-gas regulation (excerpt) [8]

⁹ The use of isobutane (R600a) and propane (R290) is restricted to 150g per cooling circuit because they are flammable. CO2 is more commonly used for remote cabinets and is not flammable / restricted.

Refrigerant	Global warming potential (GWP) compared to 1 kg of CO2	
R134a	1'430	very high GWP = climate-damaging
R404A	3'990	
R290 (propane)	3	climate-friendly, green
R600a (isobutane)	3	
R600 (butane)	4	
R717 (ammonia) ¹⁰	0	
R744 (CO2)	1	

Table 7: Refrigerants commonly used in ProCold products

¹⁰ Used in absorption-type appliances like minibars. Compression-type minibars use R600a and in some cases still R134a. Wine storage appliances use mostly R600a.

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