Analysis of specific issues regarding EU policy proposals for DG ENER Lot 12 Commercial Refrigeration

Including 'best-in-world' requirements; integral/remote cabinets; representative cabinets; reducing 'gaming'; impact on SMEs; comments on Eurovent proposals of 1 September 2014

FINAL REPORT

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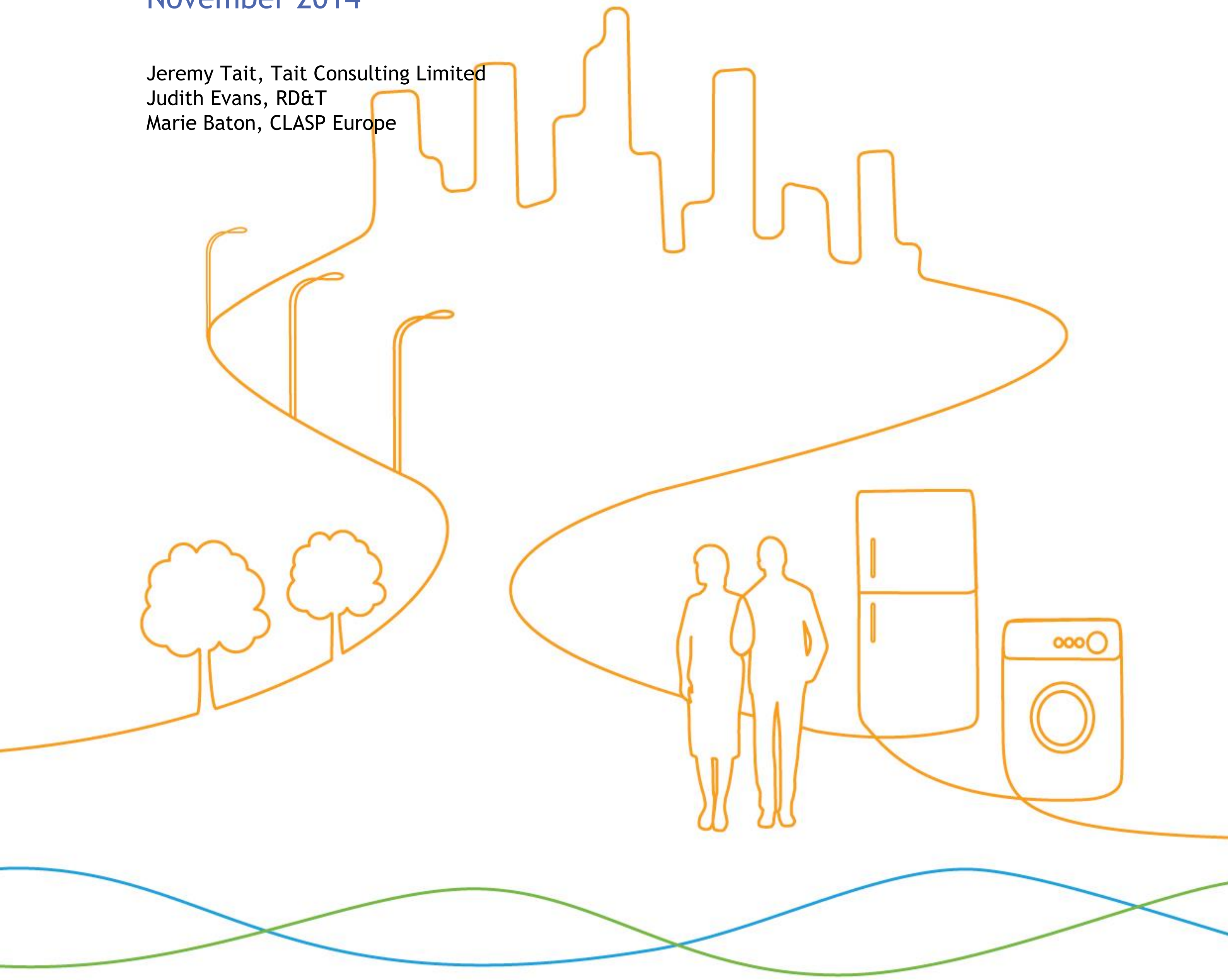

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Foreword

This report has been prepared by CLASP with input from experts and is presented to the European Commission and the Consultation Forum as an independent contribution to the development of ecodesign and energy labelling criteria for commercial refrigeration equipment. This analysis is in support of the development of energy labels and ecodesign minimum requirements for DG ENER Lot 12 commercial refrigeration equipment, including retail display cabinets, beverage coolers and vending machines.

Starting in July 2014, CLASP has prepared and submitted several contributions to this policy-development process, including:

- Early analysis from this work was presented by Jeremy Tait on behalf of CLASP at the DG ENER Consultation Forum on 2 July 2014;
- Additional input was provided in an interim report made available to stakeholders on 17 July 2014; and
- A report with refined analysis and additional research circulated to stakeholders on 21 August 2014.

This report has been prepared to address several specific issues identified as research priorities by DG ENER and by the JRC in support of the Impact Assessment and finalising the regulatory proposals for Lot 12.

CLASP would like to thank Sietze van der Sluis (independent consultant) and others for their kind support with data, comments and other input to make this work possible.

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Executive summary

CLASP is making this analysis available to DG ENER and to the JRC Seville as an independent contribution to support the development of energy labels and ecodesign minimum requirements for DG ENER Lot 12 commercial refrigeration equipment.

Best in world MEPS

CLASP reviewed the current and proposed minimum energy performance standards (MEPS) for commercial refrigeration equipment in Australia, Canada and the USA to develop a set of requirements that would be equal with the most energy-efficient MEPS around the world. These countries were selected because they are major economies who have mature, leading efficiency regulations for this product group. From these policy measures, a benchmark was derived that approximates the 'best in world' MEPS levels for the proposed EU ecodesign requirement categories. Table S1 presents these levels using the DG ENER proposed reference lines and EEI values as a 'close equivalent' to the best in world MEPS scenario for consideration in the Impact Assessment for DG ENER Lot 12.

Table S1. Summary of best in world requirements in EU format

Cabinet type using EU segmentation	Close equivalent to 'best in world' threshold in EU terminology	Comment and description of EU close equivalent threshold
Vertical chilled supermarket cabinets	7.28 x TDA + 7.28 EEI = 80	Applicable to remote cabinets only. This is the line **of EEI 80 based on the DG ENER reference line of June 2014**. This would still allow the most energy efficient open cabinets to remain on the market. Based on Australian 2004 MEPS for closed cabinets.
Horizontal frozen supermarket cabinets	4.90 x TDA + 2.1 EEI = 50	Applicable to remote cabinets only. This is **EEI 50, or the B/C label class threshold using the DG ENER** reference line and label classes for horizontal freezers. This would force almost all horizontal freezer cabinets to be closed top. Based on US DOE requirements for 2017 for glass top frozen cabinets.
Beverage coolers	0.0042 x V + 1.12 EEI = 70	Applicable to beverage coolers only (which are all of integral type). **This is the line with EEI of 70 based on a reference line of (0.006 x V + 1.6).** This line takes account of the need for pull-down capability. Based on US DOE requirements for 2017 for beverage coolers.
Vending machines	0.003 x V + 3.075 EEI = 75	This is EEI 75, or the **B/C label class threshold, using the DG ENER** reference line and label classes for vending machines[1]. Based on the US DOE requirements for 2012 for class B vending machines (partially cooled).

Integral versus remote cabinets

Evidence has been reviewed on how the efficiency of integral cabinets compares to that of remote cabinets. On balance it appears that integral cabinets are highly unlikely to be as energy efficient as

[1] This aligns closely with the Tier 3 (2021) MEPS proposal by CLASP, using an alternative reference line, as per *Analysis of EU policy proposals for DG ENER Lot 12 Commercial Refrigeration* of 16 October 2014 available from the CLASP publication library at http://clasponline.org/en/Resources/Resources/PublicationLibrary.aspx?e=Europe&p=Commercial+Refrigeration..

remote cabinets. This situation is evident in the MEPS set in the USA, where requirements for remote cabinets require significantly lower kWh per day than those for equivalent integral cabinets.

However, because of a bias in the EU test method EN 23953, it may make sense to set MEPS at the same level for integral and remote cabinets until the method is updated. Indeed, the energy consumption data returned by the EU test method EN 23953 show almost no difference between the measured energy consumption of integral and remote cabinets. This is because the assumptions built into the EN 23953 calculation of *remote* condensing unit energy consumption are based on outdated efficiency levels. Modern remote condensing equipment is much more efficient than is assumed in EN 23953, and so the energy consumption of remote cabinets is over-estimated by about 50% (i.e. if tested on a fair comparative basis with modern condensing plant, remote cabinets will be shown to be significantly more energy efficient than integral cabinets, as seen with measured test results in the USA). In this specific context, it would not seem justified to define different MEPS for integral and remote cabinets when using the EU test method EN 23953:2005 (AMDT 2012). Note that Eurovent has proposed a correction factor of 1.1 between integral and remote performance. CLASP would suggest that such a factor should only be considered once the test method has been revised and the factor value should be based on the best data available at that time.

Hence, based on the interim analysis carried out so far, it appears appropriate to set EU MEPS levels for integral and remote cabinets as identical as long as they are based on EN 23953:2005 (AMDT 2012). It is likely, however, that EN 23953 will be updated to better reflect modern remote plant efficiency – such work has already been mentioned informally in the CEN TC44 working group. Indeed, the Commission may wish to request better estimates of modern remote plant performance in a Mandate issued to CEN/CENELEC to help support the review of the regulation. When the update happens, the regulatory MEPS and label thresholds should be adjusted accordingly. CLASP suggests that this issue should be carefully considered when the regulation is reviewed.

Over-estimated energy savings

Available evidence supports the comment made by Eurovent that energy savings for supermarket cabinets in the preparatory study are substantially over-stated. This is because energy consumption in real shops will be lower than that measured in the laboratory under EN 23953 due to the lab conditions being much warmer than is typical in shops across at least central & northern Europe. Eurovent technical committee members presented a paper on this topic at 2011 conference indicating that shop conditions result in between 30% and 60% lower consumption; anecdotal evidence suggests that retailers expect to reduce declared lab test cooling demand figures by between 30% and 40% to arrive at an estimate of the cooling duty their plant must deliver. The Eurovent suggestion that real consumption and savings will be 50 to 60% lower than the preparatory study estimate is at the top end of the range indicated by available evidence. A reduction of 40% is a more appropriate average figure.

Steps to minimise gaming of results

The most important consideration to reduce the risk that some manufacturers may make ‘favourable interpretations’ of energy results is to specify the internal storage temperature at which cabinet performance thresholds must be measured. One step would be to specify an EN 23953 temperature class, such as M2 for chilled and L1 for frozen. A number of other aspects of EN 23953 are open to interpretation, which reduces the accuracy and repeatability of measurements. CLASP has identified approaches and mitigating strategies that will reduce the scope for measurement variation. The rating standard for Eurovent Certification aims to achieve a similar objective and contains useful material for the Commission to consider in this task. Further consideration must be made as to how any guidance or clarification on the use of EN 23953 could best be communicated to manufacturers and test laboratories, but options include a Commission Communication document, notes in the regulation (not preferred for highly technical issues), a Frequently Asked Questions webpage, and/or best practice guidance published through the relevant industry associations, including manufacturers of commercial refrigeration equipment and their customers.

Steps to minimise testing burden for manufacturers

The new regulatory requirements will result in the need for more equipment testing than exists in the current market. Several options have been identified to minimise the burden on manufacturers, particularly small and medium sized enterprises (SMEs) that may lack the technical and/or financial resources to carry out the necessary testing. It is suggested that text be adapted to Lot 12 that is similar to that used in DG ENTR Lot 1 draft regulation regarding the use of calculated and extrapolated efficiency data. This new text could be qualified as using 'best practice guidance' as it is based on the use of representative models such as is done for the UK Enhanced Capital Allowance (ECA) scheme (although additional detail and adaptations would be necessary to make this more robust). A second option to consider would be to investigate the potential to apply the US Department of Energy's alternative efficiency determination method (AEDM), which is used for compliance certification reporting of commercial refrigeration equipment in the USA.

Impact of regulations on SMEs in the EU

Nearly 70% of the EU sales in 2007 were supplied by 5 large manufacturers. Most medium-sized SMEs are likely to develop their own cabinets and have some form of testing capability; however small enterprises may not have the same testing resources and distributors and very small SMEs who produce limited custom designed equipment will rarely have test facilities.

CLASP's experts estimate that building a new EN 23953 test room would cost approximately €40-65k plus equipment required for testing at between €25-65k (depending on the type of cabinets tested and how many of the detailed aspects of EN 23953 are complied with regarding the design of the test room). However, compliance testing can also be contracted out to an accredited laboratory and with the steps being considered to minimise test burden (see recommendations above under "steps to minimise testing burden for manufacturers" and section 6 of this report), testing is not perceived as a significant issue.

Observations on EPEE / Eurovent proposals of 1 September 2014

Manufacturers are calling for the separation of roll-in cabinets from other vertical types as they are far less energy efficient due to their current design approach, but the justification for this is inconclusive. Indeed, some retailers have already specified that doors must be placed on their roll-in cabinets which substantially improves their efficiency. If carefully designed with efficiency in mind, roll-in cabinets should have no problem meeting proposed MEPS and so should remain grouped with other vertical cabinets.

Semi-vertical cabinets typically have higher energy consumption than other vertical cabinets and it would be challenging to make semi-vertical cabinets highly efficient due to the interrupted air flow cascading over the front of successive shelves, although design improvements are possible. CLASP proposes that the energy labelling of semi-vertical cabinets should remain under the same criteria as other vertical cabinets (as was done in the DG ENER original proposal), so that it is clear to buyers how the energy consumption of semi-vertical cabinets compares relative to other vertical cabinets. In addition, the MEPS will bring about design improvements and ensure a selection of more efficient models on the market.

The EPEE / Eurovent proposals for vertical chilled cabinets (the highest volume category) lack ambition and will not ensure Europe meets its energy-efficiency targets. Their proposal for vertical chilled cabinets equates to a 2 year delay in MEPS over those proposed by DG ENER in June 2014, or around 10% less stringency. And the EPEE / Eurovent MEPS line of 2021 has approximately the same stringency as those of the USA MEPS of 2012 (when normalised), i.e., placing the European market 9 years behind that of the USA. (The MEPS are compared with those of other regions in more detail in the CLASP report *Analysis of EU policy proposals for DG ENER Lot 12 Commercial Refrigeration* of 16 October 2014[2]).

As further illustration of the lack of ambition in the EPEE / Eurovent proposal, the MEPS for vertical chilled cabinets in 2021 would only remove one Eurovent certified cabinet from the 2014 Eurovent certified data set in 2021. And, the proposed MEPS for 2017 and 2019 would not remove any of the 2014 Eurovent certified products of this type.

The EPEE / Eurovent proposed MEPS for frozen horizontal cabinets are very close but slightly less stringent than those proposed by DG ENER in June 2014. In the CLASP report of October 2014 mentioned above, it was reported that the US MEPS of 2012 for open frozen horizontal remote cabinets are more stringent than the requirements for 2021 proposed by DG ENER, also placing Europe at least 9 years behind the US market.

EPEE / Eurovent propose that corner (or transition shape) cabinets should be excluded from the scope of the regulation because no test methodology covers them. Whilst this is not strictly true (i.e., corner cabinets are within the scope of EN 23953), testing does require some interpretation of the test method and it is expected that their energy performance will be poor due to uneven air flow within the cabinet shape. A key point, however, is that corner / transition cabinets are sold in very low volume compared with straight cabinets and so the Commission may choose to exclude them from Tier 1, but include them in future Tier 2 to allow manufacturers to prioritise improvements to the products that represent the majority of sales and energy consumption. These units should be listed for inclusion at Tier 2 to ensure they do not become a future loop-hole. That said, it should be noted that corner / transition shape cabinets were not given any special treatment in the US DOE regulation of 2009 and in the regulation of 2014 are allocated a specific method to calculate a suitable Total Display Area (TDA) but are subject to identical requirements.

[2] Report *Analysis of EU policy proposals for DG ENER Lot 12 Commercial Refrigeration* of 16 October 2014 available from the CLASP publication library at http://clasponline.org/en/Resources/Resources/PublicationLibrary.aspx?e=Europe&p=Commercial+Refrigeration.

1 Introduction

This work builds upon analysis by CLASP during August, September and October 2014 and addresses several specific gaps or weaknesses in the evidence available to the Commission. This report also includes an assessment of the EPEE / Eurovent proposals of 1 September 2014. This report has been prepared by CLASP with input from experts and is presented to the European Commission and the Consultation Forum as an independent contribution to the development of ecodesign and energy labelling criteria for commercial refrigeration equipment.

2 EU MEPS to match 'best in world'

CLASP reviewed the current and proposed minimum energy performance standards (MEPS) for commercial refrigeration equipment in Australia, Canada and the USA to develop a set of requirements that would be equal with the most energy-efficient MEPS around the world. These countries were selected because they are major economies who have mature, leading efficiency regulations for this product group.

2.1 Comparing Regulatory Stringency

When comparing regulatory stringency between different markets and MEPS programmes, it must be borne in mind that:

i. Comparison is only possible where metrics have the same basis as those considered in EU (i.e., total display area (TDA) versus volume);

ii. Scope of cabinets included in a category may not match with the EU approach to segmentation, part of which is pre-set by EN 23953 and other aspects of which will be set by the ecodesign regulation. Hence, a very stringent MEPS for one category in one economy may not be applicable to another economy that must, for example, include inherently less efficient type(s) of cabinet in the same category – and vice versa, an unambitious MEPS for one category in one economy may not be relevant for another economy that has decided to divide the category in several sub-groups (such as with and without doors). In any case, the definition of the categories for MEPS must be carefully thought through;

iii. In the EU, where cabinets have not been subject to any efficiency related regulation and little stimulus toward efficiency for the bulk of the market, there should be a rapid improvement from performance levels of recent years, as technologies already deployed in regulated markets are transferred. Thus, standards that appear stringent against current performance of EU cabinets will not appear so stringent after 2 years;

iv. Due to the fact that energy performance of refrigerated equipment can be encouraged to improve significantly, the level of ambition is crucially dependent upon timing, when policies came or will come into force;

v. Terminology and definitions of product types differ by region and comparability is not always entirely clear outside of the main categories of product;

vi. The standards in each country/region are based on different test methods and so thresholds must be normalised first for fair comparison (this is done for all thresholds presented in this report);

vii. Thresholds from different countries are based upon evidence and local judgements that may not always be robust as there has been little co-ordination between regions to date. Hence some thresholds in any given country may not be fully appropriate for that country;

viii. Energy performance standards achievable by remote cabinets may not be achievable by integral cabinets (see section 3); and

ix. Only mandatory minimum requirements are analysed (voluntary and endorsement levels may be useful benchmarks but are not strictly comparable to MEPS).

2.2 Principles underpinning 'best in world' ambition

There is no single set of criteria that can be copied and adapted as a 'best in world' scenario, but a number of features should be considered to contribute to a robust and ambitious regulatory framework:

1. Closed cabinets offer far superior efficiency in the majority of applications[3] and so should be encouraged over open cabinets. Thresholds can be set such that only the best designed open cabinets can meet the requirement and so some open cabinets can remain on the market for applications in which they are essential, but the majority are removed.
2. Open cabinets should be on the same relative energy label scale and subject to the same ecodesign energy performance requirements as closed cabinets. This ensures transparency on relative performance for buyers as well as fair competition for products that fulfil the same basic function.
3. Time must be allowed for the EU market to adapt to the new test methods and to the performance standards, and so matching best in world may not be feasible within 2 years. It should, however, be feasible within 4 or 5 years.

2.3 Which region is 'best in world'?

There is no one region that could be classified as 'best in world'. However, there are eight countries that had mandatory minimum energy performance requirements for commercial refrigeration equipment at the end of 2013[4], as listed below:

1. Australia (since 2004). These are the longest established and are known to be ambitious for some product types. The first update is underway with no proposals published as of October 2014.
2. New Zealand (harmonised with Australia, since 2004).
3. Canada (only covering integral cabinets, since 2007). Updated standards were under development in 2012 but not finalised at October 2014.
4. Mexico (only covering integral cabinets, since 2009). No published analysis of levels identified.
5. USA (since 2010, some types). Revised standards for 2017 have been published. Shown to be highly ambitious in the CLASP analysis of August 2014.
6. Republic of Korea (since 2010). No analysis has been identified that compares these standards on a fair basis. Korea recently proposed a revision to their regulation.
7. China (since 2012). Not analysed.
8. Iran (since 2012). Not analysed.

[3] See the previous CLASP report on EU proposals (August 2014) for details of when this is not the case – which is in situations of very high rates of customer access (i.e., more than 60 door openings per hour). Report *Analysis of EU policy proposals for DG ENER Lot 12 Commercial Refrigeration* of 16 October 2014 available from the CLASP publication library at http://clasponline.org/en/Resources/Resources/PublicationLibrary.aspx?e=Europe&p=Commercial+Refrigeration.

[4] According to the global review 'Energy standards and labelling programs throughout the world in 2013', May 2014, Department of Industry, Australia.

A further four countries/regions have proposed measures (EU, Indonesia, Kenya and Vietnam) and one has a voluntary measure (Japan).

Only since 2012 has a significant effort been made to normalise and compare regulatory requirements for commercial refrigeration equipment across the different test methods (IEA 4E[5] and CLASP[6]) and thereby compare the stringency of the MEPS. The ranking of ambition was found to vary across the different cabinet types – there was no one region with the highest ambition across all types.

Whilst a number of reports document the scope and differences in test methodology across most of these sets of regulations, two have been identified that have attempted direct comparison of stringency on a fair (if approximated) basis[7]: The *Benchmarking report for Retail display cabinets*[5]; and the CLASP review of the EU regulatory proposals (August 2014)[6].

The IEA 4E retail display cabinet benchmarking report covers only integral vertical glass door chilled and integral horizontal ice cream freezer cabinets with standards compared for Australia, Canada and the USA. It shows the USA to have the more stringent requirements for these two types of cabinet, but is based on the USA standards of 2012 (which were published in 2009) and was written before those for 2017 were available.

The relative stringency of Australian, Canadian and US standards was analysed and compared for certain refrigerated cabinet types in the August 2014 CLASP report on EU proposals. This report provides some of the background for this analysis and is summarised on the following page in Table 1.

2.4 Defining EU MEPS to match 'best in world'

The thresholds that represent 'best in world' for the most common types of refrigerated display cabinets and vending machines are summarised on the next page in Table 1, along with explanation of why that threshold has been selected. A further consideration is clearly when the EU 'best in world' threshold might come into force. Table 1 does not suggest a date for entry into force in the EU, but does mention the date of entry into force in the country of origin.

The equation for the threshold stated in the original local policy is given in a format normalised as closely as possible to EN 23953:2005 with the 2012 amendment (in the case of supermarket cabinets). In addition, a reasonably close equivalent to that 'best in world' threshold is suggested in the format used for the EU regulatory proposals (using the proposed EU reference line[8] and EEI). This is either based on alternative reference lines proposed by the JRC in October 2014 (in the case of beverage coolers) or based on the DG ENER reference lines of June 2014 for all others.

'Best in world' proposals are given that are applicable to *remote* supermarket cabinets – equivalent proposals for integral cabinets can potentially be derived based on these and the evidence

[5] Benchmarking report for Retail display cabinets, IEA 4E Mapping and Benchmarking Annex, December 2012. Available from http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=9.

[6] Report *Analysis of EU policy proposals for DG ENER Lot 12 Commercial Refrigeration* of 16 October 2014 available from the CLASP publication library at http://clasponline.org/en/Resources/Resources/PublicationLibrary.aspx?e=Europe&p=Commercial+Refrigeration.

[7] A third report, from CLASP, does also set out methodologies to normalise test results from different test methodologies - *CLASP Commercial refrigeration equipment: mapping and benchmarking*, January 2014.

[8] Reference lines represents the efficiency (energy consumption vs total display area) of standard (EEI=100) cabinets for each category, as defined in Annex IV of the Commission Working Document of June 2014.

presented in section 3. Alternatively, these could be derived from empirical evidence on EU models and policies/data from other regions – where this exists.

Thresholds that appear best in world for other the types of cabinet appearing in the EU regulatory proposal – namely, vertical freezer; horizontal chilled; small ice cream freezer and gelato cabinets – have not yet had their ‘best in world’ standards determined.

Table 1. Summary of 'best in world' standards for some commercial refrigeration categories, along with an equivalent threshold based on proposed EU approach and terminology.

Cabinet type using EU segmentation	'Best in world' - most ambitious standard identified, with year into force	Local threshold kWh/24 hrs (normalised to EN 23953; TDA m^2; V litres)	Approximately equivalent to 'best in world' threshold defined using EU efficiency metric[9]	Comment and description of EU level that is approximately equivalent to best in world
Vertical chilled supermarket cabinets	Australia 2004 MEPS for vertical chilled remote glass door cabinets (RS4[10]). This is for CLOSED cabinets and so is more stringent than would be expected for only OPEN cabinets. See Figure 1.	9.50 x TDA	7.28 x TDA + 7.28 EEI = 80	Applicable to remote cabinets only. This is the line **of EEI 80 based on the DG ENER reference line of June 2014.** The EEI 80 line is slightly less stringent than 'best in world' for cabinets <3 m^2 TDA; slightly more stringent above that size. This would still allow the most energy efficient open cabinets to remain on the market. (Five Australian *open* vertical *integral* 3M2 cabinets of 2014 meet the Australian MEPS for remote closed cabinets, as well as many more that are closed – shown on Figure 1).
Horizontal frozen supermarket cabinets	US DOE 2017 (same as 2012), HCT.RC.L[11], for horizontal glass top remote cabinets. See Figure 2.	4.50 x TDA + 0.32	4.90 x TDA + 2.1 EEI = 50	Applicable to remote cabinets only. This is **EEI 50, or the B/C label class threshold using the DG ENER** reference line and label classes for horizontal freezers. It allows around 20% higher consumption than the 'best in world' level. This would force almost all horizontal freezer cabinets to be closed top. US appears content that this MEPS is fair, since it was not changed between 2009 and 2014 regulations.
Beverage coolers	US DOE 2017, PD.SC.M[12], beverage cabinets with pull-down capability. See Figure 3.	0.0044 x V + 0.91	0.0042 x V + 1.12 EEI = 70	Applicable to integral beverage coolers only. **This is the line with EEI of 70 based on a reference line of (0.006 x V + 1.6)**, as advised in personal communication by JRC on 9/10/14. The EEI 70 line is a close match to the 'best in world' level that includes pull-down capability.
Vending machines	US DOE 2012, class B[13] (partially cooled) federal MEPS, see Figure 4.	0.00258 x V + 2.56	0.003 x V + 3.075 EEI = 75	This is EEI 75, or the **B/C label class threshold, using the DG ENER** reference line and label classes for vending machines[14]. This EEI 75 line aligns very closely with the 'best in world'.

[9] EEI equation and values for M and N as defined in the WD from June 2014, except for beverage coolers.
[10] RS4 is defined as a remote self-service and storage closed cabinet – whilst this is not a close technical match to a chilled multi-deck, it is nevertheless a vertical chilled supermarket cabinet and is *functionally* an adequate match.
[11] HCT.RC.L is US DOE terminology for horizontal closed transparent top remote cabinet for low temperature (i.e. frozen) applications.
[12] PD.SC.M is US DOE terminology for self-contained medium temperature (i.e. chilled) glass door cabinet capable of meeting pull-down requirements (ability to lower the temperature of a given number of drinks containers inserted during a test within a given period).
[13] The US 'class A' MEPS level is more stringent, but is likely to be measured at a different temperature class to that used for EU models and so is not used as the benchmark.
[14] This aligns closely with the Tier 3 (2021) MEPS proposal by CLASP, using an alternative reference line, as per the August 2014 CLASP report on EU proposals.

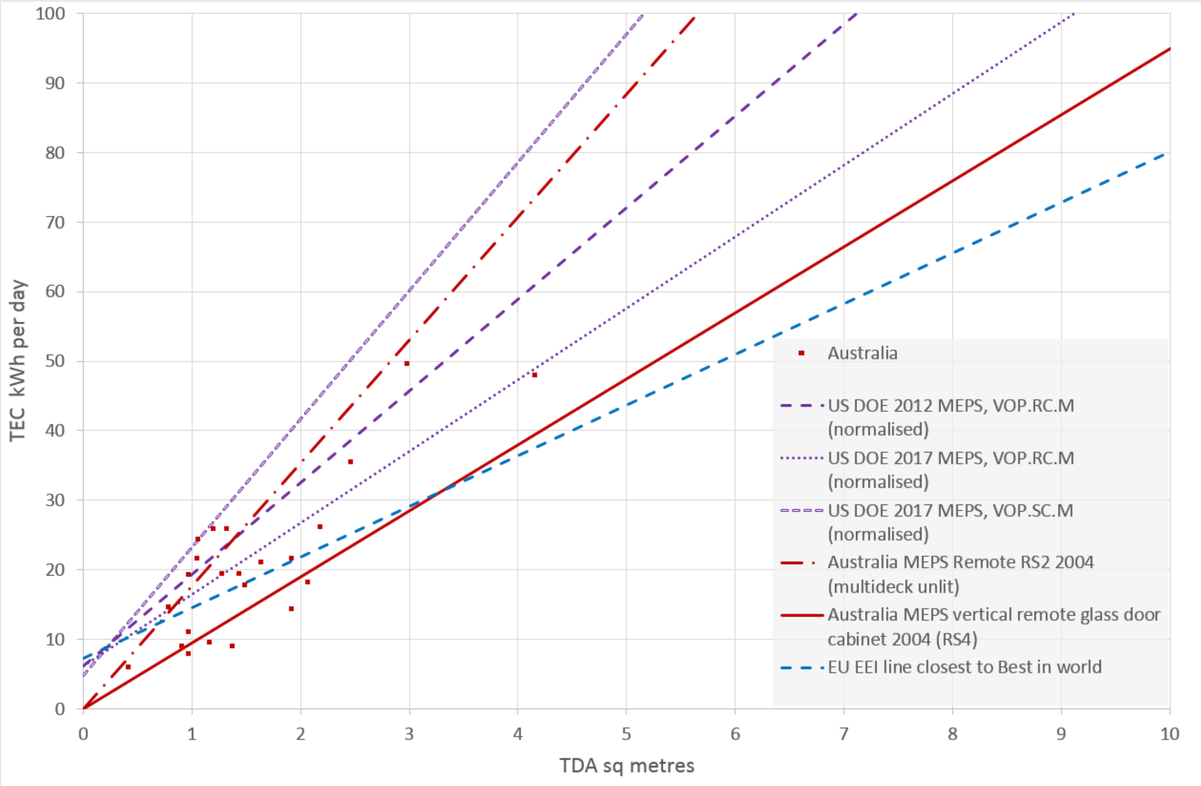

Figure 1. MEPS for vertical chilled supermarket cabinets. All thresholds are normalised to EN 23953 equivalent. US DOE MEPS of 2012 also shown, along with Australian open vertical integral chilled (3M2) cabinets of 2014.

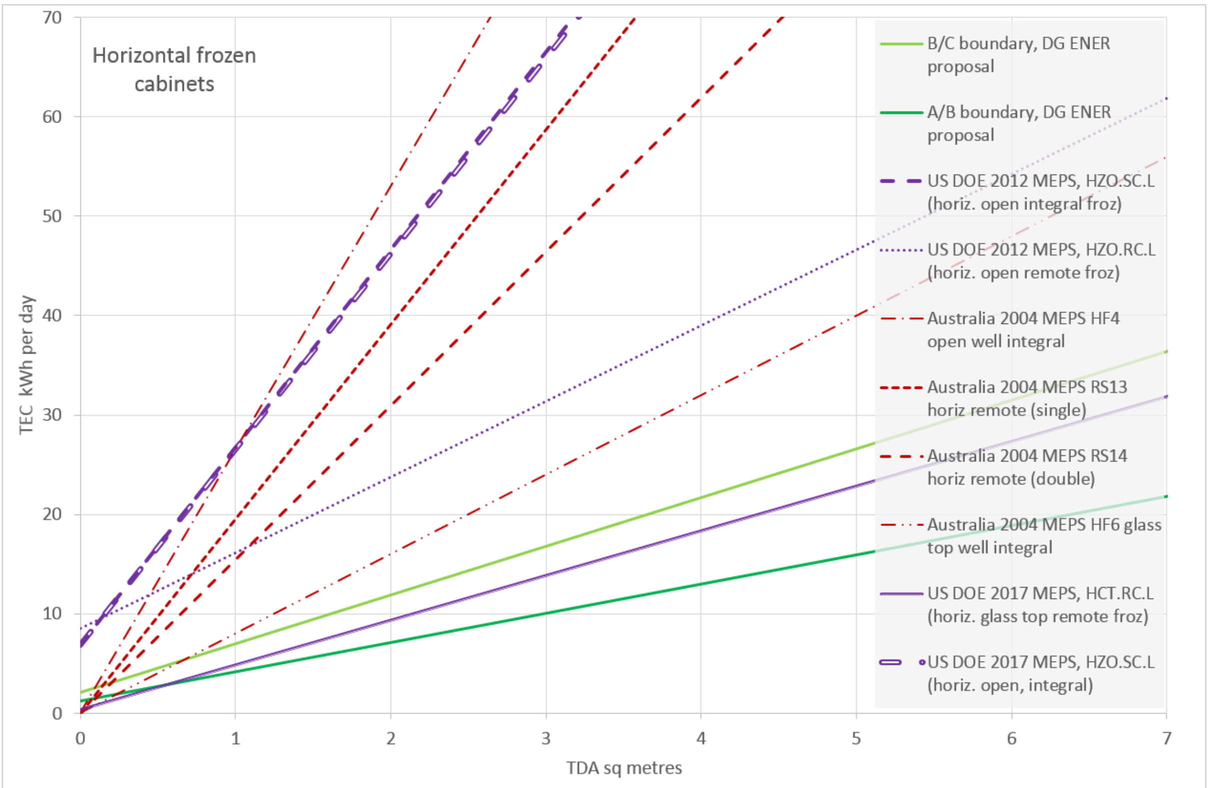

Figure 2. MEPS for horizontal frozen supermarket cabinets. All thresholds are normalised to EN 23953 equivalent.

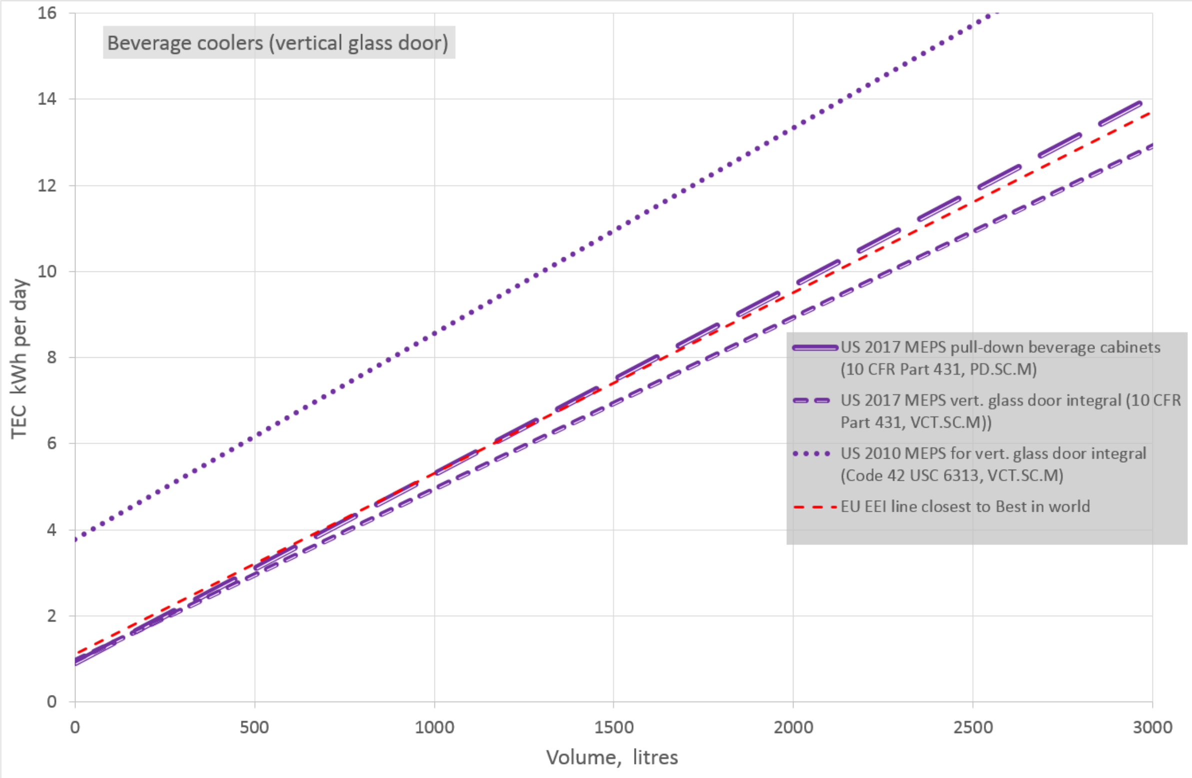

Figure 3. MEPS for beverage coolers (vertical chilled integral glass door cabinets). One threshold is shown for pull-down capability; other two for storage only. All thresholds are normalised to EN 23953 equivalent.

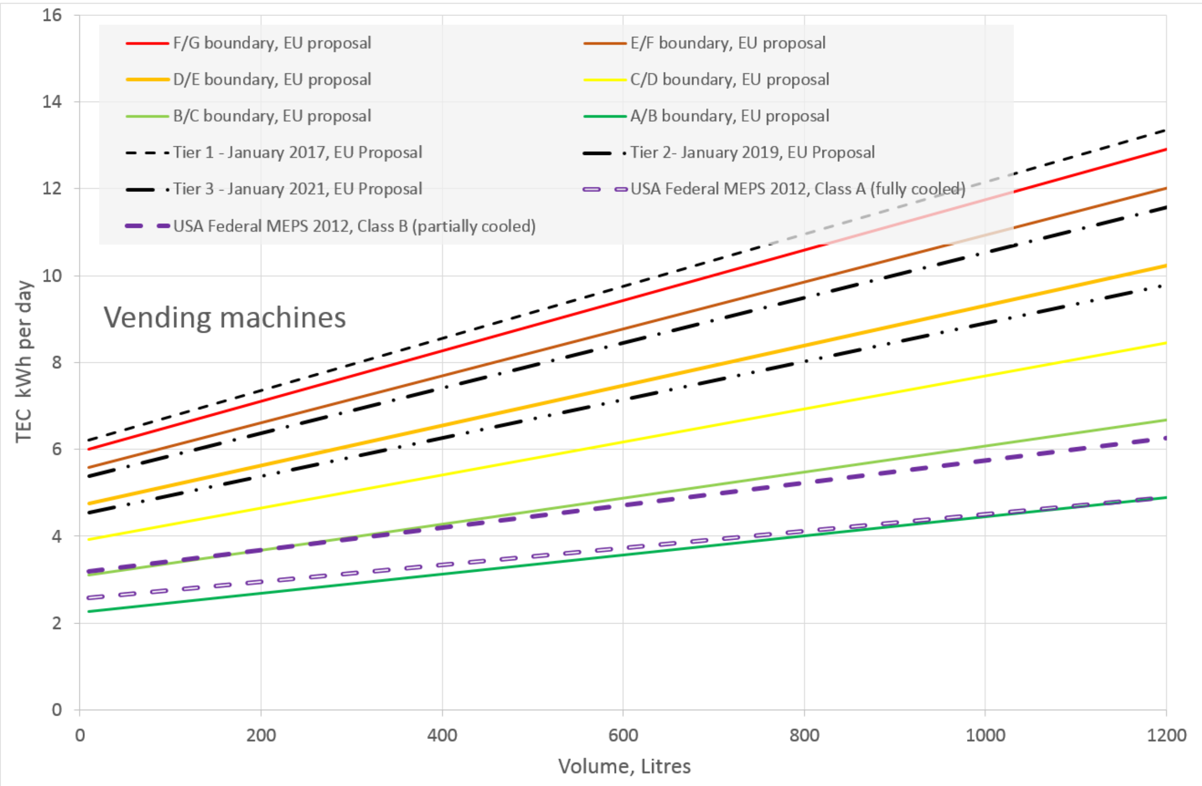

Figure 4. MEPS for vending machines from the USA, compared with the DG ENER proposed MEPS and label thresholds. No normalisation was deemed necessary. US DOE 2012 MEPS are shown.

3 Approach to deal with integral versus remote cabinets

3.1 How other regions deal with integral and remote cabinets

This section looks at how the standards set for integral and remote cabinet types compare in some other regions of the world.

It is the US comparison that is most significant in this analysis, as that is based upon the AHRI 1200 / ASHRAE 72 test method that more accurately reflects differences between integral and remote plant.

The Australian differences between integral and remote MEPS may stem from the very different approach to setting the standards that were used between those two – separate technical teams tackled them with different manufacturers and market survey data sets. This is despite the similarity of EN 23953 and the precursor test method on which the Australian standards are based (EN 441, now withdrawn in the EU).

The UK ETL programme is not a MEPS scheme, but has been included in this study as it does include standards for integral and remote cabinets.

3.1.1 Australian regulations

The Australian approach uses completely different requirements and nomenclature for integral and remote cabinets:

- Category names for integral cabinets are taken entirely from the EN 23953 families of cabinet[15] (VC2, HF5 etc.)
- Category names for remote cabinets follow a nomenclature unique to Australia (RS2, RS7 etc.). These have very little correlation with the remote categories of EN 23953.

It is also difficult to correlate the remote equivalent of integral types, and vice versa. In addition, the thresholds were developed separately using different evidence bases. The closest integral / remote equivalents of four selected types are shown in Table 2. Thresholds vary in relative stringency (integral to remote) from being 80% higher (less demanding) for the integral type of vertical glass door chilled cabinets, down to being almost equivalent in the case of open multi-deck cabinets and almost so for frozen vertical glass door cabinets.

Australian regulations for retail display cabinets are entirely based on the TDA metric and so provide no comparison for EU beverage coolers.

It is now apparent that the Australian standards set for integral cabinets in broad terms could have adopted a higher level of ambition since this category of commercial refrigeration equipment has a far higher proportion of products registered as 'high efficiency':

- In 2009 Australia had about 350 registered high efficiency integral cabinets compared with only 84 for remote cabinets[16]. This represents over 300% more 'high efficiency' integral models, although there were just 70% more integral cabinets than remote in the total registration database.
- Australia had 140 models registered as high efficiency for the integral glass door cabinets, twice as numerous as any other integral category (the allowance for glass

[15] Three families that appear in EN 23953 do not appear in the Australian regulatory definitions: those for serve over counters with closed service access.

[16] Source: in from the cold, strategies to increase the energy efficiency of nondomestic refrigeration in Australia and New Zealand, background technical report volume 1, October 2009, page 12-15. The report also notes that '*higher numbers of product are more efficient than the high efficiency Level however the option of having these listed as high efficiency has not been taken up*'.

door vertical chilled integrals is 80% less demanding than that for equivalent remote cabinets - see Table 2).

- Australia's database in June 2014[17] had 528 integral cabinets registered as "high efficiency" and only 182 "high efficiency" remote cabinets. This is 190% more "high efficiency" models when the total number of integral cabinet registrations in the database is only 66% more.

The disparity in the proportion of high efficiency models relative to the total number of models in the registration database suggests that the Australian criteria for integral cabinets may need to be made more stringent. This has further amplified the difference between the threshold values for integral versus remote shown in Table 2 (remembering that EN 441 / EN 23953 already includes an over-estimate of remote cabinet consumption and so requirements set as equal (integral vs. remote) would have built-in leniency to integral cabinets). Australia has a largely similar test method to Europe although based on EN441 which has longer door openings than EN 23953:2005 (Amdt 2012).

Table 2. Australian regulations: comparing selected types of cabinet of integral and remote types, where approximate equivalents exist.

Generic cabinet type	Specific integral cabinet type	Integral cabinet MEPS TEC/TDA kWh/24 hrs/m^2	Remote cabinet MEPS TEC/TDA kWh/24 hrs/m^2	Specific remote cabinet type
Chilled, vertical, open multi-deck cabinet	Chilled multi-deck, VC2 (M1 and M2 temp. classes)	15.5 (roughly equivalent to remote MEPS)	14.84	Medium open multi-deck, RS2, unlit shelves
			16.98	Medium open multi-deck, RS2, lit shelves
Chilled vertical glass door cabinet	Chilled, glass door vertical, VC4, class M2	17.5 (80% higher)	9.73	Self-service & storage closed cabinet, RS4, glass door
Frozen horizontal open cabinet	Frozen open top island site, HF4	26.5 (c. 45% higher)	19.48	Well-type single width cabinet, RS13, solid sided
			15.49	Well-type double width cabinet, RS14, solid sided
			19.29	Well-type double width cabinet, RS14, glass sided
Frozen vertical glass door cabinet	Frozen glass door, VF4, L1	44.0 (10% higher)	40.56	Medium self-service and storage closed cabinet, RS16, glass door
	Frozen glass door, VF4, L2	39.0 (3% lower)		

3.1.2 US regulations

The US approach in the US DOE's 2017 Final Rule uses a consistent notation across all cabinet types but mixes some cabinet types using TDA and others based on a volume based metric (using imperial units (e.g., ft^2 and ft^3) rather than metric (e.g., m^2, l)).

[17] According to the Australian E3 product data set downloaded in June 2014, available from http://reg.energyrating.gov.au/comparator/product_types/37/search/comprehensive/?

Allowances for integral cabinets are significantly higher in kWh/day than those for remote cabinets for the two types for which equivalent MEPS were identified – and this probably reflects the higher relative consumption of an integral unit compared with a similar remote unit, since the US test method provides a fairly robust calculation to account for remote plant consumption (whereas EN 23953 over-estimates remote plant consumption – see section 3.3). For a typical 3 m^2 (32 sq. ft.) TDA open chilled cabinet, the energy consumption allowance (kWh/day) is 70% higher for the integral version, and over twice as high for the frozen horizontal open cabinet.

The US DOE significantly increased the stringency of their requirements for closed integral cabinets between the 2012 and 2017 regulations[18] (e.g. 60% lower for VCT.SC.L[19] and 47% lower for VCT.SC.M[20] – far more so than for the equivalent remote cabinets: by 12% for VCT.RC.L[21] and 28% for VCT.RC.M). This implies that allowances for integral units in the USA were previously more lenient (relative to remotes), and have been tightened to this level of relative difference.

Table 3. US regulations for 2017: comparing selected types of cabinet of integral and remote types, where approximate equivalents exist (normalised items are to ISO 23953 and TDA in sq. metres).

Generic cabinet type	Specific integral cabinet type	Integral cabinet MEPS kWh/24 hrs (TDA in sq. foot)	Remote cabinet MEPS TEC/TDA kWh/24 hrs (TDA in sq. foot)	Specific remote cabinet type
Chilled, vertical, open multi-deck cabinet	Vertical open self-contained medium temp., VOP.SC.M	1.69xTDA+4.71 [normalised as 18.5xTDA+4.8] (70% higher for 4m^2)	0.64xTDA+4.07 [normalised as 10.3xTDA+6.1]	Vertical open remote medium temperature, VOP.RC.M
Chilled vertical glass door cabinet	Vertical closed transparent door self-contained medium temp., VCT.SC.M	[metric is by Volume not TDA]	0.15xTDA+1.95	Vertical closed transparent door remote medium temp., VCT.RC.M
Frozen horizontal open cabinet	Horizontal open self-contained low temp., HZO.SC.L	1.9xTDA+7.08 [normalised as 19.7xTDA+6.8] (120% higher for a 3m^2 TDA cabinet)	0.55xTDA+6.88 [normalised as 7.4xTDA+8.6]	Horizontal open remote low temp., HZO.RC.L
Frozen vertical glass door cabinet	Vertical closed transparent door self-contained low temp., VCT.SC.L	[metric is by Volume not TDA]	-	[no equivalent identified]

3.1.3 UK Energy Technology List criteria (voluntary tax break scheme)

The UK Energy Technology List (ETL) is a voluntary scheme in the UK that aims to identify the best 25% of cabinets on the market in terms of energy efficiency and offer consumers of these models a tax break. The absolute thresholds used in the UK ETL scheme are not comparable with the MEPS in

[18] See presentation at US Energy and Store Development conference, *DOE Case Standards Update*, Larry Howington, Hillphoenix Case Division, September 2014. Available from http://www.fmi.org/forms/meeting/Microsite/ESD2014,3, accessed 19 September 2014.
[19] VCT.SC.L is US DOE terminology for vertical closed transparent (VCT) self-contained (SC) cabinet for low (L) temperature (i.e. frozen) applications.
[20] M means medium temperature, or 'chilled' applications.
[21] RC means 'remote condensing'.

other regions, but they are included here simply as an additional barometer of relative performance.

Segmentation is only by EN 23953 temperature class and by integral/remote, for example, L1 integral cabinets of all configurations are subject to the same performance threshold.

For chilled temperature range cabinets the requirements for integral are 4% higher kWh/day, but for frozen cabinets the requirements for integral cabinets are much more demanding (35% lower). This situation does not to match expectations for relative performance and is due to be changed in 2015 (see below). The unexpected difference is probably due to the data on which the original criteria were based. Looking at product registrations[22] it is clear that chilled vertical cabinets account for just over 80% of registrations, and of them nearly 90% are of the remote type. This could imply that the requirements for chilled integral cabinets are relatively stringent, but is also affected by the fact that the market interested in the ETL (large retailers) is much more focused on remote cabinets. For the frozen cabinets, products in ETL indicate that registered frozen integral cabinets are mostly for point of sale *horizontal* units (often for ice cream) which are inherently efficient due to low loss of cool air and so it could be that a much tighter requirement was selected than would be possible for vertical cabinets. The frozen remote cabinets in the ETL are all of the vertical type.

The UK Carbon Trust has proposed to make their Enhanced Capital Allowance (ECA) thresholds for commercial refrigeration more stringent in 2015. The proposed thresholds are 12% to 62% more stringent and are proposed to be divided into vertical and horizontal types. The new requirements show less than a 5% difference in demand between equivalent integral and remote categories (note: reduced from the 35% mentioned in the preceding paragraph).

Table 4. UK Energy Technology List (ETL) criteria: comparing selected types of cabinet of integral and remote types.

Generic cabinet type	Specific integral cabinet type	Integral cabinet MEPS kWh/24 hrs/m^2	Remote cabinet MEPS TEC/TDA kWh/24 hrs/m^2	Specific remote cabinet type
Chilled, vertical, open multi-deck cabinet	Temperature M2, integral type	11.10 (4% higher than remote)	10.70	Temperature M2, remote type
Chilled vertical glass door cabinet				
Frozen horizontal open cabinet	Temperature L1, integral type	14.70 (35% lower)	21.10	Temperature L1, remote type
Frozen vertical glass door cabinet				

3.2 Evidence on relative performance of integral and remote cabinets

Expert input from refrigeration engineers as well as test results derived from US ASHRAE and AHRI test methodologies and the preceding comparison of MEPS in Australia and the US, as well as the UK ETL all suggest that remote cabinets should be able to operate at higher overall energy efficiency than integral cabinets. This potential for better performance with remote refrigeration cabinets is because:

[22] Data is accessible at https://etl.decc.gov.uk/etl/site/etl.html.

- Condensers and other components are space restricted for integral plant but smaller condenser heat exchanger means lower efficiency;
- Remote systems enable the cooling load to be shared and system optimised across many cabinets
- The remote plant shared across many cabinets also justifies proportionally higher investment in controls and other condenser-related components; and
- Remote systems can take advantage of lower ambient temperatures in autumn/winter as condensers are usually outside.

Conversely, the pressure losses due to longer pipework in remote systems can be minimised by careful design but this particular loss cannot be reduced as low as that found in integral (close coupled) cabinets.

However, test results[23] with energy consumption calculated according to EN 23953 indicate no significant difference between integral and remote multi-deck cabinets; or between integral and remote full glass door cabinets. This is because of the assumptions about efficiency of condensing plant that are embedded in the EN 23953 calculations (see following section). This apparent equivalence of integral and remote energy consumption under EN 23953 means that MEPS for Europe (where the harmonised standard is EN 23953:2005 AMDT 2012) should be set at the same level for integral and remote cabinets.

Eurovent suggests a correction factor of 1.1 higher energy consumption for an integral cabinet compared with an equivalent remote cabinet, but CLASP's experts do not believe a correction factor is needed. Although the compressor efficiency data on which this is partly based has not been specifically verified, there is no reason to doubt it. However the key factor is the assumption that the typical condensing temperature for an integral cabinet is 40°C. Whilst this is reasonable for a condenser without a fan (as for most domestic refrigerators), it is too high for the fan-assisted condensers as used on most commercial plant. A figure of 35°C is more typical and would give more efficient operation for integral units than estimated by Eurovent. Furthermore, this lower condensing temperature cancels out the additional 10% energy allowance (factor 1.1) proposed by Eurovent. The Eurovent analysis also misses the point that the calculation of refrigeration energy consumption (REC, for the remote plant) incorporated in EN 23953 is flawed – see following section.

3.3 Flaw in EN 23953: 2005 calculation for remote cabinets

The methodology in EN 23953: 2005 for estimating the efficiency of remote plant, specifically the method to estimate the refrigeration energy consumption or REC, appears to be based on old and possibly inaccurate data. Modern remote plant is around 50% more energy efficient (lower consumption) than the estimates provided for in EN 23953:2005 (based on UK data – figure could be lower for southern Europe, see Annex 1)[24]. EN 23953 includes a calculation formula for remote energy consumption (REC) with a factor that represents the efficiency of the remote plant as '0.34', which is based around a coefficient of performance (COP) of 2. When this is compared to more recent sources of COP data for retail remote plant, figures ranging from COP of 3 to 3.75 are now typical (for chilled plant; 1.75 for frozen plant). See Annex 1 for more details.

If the calculation methodology for EN 23953 is updated to better reflect performance of modern plant, then the calculated energy consumption of remote cabinets could reduce by as much as 50%. It will then be more closely aligned with the results from the US AHRI 1200 / ASHRAE 72 test methodology. This means that the MEPS for remote cabinets would have to be adjusted by a similar proportion to maintain equivalent stringency (those for integral cabinets would not be affected by

[23] RD&T data covering a total of 40 tests (24 remote and 16 integral) to the EN23593:2005 standard over a period of November 2009 to July 2014.

[24] Also supported by anecdotal evidence that retailers typically use a reduction of 30-40% from EN23953 results when estimating real in-store consumption.

this change). Making such an adjustment to the European proposals brings the remote / integral cabinet MEPS ratio fairly closely in line with that of the US.

3.4 Conclusion regarding relative MEPS between integral and remote cabinets

Based on the current version of EN 23953, there is no convincing case to set MEPS for integral cabinets at a different level to equivalent remote cabinets. The 2015 update to EN 23953 is not expected to change this issue, but a future update is highly likely to do so (such a move to become more like the AHRI 1200 approach has already been informally discussed in the standards committee). This difference in calculation method is consistent with the evidence on parity from the available (but limited) EU cabinet test data. Differences between integral and remote MEPS seen in the USA regulations reflect the more representative efficiencies assumed for the remote plant in the AHRI 1200 /ASHRAE 72 standards.

When EN 23953 is updated to better reflect the efficiency of modern remote plant, then the MEPS for remote plant will have to be adjusted by the same proportion (possibly as much as 50% lower daily consumption). This reinforces the case for separating requirements for integral and remote cabinets in the regulation at the outset and is an item that should get particular focus at the time of review of the regulation. The Commission may also wish to include a request for better estimates of modern remote plant performance in a Mandate issued to CEN/CENELEC to help support the review of the regulation.

4 Potential over-estimate of energy consumption and savings for supermarket cabinets

The basis of the Eurovent case for the preparatory study having a substantial over-estimate of the energy consumption and also energy savings has been investigated. It is derived from a conference paper presented in 2011[25] that was written by Eurovent committee members, and subject to a degree of peer review. The paper uses evidence from the testing of 2 cabinets in 2 different stores and found that the cabinets consumed between 28.1% and 57.5% less energy in the store when compared to the test room. The range of variation suggests that store conditions are quite variable and to fully predict the energy savings a deeper in depth analysis of conditions in stores in Europe would be needed, and the difference between test room and store conditions will vary depending on location and time of year.

Anecdotal evidence suggests that when retailers wish to make an estimate of the cooling duty required for their retail space, they will take the manufacturers declared consumption data under EN 23953 and reduce those lab test figures by 30% to 40%. This gives them a cooling duty (demand) figure that is more accurate for sizing of the remote condensing plant. It therefore seems realistic that the energy consumption for supermarket cabinets estimated in the Preparatory study should be corrected by a similar factor of around 40%.

The conclusion is that the Eurovent suggestion that real consumption and savings will be 50 to 60% lower than the preparatory study estimate is at the top end of the range indicated by available evidence. A reduction of 40% is a more appropriate average figure.

[25] Mousset, S. and Libsig, M. Energy consumptions of display cabinets in supermarket. ICR 2011, August 21 - 26 - Prague, Czech Republic.

5 Steps to minimise gaming of results

The DG ENER draft omitted specification of storage temperature classes at which the requirements shall be measured. This has to be specified as a primary consideration to reduce scope for manufacturers to make ‘favourable interpretations’ of energy results. One approach would be to specify an EN 23953 temperature class, such as M2 for chilled and L1 for frozen. The ambient temperature class is appropriately specified in Annex IX of the Working Document.

Beyond these two fundamentals, there are many further considerations that would further improve the robustness and comparability of results between tests and between manufacturers – the more important of these are detailed in Table 5, with possible clarifications.

The Eurovent Certification Programme for refrigerated display cabinets includes a 12 page rating standard for certification[26] that specifies the exact conditions under which testing must be carried out. This rating standard was produced with a similar aim to improve comparability of test results and sets out the requirements for which EN 23953 allows options or is not specific.

In a similar way, an EU ‘good practice guidance document’ could be envisaged for Lot 12 that sets out to specify or limit areas of doubt or excessive flexibility in testing for the ecodesign regulation.

Further consideration must be made as to how any guidance or clarification could best be delivered to manufacturers and test houses, but options include:

- Inclusion in a Commission Communication
- Inclusion in the regulation (not preferred for highly technical issues)
- Covered by best practice guidance published by industry association(s)

Industry ownership of the guidance would be ideal to ensure its acceptability and maintenance to keep pace with best practice, evolving technologies and test methods. We suggest that the Commission may want to highlight the existence of detailed guidance and encourage its use in a Commission Communication to ensure that manufacturers are aware. Some of the more important aspects could be made clear in the regulation.

In Table 5, use of the word ‘shall’ implies that the action is seen as mandatory; ‘should’ implies a desirable but optional action, in line with standard wording for test methodologies.

[26] Eurovent Rating Standard For The Certification Of Remote Refrigerated Display Cabinets, Eurovent Certification Company, RS 14/C/001-2012 Issued May 2013, available from http://www.eurovent-certification.com/en/Certification_Programmes/Programme_Descriptions.php?lg=en&rub=03&srub=01&select_prog=RDC

Table 5. Areas of EN 23953 and associated aspects that remain open to interpretation, with suggested clarifications that would reduce or remove doubt.

	Issue	Suggested clarification
1.	Rounding of all figures. Currently it is not clear whether rounding of numbers is accepted. For example the M1 temperature classification states that all 'm' packs must be within 5 and -1°C throughout the test period. If rounding is allowed temperatures between 5.49 and -1.49°C would be allowed.	**Suggested for the regulation:** Accept that rounding of declared parameters is allowed. (The alternative is to clarify the number of decimal points for each measurement within EN23953 but this would be impractical).
2.	Manufacturers and test houses can be confused between measurement accuracies and uncertainties. Many test facilities interpret accuracy as the inherent accuracy of the sensor. Specifying accuracy of measurement can be misleading (accuracy is a measure of the agreement of a particular measurement with the true value of the parameter under the conditions and has a sign that indicates whether the experimentally measured value is high or low).	**Suggested for the regulation**: Ensure that the content and wording of regulation and test method are in line with the recent guidance developed for ecodesign (including reference to ISO 5725-1).
3.	Number of shelves fitted in the cabinet model being tested – since having a large number of shelves acts to improve the flow of the air curtain and so can improve the achieved efficiency; having larger gaps between shelves usually entrains more air and so reduces efficiency.	**Suggested for a guidance document:** That the number of shelves included for test should reflect the cabinet configuration as typically sold.
4.	Data currently in circulation in technical documentation could have been obtained through use of several test methodologies and versions. It is possible that manufacturers remain unclear as to which version should be used.	**Suggested for a guidance document:** To specify exactly which test method and version is expected to be used for results under the labelling and ecodesign requirements.
5.	Refrigerants with glide. Refrigerants such as R407A and R407F are becoming more common and they have 5-6°C of glide. Currently the evaporating temperature (used for the REC calculation) is not defined. For a cabinet without glide it is assumed to be the saturation temperature at the pressure measured at the outlet of the evaporator. For refrigerants with glide the evaporator will have a temperature range from inlet to outlet as the bubble point (liquid pressure) and dew point (vapour pressure) temperature will be different. If the evaporating temperature is assumed to be the dew point, this gives refrigerants with glide an added advantage when compared to refrigerants that have no glide. This is because the dew point temperature will be higher than the average evaporating temperature causing the REC to be lower.	Ideally the evaporating temperature of refrigerants with glide should not be calculated as the dew point temperature. **Suggested for a guidance document** Either a log mean temperature difference throughout the evaporator shall be calculated or a mean shall be taken of dew and bubble point temperatures (or more correctly a mean of evaporator inlet and outlet enthalpies).
6.	Sub cooling of refrigerant. EN23953 does not prescribe the condition of refrigerant entering the evaporator in any great detail. In section 5.3.2. the standards states '*Liquid refrigerant inlet condition. The liquid refrigerant temperature at the cabinet inlet shall not be more than 10°C above the specified test room temperature*.' For all refrigerants the level of sub cooling can therefore vary. In particular for a refrigerant with glide the level of sub cooling has an effect on temperatures within the evaporator and more sub cooling is a benefit as there will be a greater refrigeration capacity.	**Suggested for the regulation:** The amount of sub cooling inherent in the declared efficiency shall be listed on the product fiche.
7.	Use of REC_{75} and REC_{RC}. These are alternative approaches to calculation allowed in EN 23953. There is sometimes an unwarranted benefit (improved efficiency figure) in presenting REC data as REC_{75}. This is particularly the case if a cabinet has a large pull down after defrost.	**Suggested for a guidance document:** Use REC_{RC} as the calculation method. This is commonly used (apart from ECA scheme in UK).

	Issue	Suggested clarification
8.	Test room temperature, humidity and air velocity – EN23953 specifies a range of allowable conditions in the test facility. Running the test room at the minimum allowance can be beneficial.	**Suggested for a guidance document:** Make it clear to manufacturers that compliance testing will be carried out as close to the mean of the allowable range.
9.	Currently no time is prescribed for the time between initial 3 minute door openings and cyclical door openings for full glass door cabinets. Generally the time lag is interpreted as either the time interval for the cyclical door openings or that there is no time lag. However, there is nothing preventing several hours being left between the initial and cyclical door openings. This would give cabinets a better chance to recover from the initial door openings and potentially reduce maximum temperatures in the test.	**Suggested for a guidance document:** Prescribe a time lag between initial and cyclical door openings.
10.	The method to calculate TDA (Total Display Area) currently ignores ticket strips and risers on shelves. Adding risers to shelves has an advantage as it reduces air entrainment in an open fronted cabinet by reducing its open area. Currently shelf risers covering all the shelf opening would not reduce the cabinet TDA. Ticket strips may have a benefit of assisting air to be ducted better. The risk is that a manufacturer could use excessively large risers to reduce energy consumption during a test, when such risers actually make shelf access difficult and so would never be used in practice. However, moderate or small risers are useful both to ensure product does not fall from shelves and also to improve air flow slightly and so are useful features that should not be totally discouraged. They could also of course be transparent and so still allow product to be seen.	**Suggested as a change to the standard:** Exclude (or define a maximum for) the area of ticket strips and risers from the calculation of TDA. [This is likely to be addressed in the 2015 version of EN23953].
11.	Cabinet glazing factor. Cabinets with glass doors have a glazing factor applied to the TDA calculation. In terms of the TDA calculation the poorer the glass transmission the lower the TDA value. As lower transmission glass generally has a better insulation effect, this negates some of the effect of more energy efficient glass in the TEC/TDA calculation.	**Suggested as a change to the standard:** Remove the glazing factor from TDA calculations. [This is being addressed in the 2015 version of EN23953].
12.	Use of tylose test packs versus filler packs. Tylose test packs have a greater thermal mass than filler packs. When testing there is usually a benefit of thermal inertia in a cabinet as this helps reduce temperature fluctuations in the cabinet and in particular overcomes dynamic transitions such as door openings.	**Suggested for a guidance document:** Clarify to manufacturers whether filler packs will be used in compliance tests. An alternative is to assume the worst case scenario which is for the maximum number of filler packs to be loaded into a cabinet.
13.	Shelf loading. Cabinets with shelves in open multi-deck cabinets can be fully loaded or light loaded (loaded to 2 test packs high). Generally there is an advantage in fully loading shelves as this prevents the air curtain bending into the cabinet and drawing in warm ambient air. However, there is occasionally an advantage in light loading if the air from the cabinet back panel is needed to cool packs.	**Suggested for a guidance document:** Specify that only cabinets with sloping shelves should be light loaded and that all horizontal shelves shall be fully loaded. Alternatively (**in the regulation**) require a description on the product fiche of the loading pattern of products used to obtain the declared efficiency.
14.	Time intervals for measurement of 'm' packs and test room conditions. EN23953 states that 'All the temperatures are checked every 60s.' However, no timescale is provided for measurement of refrigerant mass flow rate, inlet/outlet temperature and inlet and suction pressure. Therefore it might be possible to select measurements that are favourable for the performance of a cabinet.	**Suggested for a guidance document:** Specify a logging interval for all measurements (maximum 60 s - note 20 s is stipulated for REC measurements).

	Issue	Suggested clarification
15.	All tests must be begun after a stable 24 hour period. The definition of stability is; 'A cabinet is considered to operate under stable conditions if, during a period of 24 h, the temperature of each M-package agrees within ±0.5°C at the corresponding points on the temperature curve'. For some cabinets ±0.5°C is not sufficient to guarantee stability. This is in the case of cabinets that stabilise very slowly (e.g. large chest freezers) or where test packs are passing through the latent heat plateau.	**Suggested for a guidance document:** Specify that there must not be any general trend to increase or decrease temperature.
16.	The well in multi-deck cabinets can be square or angled loaded. There is generally an advantage in angled loading as the top packs are further in to the cabinet and therefore in a colder region.	**Suggested for a guidance document:** Specify that cabinets shall be square loaded unless there is a marked load line specifying an angled loading.
17.	In the experience of test houses, cabinets provided for testing to derive technical data are often slightly modified or specifically selected for testing. This can make their performance better than a cabinet randomly selected from the production line.	**Suggested for a guidance document:** Clarify that cabinets randomly selected from the production line will be subject to compliance testing.
18.	No details of the method to calculate REC is provided. The values can be calculated from mean input values or can be calculated at each time measurement step.	**Suggested for a guidance document:** Specific that REC should be calculated at each measured time step.
19.	No reference for thermal properties of refrigerant used for REC calculations is given.	**Suggested for a guidance document:** Specify that NIST[27] refrigerant properties should be used.

[27] This refers to the US National Institute of Standards & Technology (NIST) Standard Reference Database 23 - Thermodynamic and Transport Properties of Refrigerants and Refrigerant Mixtures Database: Version 6.0 or later. See http://fluidproperties.nist.gov/ or http://www.nist.gov/.

6 Steps to minimise burden of testing for manufacturers

Regulatory requirements will result in the need for more product testing than for the existing market. This is not new to ecodesign, or unique to retail display cabinets. Several options exist to minimise the burden on manufacturers, particularly thinking of SMEs that may at the outset, and even after an accommodation period, lack the technical and financial resources to carry out the necessary product re-design and testing. One or several of these approaches could be applied in conjunction. Similar topics were discussed extensively under DG ENTR Lot 1 Professional Refrigeration.

The premise is that a requirement to test all products is untenable as some are produced in very small numbers. Features that are often altered to give rise to variants are:

- Temperature settings
- Dimensions
- Refrigerant
- Evaporator fan motor type
- Defrost method
- Lighting
- Shelf number and arrangement
- Door seals
- Cosmetic differences

Most of these (except cosmetic differences) could affect energy efficiency to a greater or lesser degree and this must be taken into account when setting the guidelines for representative cabinets.

The revenue from products sold in large quantities would justify a reasonable amount of testing, but it could be challenging to decide when special concessions should be accepted for products sold in low numbers.

Having reviewed these various approaches, the simplest and most directly applicable for ecodesign regulatory purposes is text similar to that used for DG ENTR Lot 1, see section 6.2. This does not preclude the use of much more specific 'best practice' guidance regarding representative models and extrapolation processes. This could include lessons from the UK ECA scheme (section 6.1), and/or from the US AEDM approach (section 6.4). It seems clear that the Australian deemed to comply provisions (section 6.5) are not appropriate for EU use. The Eurovent certification approach on this issue (section 6.3) is not explained in publicly available documentation.

6.1 Representative models and cabinet families

The approach of 'representative models' is used in the UK ECA scheme for display cabinets[28] and also for most other product categories. The basic premise is that:

> "Where applications [to be listed on the scheme] are being made for two or more products that are variants of the same basic design, test data may be submitted for a representative selection of models, provided that all variants:…"

The requirements go on to list some specific conditions under which the representative model may be used – as shown in Table 6. Further consideration of these issues would be needed to make the criteria more robust for an EU regulation.

[28] See https://etl.decc.gov.uk/etl/site/etl/browse-etl/refrigeration/refrigerated-display-cabinets/criteria.html?SUB_TECH_ID=65.

Table 6. Extract of the UK Energy Technology Criteria List showing the conditions under which representative models of refrigerated display cabinet may be selected (from Table 3 of that document, page 178).

Variation between models	Selection rule
Cosmetic differences to the exterior	Any model may be selected to be the representative model.
Heaters (door, trim etc.), fans, defrosts, lighting and other accessories	The model with the greatest direct electrical energy consumption (DEC) must be the representative model.
Temperature level	The model with the lowest temperature setting must be the representative model.
Length	The representative model must be either 2.44 or 2.5 metres in length. This length of model can only be used to represent models between 1.8 m and 5m in length; and separate data must be submitted for each model outside of these limits.
Cabinet depth	The model with the greatest cabinet depth must be the representative model.
Shelves	The model with the lowest number of shelves must be the representative model.
Front-opening height (throat):	The model with the largest front-opening height (throat) must be the representative model.
Two or more of the above variations	The rules set out above must be combined when selecting the representative model

Additional safeguards are given:

> "It should be noted that:
> - If a manufacturer voluntarily removes the representative model from the Energy Technology Product List (ETPL) then other products linked with that representative model may or may not be permitted to remain on the ETPL.
> - If any product submitted under these representative model rules is later found not to meet the performance criteria when independently tested, then all products based on the same representative model will be removed from the ETPL."

A further piece of guidance for 'representative cabinets' is that the cabinet used for test should have a number of fans per metre length that is typical of the figure in cabinets as sold (relevant to remote cabinets that may be sold in almost any length).

The premise is that one test can cover a family of variants, where the representative model consumes the most energy of the defined family. Guidelines could be agreed amongst suppliers about what features are allowed to change and by how much before a cabinet can no longer be considered one of the family (Table 6 could be used as a starting point). Such rules could be included in good practice guidelines published by industry, or possibly included in a harmonised test standard. Guidelines are also required about which model must be tested from the family and about adjusting baselines, re-evaluating with expansion of families over time.

6.2 Provisions as used under DG ENTR Lot 1 professional refrigeration

In common with many ecodesign regulations, that for professional storage cabinets and blast cabinets includes the concession that declared efficiency may be obtained by calculation or extrapolation.

This appears in Annex II of the draft regulation submitted to WTO in February 2014 and requires that the technical documentation must contain this, amongst other elements:

> "Where the information included in the technical documentation file for a particular model has been obtained by calculation on the basis of design, or extrapolation from other equivalent refrigerating appliances, or both, the documentation shall include details of such calculations or extrapolations, or both, and of tests undertaken by suppliers to verify the accuracy of the calculations undertaken. The information shall also include a list of all other equivalent models where the information was obtained on the same basis."

This text could be included in the regulation for refrigerated display cabinets as well.

6.3 Eurovent certification approach

Eurovent has developed a substantial set of requirements[29] for manufacturers to certify the performance of cabinets. Certification is voluntary and it is worth noting that only two manufacturers have maintained their membership of Eurovent Certification under the new criteria that were adopted in May 2013 (one manufacturer is listed under two of its brand names). Both are French and many French retailers require Eurovent Certified products to be used in their stores. The Eurovent Programme Description web page, the Operation Manual for Certification and the Rating Standard do not include any specific reference to how representative cabinets shall be chosen. It is therefore not clear how any arrangement for representative cabinet testing works under Eurovent Certification.

6.4 US AEDM

In the USA, DOE gives each manufacturer significant freedom to develop their own alternative efficiency determination method (AEDM). DOE published a Final Rule on AEDMs for commercial refrigeration[30] in December 2013 after nearly a year of discussions between DOE, manufacturers, trade associations, energy advocates and end users.

The Final Rule states that "AEDMs are computer modeling or mathematical tools that predict the performance of non-tested basic models". It goes on to explain:

> "[AEDMs] are derived from mathematical models and engineering principles that govern the energy efficiency and energy consumption characteristics of a type of covered equipment. These computer modeling and mathematical tools, when properly developed, can provide a relatively straight-forward and reasonably accurate means to predict the energy usage or efficiency characteristics of a basic model of a given covered product or equipment and reduce the burden and cost associated with testing."

And furthermore that:

> "Where authorized by regulation, AEDMs enable manufacturers to rate and certify their basic models by using the projected energy use or energy efficiency results derived from these simulation models in lieu of testing."

The guiding principle is to have a basic energy model of a family of case products that allows algorithms to be developed that are supplemented by empirical lab test data. The basic model is defined as:

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[29] All requirements, including the certification manual, are obtainable from http://www.eurovent-certification.com/en/Certification_Programmes/Programme_Descriptions.php?lg=en&rub=03&srub=01&select_prog=RDC.

[30] Energy Conservation Program: Alternative Efficiency Determination Methods, Basic Model Definition, and Compliance for Commercial HVAC, Refrigeration, and WH Equipment, 10 CFR Parts 429 and 431, [Docket No. EERE-2011-BT-TP-0024] RIN 1904-AC46, US Department Of Energy. Appeared in Federal Register/Vol. 78, No. 251, Tuesday December 31, 2013, 79579.

> "Basic model means all commercial refrigeration equipment manufactured by one manufacturer within a single equipment class, having the same primary energy source, and that have essentially identical electrical, physical, and functional characteristics that affect energy consumption."

The idea is to allow testing of a reasonably small sample of products from the family and produce accurate published data (working within a 5% tolerance). A manufacturers range is made up of multiple cabinet families. DOE asserts that a basic model cannot extend across (or represent) multiple equipment classes under the regulation.

The Final Rule specifies a validation process for AEDMs. This includes a minimum number of basic models that must be tested to validate the AEDM (which is 2 for each type of refrigerated cabinet where a 'type' might be 'Self-Contained Open Refrigerators' for example); tolerances and certified ratings. It also sets out a verification process to be followed by DOE and consequences of an invalid rating being found. Finally, the Final Rule sets out statistical accuracy criteria that samples of declared values must meet (mean value of samples etc).

6.5 Australian 'Deemed to Comply' Provisions

One solution proposed in Australia[31] is that a variant must include certain features and specified components that meet minimum performance levels which together ensure that the product should achieve a pre-decided level of performance. The proposal is based on building these refrigeration cabinets with components that are in themselves highly energy efficient. DG ENTR has previously indicated that this approach, in which technology options are stipulated, is highly undesirable for a regulation[32] – not least because it could inadvertently reduce the scope for innovation.

[31] See http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Library/Refrigeration/Commercial_Refrigeration/200912a-in-from-the-cold-technical-vol1.pdf pages 8 and 45.

[32] Personal correspondence with the author during the impact assessment study for professional refrigeration in 2012.

7 Impact of regulations on SMEs in the EU

7.1 Proportion of the commercial refrigeration market accounted for by SMEs

This section includes interpretation of some material that appears in the BioIS preparatory study[33], as well as additional insight. It is difficult to find statistics listing the number of commercial refrigeration SMEs. Eurostat (2008[34]) suggests that 43% of the commercial refrigeration retail trade and repair category businesses are accounted for micro SMEs; 7% by medium SMEs. The majority of the EU market was held by 5 large manufacturers holding 67% of the market in 2007 and 62% in 2006 (adapted from RD&T internal sources). Figure 5 shows the main manufacturers and distributors of commercial refrigerators and their approximate market share in Europe.

Greater market fragmentation is observed in the plug-in market, which is believed to be split between more than 50 manufacturers in the EU, with the Austria-based AHT being a major manufacturer of integral units (Bio Intelligence Service, 2007; Greenpeace, 2012).

Refrigeration equipment is also produced in the mature markets of Western Europe, Japan and the US; however, there has been an increase in manufacturer from countries with low labour costs, such as Eastern European countries and Turkey, which aim to compete on price (Bio Intelligence Service, 2007).

The major manufacturers in the integral and the remote commercial refrigeration markets tend to differ although it is more common for larger manufactures to produce integral and remote cabinets. Generally within the EU, manufacturers of remote cabinets are located in Italy, France, Germany, the Czech Republic and Hungary whereas manufacturers of integral cabinets tend to be found in Italy, Germany, France, Sweden and Spain.

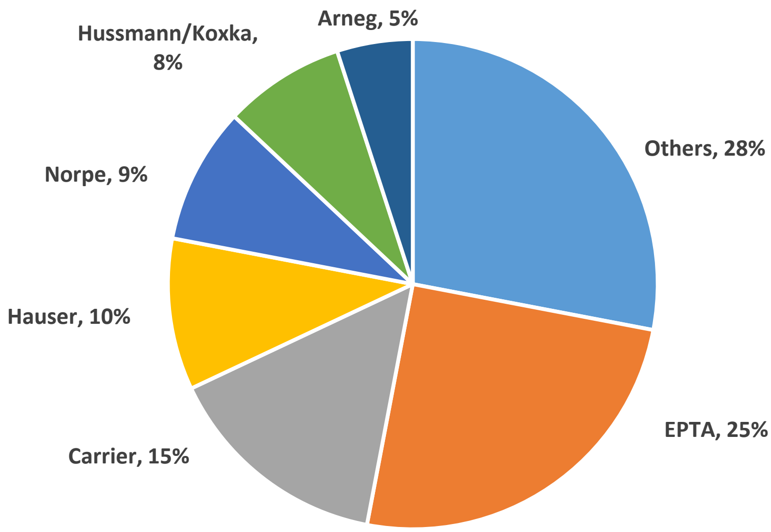


Figure 5. Market share of manufacturers and distributors of retail display cabinets in Europe (adapted from RD&T internal sources). SME's would fall within the category of 'others'.

[33] Bio Intelligence Service (2007). Preparatory studies for eco-design requirements for EuPs: Commercial refrigerators and freezers. Retrieved from https://www.energimyndigheten.se/Global/F%C3%B6retag/Ekodesign/Ekodesign/Kyl%20och%20frys/EuP_Lot_12_Final_Report.pdf.
[34] Eurostat. Statistics in focus. Industry, trade and services. Author: Manfred Schmiemann, 31/2008.

7.2 Technical competence of SMEs compared with large manufacturers

Most medium sized SMEs are likely to develop their own cabinets and to have some form of design and testing capabilities. Small enterprises may have some testing and development expertise but this depends on whether the company is primarily a manufacturer or a distributor. Distributors rarely have detailed engineering knowledge of their products and reply on their manufacturers to provide information. Small SMEs who manufacture their own products often do have design expertise, although this may be contained within 1 or 2 critical staff. They may have test facilities ranging from fully compliant with test standards to no ability to test and optimise designs. Micro SMEs tend to be either entrepreneurs who often have great knowledge of their products, distributors or companies who manufacture limited bespoke equipment. These companies rarely have test facilities, although occasionally they will have simple quasi facilities that they have developed themselves.

The technical competence of SMEs is very variable. There appear to be several types of SMEs that sell commercial cabinets:

1. Larger SMEs who have their own test facilities and experienced engineers to operate the rooms and develop the cabinets (mainly medium and small SMEs). These companies often have equivalent knowledge and experience to large companies. They however, may not have access to more expensive equipment or design capabilities (e.g. CFD modelling).
2. SMEs that sell cabinets manufactured elsewhere and so do not have any detailed knowledge of how the cabinets were designed (distributors).
3. SMEs that developed from companies who cut metal and made metal shelves or components. Often these companies have less experience of refrigeration design and air flow optimisation. They often do not have test facilities and have less knowledge of design and optimisation of cabinets.
4. There are other SMEs that developed from companies who cut metal (as 3. above), but have experienced engineers who understand refrigeration systems and how to optimise the performance of a commercial cabinet. Often these companies do not have test facilities that comply with EN23953 but are able to achieve similar results in a quasi-test room that they have built. These companies can produce excellent well-built and energy efficient cabinets, often with innovative designs.
5. There are also innovative SMEs who design and build novel commercial refrigeration systems. Again these companies have a good grasp on the market and have engineers who understand how to optimise refrigeration systems. These companies sometimes invest in test facilities, even if they do not fully comply with EN23953 standards.

7.3 Access to test facilities for SMEs

Micro and small SMEs are less likely than medium sized SMEs and large companies to have access to a range of test facilities. Small and micro SMEs usually produce fewer cabinets than large companies and so have less incentive to build and manage test rooms. For a small or micro SME it is relatively expensive to install test facilities and to dedicate staff to manage these facilities. To build a new EN23953 test room the cost would be approximately €40-65k and would depend on the ability of the SME to fabricate the room themselves or to be able to build the room air conditioning system. The equipment required for testing is an additional cost and would add €25-65k depending on the type of cabinets that were tested and the level of compliance the company wished to have (it would probably not be necessary for a company to totally comply with EN23953 to achieve results that would be indicative of the cabinet performance).

All companies, whether they are an SME or a large company, can have their cabinets independently tested. Depending on the number of cabinets that a company produces the costs for testing may look attractive when compared to setting up and operating a test facility. Currently it is not perceived that independent test room availability is an issue.

8 Observations on the EPEE / Eurovent reference lines, as proposed on 1 September 2014

These observations are the result of an examination of the proposals made by EPEE / Eurovent in their letter to Santiago Gonzalez Herraiz of the European Commission DG ENER dated 1 September 2014.

Vertical chilled cabinets and frozen horizontal cabinets represent the most common cabinet types and so have been the focus of these observations. The EPEE / Eurovent proposals for other cabinet types have not been analysed by CLASP. Note that the EPEE / Eurovent proposals only cover supermarket type remote cabinets (and not beverage coolers, integral ice cream cabinets or vending machines). A more detailed assessment of the DG ENER MEPS proposals, including comparison with MEPS from other regions (USA and Australia) is made in the CLASP report *Analysis of EU policy proposals for DG ENER Lot 12 Commercial Refrigeration* of 16 October 2014.[35]

The EPEE / Eurovent proposals call for additional segmentation of the cabinet types compared with the DG ENER proposals – dividing the cabinets by temperature class (3M2; 3M1; 3H) and separating vertical from semi-vertical and from roll-in types – as shown in Table 7. In these notes, the DG ENER proposals for the broader types are compared with the EPEE / Eurovent proposals for vertical chilled cabinets of 3M2 temperature class. It is not clear why Eurovent specified a maximum width of 1.6m for their semi-vertical category proposals.

The reference line[36] proposals by EPEE/Eurovent as used in this analysis are replicated in Table 7. These reference lines are plotted in Figure 7, which also shows the reference line for vertical and semi-vertical chilled cabinets as proposed by DG ENER at June 2014.

Figure 8 shows how the reference lines for the three temperature classes compare for each cabinet type. The MEPS for the cabinets are calculated from these reference lines by applying the EEI values that were proposed in the regulation draft of June 2014, reproduced as Table 8. The MEPS for vertical chilled (3M2) cabinets resulting from these EPEE / Eurovent reference lines are shown in Figure 9 as compared with the DG ENER proposals and US DOE MEPS for 2012. Figure 10 shows the same thresholds as Figure 9 but also with normalised cabinet data for vertical, chilled supermarket cabinets of both open and closed types; integral and remote.

The MEPS proposed by Eurovent for frozen horizontal cabinets (3L1 temperature class) are shown in Figure 11 and against some normalised cabinet data in Figure 12.

8.1 Observations on the EPEE / Eurovent reference lines and MEPS

1. Typical performance of roll-in cabinets is poor and so there is good reason to ensure that it improves. Since the Eurovent data set shows that some roll-in cabinets can match the performance of open cabinets, there seems little justification for separating them. This is particularly true since some retailers are already placing doors on their roll-in cabinets[37] which substantially improves efficiency and such cabinets, if carefully designed, should have no problem meeting proposed MEPS.
2. From the relative positions of the reference lines proposed by EPEE / Eurovent, it seems that semi-vertical cabinets typically have higher energy consumption even than roll-in

[35] Report *Analysis of EU policy proposals for DG ENER Lot 12 Commercial Refrigeration* of 16 October 2014 available from the CLASP publication library at http://clasponline.org/en/Resources/Resources/PublicationLibrary.aspx?e=Europe&p=Commercial+Refrigeration.
[36] Reference lines represents the efficiency (energy consumption vs total display area) of 'standard' or typical (EEI=100) cabinets for each category.
[37] Personal correspondence with Environmental Investigation Agency (EIA), August 2014.

cabinets, and that vertical cabinets consume less than both of those. Frozen horizontal cabinets typically consume the least of the four types (this is not unexpected as the horizontal cabinets have low loss of cooled air). It would be challenging to make semi-vertical cabinets highly efficient due to the interrupted air flow cascading over the front of successive shelves, although improvement is of course possible. Their energy labelling under the same criteria as other vertical cabinets would make plain to buyers how the consumption compares, and MEPS would force improvement and probably a much more restricted choice of this type of cabinet on the market.

3. The EPEE / Eurovent reference line proposals are based on typical energy consumption higher than the DG ENER proposals (and significantly higher than the reference lines proposed by CLASP in August 2014 that are based on 2014 Eurovent certified data and data from other regions), judged from the relative positions of the reference lines as in Figure 7. The difference in reference lines equates to **around 11% higher consumption for a 4 square metre TDA cabinet** (and 60% higher than the CLASP proposal). Note that the DG ENER proposals group vertical, semi-vertical and roll-in chilled cabinets in the same category and so subject to equal stringency and pressure to improve; whereas the EPEE / Eurovent proposals make requirements for some cabinet types less stringent (separate reference lines) and so could act to perpetuate lower efficiencies for those types.
4. The EPEE / Eurovent proposed MEPS for 2017 **allow 10% higher energy consumption than those proposed by DG ENER** for a vertical cabinet of 3 square metre TDA - see Figure 9. In fact for this cabinet type, the **EPEE / Eurovent proposals are similar to a 2 years delay in the DG ENER proposals** (2017 under DG ENER is similar to 2019 under EPEE / Eurovent). (Note: for a 3 square metre TDA cabinet the EPEE / Eurovent proposals allow 50% higher energy consumption than those proposed by CLASP in August 2014, which are designed to discourage use of open cabinets).
5. Furthermore, the EPEE / Eurovent MEPS line of 2021 for vertical chilled cabinets has approximately the same stringency as the USA MEPS of 2012 (i.e. **9 years behind the USA**) - see Figure 9.
6. The EPEE / Eurovent proposed MEPS for 2021 for vertical chilled cabinets would remove from the market only one Eurovent certified cabinet from the 2014 Eurovent certified data set. (The **MEPS for 2017 and 2019 would not impact any of the 2014 Eurovent certified products** of this type). See Figure 10.
7. The EPEE / Eurovent proposed MEPS for frozen horizontal cabinets are very close but slightly less stringent than those proposed by DG ENER in June 2014 (Figure 11). No specific proposals for different MEPS or reference lines for horizontal frozen cabinets were made by CLASP in August 2014, although there is significant scope to make the MEPS more stringent since most open top cabinets in the 2014 data sets can remain on the market after 2019, although the 2021 MEPS proposed by DG ENER would remove most of the 2014 open cabinets (Figure 12).

Table 7. M and N coefficient values for the reference lines as proposed by EPEE / Eurovent, DG ENER and CLASP.

<table>
<tr><th colspan="2" rowspan="2">Cabinet type using EPEE / Eurovent segmentation</th><th colspan="2">Eurovent proposal of Sep 2014 (Remote only)</th><th colspan="2">DG ENER proposal of June 2014 (Remote and integral)</th><th colspan="2">CLASP proposal of Aug 2014 (Remote and integral)</th></tr>
<tr><th>M</th><th>N</th><th>M</th><th>N</th><th>M</th><th>N</th></tr>
<tr><td rowspan="3">Remote Vertical Chilled</td><td>3H</td><td>7.02</td><td>8.79</td><td rowspan="9">9.1</td><td rowspan="9">9.1</td><td rowspan="9">7</td><td rowspan="9">7</td></tr>
<tr><td>3M2</td><td>8.56</td><td>10.72</td></tr>
<tr><td>3M1</td><td>9.84</td><td>12.32</td></tr>
<tr><td rowspan="3">Remote Semi-Vertical chilled (≤1.60m)</td><td>3H</td><td>7.91</td><td>9.91</td></tr>
<tr><td>3M2</td><td>9.65</td><td>12.08</td></tr>
<tr><td>3M1</td><td>11.1</td><td>13.89</td></tr>
<tr><td rowspan="3">Remote Roll-In Chilled</td><td>3H</td><td>7.58</td><td>9.49</td></tr>
<tr><td>3M2</td><td>9.24</td><td>11.57</td></tr>
<tr><td>3M1</td><td>10.63</td><td>13.31</td></tr>
<tr><td rowspan="3">Remote Horizontal Chilled</td><td>3H</td><td>1.27</td><td>4.81</td><td rowspan="3">3.7</td><td rowspan="3">3.5</td><td colspan="2" rowspan="3">No specific proposal</td></tr>
<tr><td>3M2</td><td>1.38</td><td>5.23</td></tr>
<tr><td>3M1</td><td>1.48</td><td>5.65</td></tr>
<tr><td rowspan="2">Remote Vertical Frozen</td><td>3L1</td><td>7.51</td><td>19.34</td><td rowspan="2">1.6</td><td rowspan="2">19.1</td><td colspan="2" rowspan="2">No specific proposal</td></tr>
<tr><td>3L2/3L1</td><td>6.76</td><td>17.4</td></tr>
<tr><td rowspan="2">Remote Horizontal Frozen</td><td>3L1</td><td>3.98</td><td>10.27</td><td rowspan="2">4.2</td><td rowspan="2">9.8</td><td colspan="2" rowspan="2">No specific proposal</td></tr>
<tr><td>3L2/3L1</td><td>3.66</td><td>9.45</td></tr>
</table>

Table 8. Table of EEI values for MEPS, reproduced from DG ENER *WORKING DOCUMENT with regard to ecodesign requirements for refrigerated commercial display cabinets* of June 2014.

ANNEX II

ECODESIGN REQUIREMENTS FOR REFRIGERATED~~REFRIGERATED~~ COMMERCIAL DISPLAY CABINETS

1. REQUIREMENTS FOR ENERGY EFFICIENCY

(a) Refrigerated ~~C~~commercial display cabinets within the scope of this Regulation shall comply with the following Energy Efficiency Index (EEI) limits:

i) From 1 January 2017: EEI < 150

ii) From 1 January 2019: EEI < 130

iii) From 1 January 2021: EEI < 110

The EEI of refrigerated commercial display cabinets is calculated in accordance with the procedure described in Annex IV.

8.2 EPEE / Eurovent proposal regarding exclusion of corner cabinets

Corner cabinets, or transition shape cabinets, are cabinets that ensure continuity between cabinets whose extremities are not aligned: they have a wedge shape in plan view. They are sold in low numbers and anecdotal evidence (from test houses) implies that they are very rarely, if ever, tested for performance.

The proposal made by EPEE / Eurovent in Section 6 of their document is that:

> "*All corner units and all specially designed models of supermarket display cabinets shall be excluded from the considered product scope of ENER Lot 12 products as no related standards for the design and testing of such products are available*".

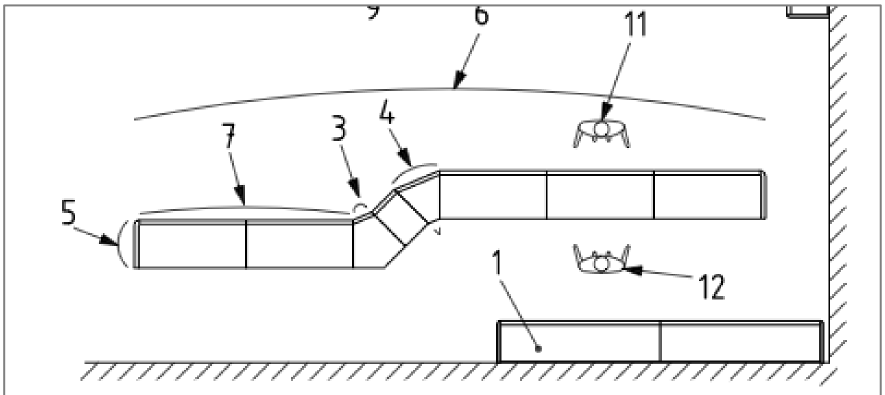
This statement of coverage is not strictly accurate, since the scope of EN 23953 includes "*refrigerated display cabinets used in the sale and display of foodstuff*"[38] and only excludes vending machines and cabinets for catering or other non-retail applications – hence all other types are by definition included. Indeed transition cabinets are illustrated and labelled in Figure 1 of ISO 23953 part 1 (reproduced in part as Figure 6 below) – which shows internal angle cabinets and external angle cabinets. It is, however, evident that the measurement and testing of these cabinets would require interpretation of the text of EN 23953 and best practice guidance would be advisable to ensure comparability - but testing would be possible. Their performance would almost certainly be poor in terms of maintaining temperature due to the challenges of achieving an effective and uniform air flow when the back and front have such different widths.

It should be noted that corner / transition shape cabinets were not given any special treatment in the USA regulation of 2009[39] (in which they are referred to as 'wedge cases' and discussed at length in the Final Rule document), but were instead expected to comply with the same requirements as other commercial refrigeration equipment. In the USA regulation of 2014, wedge cases are allocated a specific method to calculate a suitable TDA[40] but are subject to identical requirements.

However, there is a more fundamental issue of priority to consider since corner or transition cabinets are sold in low numbers: the Commission may choose to exclude them from Tier 1, but include them in future Tier 2, to allow manufacturers to prioritise improvements to the products that represent the majority of sales and energy consumption. These units should be listed for inclusion at Tier 2, however, to ensure that they do not represent a future loop-hole.

[38] Quotation from SO 23953-2:2005, Scope section.
[39] See section 4) Wedge cases, page 1102, of Federal Register/Vol. 74, No. 6/Friday, January 9, 2009/Rules and Regulations.
[40] See § 431.66 Energy conservation standards and their effective dates, paragraph € (3), page 17818 of Federal Register/Vol. 79, No. 60/Friday, March 28, 2014/Rules and Regulations.

Figure 6. Shapes of cabinet included under ISO 23953-1:2005. Corner cabinets, or transition cabinets, are shown as type3 and type 4 in this figure.



Key		Légende	
1	back wall service cabinet	1	meuble arrière à service assisté
2	island run	2	îlot
3	internal angle	3	angle fermé
4	external angle	4	angle ouvert
5	end wall	5	joue/panneau d'extrémité
6	line up/run	6	linéaire
7	technical line up/zone	7	linéaire technique
8	wall cabinet	8	meuble mural
9	island cabinet	9	meuble îlot
10	end cabinet	10	meuble tête de gondole
11	consumer	11	consommateur
12	serving personnel	12	personnel de service

8.3 Conversion factors between temperature classes

The EPEE/Eurovent paper presents factors to quantify the relative performance between the different temperature classes within each cabinet type. Analysis of this type could potentially be useful for manufacturers to adjust cabinet data tested at one class in order to present a declared performance at a different temperature class. The validity of these particular factors has not been explored by CLASP.

8.4 Alternative segmentation by type

The proposals for alternative segmentation are not convincingly or clearly demonstrated by the paper. The types of cabinet that are included in the many graphs are not sufficiently explained to allow judgement as to their relative performance. Segmentation of cabinet types into so many different categories and each with a different reference line results in a loss of clarity for buyers as to their relative performance, and buyers would benefit from knowing clearly which type consumes more energy. The greater segmentation could also protect some inherently poorer cabinet types from pressure to improve.

The Commission's proposed approach of grouping as many types as practical in the same category serves for maximum comparability. Any case for temporary or longer term exemption for certain types of cabinet could be considered on a case by case basis, for which any functional need of users (that cannot be met in other ways) must be weighed against the energy penalty from allowing poor efficiency to continue.

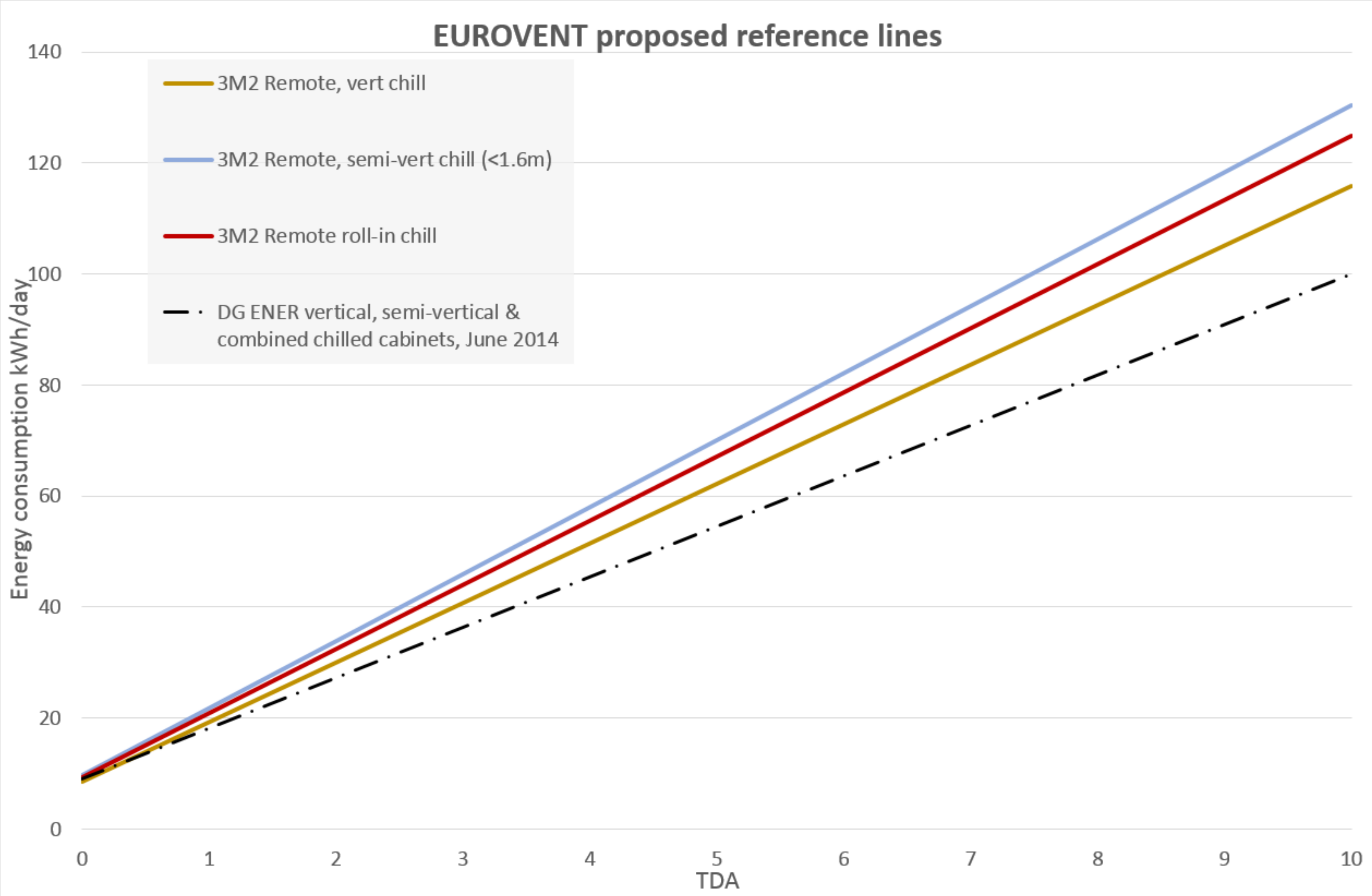


Figure 7. Reference lines for 3M2 temperature class cabinets as proposed by Eurovent at 1 September 2014. Also shows the reference line proposed by DG ENER in the June 2014 working document for vertical, semi-vertical and combined cabinet types of chilled temperature class.

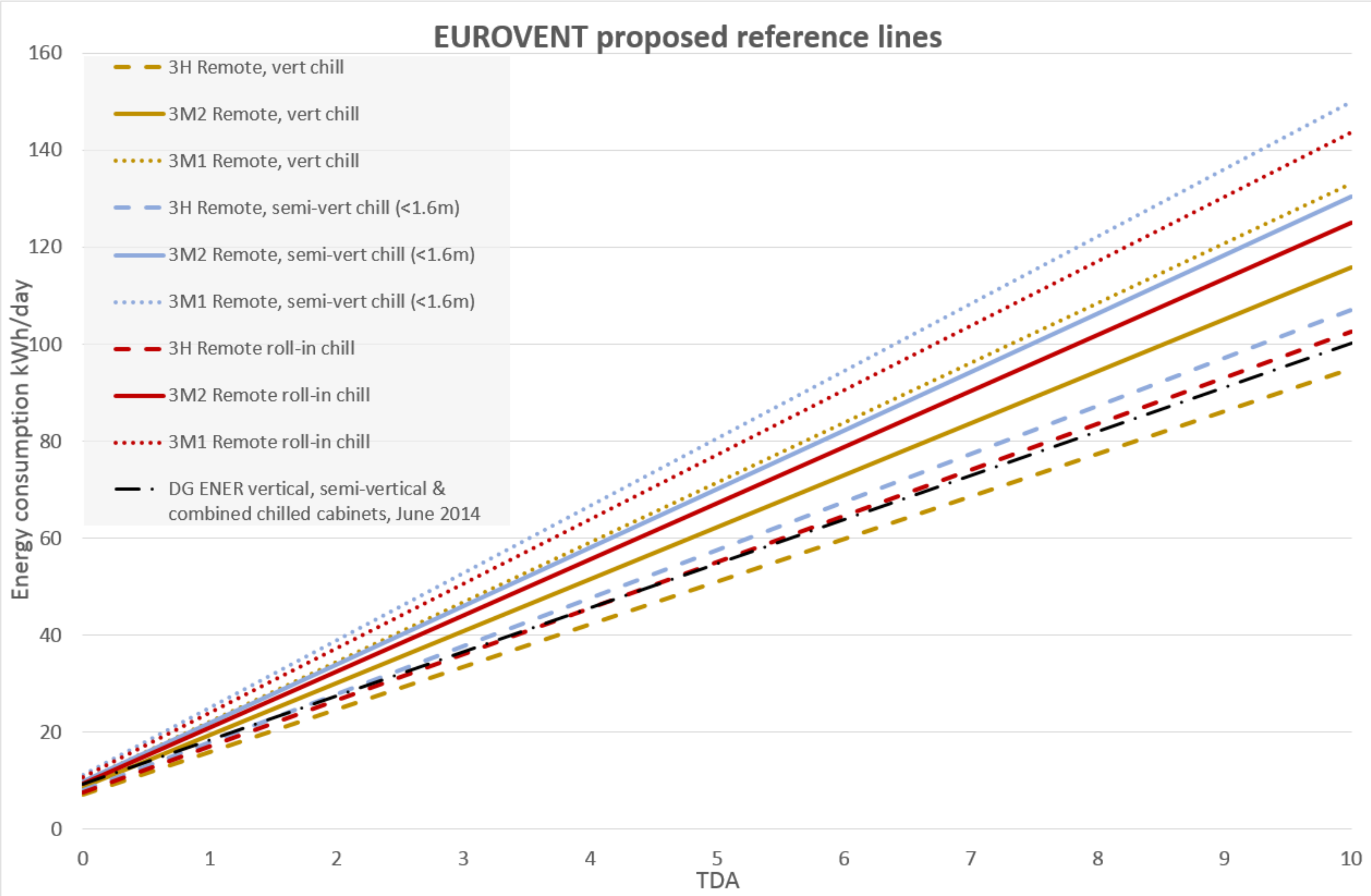


Figure 8. Reference lines for 3M2, 3M1 and 3H temperature class cabinets as proposed by Eurovent at 1 September 2014 and compared with the DG ENER proposed reference line of June 2014.

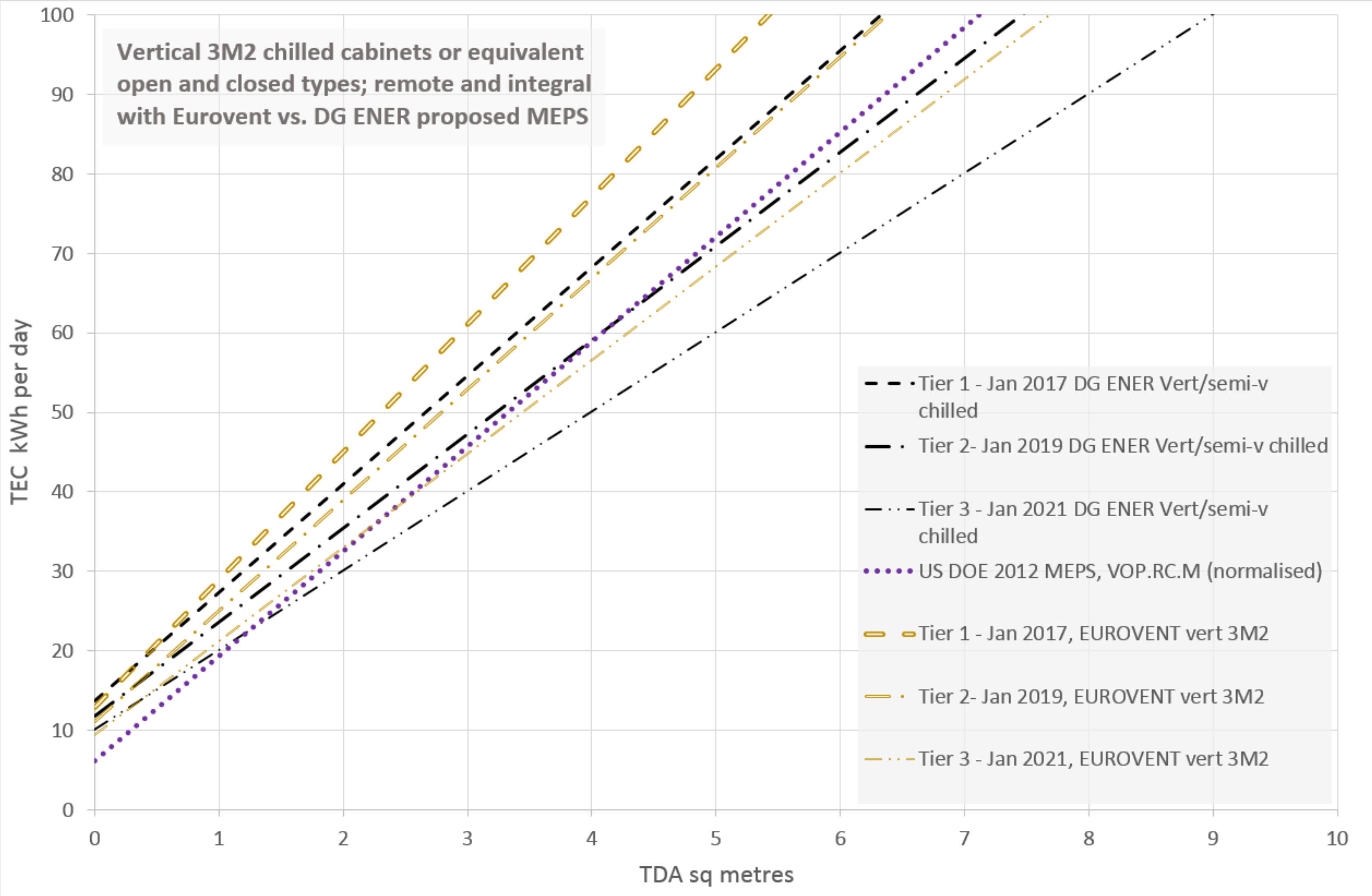


Figure 9. Comparison of the MEPS calculated from the EPEE / Eurovent reference lines for vertical chilled cabinets of 3M2 temperature class, compared with those for vertical, semi-vertical and combined cabinets as proposed by DG ENER at June 2014. Also showing the 2012 US DOE MEPS for this cabinet type (normalised).

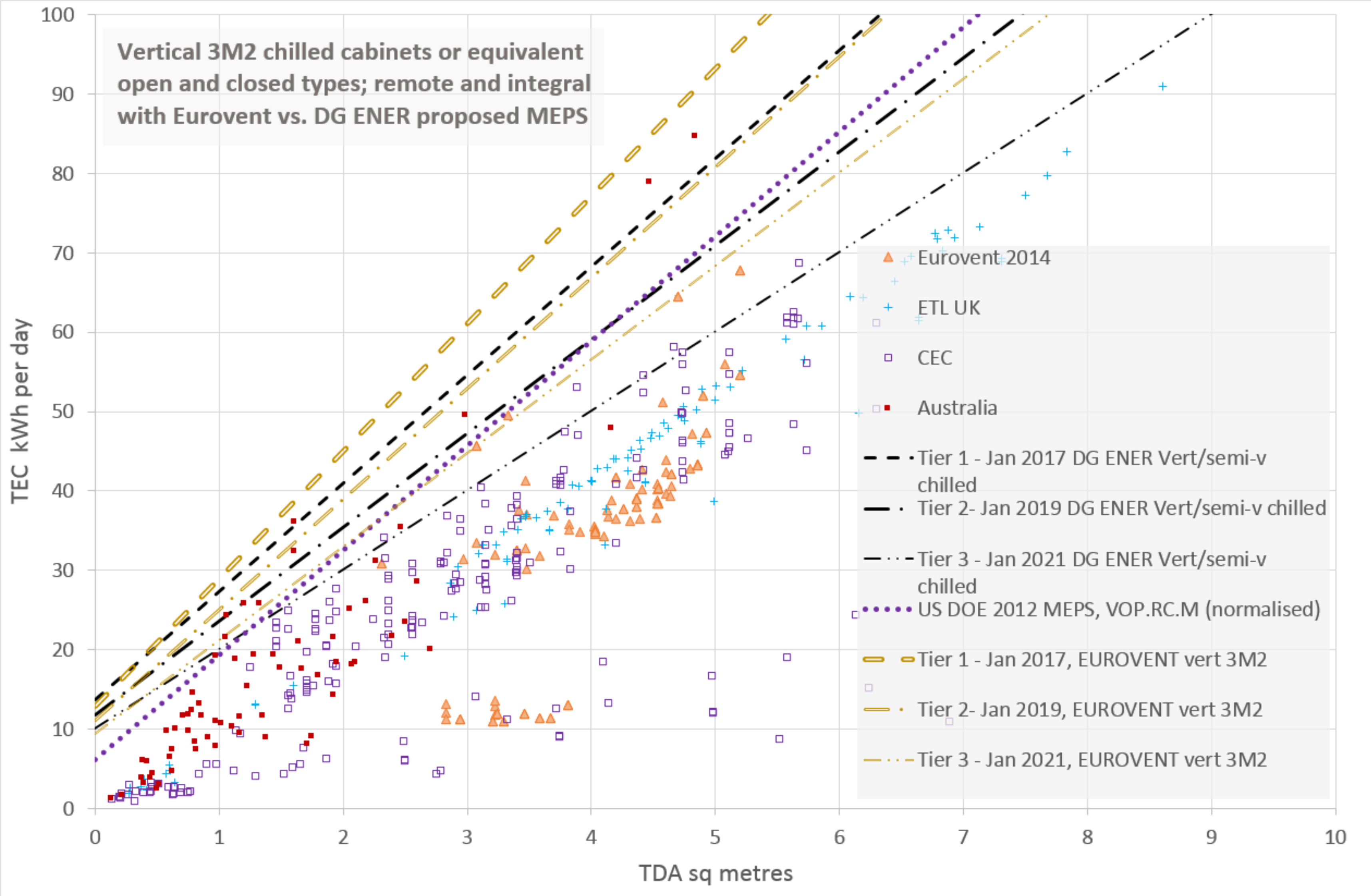


Figure 10. As Figure 9 but also showing cabinet model data for vertical chilled supermarket type cabinets (both open and closed; integral and remote – all normalized to 3M2 temperature class). Also shown with the US DOE requirements of 2012.

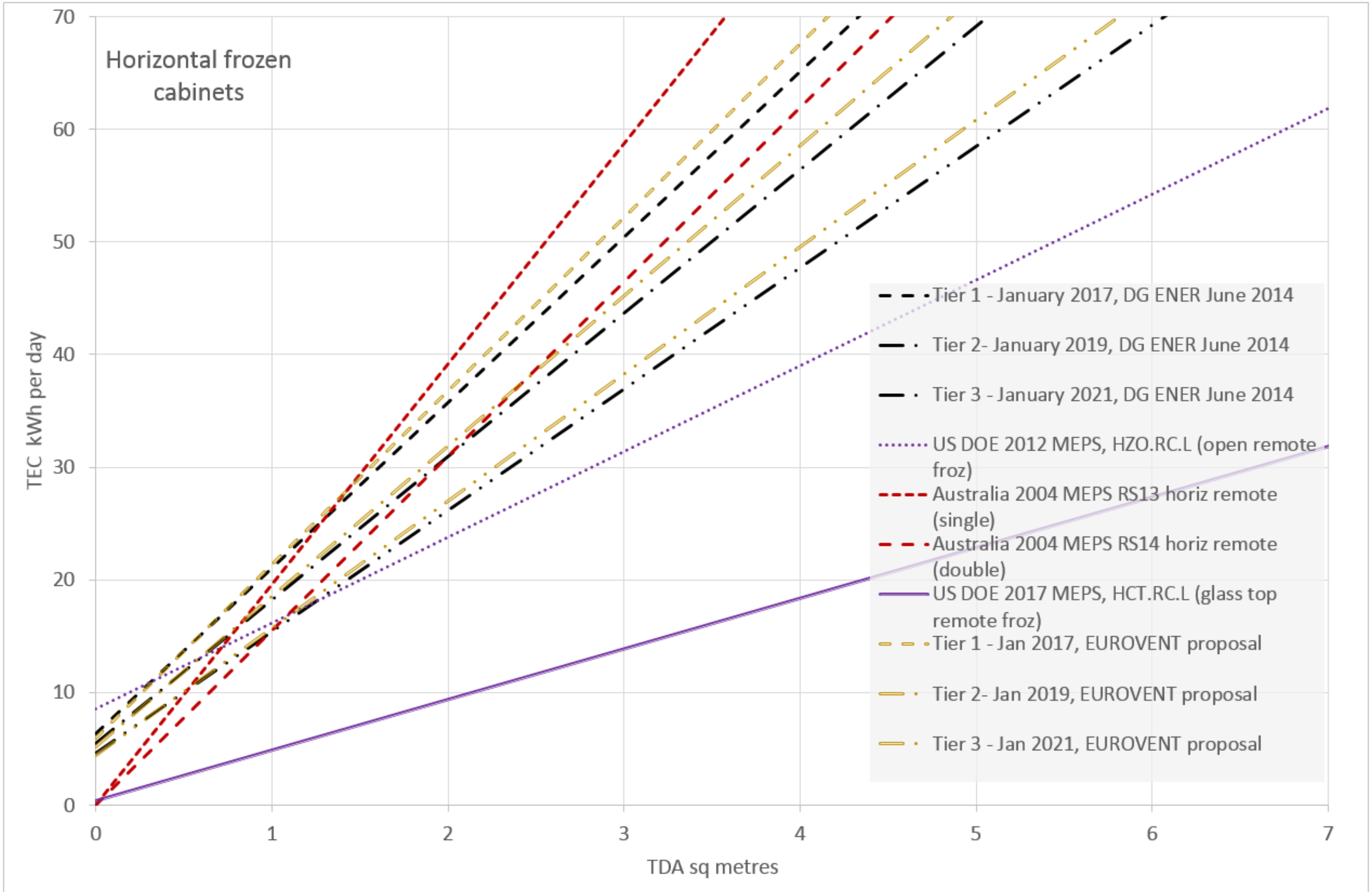


Figure 11. Comparison of the MEPS calculated from the EPEE / Eurovent reference lines for remote horizontal frozen cabinets of 3L1 temperature class, compared with those for horizontal frozen cabinets as proposed by DG ENER at June 2014. Also showing the 2012 US DOE MEPS for open and closed top cabinets and for Australia for this type (normalised).

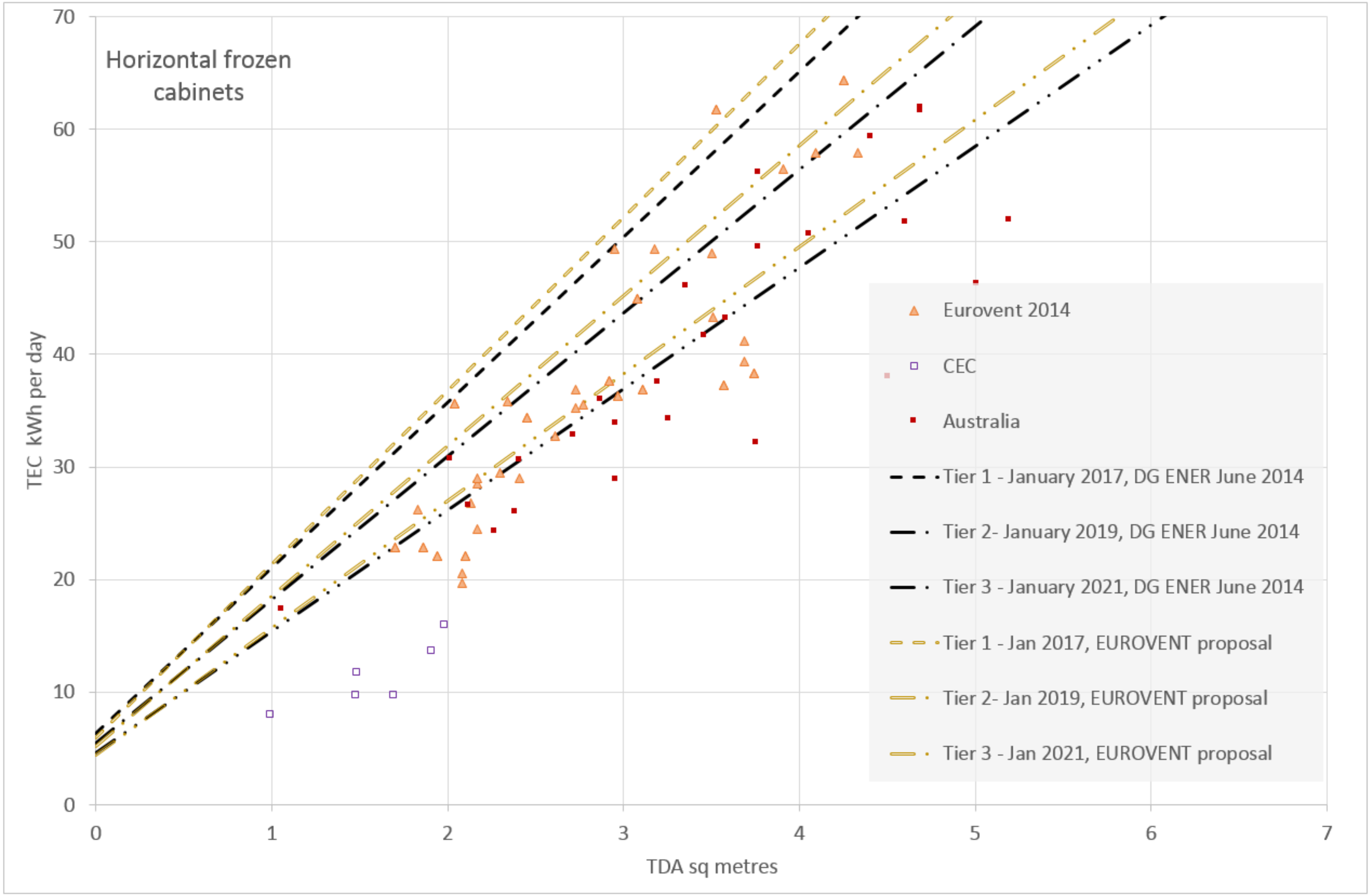


Figure 12. As Figure 11 but also showing cabinet model data for horizontal frozen supermarket type cabinets (both open and closed; remote only) - all normalized to EN23953

Annex 1: Source data on comparison of integral and remote test data by RD&T (UK)

RD&T data

Using RD&T data covering a total of 40 tests (24 remote and 16 integral) to the EN23593:2005 standard over a period of November 2009 to July 2014, the following conclusions can be drawn;

1. When comparing integral against remote multi-deck cabinets; or integral against remote full glass door cabinets, there is no significant difference.
2. When examining all the data there is a significant difference (95% probability) between integral and remote TEC_{75}/TDA, but this difference is due to the fact that integrals are far more likely to have doors than remotes and door cabinets have a significantly lower TEC_{75}/TDA. The remote tests have a mean TEC_{75}/TDA of 10.64 (stdev = 2.22). Due to the fact that a larger share of them have doors, the integral tests have a mean TEC_{75}/TDA of 7.63 (stdev = 2.79).

This confirms that care should be taken when examining data as spurious conclusions can result. In addition the points raised later in this report regarding the method to calculate REC should be considered.

Testing methods

It is stated in the EPEE and EUROVENT Joint Industry Expert Group report that:

> "The available around 2,600 product data points cover a wide variety of product categories with different specifications. These different product categories cannot be represented by one single linear regression model, because it does first and foremost not take into account the broad offer of different product designs in the market of the EU and hence, an appropriate product segmentation".

When setting an energy threshold cabinet, functionality should ideally be considered and products with common functionality should be compared against each other. Although identifying the most efficient amongst products with a same functionality can seem straightforward, the RD&T analysis related above illustrates that a direct comparison between cabinets within one type can be essential to prevent spurious results.

Most of the currently available data used for the analysis must have been generated using EN23953, version 2005 or 2012. There are some significant differences between the 2005 and 2012 versions of the standard. Probably the most significant is the change in door opening regime for chillers which changed from a 6 second every 10 minutes door opening in the 2005 standard to a 15 second every 10 minutes door opening in the 2012 standard. As there appears to be a tendency for integral cabinets to have doors or lids, this change in the test standard may have affected the measured efficiency for integral cabinets more than for remote cabinets.

The data from remote cabinets may be affected by the method used to calculate REC (Refrigerated Energy Consumption). The 2 methods used are REC_{RC} and REC_{75}. REC_{75} is used in the UK ECA scheme (it is not a method within EN23953) whereas REC_{RC} is used by Eurovent (this is the method of EN23953). This may explain some of the variations seen in the data collected as part of the energy label setting. The difference between the methods is varied and depends on the pull down after defrosts. Where pull down is large (for example in an electric defrost cabinet) the difference can be significant. For cabinets with off cycle defrost (where there is little pull down after defrosts) the difference between the methods is usually negligible.

Future

There are also a number of changes that are proposed to be applied to the latest version of EN23953 that is due to be published mid-2015. These may have an impact on future energy labelling levels:

1. Change to the definition of frozen cabinets:
   Currently the L1 classification is defined as:
   > "The warmest 'm' pack should have a highest temperature equal to or lower than –15°C and lowest temperature equal to or lower than –18°C"

   In the latest version of the standard the L1 classification is defined as:
   > "the highest temperature warmest 'm' pack should be colder than or equal to –15°C and highest minimum temperature of all 'm' packs should be colder than or equal to–18°C"
2. Use of filler packs (this is part of the 2012 standard but not yet widely applied). The filler packs have less thermal mass (than the tylose test packs) and so if a large number are used in a cabinet it would be expected that fluctuations in temperature would be greater than they would have been with tylose test packs, bringing higher risk of cabinet failure against temperature requirements.
3. Currently chilled glass door cabinets are tested with test packs loaded to half height. In the new version of the standard this will change so that shelves are loaded to full height. Since the current half-height loading probably results in more air infiltration during door openings, then measured energy consumption could reduce under the new standard for glass door cabinets and so net stringency of requirements would reduce slightly.

Review of Eurovent document (Ecodesign Directive for Energy related Products (ErP) ENER Lot 12- Commercial Refrigerators and Freezers)

The Eurovent document comments on several aspects of the JRC energy labelling proposal:

1. Difference between test room and store conditions. Eurovent claim that the energy savings predicted by the JRC are higher than is realistic.

Eurovent claim that cabinets use 40-50% less energy in a store than they do in a test room. There is very little published evidence on differences between stores and test facilities. Store temperatures are usually between 20-21°C (although they can be lower or higher in certain circumstances) and so are lower than test room conditions (25°C). In addition humidity is generally lower in stores than in a test room (60% at 25°C). There is also an effect of cold air collecting in the store aisle that reduces the energy used by the cabinets in a store.

Mousset and Libsig (2011) compared the performance of 2 open fronted cabinets (one at 2 temperature classifications, M1 and M2) in 2 stores. The work described was presented at the IIR International Refrigeration Congress in Prague and is a peer reviewed conference paper. They found a good relationship between enthalpy of the ambient air surrounding the cabinet and heat extraction rate. They found that the cabinets consumed between 28.1% and 57.5% less energy in the store when compared to the test room. This indicates that store conditions are quite variable and to fully predict the energy savings a deeper in depth analysis of conditions in stores in Europe should be carried out. The figures presented by Mousset and Libsig (2011) compare reasonably well with the figures presented by Eurovent (they may have been the source of the Eurovent figures).

2. Eurovent claim that integral and remote cabinets should be treated differently within energy labelling.

Background

It is clear that any comparison between integral and remote cabinets must be carried out on comparable cabinet types (see above). It appears that there is little difference between integral and remote cabinets when tested to EN23953. Whether this translates to real life is critical to whether integral and remote cabinet should be compared together in an energy labelling scheme.

The performance of integral cabinets is influenced by the ambient conditions in which they are placed. Remote cabinets are also influenced by the ambient conditions where they are located but they are also affected by the ambient conditions around the condenser (that varies daily and annually). In real life the efficiency of remote cabinets is also influenced by pressure drops and suction line gains. The efficiency of both cabinet types is affected by the efficiency of the compressor which is likely to be more efficient in a remote pack.

Although there are differences between how integral and remote cabinets operate in real life the question is whether the EN23953 test identifies these differences. The RD&T data and that analysed by the JRC indicates that the standard does not differentiate between integral and remote cabinets. If real life differences exist then these should be apparent to end users who can use the information to make informed choices on the most efficient equipment for their particular application.

Calculation of REC – efficiency coefficient

The lack of differentiation between integral and remote cabinets in EN23953 may have been deliberate, although no evidence for this has been uncovered. The REC calculation in EN23953 uses the heat extracted by the evaporator and converts it though a Carnot efficiency calculation to energy used in real life. The REC calculation incorporates a coefficient (0.34) that aims to convert the Carnot efficiency calculation to a COSP calculation:

$$REC = Q * \frac{T_c - T_e}{0.34 * T_e}$$

Where:

T_c is condensing temperature (K), set at 35°C or 308 K

T_e is evaporating temperature (K)

The 0.34 figure originated from TNO report R95-164. The section of the report dealing with this figure states:

> "The value of η_{carnot} reflects the Carnot efficiency of 'standard' refrigeration machinery. An analysis of available measurement data shows an average value of 0.34, while an analysis of refrigeration systems using a model produces values between 0.11 and 0.37"

The 0.34 figure was obtained from internal TNO reports and includes a time-averaged electrical energy consumption for the whole refrigeration installation (excluding condenser fans) (Sietze van der Sluis, personal communication). This is not a true COSP as the condenser fans are not included.

Whether the 0.34 figure is truly representative of current refrigeration plant is debatable. Figure 13 compares the COP used in EN23953 compared to COPs for chilled and frozen plant (chilled at -10°C and frozen at -35°C evaporating temperature) used in the ARI standard (Performance rating of commercial refrigerated display merchandisers and storage cabinets, Standard 1200) and in data presented by EPTA (John Austin-Davies, personal communication) and Girotto et al (2004). The COP at the European (weighted by population) average annual temperature of 10°C is extracted from the data (taken from real measured data on a supermarket) presented by Girotto et al (2004) for a CO_2 and a R404A refrigeration system. In all cases the COPs presented are always greater than the value used in EN23953. Differences were between 46% and 91% greater than the figure used in EN23953.

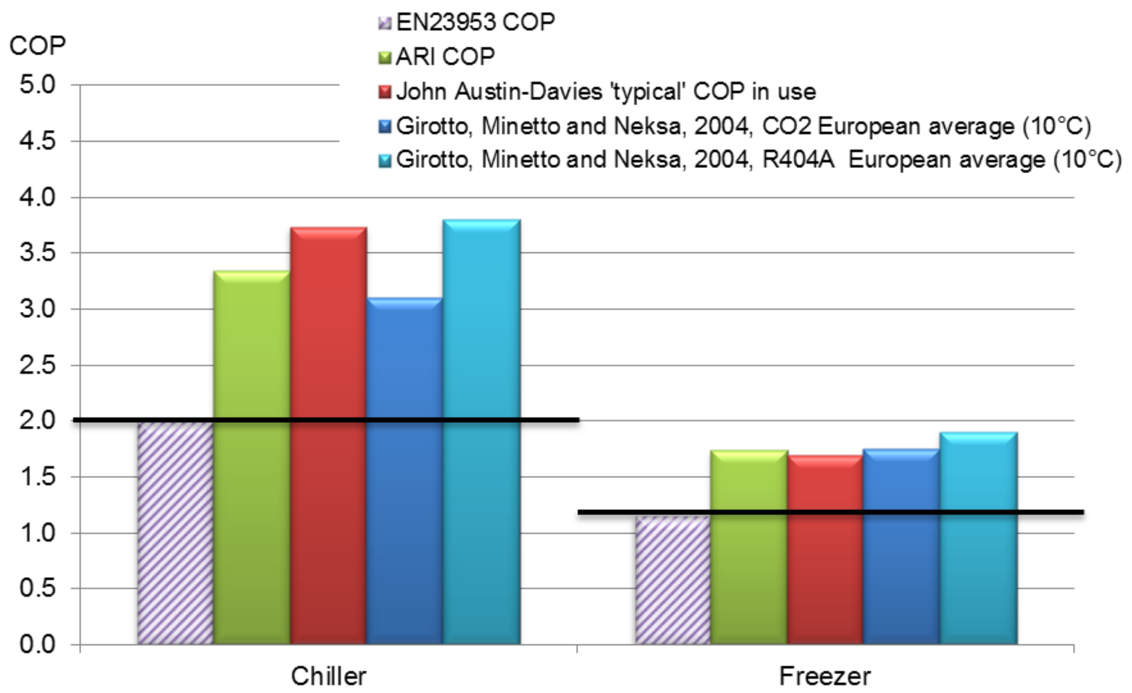


Figure 13. COP values from published information compared to the COP values used in EN23953. (Note: John Austin Davies data is for typical plant in the UK).

Calculation of REC – condensing temperature

Another additional or alternative reason for REC values appearing to be low may be due to the condensing temperature of 35˚C used in the EN23953 calculation of REC. Obviously COP values vary considerably depending on location of the refrigeration plant. For example taking the minimum and maximum average ambient temperatures in Europe (minimum = 4.6˚C in Sweden and maximum = 16.3˚C in Greece) and assuming that the refrigerant condensed at 10˚C above ambient the quasi COSP calculated according to EN23953 (using the revised condensing temperature) would be as follows:

	Average annual ambient (˚C)	Chilled COSP (-10˚C evaporating)	Frozen COSP (-35˚C evaporating)
Sweden	4.6	3.63	1.63
Greece	16.3	2.46	1.32

Using the current EN23953 calculation the COSP would be 1.99 for a chiller and 1.16 for a freezer (14-24% lower than then figures for Greece). It therefore appears that the REC calculation uses a condensing temperature that is higher than would be encountered in real life and this may also be one of the reasons why REC values are higher than in real life.

REC calculation

It would appear that the efficiencies assumed for the whole system (i.e. including remote condensing unit) used in EN23953 are lower than in real life. Whether this is due to the 0.34 conversion factor or the 35˚C condensing temperature (or both) needs further analysis.

The figures for COP used in the ARI standard appear to be more in line with published data (see Figure 1). If the ARI COP figures were used to calculate REC, these would be 41% lower for a chiller and 33% lower for a freezer. Whether this translates well to real life needs further analysis (and also depends on the DEC figures that will be added to REC to make the final TEC). Information from retailers who currently down rate EN23953 TEC data from climate class 3 to supermarket conditions generally reduce the TEC by between 30-40%. This again would indicate that the current COP used in EN23953 results in an exaggerated figure for the REC.

Eurovent argument that integrals are less efficient than remotes

In their document Eurovent claim that integral cabinets use 10% more energy than remotely operated cabinets under EN23953. The Eurovent analysis of the integral cabinet efficiency is based on a condensing temperature of 40°C. No evidence is presented on why this figure was selected. Condensing at 40°C seems quite a high temperature compared to measured and published figures. Measurements by RD&T of an integral multi-deck cabinet with a fan assisted condenser and R1270 refrigerant indicated a condensing temperature of 39ºC. However, this was in a test facility at an ambient of 25°C and not in a shop environment where the condensing temperatures would theoretically be at least 5°C lower, implying a condensing temperature closer to 30°C.

Most of the published data that present information on condensing temperatures are for domestic refrigerators where condensers are usually not fan assisted and so condensing temperature would be assumed to be higher than with a fan assisted condenser (which would be more usual in a commercial integral cabinet). Data from RD&T for a domestic chest freezer show a condensing temperature of 37°C and 41°C at an ambient temperature of 23°C and 29°C respectively for a non-fan assisted condenser. Alsaad and Hammad (1998) tested the performance of a domestic refrigerator and claimed the condenser temperature was 27°C in an ambient of 20°C (no details of the condenser were given). James and Missenden (1992) stated that the condensing temperature in a domestic refrigerator with propane was 40°C (no stated ambient temperature). Therefore it appears that 40°C is not an unreasonable condensing temperature for a non-fan assisted condenser. Assuming that a fan assisted condenser is more effective, the condensing temperature should be lower than in cabinets with fan assisted condensers. Therefore 40°C seems a high temperature for a cabinet with a fan assisted condenser. Theoretically a 5°C reduction in condenser temperature (all else being equal) would generate a 7-10% reduction in energy (depending on evaporating temperature).

The use of integrals with water cooled condensers is not included anywhere in the energy labelling proposals or in the Eurovent document. Using water to cool the condenser would reduce the condensing temperature considerably. In RD&T tests (at climate class 3) with water supply at 18°C the condensing temperature was 26-31°C. This type of cabinet might look particularly energy efficient compared to other integral cabinets (depending on the methodology used for overall energy calculation that should theoretically take into account the energy used by the water chiller and pumps).

Eurovent present a case for integral cabinets being less efficient than remotes (due to COP of small compressors, condensing temperature being higher than for remote products and smaller cabinet dimensions allowing higher impact from boundary effects). However, there are also significant sources of losses for remote systems, which include pressure drops and suction line losses (for example heat gain into the cold pipe). To fairly compare integral and remote cabinets, all of these factors should be taken into account.

References for Annex 1

1. Alsaad, M.A. and Hammad M.A. The application of propane/butane mixture for domestic Refrigerators. Applied Thermal Engineering 18 (1998) 911-918.
2. EPEE and EUROVENT Joint Industry Expert Group Position on the Preparatory Study Update Final Report for Energy related Products (ErP) in ENER Lot 12 of the EU Ecodesign Directive 2009/125/EC
3. Girottoa, S.; Minettoa, S. and Neksa, P. Commercial refrigeration system using CO_2 as the refrigerant. International Journal of Refrigeration 27 (2004) 717–723.
4. James, R.W. and Missenden, J.F. The use of propane in domestic refrigerators. Rev. Int. Froid 1992 Vol 15, No 2.
5. John Austin-Davies. Personal communication as part of book chapter submitted for publication.
6. Mousset, S. and Libsig, M. Energy consumptions of display cabinets in supermarket. ICR 2011, August 21 - 26 - Prague, Czech Republic.
7. Sietze van der Sluis. Personal communication 06-08/10/14.