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

Including comparison with policy thresholds and product data from other regions

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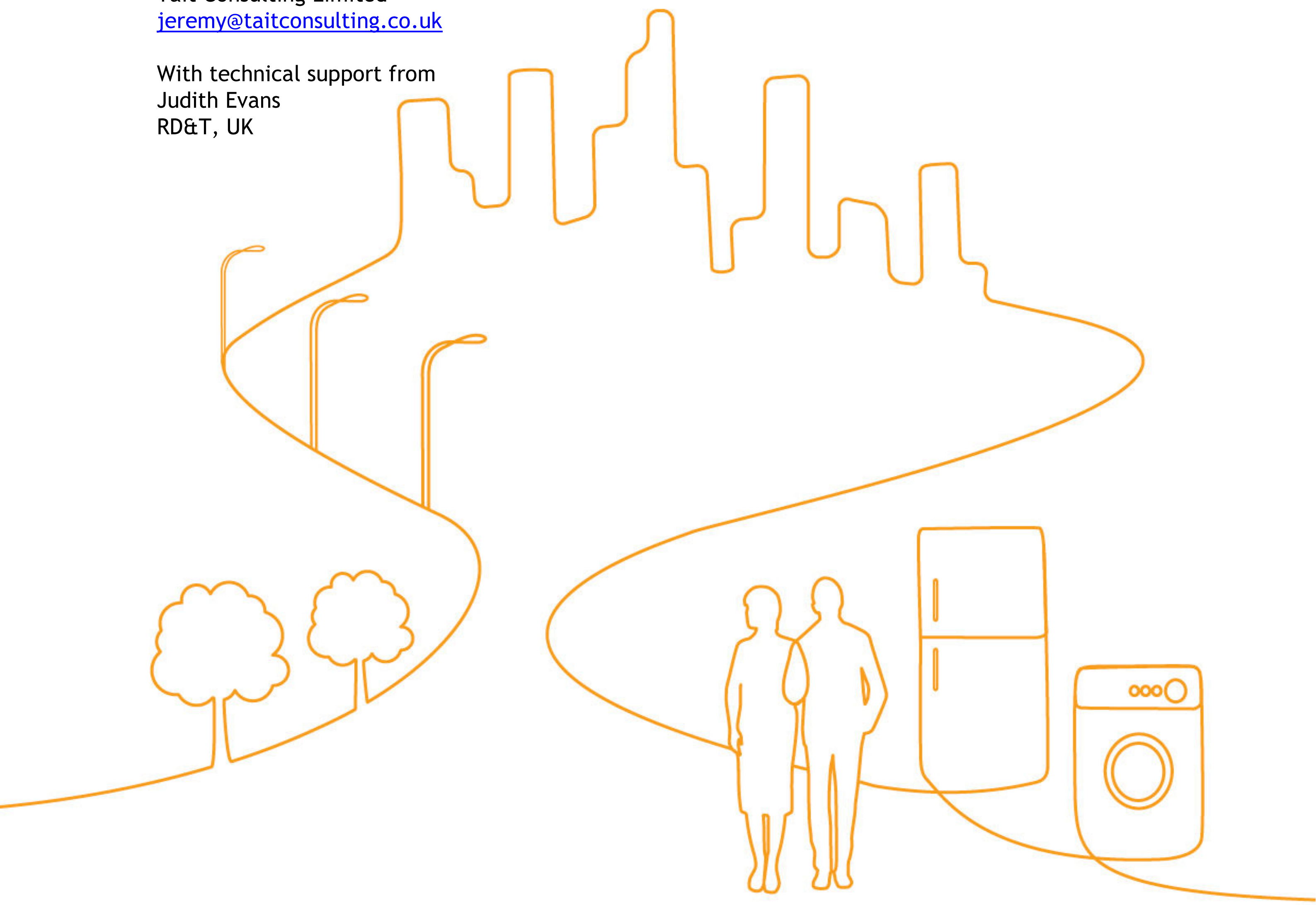

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Foreword

This report presents analysis prepared by CLASP 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. Early analysis from this work was presented by Jeremy Tait on behalf of CLASP at the DG ENER Consultation Forum on 2 July 2014 with further details provided in an interim report made available to stakeholders on 17 July 2014 via the Ecodesign Forum CIRCABC portal at https://circabc.europa.eu. This report supersedes all of that previous material due to refined analysis approaches and additional research.

CLASP would like to thank the Commission's Joint Research Centre (JRC) Seville, The UK Carbon Trust, the European Vending Association, DG ENER and others for their kind co-operation, supply of data, comments and other input to make this work possible. In particular, the technical analysis of cabinet performance was made possible through a normalisation process developed by Judith Evans of RD&T. The normalisation process follows earlier work on this topic by CLASP[1] and by the IEA 4E Mapping and Benchmarking Annex[2].

CLASP is providing this analysis to support DG ENER in their analysis of this product group and also to give stakeholders the opportunity to consider the material before they submit their comments to DG ENER on the Lot 12 working documents by the deadline of 2 September 2014. Stakeholder comments can be sent to DG ENER at ENER-ECODESIGN@ec.europa.eu, and copied to JRC-IPTS-COMREFRIG@ec.europa.eu.

[1] See CLASP Commercial refrigeration equipment: mapping and benchmarking report of January 2014, available from http://www.clasponline.org/en/Resources/Resources/PublicationLibrary/2014/Benchmarking-Analysis-Compares-Commercial-Refrigeration-Equipment.aspx.
[2] See Benchmarking report for Retail display cabinets Issued December 2012, available from http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=9.

Executive summary

This analysis by CLASP is made available to stakeholders for energy labels and ecodesign minimum requirements for DG ENER Lot 12 commercial refrigeration equipment. The analysis compares the European thresholds for labels and MEPS proposed by DG ENER in July 2014 with policies and product data from other parts of the world. It is intended to help stakeholders prepare their final comments on the Lot 12 working documents by the deadline of 2 September 2014.

The report does not cover all Lot 12 product types, but focuses on those with the greatest energy saving potentials: Supermarket refrigerated display cabinets (vertical chilled and horizontal frozen types); beverage coolers (integral chilled cabinets); and vending machines. The report has not analysed the proposals for frozen vertical and horizontal chilled cabinet types, nor for small ice cream freezers or gelato ice cream cabinets.

The product data and policies from other parts of the world were all adjusted for the differences in the test methodologies so that data and policy levels presented are comparable. All of the graphs and quoted performance levels in this report have been adjusted to be comparable with each other, in line with the normalisation methodology provided in Annex 1. The EU test methodology EN23953:2005 was the baseline method adopted for supermarket cabinets and for beverage coolers; no normalisation was deemed necessary for vending machines.

General issues

1. In the regulations for these products it is necessary to specify at least some additional specific test conditions at which the regulatory thresholds (i.e., minimum energy performance standards (MEPS) and energy labels) are valid – this is not done in the July 2014 draft. Without the specific test conditions, product performance could be non-comparable due to variation in the conditions selected by manufacturers for testing, even when working to the current harmonised standards. Suppliers seeking to misrepresent products would have wide scope to perform tests at conditions that are not appropriate for the end use but achieve good energy results. To address this risk caused by a lack of specific test conditions, representative temperature classes of M2 for chilled and L1 for frozen are suggested. In addition, clarity on use of night blinds (it is suggested that they are not allowed), the method to calculate consumption for remote cabinets (the harmonised standard presents 4 options) and lighting conditions during the test could also be specified and help reduce any 'gaming' of the test results.
2. Harmonised test methodologies will not be available until July 2016 for 4 of the 5 product groups. If these new test methods incorporate changes to the methods used to generate the performance data on which the proposed MEPS and energy labels are based, then the thresholds may no longer be appropriate. The Commission will need to monitor the standardisation process for these product groups carefully, especially for beverage coolers.
3. A policy objective to strongly encourage use of doors but to allow continued availability of highly efficient open cabinets could be achieved, and is supported by an overwhelming level of evidence. However, the current proposals will not achieve this objective as a majority of the open cabinets can remain on the market even after 2021 (Tier 3).
4. The proposed review period of 5 years seems too long for this product group since average performance is expected to advance rapidly once regulatory pressure is applied and product performance data may change due to the new test standards.
5. The presentation and content of benchmark levels (best available technology) should be reviewed / refreshed and more detail included indicating which product types are being represented. The current proposals are not fit for purpose.
6. Evidence suggests that it would be prudent to divide the regulatory segment for supermarket cabinets into integral and remote cabinets for two main reasons. Firstly, remote cabinets involve a more complex test, and the current test standard offers several options for specific test conditions and calculation methods, which could result in the manipulation of test results (Note: the Eurovent Certification scheme developed an

approach to ensure comparability of remote cabinets and lessons could be learnt from that scheme). The testing of integral cabinets does not incur these same test condition problems. Secondly, whilst current evidence is inconclusive on comparability of integral and remote performance, if differences are later proven and/or if changes to the test methods amplify or create differences, then the regulatory thresholds will be inappropriate for one of the other type. Separating integral from remote is easily achieved (even if they start with identical MEPS) and would provide regulatory flexibility in the future.

Supermarket refrigerated retail display cabinets - vertical chilled type

Refrigerated vertical display cabinets account for the biggest portion of total energy consumption for Lot 12. Comparison of the proposed EU MEPS with policies and data from other regions suggests that there is scope for the EU proposals to significantly increase energy savings.

Using the normalised data, as seen in Figure S1, the 2017 EU MEPS are approximately 20% less demanding than the MEPS adopted 8 years earlier (2009) by the US DOE. The most ambitious EU requirement, Tier 3 which takes effect in 2021 is about 8% less demanding than the 2017 standards for the USA. If the proposed draft working document is adopted without modification, Europe would be years behind the USA with less stringent requirements. Furthermore, the Australian MEPS that became effective in 2004 for vertical multi-deck cabinets are more demanding than EU proposals for 2017 for small and medium sized cabinets; cabinets considered high efficiency in Australia in 2004 would easily meet the 2021 EU proposed MEPS. And finally, if it is a policy intention to move the market towards the use of closed cabinets, then the proposed EU MEPS will not achieve this since a significant portion of current open cabinets will remain unaffected.

Regarding the label class proposals for vertical chilled cabinets, the classes F and E are very narrow and those for D, C and B very wide: unfortunately, this leaves very little scope to differentiate products in the most highly populated EEI zone. The scheme is also not future proof as most of the closed cabinets already achieve EU class A or B – and it is expected that all closed cabinets will be A class within a short time.

A revised reference line, label classes and MEPS levels is therefore proposed for vertical chilled cabinets as in Table S1 and shown in Figure S2, with the following benefits:

1. The label classes ensure continued differentiation of best cabinets into the future.
2. More even distribution of classes F, E and D means more scope to differentiate the current majority of open cabinets, so better encouraging progress.
3. The majority of open cabinets on the EU market would be energy labels E, F and lower and so would discourage their use.
4. It ensures that the EU industry is globally competitive on energy efficiency.
5. MEPS ensure significant improvement in the performance of open cabinets and will allow the best open cabinets to remain on the market after 2021 for use in applications where they are necessary.

Table S1. Proposed alternative distribution of energy label classes for chilled vertical cabinets compared with the July 2014 working document.

Label class	EEI thresholds from the Commission's 2014 draft working document	Alternative proposed EEI thresholds
A/B boundary	30	30
B/C boundary	50	50
C/D boundary	80	70
D/E boundary	110 and Tier 3 MEPS	90
E/F boundary	120	110 and Tier 3 MEPS
F/G boundary	130 and Tier 2 MEPS	130 and Tier 2 MEPS
-	150 Tier 1 MEPS	150 Tier 1 MEPS
M coefficient (slope)	9.1	7.0
N value (intercept)	9.1	7.0

Supermarket refrigerated retail display cabinets - horizontal frozen type

The normalised data examined indicates that there is scope to achieve higher energy savings from this segment. None of the open remote cabinets in the available data sets will be affected by the proposed EU 2017 MEPS, and most can remain on the market after the 2019 MEPS. Although the 2021 MEPS would remove the majority of open cabinets, a significant market shift away from open cabinets could be achieved at least three years earlier, at Tier 2. The US MEPS of 2009 for open frozen horizontal remote cabinets are more stringent than the 2021 requirements for the EU. As with the proposals for vertical chilled cabinets, closed cabinets are already seen to cluster in energy class B with some already in class A and so there will soon be little scope to differentiate future best performing cabinets. Revisions to the reference line, labels and MEPS could facilitate an earlier market transformation to efficient horizontal frozen cabinets, and mostly closed type, in a similar way to the alternative proposal for vertical chilled cabinets.

Beverage coolers

If the proposed draft working document is adopted without modification, the normalised data implies that the general slope of the energy performance versus volume lines in the EU proposal for beverage cabinets appears to be problematic. It is stringent on very small cabinets but has no effect on larger cabinets (see Figure S3). The lines are also significantly different to the slope deemed appropriate for all US regulations. Furthermore, the lower classes are very narrow (a small adjustment in volume could easily shift the cabinet by one energy class or more). Since classes A and B are very broad, differentiation of products in future years will be harder and this brings a risk that the bulk of the market could stall at class B (due to the disincentive of investing in a big jump in performance up to efficiency class A). Compared to the US MEPS from 2010, a standard full height single glass door cabinet under the 2017 EU requirements is allowed nearly twice the energy consumption of a similar cabinet in the US. Even the 2021 EU requirements for this popular size allows 25% higher consumption than the US MEPS from 2010 – implying that the EU market would be allowing efficiency levels over *15 years behind those of the US*.

To address some of these issues, possible alternative MEPS for beverage coolers are proposed in Table S2 and Figure S4. These levels will have an impact on cabinets across the whole size range and give scope to encourage further improvements by having no cabinets currently in class A. With the alternative proposed Tier 2 in 2019, the EU market would be better than the US market of ten years earlier (2010). EU Tier 3 of 2021 is almost identical to the ENERGY STAR requirement of 2009 (12 years earlier). Arguably 2021 stringency could be further increased since it still allows 30% higher consumption than the US MEPS of 2017 (4 years earlier), but this should be reviewed after 3 years once data from the new EU test method is established.

Table S2. Proposed alternative EEI levels for MEPS thresholds for beverage coolers compared with the July 2014 working document (EEI thresholds for energy label classes are identical).

Label class	EEI thresholds from the Commission's 2014 draft working document	Alternative proposed EEI thresholds
A/B boundary	30	30
B/C boundary	50	50
C/D boundary	80	80 and Tier 3 MEPS
D/E boundary	110 and Tier 3 MEPS	110 and Tier 2 MEPS
E/F boundary	130 and Tier 2 MEPS	130
F/G boundary	140	140 and Tier 1 MEPS
-	150 Tier 1 MEPS	
M coefficient (slope)	0.013	0.0055
N value (intercept)	1.0	2.1

Vending machines

Type A machines in the US are identical in principal to EU spiral vending machines and so data and policies are considered comparable (although there remains uncertainty on how the ASHRAE 32.1 test method is interpreted in the US for testing spiral vending machines). These account for a majority of EU stock, but a minority in the US. No normalisation of data was deemed appropriate for vending machines. There appear to be significant weaknesses in the available EU performance data for vending machines, not least because the only EU test method over the past decade is that drawn up by the industry association, with no independently tested data arising from that methodology at all. The assessment of the July 2014 proposed MEPS and labels, and an alternative proposal, are based on US Type A data plus the first and only independent test of an EU machine according to the new draft EU test method.

The proposed EU MEPS and labels are shown in Figure S5: the proposed EU MEPS do not coincide with any label levels which is potentially confusing and MEPS could easily be aligned with the G, F and E label thresholds. On stringency and if the proposed draft working document is adopted without modification, even the 2021 requirements for the EU allow twice the energy consumption per day of US MEPS that became effective in August 2012. The reason for this large difference is not clear, but evidence indicates that a significant portion of the EU data set may be outdated or unreliable – especially since there is no significant difference in the basic technologies employed in the products.

An alternative proposal of MEPS and EEI reference line were developed and are presented in Table S3 and Figure S6. This alternative proposal ensures the energy label better covers the current range of market performance (leaving legacy products in label class G). It also allows for the differentiation of the best performing models and scope for future improvements. And the MEPS align with the energy label classes to minimise confusion in the market and facilitate market surveillance. Whilst the minimum requirements are closer to the US MEPS than those in the Commission's draft working document, they are not as stringent as the US. The reason for this is to allow a period of grace for the new EU test method to become established; and then a suggested regulatory review by 2017 of the level of ambition for Tiers 2 and 3.

Table S3. Proposed alternative EEI levels for MEPS thresholds for vending machines compared with the July 2014 working document (EEI thresholds for energy label classes are identical).

Label class	EEI thresholds from the Commission's 2014 draft working document	Alternative proposed EEI thresholds
A/B boundary	55	55
B/C boundary	75	75
C/D boundary	95	95
-	110 Tier 3 MEPS	-
D/E boundary	115	115 and Tier 3 MEPS
-	130 Tier 2 MEPS	-
E/F boundary	135	135 and Tier 2 MEPS
F/G boundary	145	145 and Tier 1 MEPS
-	150 Tier 1 MEPS	-
M coefficient (slope)	0.004	0.002
N value (intercept)	4.1	2.0

As a reminder, all Stakeholder comments on the Commission's draft proposal for Lot 12: Commercial Refrigeration should be sent to DG ENER at ENER-ECODESIGN@ec.europa.eu, and copied to JRC-IPTS-COMREFRIG@ec.europa.eu (for the attention of Hans Moons) by **2 September 2014**.

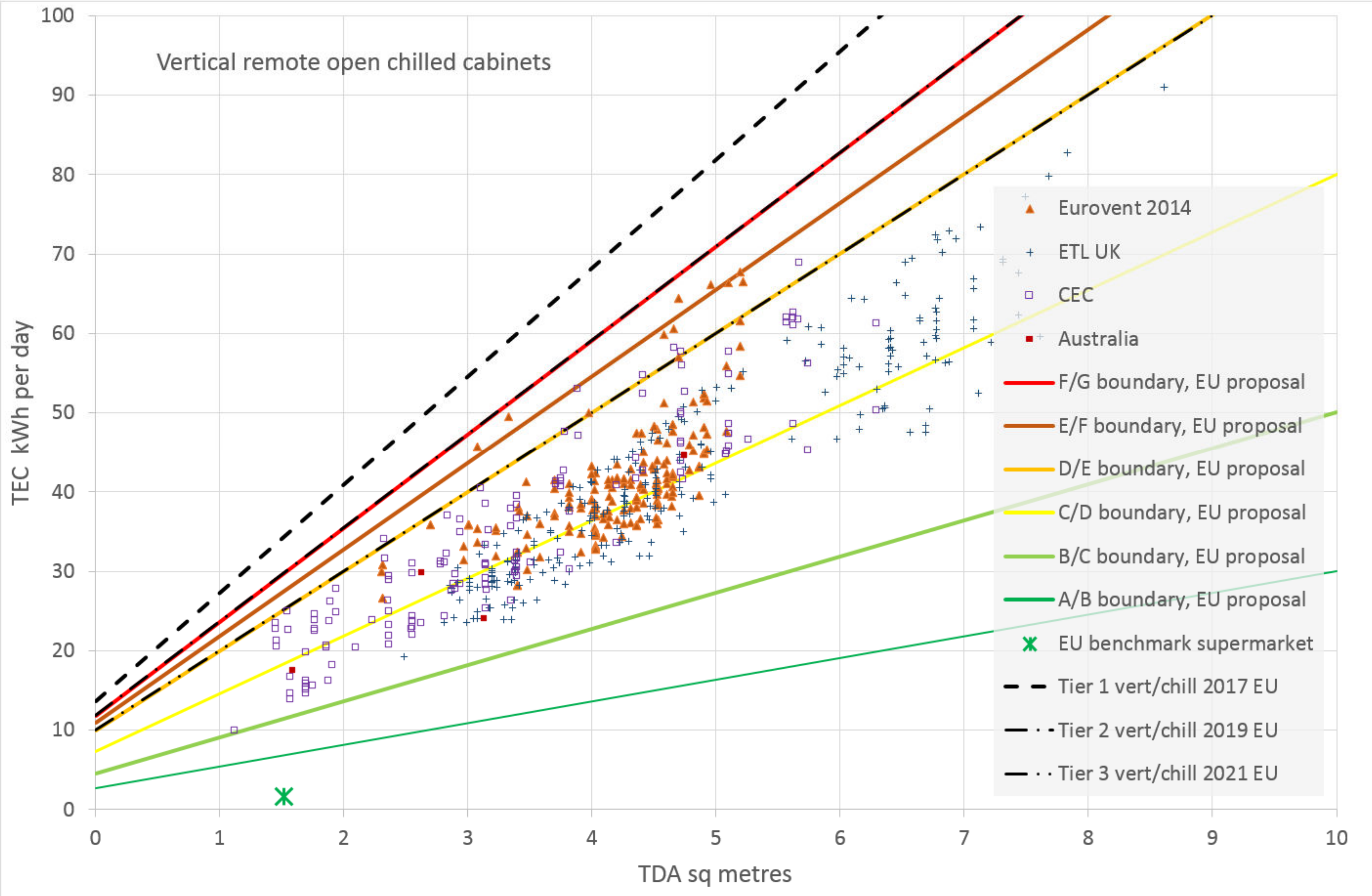

Figure S1. Comparison of proposed EU MEPS and label boundaries with normalised data from Eurovent certification data for 2014, California (CEC), Australia and the UK Energy Technology List, showing vertical, remote open cabinets of temperature M2 (chilled).

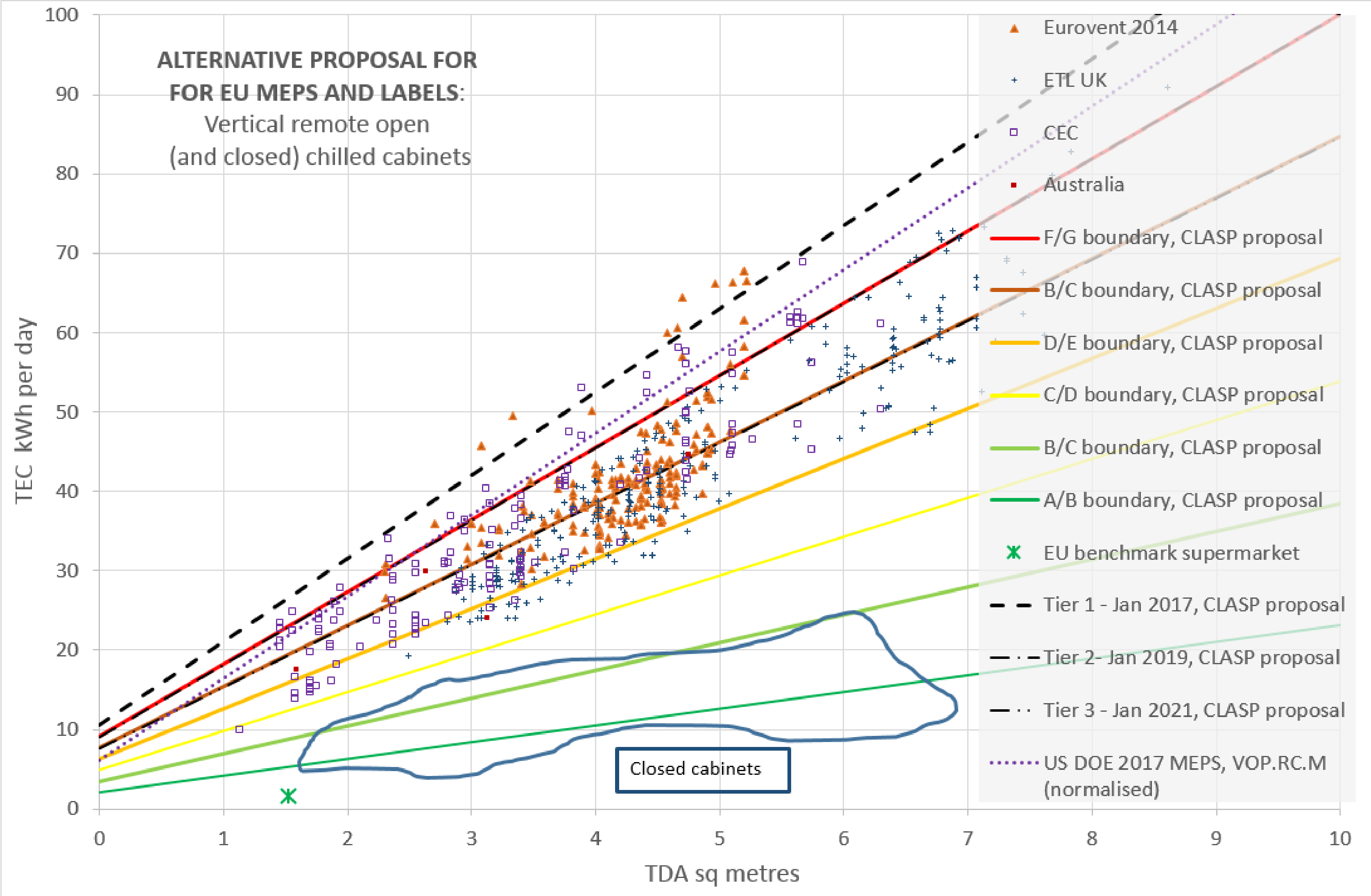

Figure S2. Alternative proposal for MEPS and labels, shown with normalised data from Eurovent certification for 2014, California (CEC), Australia and the UK Energy Technology List, showing vertical, remote open cabinets of temperature M2 (chilled). Also shows the locus of data points for vertical, closed, remote, chilled cabinets (blue loop).

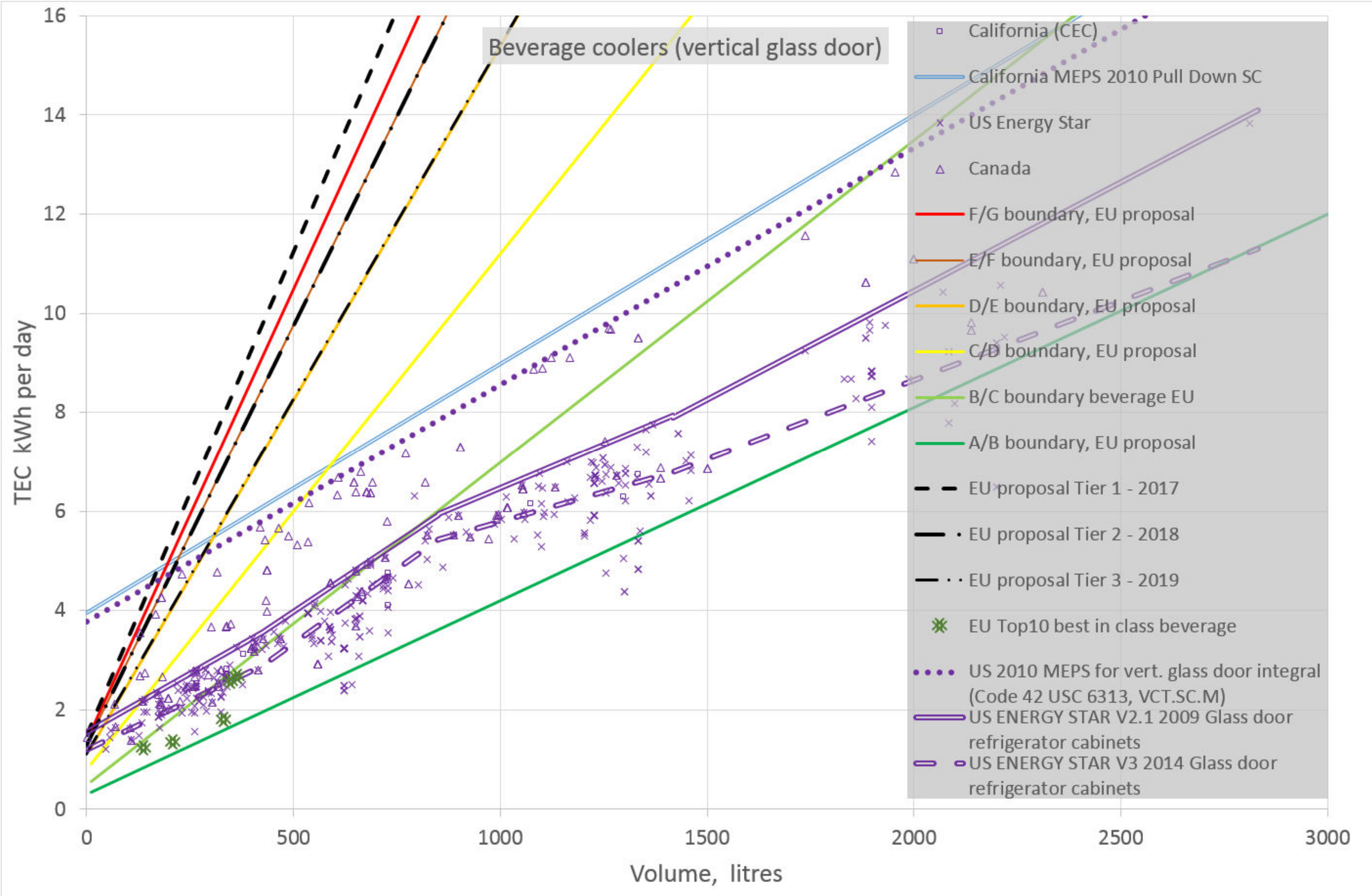

Figure S3. EU MEPS and labels for beverage cabinets compared with criteria for USA (DOE MEPS for glass door vertical cabinets 2010 and US ENERGY STAR V2.1 criteria (2009) and qualifying products, with ENERGY STAR V3 criteria (October 2014). Also shows vertical glass door integral chilled cabinets for Canada, and those with pull-down capability from California.

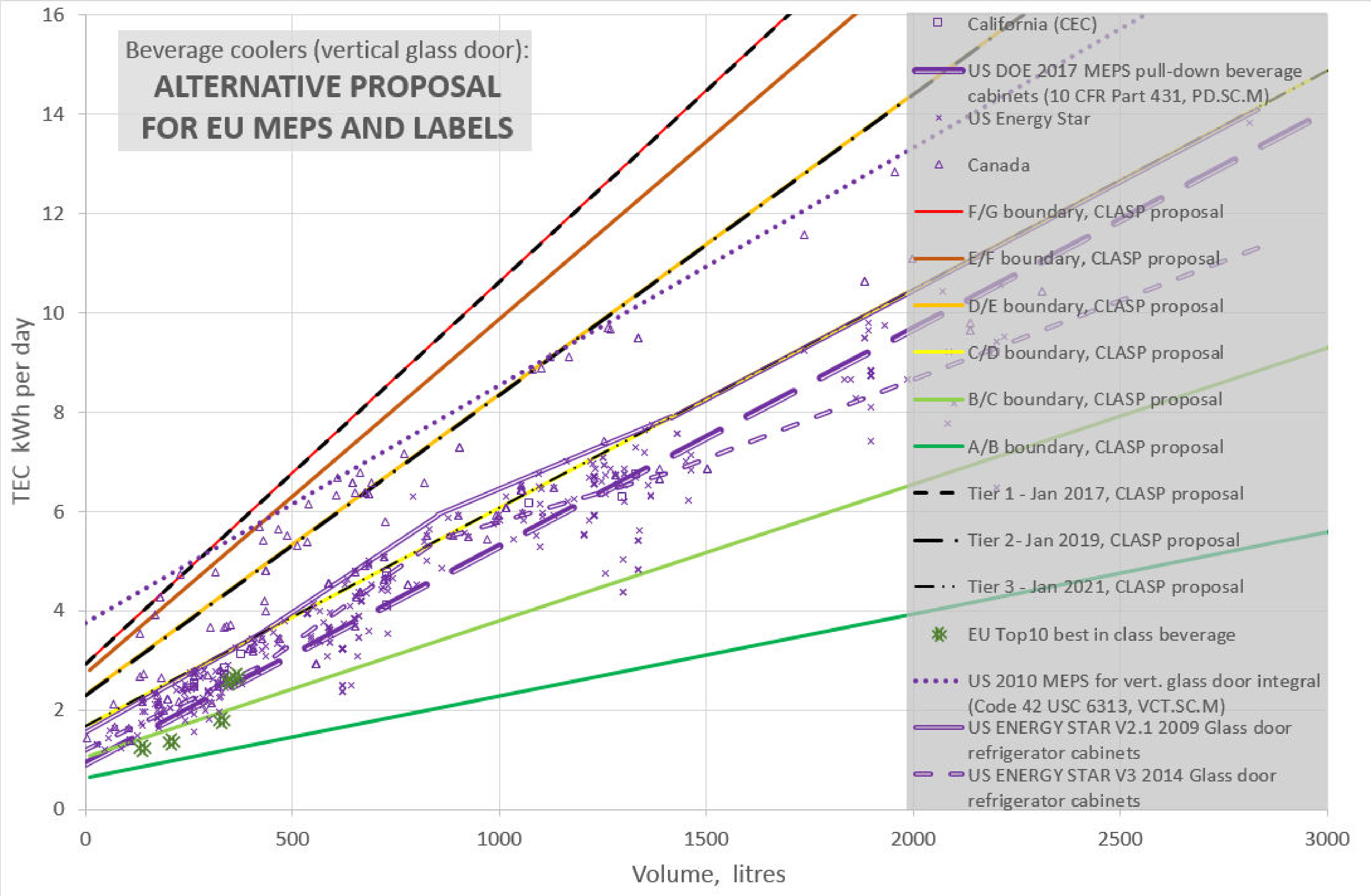

Figure S4. An alternative scheme of MEPS and label thresholds for the EU, compared with criteria for USA (DOE MEPS for glass door vertical cabinets 2010, beverage cabinet MEPS for 2017 and US ENERGY STAR V2.1 criteria (2009) with ENERGY STAR V3 criteria (October 2014).

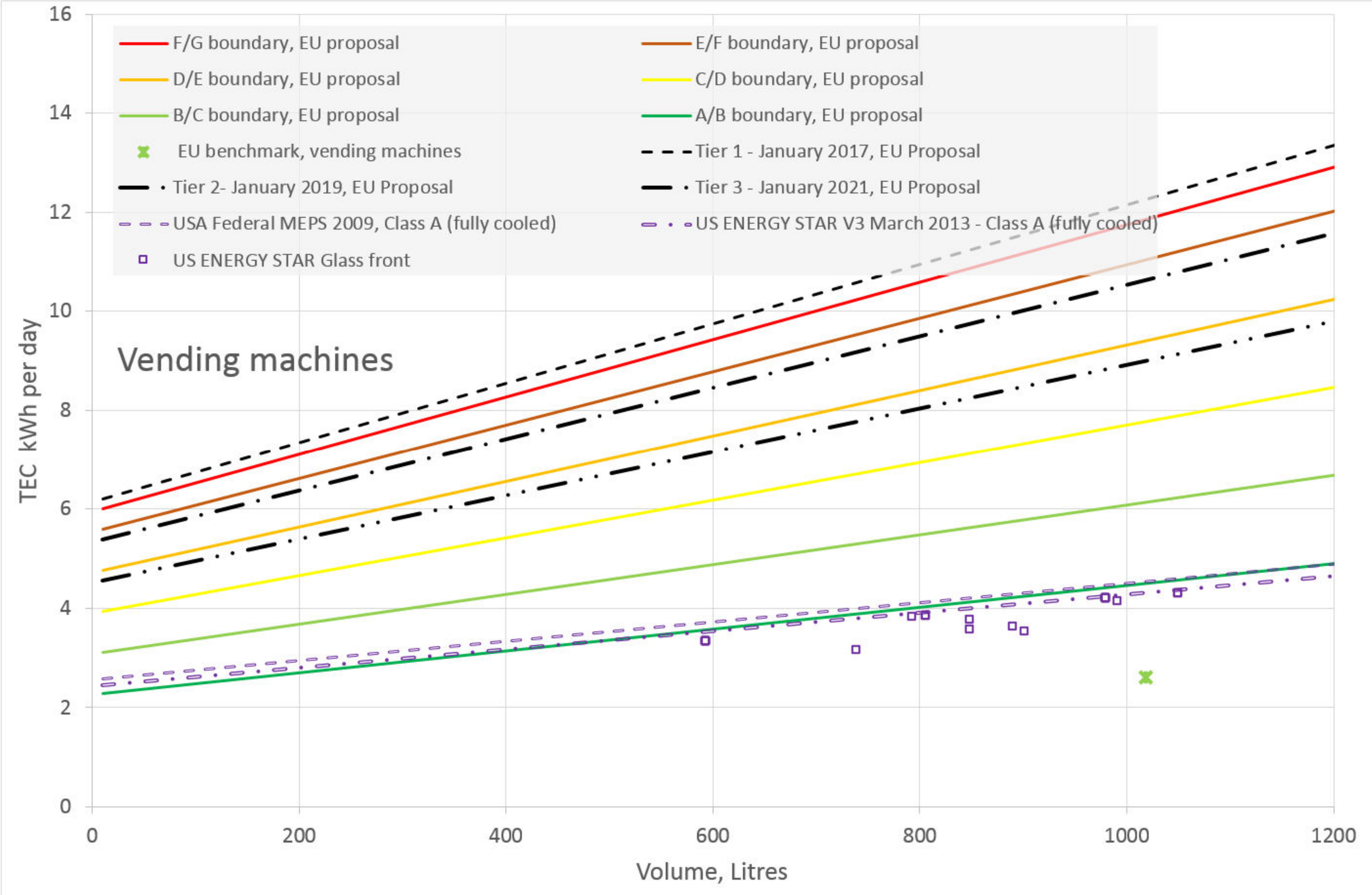

Figure S5. EU proposed MEPS and energy label classes for all vending machines, compared with requirements for US Class A vending machines under ENERGY STAR V3 (2013) and US federal MEPS of August 2012. Also showing ENERGY STAR qualified glass front products from 2014, the EU regulation benchmark product from the Working Document, and an example test result using the draft EU test method (CEN TC59X WG11).

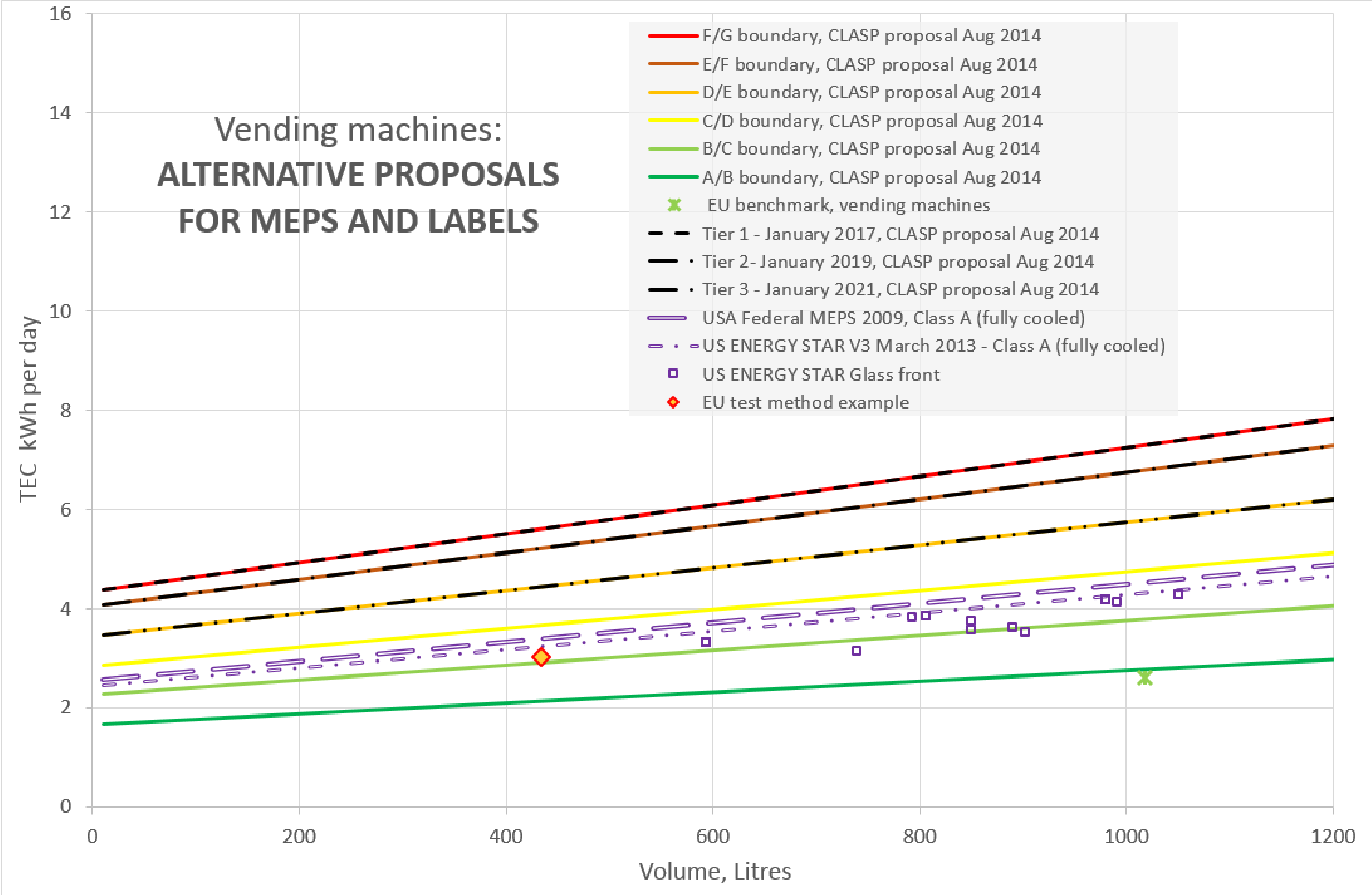

Figure S6. Alternative proposal for MEPS and energy label classes for EU vending machines, compared with requirements for US Class A vending machines under ENERGY STAR V3 (2013) and US federal MEPS of August 2012. Also showing ENERGY STAR qualified glass front products from 2014, the EU regulation benchmark product from the Working Document, and an example test result using the draft EU test method (CEN TC59X WG11).

1 Introduction

CLASP's objective in preparing this analysis is to assist stakeholders in understanding how the proposed European thresholds for labels and MEPS compare with policy thresholds for the same equipment in other parts of the world as well as compared with real product performance data. This will assist stakeholders in assessing whether the EU proposals are fair and have a level of stringency appropriate to the EU market, particularly where EU evidence may be weak.

This is not implying that thresholds from other regions should be adopted in the EU, but rather provides context and facilitates cross-examination of the EU proposals. Differences between markets and policy aims must be understood and taken into account.

A crucial part of the analysis undertaken was to adjust for the differences in the test methodologies between regions so that data and policy levels are comparable on a fair basis.

The analysis covers proposals in the DG ENER Lot 12 working documents that were made available to stakeholders in June 2014 (MS Word version with track changes[3]):

- COMMISSION REGULATION (EU) No.../...of XXX, implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to **ecodesign requirements for refrigerated commercial display cabinets**
- COMMISSION DELEGATED REGULATION (EU) NO .../.. of XXX, supplementing Directive 2010/30/EU of the European Parliament and of the Council with regards to the **energy labelling of refrigerated commercial display cabinets**
- Working Document on possible ecodesign requirements for refrigerated commercial display cabinets, **Explanatory Notes**

The DG ENER working documents cover 5 product categories:

1. **Supermarket segment refrigerated commercial display cabinets** (vertical and horizontal; chilled and frozen; integral and remote types, both with doors and open)
2. **Beverage coolers** (integral cabinets with glass doors or open)
3. **Vending machines** (including both glass fronted spiral vend and opaque fronted dedicated can and bottle beverage vending machines)
4. **Small ice-cream freezers** (integral cabinets for merchandising)
5. **Soft scoop ice-cream cabinets** (gelato cabinets, integral type)

This report focuses on product types and sub-types shown to have the greatest energy impacts, according to data in the JRC Lot 12 preparatory study which together account for the majority of the total energy impact of DG ENER Lot 12:

1. Supermarket segment refrigerated commercial display cabinets - vertical chilled cabinets (integral and remote types); horizontal frozen cabinets (integral and remote types);
2. Beverage coolers (integral cabinets with glass doors or open); and
3. Vending machines (including both glass fronted spiral vend and opaque fronted dedicated can and bottle beverage vending machines).

The report begins with a set of overarching issues identified from review of the proposed requirements. It then considers the available policy thresholds and product performance data that were available to compare with the DG ENER proposals; observations arising from that analysis are presented along with, in some cases, suggestions for alternative policy thresholds for consideration by stakeholders and DG ENER.

[3] These versions included a correction to the M and N coefficients for the reference lines and are available from https://circabc.europa.eu.

2 General issues for Lot 12 product groups

2.1 Need to specify conditions of test for validity of performance thresholds

The regulations refer to harmonised test methodologies, but those test methodologies allow flexibility in several aspects of set up and testing to accommodate a range of usage options. It would be necessary to specify at least some additional specific conditions at which the specified thresholds (MEPS and labels) are valid or results would be non-comparable due to wide variation in conditions selected for test. In addition, suppliers seeking to misrepresent products would have wide scope to perform tests at conditions that are not appropriate for the end use but achieve good energy results. The aspects currently allowing excessive flexibility that have significant impact on the measured energy consumption are:

a) Storage temperature class. The draft regulations currently include only the following simple definitions: *'chilled operating temperature' means that the temperature of products stored in the compartment or cabinet is continuously maintained between -1°C and 15°C*[4]*;* *and 'frozen operating temperature' means that the temperature of products stored in the compartment or cabinet is continuously maintained below -12°C*. For example, a chilled cabinet can be tested at temperature class M1 (nominal temperature -1 to +5°C) or class H2 (-1 to +10°C) and these would typically involve a mean temperature difference between the two of 5°C which equates to a difference in energy consumption of 10% to 13% for the same cabinet. Similar differences occur for a frozen cabinet used at -12°C versus one designed for use at -18°C. Representative temperature classes of M2 for chilled and L1 for frozen are suggested.
b) EN 23953 allows the optional use of night blinds on open cabinets. It would be necessary to clarify if night blinds are permitted - it is strongly advised not to allow them in the test. Addition of a night blind can cut energy consumption of an open cabinet by 50-60% but their performance (seal to the frame) is extremely variable and night blinds are usually an optional extra on a cabinet which the buyer may or may not use. It is suggested that data should be declared without night blinds in all cases.
c) EN 23953 includes options for loading for multi-deck cabinets, with 'light' or 'normal' load. Level of impact is highly dependent upon design of cabinet but could be over 10% in some cases. Normal load should be specified.
d) EN23953 allows 4 options on the method used to calculate remote energy consumption (REC) and this alone can alter recorded energy consumption by up to 20%, depending upon the cabinet and how it operates. Use of the REC75 method is common for EU manufacturers and could be adopted.
e) For large remote cabinets, results can be presented per linear metre of cabinet length, or for unit items (e.g. for a 2.5 metre long cabinet, but the length may be highly variable from cabinet to cabinet). It may be necessary to use an assumed default (and stated) unit length for some cabinet types, for example 2.5 metres, but this requires careful consideration.
f) Lighting conditions. EN 23953 allows for testing with 12 hour lighting or 24 hour lighting per day and measured energy will change by a few percent for the same cabinet. 12 hour lighting would be an appropriate condition.

Other possible variables for display cabinets include number and angle of shelves installed in the cabinet and type of filler packs used to simulate refrigerated products. Other issues may affect the other products groups as no exhaustive review has been carried out.

[4] Measured results and energy label classification at 15°C would be of no value to buyers since food cannot be stored safely at such a temperature. The overall 15°C range is apparently mentioned to encompass the highest temperature to which beverage coolers and vending machines would be allowed to rise under energy saving mode for non-perishable products.

Without the reference storage temperatures, manufacturers cannot make the necessary comparisons for validation of performance. Note that specifying a specific temperature class at which the requirements are valid does not necessarily mean that testing must be carried out at that temperature. As with other refrigeration products subject to ecodesign requirements, if a cabinet is tested at, say, class L3, a manufacturer can make a calculated adjustment of the result to infer what the result for that cabinet would be at class L1 (although the implications of whether a cabinet tested at L3 can meet the temperature requirements at L1 must be thought through before such a scenario is considered acceptable under the regulation). In order to ensure comparability, reference storage temperatures of EN23953 class M2 for chilled and L1 for frozen are proposed for the MEPS and labels and have been assumed as valid for this analysis.

The alternative would be to segment the regulatory requirements by temperature class, setting different requirements for each. This would introduce considerable complexity to the regulation.

2.2 Changes to test methodologies that alter baseline efficiency levels

Harmonised test methodologies will not be available until July 2016 for 4 of the 5 product groups, although the method for the supermarket segment (EN 23953) should be published in 2015. The data on which the proposed policy thresholds have been developed was generated using older test methods or industry voluntary agreements. It is possible that the new harmonised test methods could produce different energy test results from the same cabinet due to appropriate and useful improvements in methodology. It would be prudent to keep under review any such changes to the test methodology as they develop, understand the size of impact on measured energy and consider if or when the regulatory thresholds must be adjusted accordingly.

For example, in the supermarket segment (tested to EN 23953), there were changes made to the door opening regime for chilled cabinets between the 2005 issue and the 2012 amendment. This added around 15% to 20% to the measured energy consumption and must be taken into account when comparing data for chilled cabinets with doors prior to and after 2012. From our review of the JRC report, it appears that the majority of data used in the analysis is for cabinets tested before 2012[5], so the proposed policy thresholds for chilled vertical cabinets may be based upon older cabinet data. Thus, similar cabinets tested using the 2012 amendment (and eventually the 2015 new harmonised version) may struggle to meet the requirements. The understanding of the authors is that, at present, the technical committee drafting the updated 2015 test standard for supermarket segment cabinets is not intending to make any significant changes to the energy consumption measurements relative to the 2012 amendment.[6]

For beverage coolers, a new test method is under development. This revision will take into account the use of energy saving devices in the measurement method, and so it is expected to return lower energy consumption than for the current set of test data on which the proposed standards have been devised. Therefore, beverage coolers measured after 2015 that have these energy saving devices may find it easy to meet the requirements. If it is a policy objective to ensure that such devices are used, then the stringency should be set with this in mind. As discussed later in this report, the current proposals will not achieve this.

Policymakers will need to be vigilant that the draft test methodologies under development now continue to be developed in an objective and technically accurate way, and are not influenced by a desire to manipulate results once the regulatory requirements are known.

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[5] This is not explicitly explained but seems likely given the volume of data. Clarity on the test method used, including version, is important to ascertain to ensure that such evidence is robust.
[6] EN23953 changes and issues, presentation by Judith Evans and Alan Foster of RD&T, July 2014.

2.3 Encouraging use of doors on cabinets as a possible policy objective

Open cabinets are undoubtedly less energy efficient than equivalent closed cabinets in the vast majority of situations. However, there are applications and usage scenarios where an open cabinet is more suited and even potentially more energy efficient. The majority of evidence sources conclude that putting doors on a refrigerated display cabinet is the most effective single energy-saving measure, being particularly effective for frozen cabinets. This is not surprising since air infiltration accounts for the majority of the heat load on an open cabinet. The actual savings achieved in practice will depend upon the number of door openings in any given day with fewer openings correspond to larger savings.

On balance, a policy objective to strongly encourage use of doors but to allow continued availability of highly efficient open cabinets is supported by an overwhelming level of evidence. This is the primary consideration in the alternative MEPS and labels proposals discussed in section 3.5. The evidence for this is summarised in Annex 2.

2.4 Review period of 5 years appears longer than appropriate

The proposed review period of 5 years seems too long for this product group due to this being the first imposition of requirements in the EU for these products which will result in rapid technological development and change in average market efficiency. Since no A+, A++ classes are foreseen, it is likely that the A label class will be very highly populated within a year or two of launch. There is also imminent release of new harmonised test methods for which no product performance data is available at August 2014. These new test methodologies will undoubtedly have some effect on the measured energy consumption, compared with results from current era methodologies. There is therefore a risk that the policy thresholds based on earlier data could be proven obsolete (or unworkable) once the new test data emerges. Thus, a review of the regulation is recommended within three or four years or as soon as market performance data, based on the new test methodologies due out in 2015 and 2016, is available.

2.5 Future performance benchmark levels

Eco-design regulations include product performance ‘benchmarks’ in an Annex. These indicate the ‘best available technology on the market in terms of their energy efficiency index (EEI)’. These can help clarify ambition levels for future market performance and provide manufacturers with long-term performance targets for possible future policy thresholds.

Benchmarks in the form of an annual energy consumption combined with a corresponding volume or total display area (TDA) are included in Annex VI covering supermarket cabinets, beverage coolers, small ice cream freezers, vending machines and soft scoop ice cream cabinets. However, in order to be of value to cabinet designers, these should each be specific as to what type of product they refer: for example, there is no statement of whether the benchmark for supermarket cabinets applies to a chilled or a frozen, a horizontal or a vertical type cabinet (its value would imply it is likely to be a chilled, horizontal cabinet). Similarly no indication of the type of vending machine or other cabinet types, which renders the benchmarks of little practical value to suppliers.

To remedy this, examination of data sources such as the TopTen programme, best performing cabinets in registration data bases, Eurovent Certification data and endorsement labelling programmes such as ENERGY STAR and the UK Energy Technology List could all help inform the development of a robust set of benchmarks for specific product types.

2.6 Segmentation of cabinet types (especially for integral vs. remote)

There are two principal reasons why it may be prudent to segment the regulation for supermarket segment cabinets into integral and remote cabinets:

a) Remote cabinets involve a more complex test under which different approaches can be taken to settings (e.g., evaporating temperature and how ice build-up is managed) and these decisions can alter measured energy consumption. The recent remedial work on the Eurovent certification scheme took several years to address these issues. The fact that only one significant EU manufacturer remains operating within that certification scheme (EPTA, operating under its Bonnet Neve and Costan brands) may indicate that this brings a level of administration, testing and scrutiny that the other previous members of the certification scheme now find unjustifiable for their markets and/or customers. The testing of integral cabinets does not involve these problems, hence it would be prudent to clearly define and regulate integral and remote categories separately so that any future problems with enforcement, testing or regulating remote cabinets will not affect integral cabinets. Note: this is only an issue for the supermarket segment which currently includes both integral and remote in the same category.

b) The preparatory study rationale for grouping remote with integral is that there is insufficient evidence to prove they have different performance. However, if differences in performance are later proven as test methods are established and more data becomes available, or if future changes to the test methods disproportionately alter results for integral and remote cabinets, then the proposed regulatory segmentation prevents setting of appropriate standards and labels for each. These two types can easily be separated in the regulation (even if they have identical MEPS in the meantime) and this would ensure sufficient regulatory flexibility in the future.

Segmentation of all product types within the regulations should be carefully reviewed to ensure dissimilar products within the same category do not unduly constrain the scope to set appropriate requirements (for example with roll in cabinets grouped with vertical chilled cabinets).

2.7 Scope of cabinet types included

The definitions currently encompass virtually every type of cabinet with only a short list of exclusions (short compared with the actual number of variants of design at least). Consideration should be given to whether some additional exclusions may be necessary.

For example, no test methodology covering serve-over counters with integrated storage exists; nor is such included in a CEN mandate and yet this type of cabinet is not excluded from the scope[7]. Also cabinets with water-cooled condensers and pumped systems appear to be included in scope by virtue of the fact they are not included in the list of exclusions. It is likely that there are other types of cabinet that may have to be excluded or delayed due to absence of a relevant test methodology.

2.8 Rounding of performance numbers

The number of decimal places required for volume, TDA and AEC[8] in the information requirements should be reviewed. As currently drafted, TDA and volume are required to be reported to one decimal place (e.g., 0.1m^2 or about ±10% variance on the efficiency value for a small cabinet with a TDA of 1m^2 and the same for volume). This would appear to allow too much variance around the reported TDA and volume. The energy consumption requirements require accuracy to two decimal

[7] Note: "saladette" cabinets have been added to the exclusions list but this does not cover serve-over counters with integrated storage.
[8] Ecodesign WD Annex II 2 a) iv).

places when reporting kWh/year. This would equate to a difference of ±0.00004% on efficiency for a remote cabinet with AEC 25,000 kWh/year or TEC 68 kWh/day). Thus it would appear that more accuracy is needed for the TDA and volume requirements and perhaps less accuracy on energy consumption. One option might be to have two decimal places for TDA reported in m^2, one decimal place for volume reported in litres and energy rounded to nearest whole kWh of annual energy consumption per year. The accuracy and rounding of temperature data also has a significant effect and should be reviewed.

3 Supermarket segment: Retail Display Cabinets

3.1 RDC Data sources and policies

For this analysis, relevant products were selected from a series of data sets in order to conduct a comparison of each product type[9]. The data sets included some beverage coolers and small ice cream freezers (the latter were not analysed at this stage).

The following data sets are voluntary and tend to include the better performing cabinets in their respective markets:

a) UK Energy Technology List[10] for refrigerated display cabinets – 1430 qualified products made available by the UK Carbon Trust;

b) US ENERGY STAR commercial refrigerators and freezers database[11] – 1273 qualified products;

c) Eurovent certification database[12] (public domain) - 466 certified retail display cabinets, remote only;

d) TopTen Europe's six best performing beverage cabinets[13];

These following data sets are mandatory registration databases which are representative of the broad spectra of products offered in the markets of these respective regulatory agencies:

e) Australian government's E3 registration database[14] - 2411 refrigerated display cabinets;

f) California Energy Commission's registration data of commercial refrigerators, refrigerator-freezers, and freezers[15] - 7122 products;

g) Natural Resources Canada's registration database for 'refrigerators and freezers, self-contained, commercial'[16] – 729 cabinets.

The EU proposals in the draft Working Document for refrigerated display cabinets were compared to of the policies of other regions. All policy thresholds were normalised in exactly the same way as the product performance data. The following policies were used to compare:

i. Criteria for the UK Energy Technology List[17], a tax break scheme (Enhanced Capital Allowances) managed by the Carbon Trust. This scheme differentiates the better performing products on the market – aiming for top 25% or so of each market. Data is based on data declared by suppliers but is subject to random testing for enforcement purposes.

ii. US ENERGY STAR criteria[18], for Commercial Refrigerators & Freezers. ENERGY STAR differentiates better performing products in the market, aiming for top 30% or so and

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[9] It is possible that cabinets may be duplicated between the Californian and US ENERGY STAR data set which could weight performance slightly. Duplication is unlikely between America and Europe. Duplication has not been investigated due to low net impact on the analysis.
[10] See https://etl.decc.gov.uk/etl/site/etl/browse-etl/refrigeration/refrigerated-display-cabinets.html?SUB_TECH_ID=65
[11] See https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Commercial-Refrigerators-and/59dq-uw25?.
[12] See http://www.eurovent-certification.com/en/Certified_products/Access_by_programme.php?lg=en&rub=04&srub=01&select_prog=RDC.
[13] See http://www.topten.eu/?page=professional-display-refrigerators-crit&fromid=.
14 See http://reg.energyrating.gov.au/comparator/product_types/37/search/comprehensive/?.
[15] See http://www.appliances.energy.ca.gov/SearchResults.aspx.
[16] See http://oee.nrcan.gc.ca/pml-lmp/index.cfm?action=app.search-recherche&appliance=COM_REF.
[17] Criteria from: https://etl.decc.gov.uk/etl/dms/etl/Criteria/12_Refrig_RefrigDisplayCabinets/2013_Refrigerated_display_cabinets.pdf.
[18] Criteria from http://www.energystar.gov/products/specs/.

requires third party certified data. Comparison is also made with ENERGY STAR criteria for commercial refrigerators version 3 that are due to come into force in October 2014.

iii. California Energy Commission minimum efficiency requirements[19] for Commercial Refrigerators and Freezers with a Self-Contained Condensing Unit (2014 criteria for these products are the same as those valid in 2012). Note that these criteria are only expressed in terms of internal volume and so cannot be compared with supermarket segment, but are used for comparison on beverage coolers.

iv. US federal MEPS (as published in Final Rules) for commercial refrigeration equipment. Also comparison is made with the future requirements due to come into force in 2017 and beyond.

v. Canadian regulations for Self-Contained Commercial Refrigerators and Freezers – which coincide with the US Federal MEPS of 2009 for beverage coolers. Note that the Canadian refrigerator and freezer criteria for supermarket cabinets are expressed in terms of volume and therefore cannot be compared with the EU proposals (which are expressed in terms of TDA), however the Canadian data for beverage coolers are compared.

Regarding the USA MEPS that were adopted for Commercial Refrigeration Equipment and will come into force in 2017, the manufacturers association has challenged the US DOE in court[20] regarding some aspects of the standards. A recent article about this lawsuit (25 June 2014) indicates that the challenge concerns the use of certain refrigerants and the only MEPS issue is with automatic commercial ice makers (which are not part of the European scope)[21].

3.2 Normalisation of RDC data and policy thresholds

If and as required, all equipment performance test data and all policy thresholds have been normalised to make them directly comparable with products and policies tested to the European baseline standard of EN 23953: 2005. This baseline does not include the 2012 amendment which revised the opening regime for chilled cabinets with doors. This baseline was chosen as it appears to reflect the majority of data taken into account when setting the standards in the July 2014 Working Documents - the majority of data provided to JRC by European manufacturers was considered likely to have been historical and produced before 2012.

The development of the normalisation process is described in a report[22] by RD&T in the UK and is included as Annex 1. In summary, the normalisation process includes adjustments to compensate for differences in:

1. Ambient climate class temperature and humidity (e.g. EU climate class 3)
2. Frequency and duration of door openings during test period
3. Cabinet lighting
4. Calculation of refrigerated energy consumption for remote cabinets
5. Temperature classification (storage temperature, e.g. H1, M2).

In all cases, data was normalised to a 24 hour test period. In addition, bottle coolers were assessed using energy use per unit volume rather than as indicated in EN 23953 which would be according to total display area (TDA).

An additional adjustment was necessary for the 2014 European data from Eurovent's Certification scheme (publicly available from their web site): The Eurovent data declared under that certification

[19] See http://www.energy.ca.gov/appliances/.
[20] See http://www.coolingpost.com/world-news/doe-faces-court-over-impossible-standards/.
[21] See http://www.coolingpost.com/world-news/fridge-manufacturers-challenge-standards/.
[22] Normalisation methodology used to convert between European, American and Australian test standards, J Evans , RD&T, 13 August 2014, File reference number: RDT643.

scheme is not as measured under EN 23953, but includes an adjustment to make the data better reflect the energy consumption that would be experienced by users in a retail store. Energy consumption in the store will be lower because ambient temperatures within stores are typically lower than the required laboratory conditions. This is explained on the Eurovent Certification scheme web site[23] and in a PDF document available there. Unfortunately the calculation is complex and cannot easily be reversed without knowledge of further details for each cabinet that are not publicly available. A factor was developed based on assumed retail store conditions as an approximation to reverse the Eurovent adjustment, as explained in Annex 2. Data from other sources is published as per 'laboratory conditions' specified in the local test methodology.

For the purposes of this analysis, specific EU reference temperatures are assumed as the basis for the regulatory levels[24] and for normalisation:

- Chilled cabinets at EN 23953 temperature class M2
- Freezer cabinets at EN 23953 temperature class L1

Normalisation was carried out in three stages and for each stage a specific factor was derived:

$$\text{Adjusted Total Energy Consumption} = \text{Declared TEC x } [\text{Factor}_{\text{stage 1}}] \text{ x } [\text{Factor}_{\text{stage 2}}] \text{ x } [\text{Factor}_{\text{stage 3}}]$$

The adjustment factors vary according to the type of cabinet as well as according to the test methodology used. The factors are categorised using EN23953 terminology (VC1 etc.) and for datasets from other regions, the closest matching category according to the local terminology had to be selected. Any sub categories for which no direct equivalent could be identified, or for which no compensation factor was calculated were not included in the analysis. Cabinet types not matching the specific type under analysis were excluded from the analysis.

The three stages were:

1. Normalisation for test conditions and calculation methods for energy consumption. All cabinets were normalised initially to ISO EN 23953:2005. During the normalisation, cabinets were normalised for climate class temperature and humidity, door openings, cabinet lighting and calculation of refrigerated energy consumption (for remote cabinets).
2. Normalisation for temperature classification. All chilled cabinets were normalised to the M2 classification (temperature of all 'm' packs (which simulate the presence of foodstuff in the cabinet) equal to or greater than -1°C and equal to or less than 7°C) and all freezer cabinets to the L1 classification (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).
3. Adjustment for data derived from the Eurovent Certification Scheme to convert it back to an approximation of EN 23953 ambient and operational conditions (climate class 3). For other data sets $\text{Factor}_{\text{stage 3}}$ is set equal to 1.

Details of the derivation of these normalisation adjustments are provided in Annex 1.

[23] See http://www.eurovent-certification.com/en/Certification_Programmes/Programme_Descriptions.php?lg=en&rub=03&srub=01&select_prog=RDC.
[24] The EU working documents only state 'chilled' or 'frozen' and do not specify the specific temperature or temperature class at which the stated MEPS thresholds etc. are valid – see section 2.1.

3.3 Comparing policies and market data for vertical chilled cabinets

This section examines data for what the EU proposal defines as supermarket segment cabinets, which includes both open and closed cabinets of remote and integral types and for which performance is based on TEC/TDA.

Figure 1 shows the draft policy thresholds for EU – specifically, 3 tiers of MEPS and the boundaries between all energy label classes for refrigerated display cabinets. Figure 2 shows the EU MEPS with US DOE MEPS (2009 and newly adopted levels that take effect in 2017), Australian MEPS (2004) and UK Energy Technology List criteria for M1 chilled remote category (revised 2012). The California Energy Commission (CEC) state standards and US ENERGY STAR criteria are only expressed in terms of TEC per unit volume and so cannot be plotted on this graph.

If the proposed draft working document is adopted without modification, comparing the EU proposals with MEPS from other economies that regulate these same products in Figure 2 indicates there may be scope to increase the ambition of the EU proposals. Some observations on these data are:

1. The slope and offset selected for the EU reference line (where EEI = 100, just above the EU Tier 3 level of EEI 110) is fairly closely matched with the slope and offset used in the US MEPS of 2017. The slope is reasonably comparable with that used for UK ETL criteria and Australian HEPS (high efficiency level) although these two have the policy line passing through the origin (zero offset). Thus the policies are in approximate agreement on the mathematical relationship between energy consumption and display area (which is good).
2. The 2017 EU MEPS are approximately 20% less demanding than the MEPS adopted 8 years earlier (2009) by the US DOE.
3. The 2019 EU MEPS are reasonably close to the US 2009 levels (Note: this would mean that the EU requirements are 10 years behind the USA).
4. The most ambitious EU requirement, Tier 3 which takes effect in 2021 is about 8% less demanding than that which has already been adopted to take effect in the USA in 2017. Again, it would appear that Europe is years behind the USA with less stringent requirements.
5. Most EU energy class D cabinets would meet the minimum requirements in the USA in 2017 (easily for larger cabinets, but would have to be close to a C class for smaller cabinets).
6. The Australian MEPS that became effective in 2004 for vertical multi-deck cabinets are more demanding than EU proposals for 2017 for cabinets up to 3 square metres TDA.
7. Cabinets considered high efficiency in Australia ten years ago in 2004 would easily meet the 2021 EU MEPS for all cabinets up to TDA of 5 square metres[25].

Those comments notwithstanding, it should be noted that the Australian and US MEPS are for a slightly more narrowly defined type of refrigerated display cabinet (vertical open remote multi-deck; also unlit in the case of Australia) whereas the EU levels also include roll in cabinets for example – see also section 2.6.

[25] For clarity of the other observations, the Australian high efficiency requirements are not shown in Figure 2 but are similar to the UK ETL requirements but at a slightly higher slope that crosses the EU D/E label boundary at just above TDA 5.

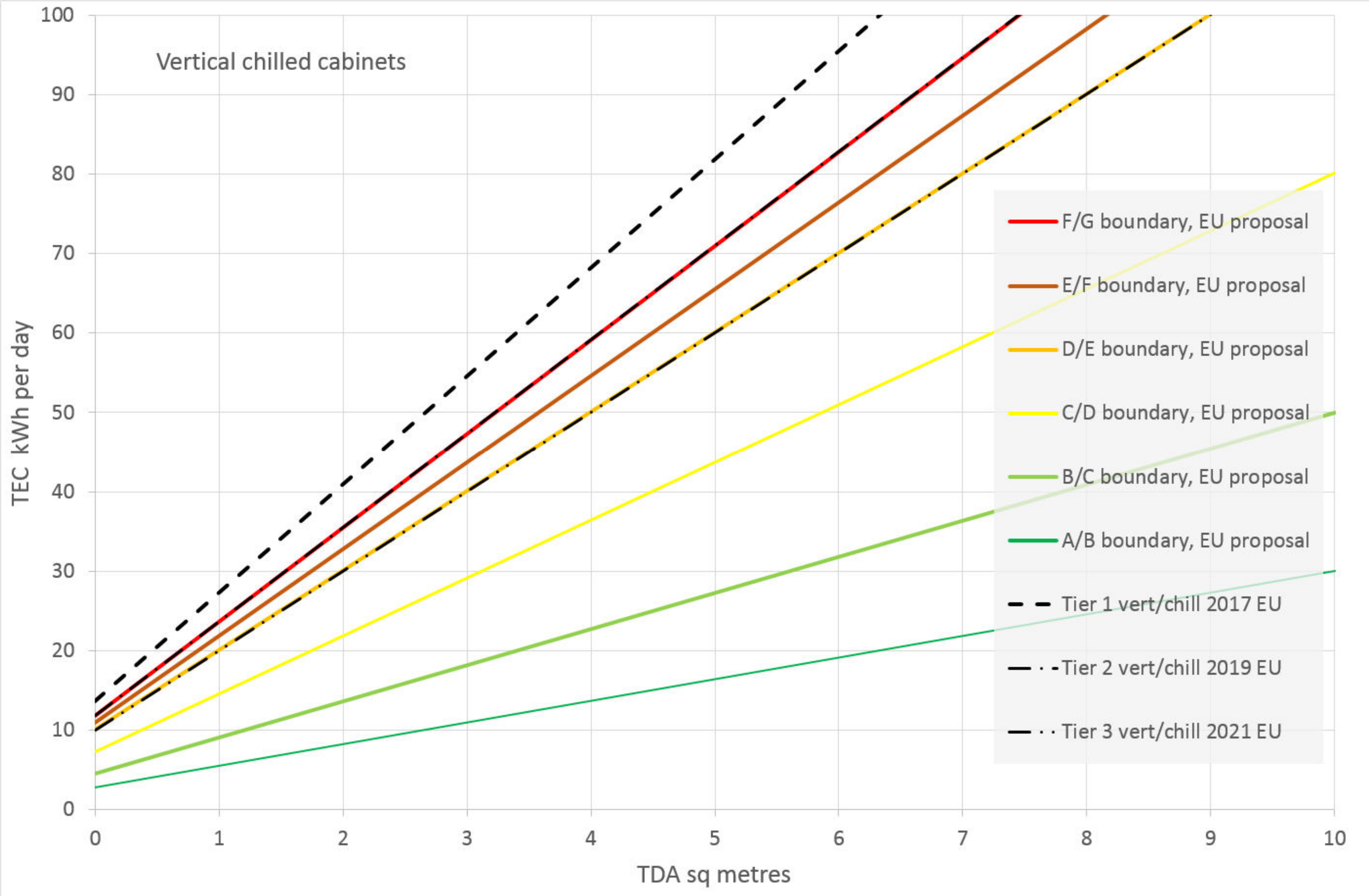


Figure 1. Chart showing proposed EU MEPS and A to G energy labels for vertical chilled supermarket segment cabinets.

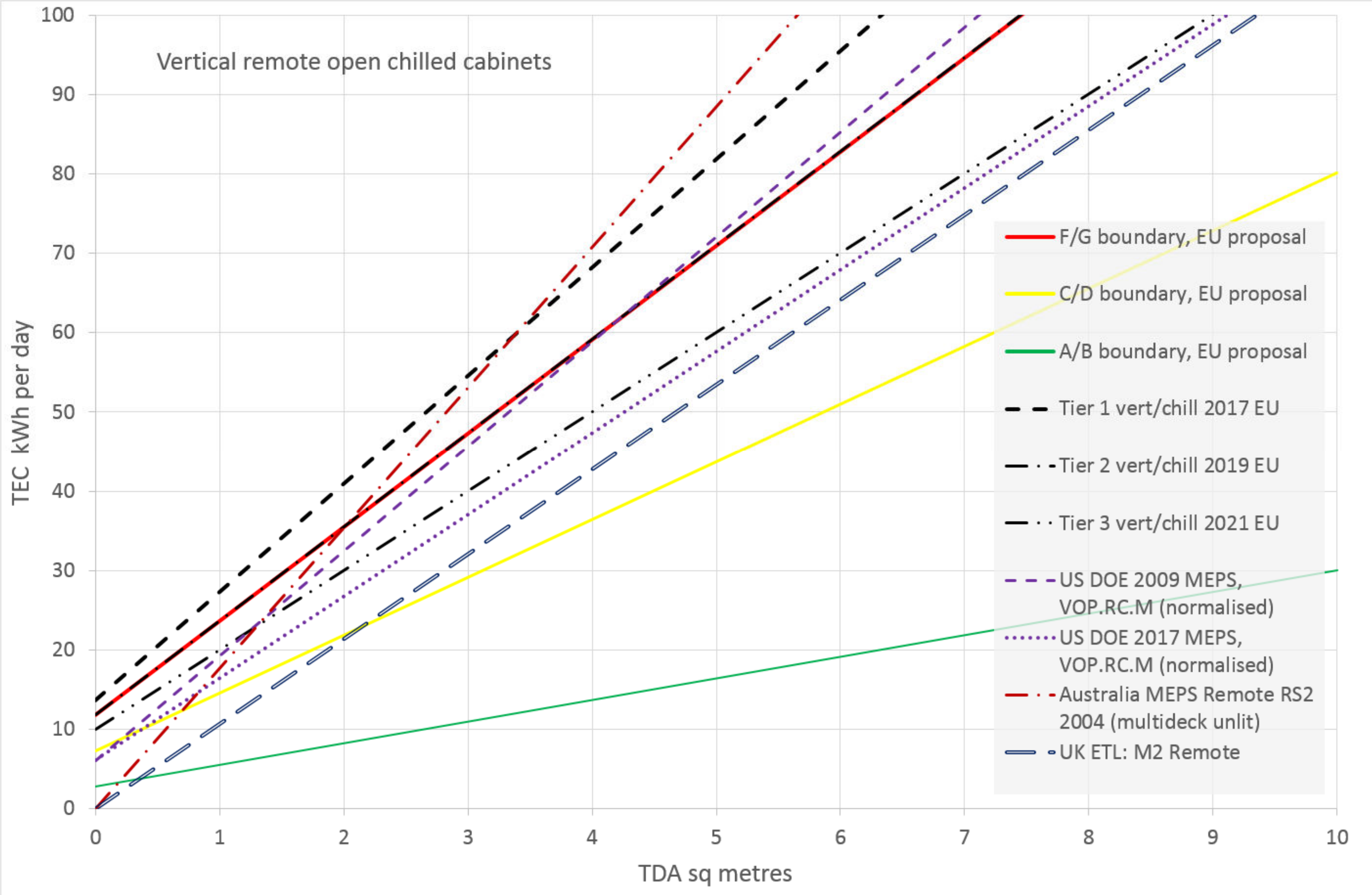


Figure 2. Comparison of proposed EU MEPS, with UK, USA and Australian policy thresholds for vertical remote open display cabinets, all normalised to EN 23953:2005.

Figure 3 shows remote, open, vertical chilled refrigerated display cabinets. The data sets used in this graph are from the general market in California and Australia, plus better performing cabinets from the UK (being those that qualify for the UK Energy Technology List) and certified data from EU cabinets registered with Eurovent certification in 2014 which also represent better performing cabinets. These products are shown in the context of the EU proposed MEPS and label thresholds. Note: 1) the set of cabinets meeting the selected category from the CEC data set are from only one supplier; 2) the Australian and CEC data sets may include legacy cabinets that no longer meet the current local MEPS. If the proposed draft working document is adopted without modification, observations on Figure 3 include:

1. Most of these open cabinets meet EU energy class D, including those from the UK ETL, with many of the Eurovent cabinets in class C.

2. No cabinets from these data sets achieve above class C and so the EU energy label proposals appear to have good capacity for improvement of remote, open cabinets.

3. The EU MEPS appear to remove from the market very few of the open cabinets included in these data sets. Some poor efficiency open cabinets that do not appear in these data sets will be removed from the market, but most of these open cabinets from 2013 will remain on the market beyond 2021 under the current DG ENER proposals. This would imply that the proposed MEPS would allow a significant portion of the open cabinet market to remain, unaffected by the regulation.

4. If the EU minimum requirement were to be aligned with the C/D label threshold at EEI 80, this would allow a reasonable choice of very best performing units today to remain on the market and advance the performance of open cabinets across the EU. MEPS at this level would also encourage some customers to consider closed cabinets and facilitate even greater energy savings. This policy objective to encourage use of close cabinets could be achieved more effectively, with other benefits, through changes to the proposed reference line and thresholds for labels and MEPS as described in section 3.5.

5. The label classes F and E are very narrow and those for D, C and B very wide. Unfortunately, this leaves very little scope to differentiate products in the highly populated EEI zone around the upper part of C and lower part of B.

The range of performance of open cabinets contrasts sharply with Figure 4 which includes only remote closed cabinets:

1. This shows how closed cabinets can consume less than one third of the energy of open cabinets for the same TDA.
2. All of these closed cabinets (which are only better performing cabinets on the markets due to data sources used) already achieve EU A or B energy class, including a few close to the proposed EU benchmark level.

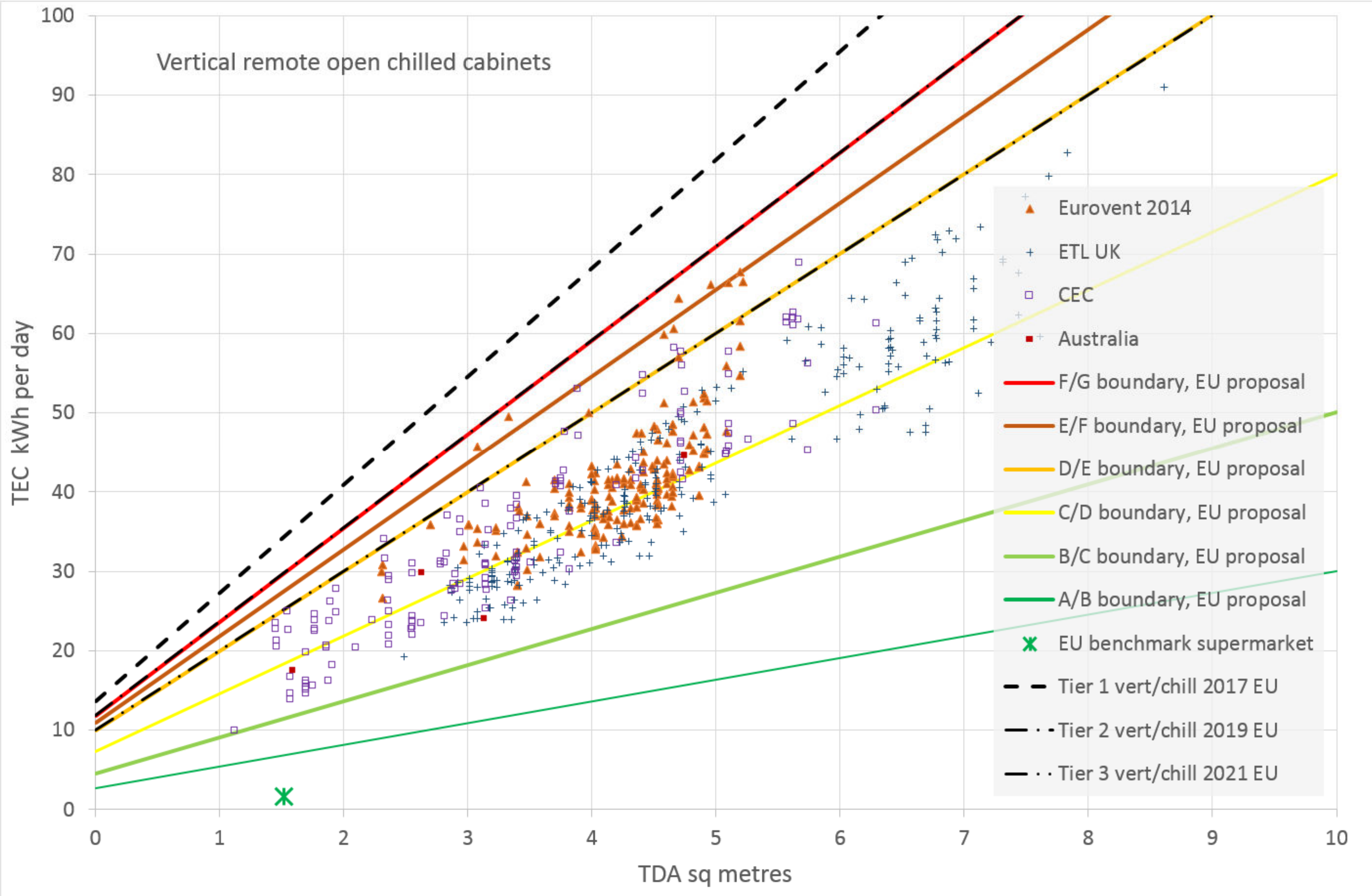


Figure 3. Comparison of proposed EU MEPS and label boundaries with normalised data from Eurovent certification data for 2014, California (CEC), Australia and the UK Energy Technology List, showing vertical, remote open cabinets of temperature M2 (chilled).

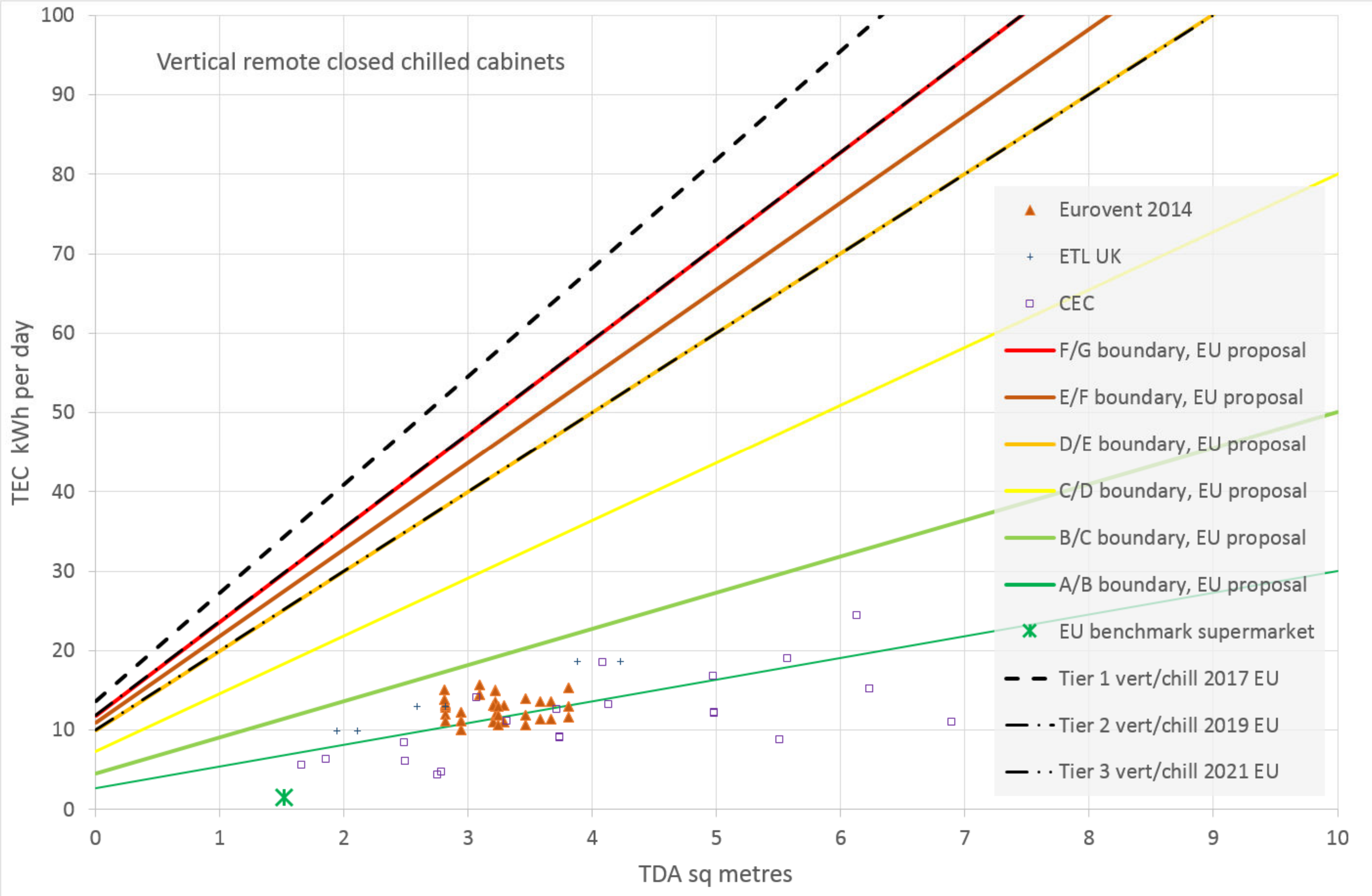


Figure 4. Comparison of proposed EU MEPS and label boundaries with normalised data from Eurovent certification data for 2014, California (CEC), Australia and the UK Energy Technology List, showing vertical, closed, remote cabinets of temperature M2 (chilled).

3.4 Comparing policies and market data for horizontal frozen cabinets

The EU proposed MEPS and labels for horizontal frozen cabinets are shown in Figure 5. These apply to both integral and remote, open and closed cabinets. In Figure 6, these EU proposals are then compared with the MEPS for open remote cabinets from other regions of the world. Figure 7 shows EU proposals compared with requirements from other regions for closed integral cabinets.

If the proposed draft working document is adopted without modification, observations include:

1. Integral cabinets tend to be much smaller than remote cabinets in terms of TDA – indeed most of the smaller cabinets are integral. Also, a far greater proportion of the integral cabinets are closed, whereas most of the horizontal remote frozen cabinets are open and use proportionally more energy as a result.
2. If more of the open remote cabinets were converted to closed type, energy savings would result, but it can be seen from Figure 6 that most of these open remote cabinets can remain on the market even after 2019, although the 2021 MEPS would remove the majority of them. None of these models will be affected by the 2017 MEPS. Worse performing open cabinets (not included in these data sets) would be forced off the market, but many open frozen cabinets could still be present in shops.
3. The US MEPS of 2009 for open frozen horizontal remote cabinets are more stringent than the 2021 requirements for the EU (Figure 6).
4. The Australians set MEPS separately for open and for closed cabinets (and also separately for integral and remote), and therefore the MEPS for closed cabinets are much more stringent (as shown in Figure 7, when compared with Figure 6).
5. Closed cabinets from the UK are seen to be clustered in energy class B, with a few in class A (Figure 7). This leaves little scope for differentiating future best performing cabinets as most are likely to be class A. At least the higher label classes (A, B, C) should be made more stringent to allow continued differentiation once the market is moved substantially over to closed cabinets. This bunching at class B currently affects only integral cabinets (being smaller in TDA) but may also be relevant to remote cabinets in due course (remote closed cabinets from Eurovent Certification are mostly label D at present).

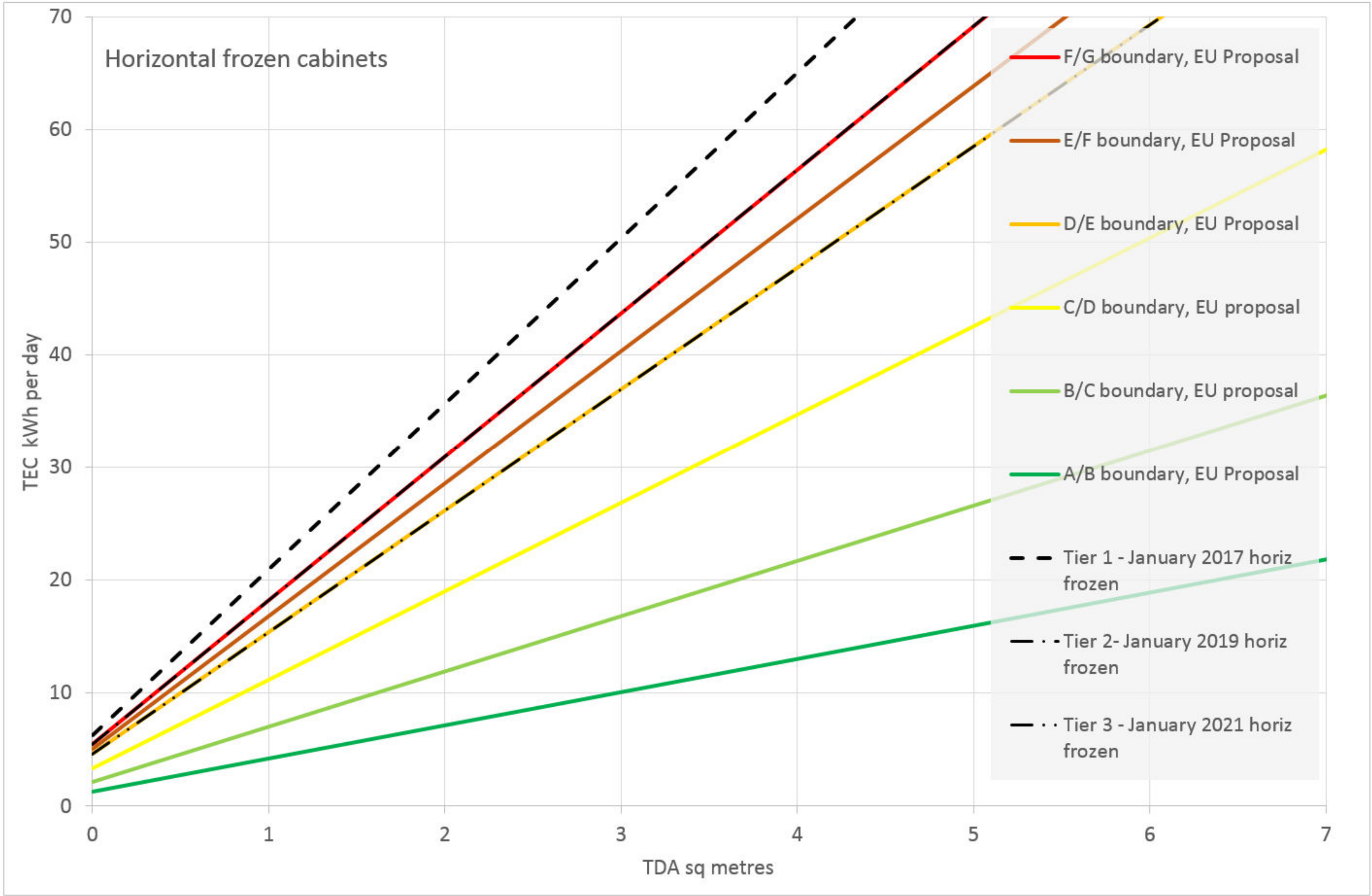


Figure 5. EU proposed MEPS and labels for frozen horizontal cabinets.

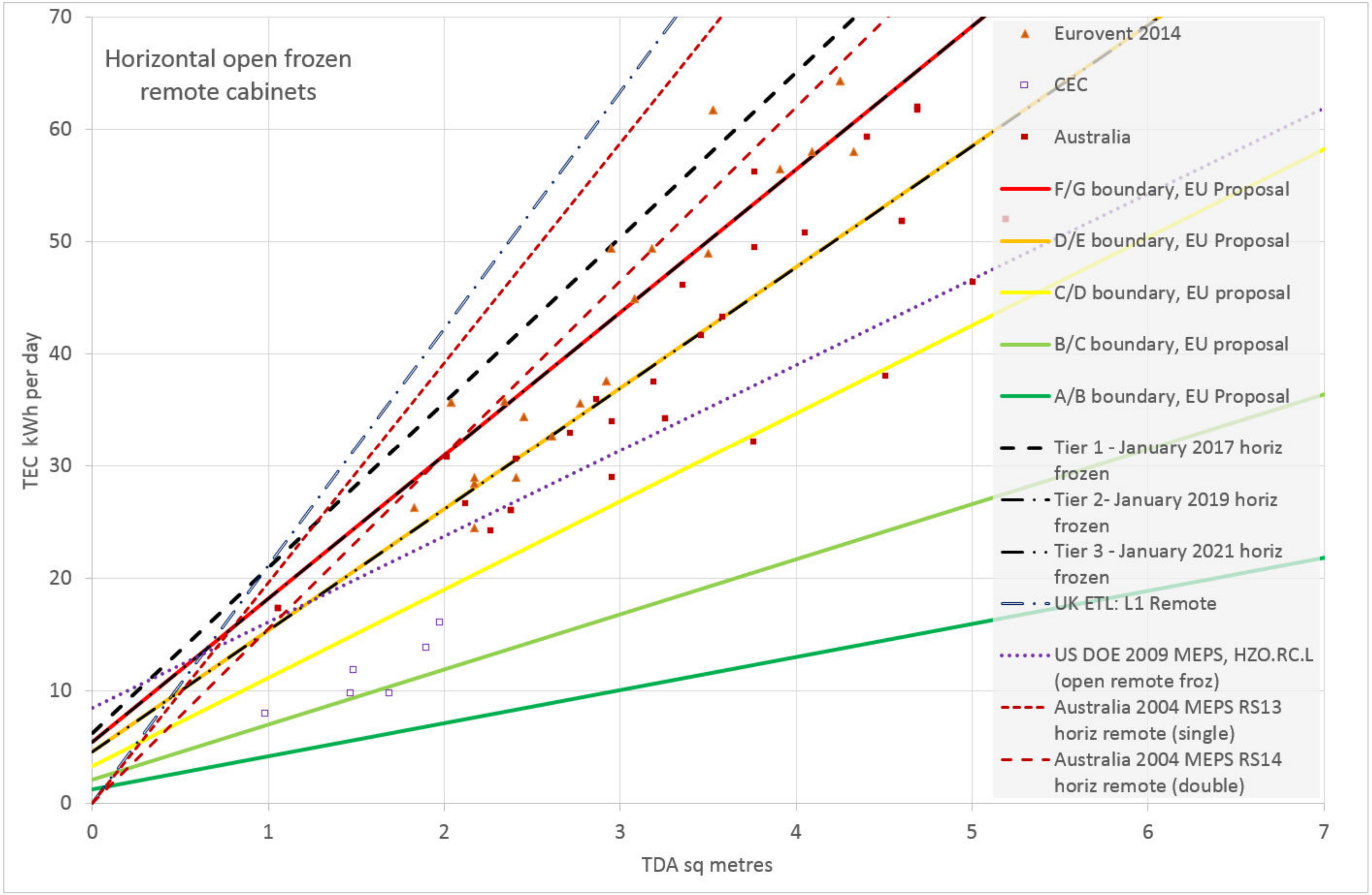


Figure 6. EU proposals alongside requirements from the UK, USA and Australia – all non-EU lines refer to remote, frozen, horizontal open cabinets and are normalized to an L1 reference temperature.

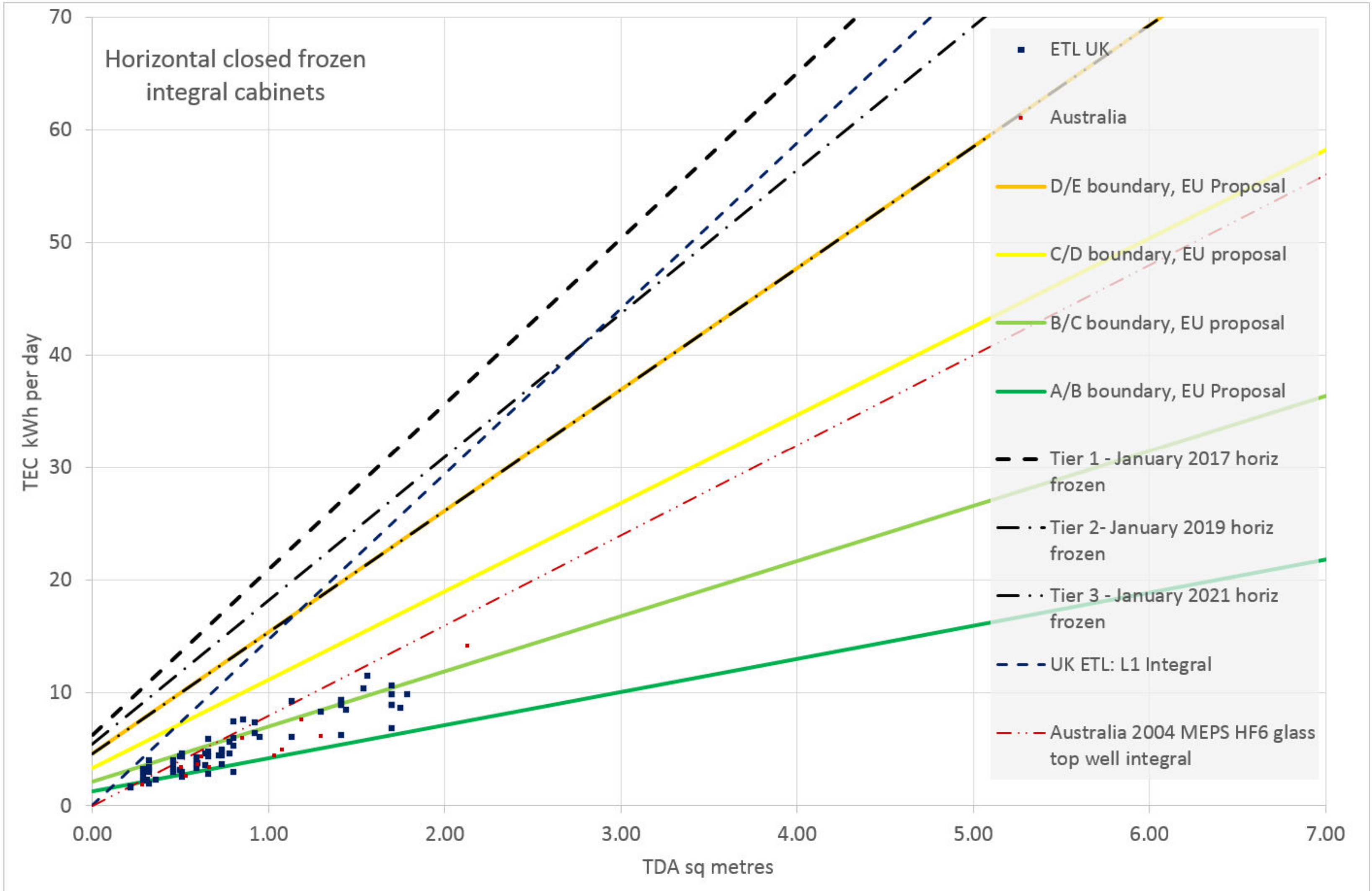


Figure 7. EU proposals alongside requirements from the UK and Australia (no relevant requirements exist for USA[26]) – all lines refer to integral, frozen, horizontal cabinets of closed type and are normalized to an L1 reference temperature.

[26] USA requirements for horizontal frozen closed self-contained cabinets (HCT.SC.L) are expressed in terms of volume, not TDA in the 2017 MEPS.

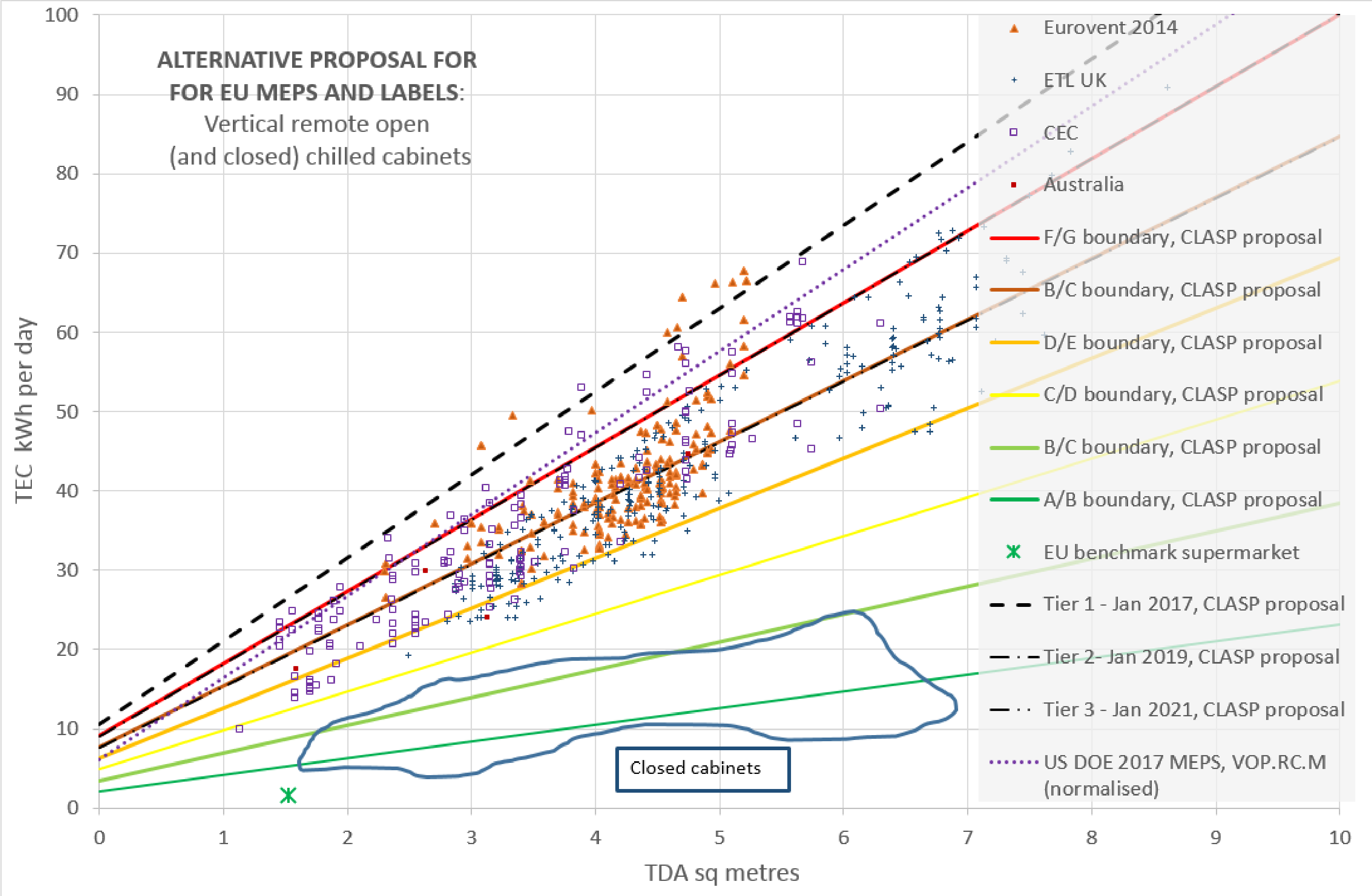


Figure 8. Alternative proposal for MEPS and labels, shown with normalised data from Eurovent certification for 2014, California (CEC), Australia and the UK Energy Technology List, showing vertical, remote open cabinets of temperature M2 (chilled). Also shows the locus of data points for vertical, closed, remote, chilled cabinets (blue loop, derived from Figure 4).

3.5 Alternative MEPS levels for refrigerated display cabinets

By far the most important segment in terms of energy consumption is the chilled, vertical remote segment, and this alternative proposal focuses on those cabinets. The same principles outlined in this section could also be applied to frozen vertical, chilled horizontal and vertical cabinets.

The primary driver for proposing alternative MEPS and labels for RDCs is to ensure that the regulations strongly encourage use of doors but still allow for continued availability of highly efficient open cabinets. Figure 3 shows that the current proposals for MEPS even at 2021 will allow continued availability of the majority of open cabinets in these data sets. Whilst many poor efficiency cabinets (not present in these data sets) would undoubtedly be removed by these MEPS, sufficient supply would remain to maintain similar presence in shops as today. Also, the uneven distribution of label classes means there is less scope to differentiate products in the most populated zone of performance.

Figure 8 shows proposed alternative MEPS and labels (and should be compared with Figure 3). For this alternative proposal, the reference line has coefficient M (slope) and N (intercept) of 7.0 and the new energy label class boundaries are shown in Table 1. This proposal makes no change to the MEPS in terms of EEI (although the reference line change alters their level of performance).

Table 1. Proposed alternative distribution of energy label classes for chilled vertical cabinets compared with the July 2014 working document.

Label class	EEI thresholds from the Commission's 2014 draft working document	Alternative proposed EEI thresholds
A/B boundary	30	30
B/C boundary	50	50
C/D boundary	80	70
D/E boundary	110 and Tier 3 MEPS	90
E/F boundary	120	110 and Tier 3 MEPS
F/G boundary	130 and Tier 2 MEPS	130 and Tier 2 MEPS
-	150 Tier 1 MEPS	150 Tier 1 MEPS
M coefficient (slope)	9.1	7.0
N value (intercept)	9.1	7.0

This proposal allows the following benefits:

1. The label classes are more stringent to ensure continued differentiation of best (closed) cabinets as few are currently label class A.
2. Even distribution of classes F, E and D means more scope to differentiate the cloud of current (better performing) open cabinets, rewarding efficiency progress for suppliers.
3. The majority of open cabinets on the EU market would be energy labels E, F and lower which is appropriate to their performance. This lower label would significantly discourage the use of open cabinets. The very best open cabinets at 2014 achieve energy label D, but open cabinets would soon be developed that achieve label C, which would be intuitively reasonably acceptable to consumers and buyers in the necessary applications.
4. The alternative proposed EU requirements for 2019 are comparable with the 2017 requirements for USA and so would ensure that the EU industry is globally competitive in this most important segment of the market (in energy terms).
5. MEPS in 2017 begin to apply pressure to open cabinets, but the majority of better performing products remain on the market until 2021, after which around half of these open cabinets will remain.

4 Beverage Coolers

4.1 Beverage cooler data sources and policies

Beverage cooler cabinets were picked out from the data sets obtained from US ENERGY STAR, Canada and California.

Since beverage coolers are regulated in terms of volume for the EU, no relevant data was usable from UK ETL, Eurovent or from Australia as all of those data sets either had no cabinet volume data (TDA based) or if they had volume data, they included no integral cabinets that met the description.

The proposed EU regulation is based on a definition that includes a ‘pull-down’ capability (ability to lower the temperature within a specified period of beverages that are at ambient temperature when loaded). This means that the unit may have a larger capacity refrigeration unit which may consume more power and so the requirements tend to be less stringent. However, there is no requirement for a pull-down test to be included within the measurement method and so test results should be comparable between beverage coolers and normal chilled cabinets. Both the Californian regulations and the US DOE 2017 regulations have requirements for pull-down cabinets; these are shown alongside requirements for conventional vertical glass door chilled integral cabinets from DOE and ENERGY STAR.

The EU definition also allows use of energy saving devices that allow the temperature to rise during extended periods with no user interaction, since beverage coolers are defined for use with non-perishable beverages. Although this is the case, there is not a European test method for beverage coolers that includes energy consumption measurements incorporating such devices, so all current energy consumption data is considered comparable at this stage.

4.2 Normalisation of beverage cooler data

Normalisation for beverage coolers was identical to that for RDCs.

4.3 Comparing policies and market data for beverage cabinets

Figure 9 shows the EU proposals for MEPS and labels for beverage coolers. Figure 10 compares the EU proposals with federal MEPS from the USA for 2010 and the future 2017 MEPS that were adopted by DOE for cabinets both with and without pull-down capability, and also with California MEPS for 2010 (with pull-down capability). The DOE MEPS of 2010 apply to cabinets with storage capability only, with no special requirement for pull-down capability.

For context on interpreting the scale of the horizontal axis: a very common unit, a single door cabinet approximately 2m high and 0.6m wide will have a volume of just over 500 litres.

Note that the EU requirements apply to both open and closed beverage coolers, of both vertical and horizontal orientations and integral and remote condensing unit types. Whereas the US requirements are selected as those applicable to closed vertical glass door integral cabinets – which represent by far the most prevalent type in the EU and US markets. In addition, the US sets slightly less demanding requirements for vertical glass door vertical chilled cabinets that have pull-down capability (these are shown as close in Figure 10).

Observations from Figure 9 and Figure 10 include:

1. Figure 9 shows that the proposed EU MEPS for 2017 do not align with any label class boundary and are set lower than G class – hence after 2017, G label cabinets can still remain on the market.
2. The general slope of the EU reference line for beverage cabinets (which lies between label class boundaries C/D and D/E, at EEI = 100, closer to D/E) appears significantly out of line with the slope deemed appropriate for all US regulations. This may be significant because the general slope should reflect the inevitable engineering/physics link between energy consumption and size of cabinet. Policy stringency (which can vary) is primarily associated with how high or how low on the vertical (energy) axis the policy threshold appears.
3. Compared to the US requirements, the steep slope of the EU proposals means they are relatively stringent for the smallest cabinets (i.e., below approximately 200 litres, or about the size of a modest under-counter cabinet).
4. Another downside of the steep reference line for EU labels is that the width of EU label classes varies enormously from F down to B. Lower classes are very narrow (slight adjustment of volume could easily shift cabinet by a class or more) and classes A and B are very broad, which will lead to less differentiation of products in future years. These broad higher categories also brings the risk of a disincentive to invest in a big jump up to efficiency class A (a substantial product price increase), and could therefore stall the market at B.
5. In Figure 10, for a standard full height single glass door cabinet (around 500 litres), the 2017 EU requirements (11 kWh/day) will allow for nearly twice the energy consumption of the US and Californian MEPS that took effect in 2010.[27] Even the 2021 EU requirements for this popular size allows 25% higher consumption than the US MEPS of 2010 – implying that the EU market would be allowing efficiency levels over *15 years behind those of the US*.
6. Beverage cabinets that just meet the US MEPS for 2017 (simple glass door vertical chilled cabinets and those with pull-down capability) would be at the top of EU label class B. This implies that higher efficiency cabinets are already on the market, and so the EU scheme would be dominated by A class products within a few years.

[27] The regulations being compared here are highly comparable, as they all apply to the same product group - glass door cabinets with pull-down capability.

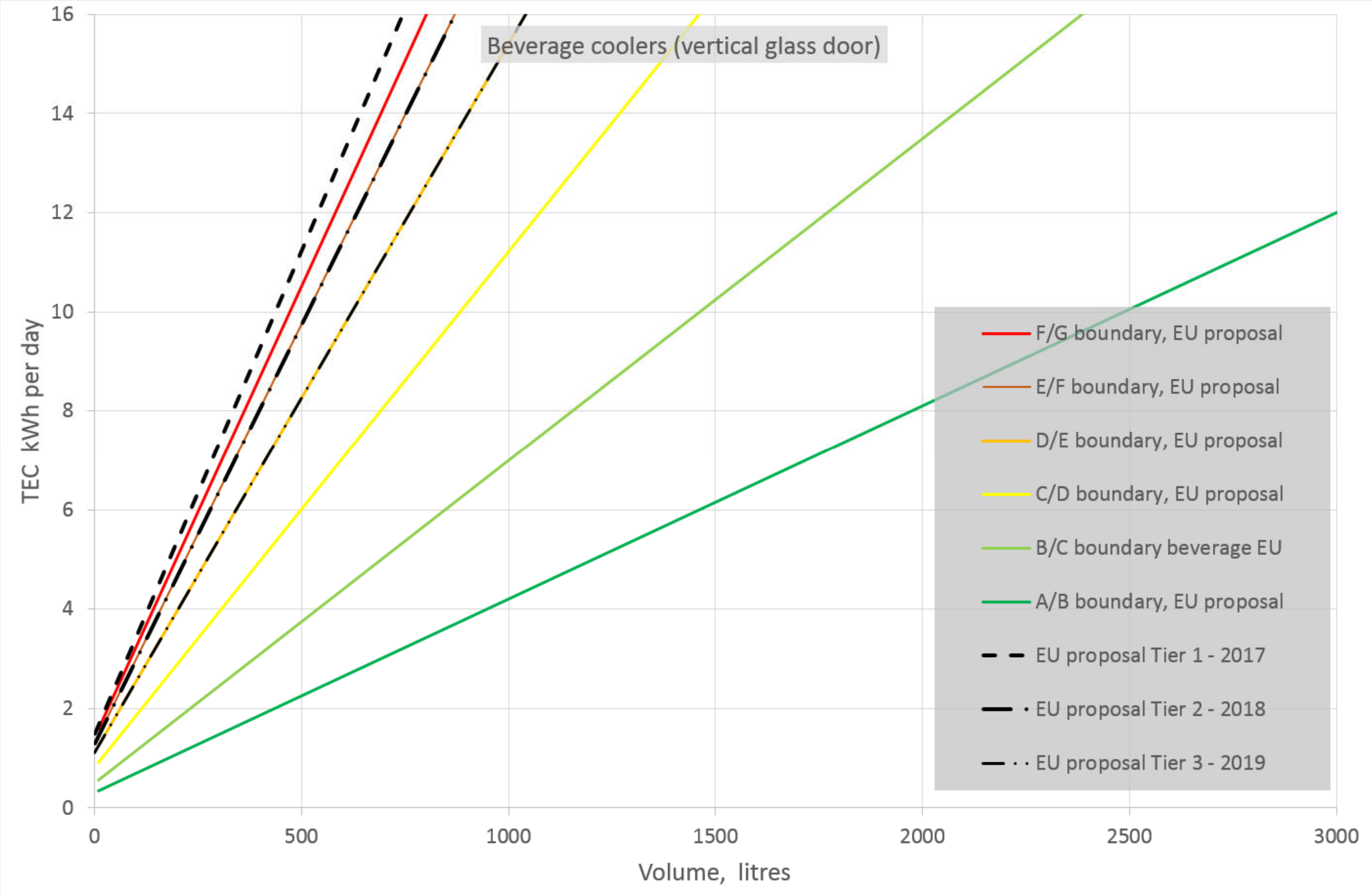


Figure 9. Proposed EU MEPS and labels for beverage cabinets.

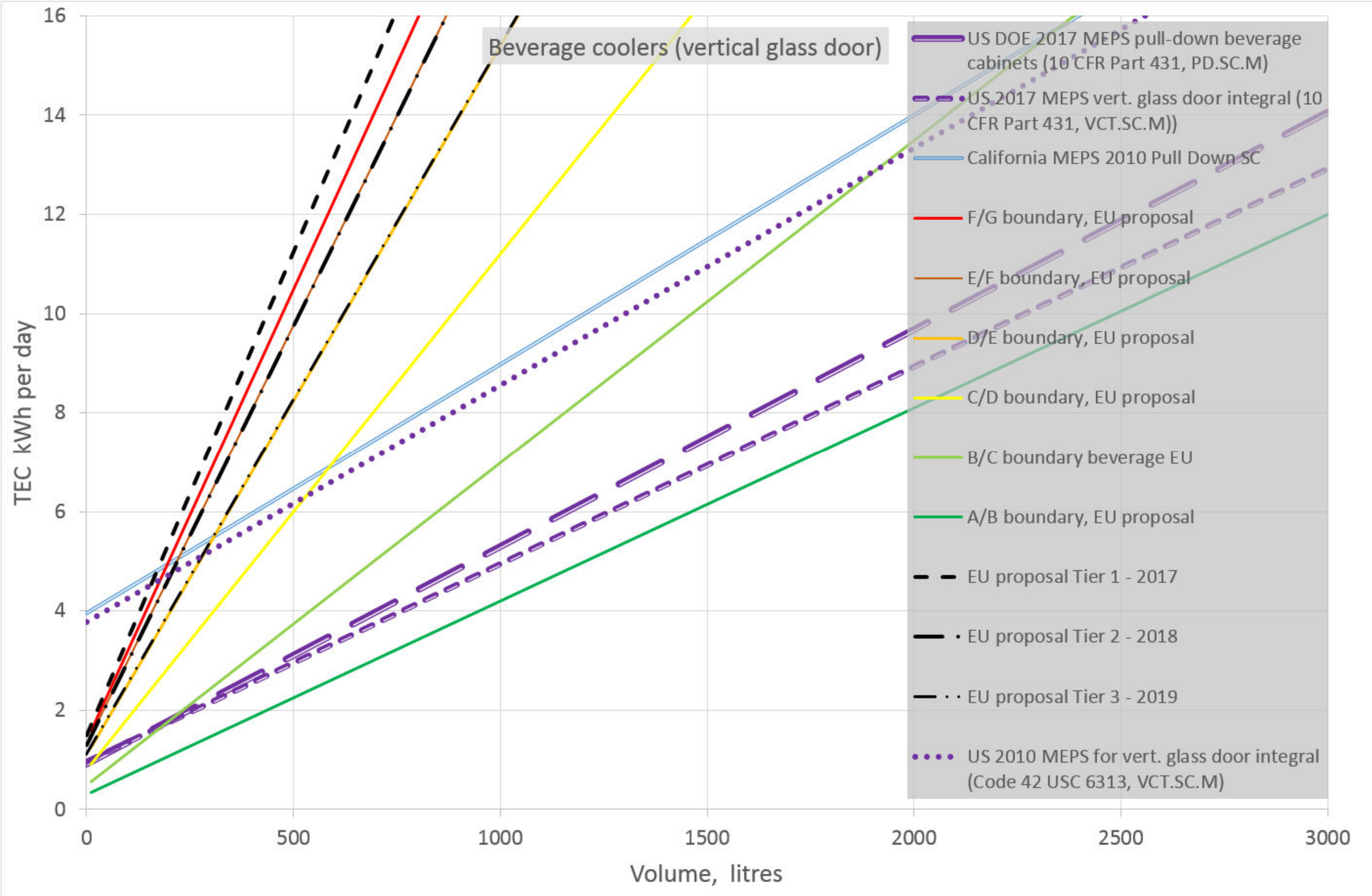


Figure 10. Comparison of proposed EU MEPS and labels for beverage cabinets with criteria for USA (DOE MEPS for beverage coolers with pull-down capability in 2017; DOE MEPS for glass door vertical cabinets 2010 (from US code section 6313) and 2017 (from 10 CFR Part 431).

Figure 11 shows the EU MEPS and labels along with vertical, integral, glass door chilled cabinet data for US ENERGY STAR (V2.1), California and Canada. It also shows the US ENERGY STAR criteria for V2.1 (valid since 2009) and V3 which comes into force in October 2014 (note that ENERGY STAR does not specify a pull-down capability requirement).

If the proposed draft working document is adopted without modification, observations on Figure 11 include:

1. North American cabinets of nearly 2500 litres are present in these US data sets, the JRC data set (provided by EU industry) has the vast majority of products under 1000 litres and only a handful of products over 1000 litres. This US data set has many cabinets that must be full height triple door and 4-door cabinets. These larger products are also available on the EU market.
2. The majority of North American under-counter size cabinets (less than 400 litres) would be EU label class C with some class B. The North American single door full height (500 litres) cabinets are primarily equivalent to EU class B with some C. The majority of double door and larger cabinets in North America would be class B with some class A. This shift in typical label classes moving up through the size range is another indicator that the EU reference lines for this product group may not reflect the product engineering principles relating performance and capacity.
3. It seems likely that the EU MEPS will have no impact on even poor performing cabinets that are above approximately 300 litres, due to the very steep upward slope of the EU MEPS.
4. However, EU best in class cabinets (from the Top10 programme) and the EU benchmark level appear to compare well with the US products, and meet the ENERGY STAR V2.1 and V3 criteria for glass door vertical cabinets, suggesting that the products are not very different.

4.4 Alternative MEPS levels for beverage coolers

An alternative reference line and alignment of minimum requirements is suggested in order to achieve the following:

1) To ensure that the MEPS have an impact across the whole range of cabinet sizes;
2) To set out label classes that have a more even transition of energy performance between levels and cannot easily be manipulated by adjusting the cabinet volume;
3) To align all of the MEPS with specific label boundaries;
4) To have sufficient headroom in the label classes to ensure that manufacturers can continue to differentiate better performing cabinets in future (rather than all cabinets being class A); and
5) To gradually bring the stringency of EU thresholds closer to that of the USA.

The alternative suggested MEPS and label thresholds are based on a reference line with coefficient M (slope) of 0.0055 and N (intercept) of 2.1 (these were 0.013 and 1.0 respectively under the July 2014 EU proposals); and sets the EEI MEPS requirements at:

- Tier 1 MEPS 2017 at EEI 140, coinciding with the F/G label boundary (was 150)
- Tier 2 MEPS 2019 at EEI 110, coinciding with the D/E label boundary (was 130)
- Tier 3 MEPS 2021 at EEI 80, coinciding with the C/D label boundary (was 110)

Table 2. Proposed alternative EEI levels for MEPS thresholds for beverage coolers compared with the July 2014 working document (EEI thresholds for energy label classes are identical).

Label class	EEI thresholds from the Commission's 2014 draft working document	Alternative proposed EEI thresholds
A/B boundary	30	30
B/C boundary	50	50
C/D boundary	80	80 and Tier 3 MEPS
D/E boundary	110 and Tier 3 MEPS	110 and Tier 2 MEPS
E/F boundary	130 and Tier 2 MEPS	130
F/G boundary	140	140 and Tier 1 MEPS
-	150 Tier 1 MEPS	
M coefficient (slope)	0.013	0.0055
N value (intercept)	1.0	2.1

This proposed alternative MEPS and labelling thresholds are shown in Figure 12, from which it can be seen that:

1. The Tier 1 MEPS are only slightly more stringent than the 2019 US MEPS for the smallest cabinets (previously, they were far more stringent than the US under 300 litres);
2. The Tiers and labels will have an impact on cabinets across the whole size range;
3. With Tier 2 in 2019, the EU market would be better than the US market of ten years earlier (2010);
4. EU Tier 3 of 2021 is almost identical to the ENERGY STAR requirement of 2009 (12 years earlier), but still allows 30% higher consumption than the US MEPS of 2017 (4 years earlier);
5. There are a few best performing cabinets on the EU market today that achieve label class B, with scope to encourage even further improvements to class A; and
6. The US minimum requirement for beverage coolers falls within label class C.

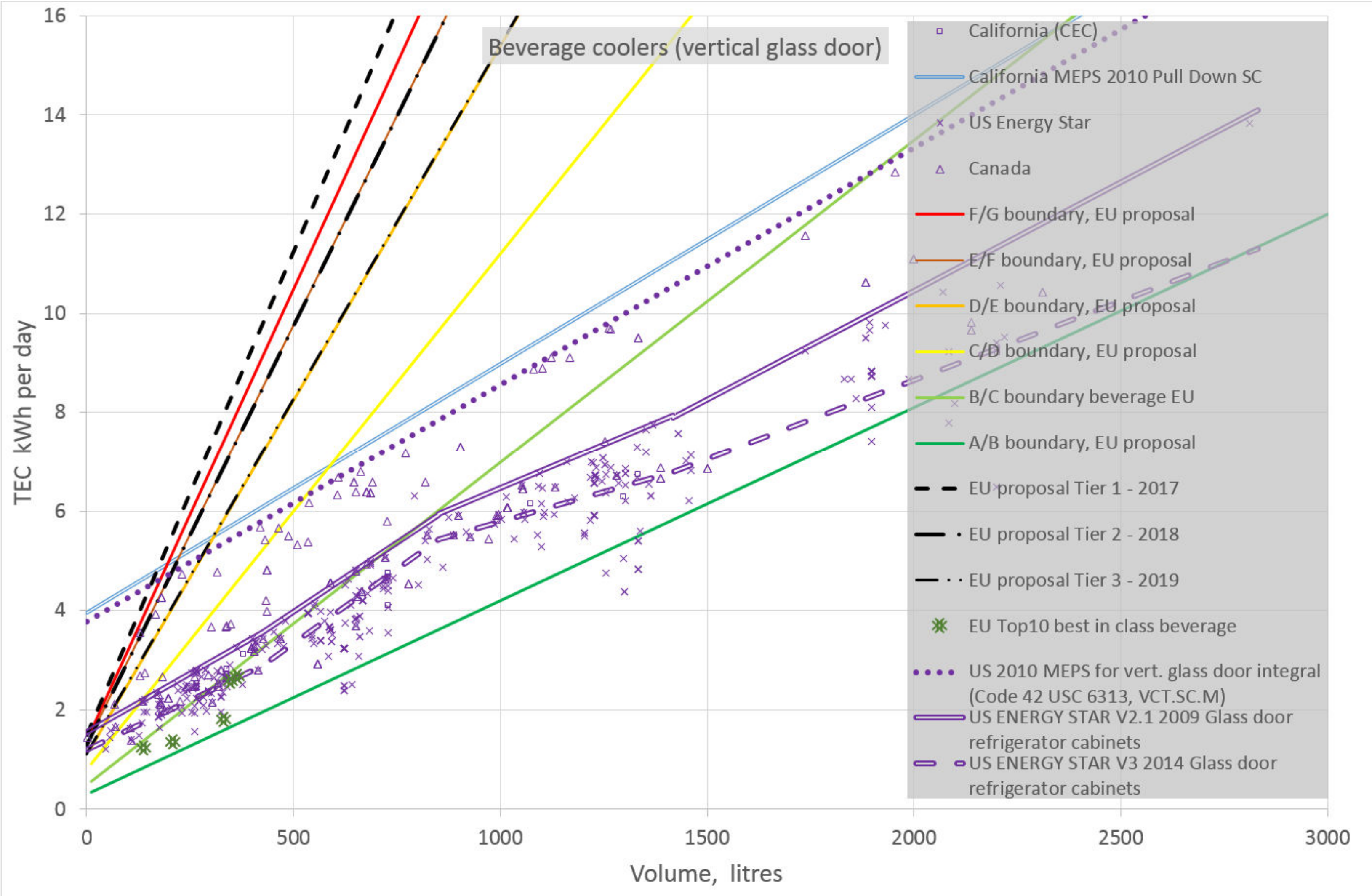


Figure 11. EU MEPS and labels for beverage cabinets compared with criteria for USA (DOE MEPS for glass door vertical cabinets 2010 and US ENERGY STAR V2.1 criteria (2009) and qualifying products, with ENERGY STAR V3 criteria (October 2014). Also shows vertical glass door integral chilled cabinets for Canada, and those with pull-down capability from California.

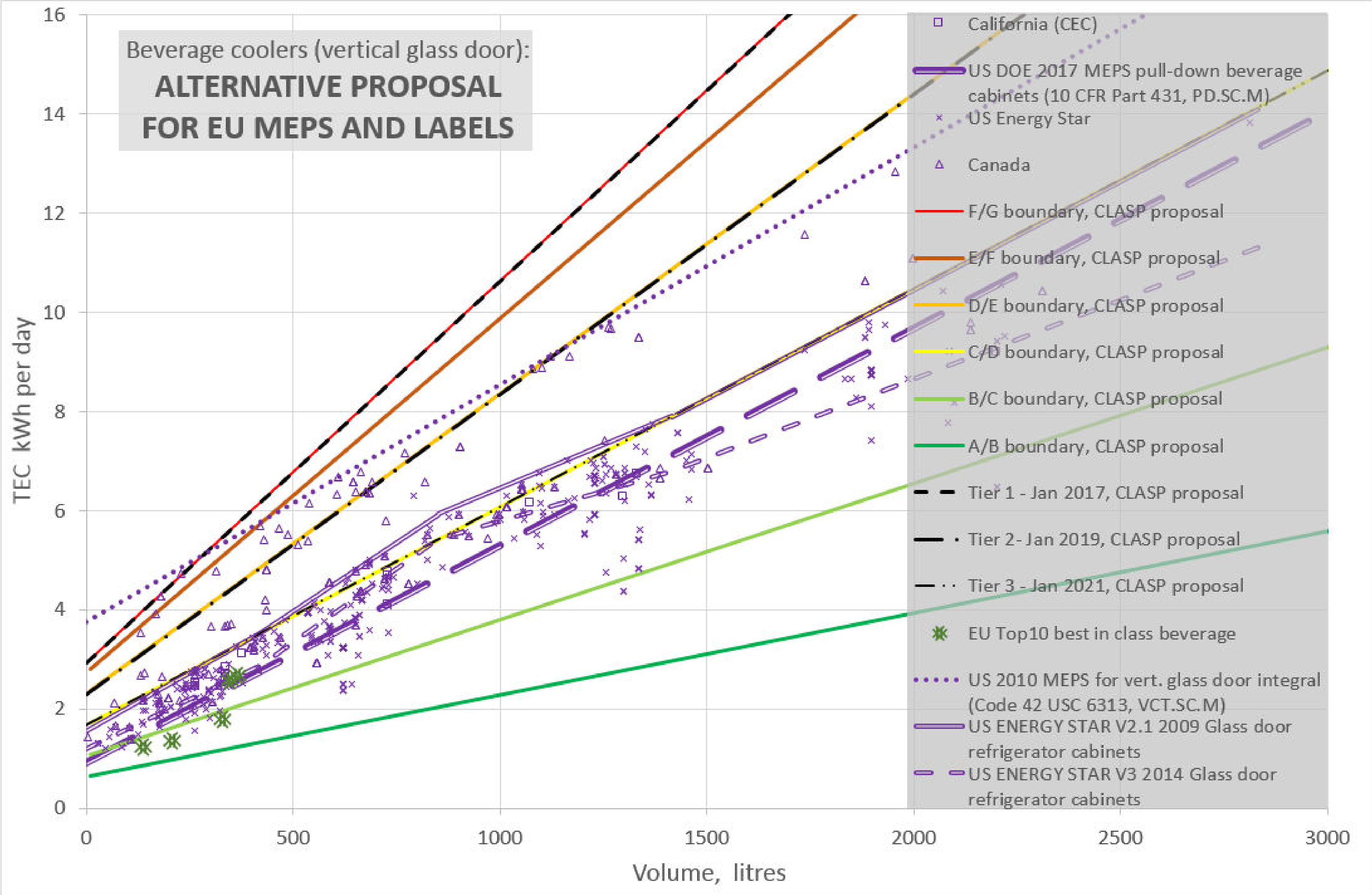


Figure 12. An alternative scheme of MEPS and label thresholds for the EU, compared with criteria for USA (DOE MEPS for glass door vertical cabinets 2010, beverage cabinet MEPS for 2017 and US ENERGY STAR V2.1 criteria (2009) with ENERGY STAR V3 criteria (October 2014).

5 Vending machines

5.1 Vending machine data sources and policies

The only data set available for vending machines was for US ENERGY STAR qualified products under the Refrigerated Beverage Vending Machines[28] category, consisting of 124 products. The EU working document includes performance data for a best available technology benchmark machine that is included in the graphs. In addition, the European Vending Association made test data available for a single cabinet tested according to the draft new EU test methodology from CEN TC59X working group 11 (appears in Figure 15).

The EU proposals were compared with the following US policies (all policy thresholds were normalised in exactly the same way as the product performance data if/as appropriate):

i. US ENERGY STAR criteria[29] for Vending machines V3 that came into force in March 2013 (the requirements of V3 are set in terms of internal volume, whereas the previous ENERGY STAR criteria were set in terms of machine capacity by count of products and so are not comparable). ENERGY STAR differentiates better performing products in the market, aiming for top 25% and requires third party certified data for this product group.

ii. California Energy Commission MEPS[30] for Refrigerated Canned and Bottled Beverage Vending Machines (which coincide with the US federal MEPS published in 2009 and which came into force in August 2012).

iii. US federal MEPS for vending machines which came into force in 2009.

Note: the US DOE published a Notice of Proposed Rulemaking (NOPR) on 11 August 2014 for a Test Procedure for Refrigerated Bottled or Canned Beverage Vending Machines[31] which aims to clarify and amend several aspects of the test method for US regulations. The implications of this draft revised US DOE test method on this analysis and the EU regulations have not yet been assessed.

The Canadian regulations for beverage vending machines are expressed in terms of machine capacity in number of products that it can stock, so it cannot be compared with volumetric efficiency requirements.

5.2 Normalisation of vending machine data and policies

No normalisation was considered necessary for vending machine data.

The US regulation is based on the test standard ASHRAE 32.1[32] which is in principal very similar to the method on which the EU working document proposal is based - the European Vending Association 'Energy Measurement Protocol'[33].

The USA distinguishes two types of vending machine (in both ENERGY STAR and in Federal Regulations):

- Type A for which the whole interior space is fully cooled – these are glass front machines (called spiral vend in the EU).

[28] See http://www.energystar.gov/productfinder/product/certified-vending-machines/results.
[29] Criteria from http://www.energystar.gov/products/specs/.
[30] See http://www.energy.ca.gov/appliances/.
[31] Federal Register Vol. 79 No. 154 , Monday, August 11, 2014, Part II Department of Energy, 10 CFR Parts 429 and 431, Energy Conservation Program: Test Procedure for Refrigerated Bottled or Canned Beverage Vending Machines; Proposed Rule. See http://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-TP-0045-0001.
[32] ASHRAE Standard 32.1-2004, Methods of Testing for Rating Vending Machines for Bottled, Canned, and Other Sealed Beverages (as used by ENERGY STAR and US DOE MEPS).
[33] Test Protocol for the Measurement of Energy Consumption in Vending & Dispensing Machines, Version 2.0 – June 2008, European Vending Association, Brussels, http://www.vending-europe.eu.

- Type B vending machines have only the zone nearest to being vended cooled to the lowest required temperature – these are generally opaque fronted with cans or bottles stacked in hoppers. This saves energy by allowing a higher storage temperature for the majority of the stock.

The US Final Rule for vending machines published in 2009[34] explains the US position that fully-cooled machines are shelf-style arrangements, usually glass or polymer fronted and users can select any of the products to vend next, so the whole volume is refrigerated. This suggests that Type A machines in the US are identical in principal to EU spiral vending machines – but US regulations apply only to can / bottle and sealed beverage machines, whereas the EU market and regulations are aimed at both beverage and snack machines. EU snack machines are used to store a wide range of snacks: biscuits, crisps, chocolate, cans and bottles and also perishables such as sandwiches.

ASHRAE 32.1 is only for beverage machines but these can be dedicated can and bottle opaque fronted machines or glass fronted spiral vend type – both are covered by US regulations. But the European Vending Association has noted[35] that there is uncertainty on how the ASHRAE 32.1 test method is interpreted for testing glass front spiral vend machines, which account for a majority of EU machines but a minority of US machines. Indeed US DOE published on 11 August 2014 their intention to clarify and develop this and other aspects of the vending machine test method for the federal regulations (in the NOPR noted above).

Ambient conditions during the test are relatively straight forward: ASHRAE 32.1 involves testing at ambient conditions of 23.9°C±1°C and 45%±5% RH (for indoor rated machines); the EU Energy Measurement Protocol requires 25°C and 60% RH (for indoor rated machines). The effect of ambient humidity on machine performance is less pronounced, especially as differences are small, and this difference was ignored.

An important factor in comparison of the data points and policy lines is the storage temperature used: No specific reference temperature for the EU proposals is quoted in the regulation, and the draft EU test methodology offers a range of options. Energy Star refers to 10 CFR Part 431.294 Subpart Q (the US DOE Final rule for vending machines published in 2009) which requires 2.2°C storage temperature for products (beverages) about to be vended. Note that this temperature is required for the whole internal volume for Type A machines in the US market and only for products about to be vended for Type B machines. A key uncertainty is the storage temperature to be used for snack machines (as opposed to can and bottle machines) since these may be for chocolate snacks and so requiring no lower than 10°C, or sandwiches that require 5°C or less.

The working assumption of this analysis is that as long as Type A and Type B machines are clearly differentiated in the analysis, the storage temperatures of glass fronted (spiral vend) beverage and snack machines should be reasonably comparable and no normalisation was carried out for storage temperature (or any other factor) in this analysis. The ENERGY STAR data set identifies glass fronted and opaque fronted machines, which are assumed Type A and Type B machines respectively.

Comments from stakeholders would be welcome to verify and/or enhance understanding of the comparability of US data and policy thresholds, as the policy levels appear so very different.

5.3 Comparing policies and market data for vending machines

The EU proposed MEPS and labels are shown in Figure 13.

Figure 14 shows EU proposals with US federal MEPS that came into force in August 2012 (published in 2009), and the US ENERGY STAR criteria V3 for beverage vending machines from 2013.

[34] See https://www.federalregister.gov/articles/2009/05/29/E9-12410/energy-conservation-program-energy-conservation-standards-for-refrigerated-bottled-or-canned#h-39.

[35] Personal correspondence with the author, August 2014.

If the proposed draft working document is adopted without modification, the following observations can be made:

1. From Figure 13, the proposed EU MEPS do not coincide with any label levels – this is potentially confusing and appears unnecessary since MEPS could be aligned with the G, F and E label levels.
2. The slope of the EU lines is very similar to that of the USA, which provides some reassurance that the slope is appropriate (no normalisation was carried out for vending machine data).
3. However, regarding stringency the EU requirements, even the 2021 requirements allow twice the energy consumption per day of US requirements that became effective in August 2012. The reason for this large difference is not clear, but may stem from the EU data set: JRC fitted the proposals with the EU data provided to them by EU manufacturers (see Figure 6.21 page 108 in the JRC preparatory study). However, the EU data covers several years and therefore may include data for legacy machines that are now obsolete and superseded by new machines that include numerous energy efficiency features. One EU machine was tested to the new EU draft test method, and that datum point is shown in Figure 15. This machine was regarded by the European Vending Association as typical of modern EU spiral vend machines[36] and was tested with an internal temperature of 12°C. This datum point is positioned alongside the US glass front machines and so would support the view that the EU proposal for vending machines is largely based on legacy data. It may be helpful to address this problem if the EU data set were filtered to include only machines entered into the EU market in the last 2 years.
4. All US ENERGY STAR V3 qualified glass front machines are EU energy label A. (Note: ENERGY STAR opaque front, partially cooled and not shown on this Figure for clarity of purpose and as these are less relevant to the EU market are EU label A or upper part of label B).

5.4 Alternative policy thresholds for vending machines

The apparent disparity in stringency between US and proposed EU regulations is surprising given that there is unlikely to be significant difference in the basic technologies employed (there are only around 20 manufacturers of vending machines globally outside of China[37]). Also, given the likelihood that the EU data includes legacy machines that are far less efficient than those currently on the market, an alternative proposal is made as Figure 15.

This alternative scheme for MEPS and label thresholds is to adopt a reference line with coefficient M (slope) of 0.002 and N (intercept) of 2.0 (these were 0.004 and 4.1 respectively under the current EU proposals). Also to set the EEI for Tiers at:

- Tier 1 MEPS 2017 at EEI 145, coinciding with the F/G label boundary (was 150)
- Tier 2 MEPS 2019 at EEI 135, coinciding with the E/F label boundary (was 130)
- Tier 3 MEPS 2021 at EEI 115, coinciding with the D/E label boundary (was 110)

[36] Personal correspondence with European Vending Association, August 2014.
[37] Benchmarking report for refrigerated vending machines (2012), IEA 4E Mapping and Benchmarking Annex, page 13. Available from http://mappingandbenchmarking.iea-4e.org/matrix.

Table 3. Proposed alternative EEI levels for MEPS thresholds for vending machines compared with the July 2014 working document (EEI thresholds for energy label classes are identical).

Label class	EEI thresholds from the Commission's 2014 draft working document	Alternative proposed EEI thresholds
A/B boundary	55	55
B/C boundary	75	75
C/D boundary	95	95
-	110 Tier 3 MEPS	-
D/E boundary	115	115 and Tier 3 MEPS
-	130 Tier 2 MEPS	-
E/F boundary	135	135 and Tier 2 MEPS
F/G boundary	145	145 and Tier 1 MEPS
-	150 Tier 1 MEPS	-
M coefficient (slope)	0.004	0.002
N value (intercept)	4.1	2.0

For the alternative proposal the distribution of labels is far more appropriate to cover the spread of the current products (leaving the legacy products in label G) and ensures differentiation of the best performing current models, with scope for future improvements. In addition, the MEPS align with the energy label classes to minimise confusion in the market and make market surveillance easier. The minimum requirements are much closer to the US MEPS, but are not as stringent to allow a period of grace for the EU market database to be developed. Regulatory review after 3 years is suggested to review the ambition of the Tier 2 (2019) and Tier 3 (2021) requirements.

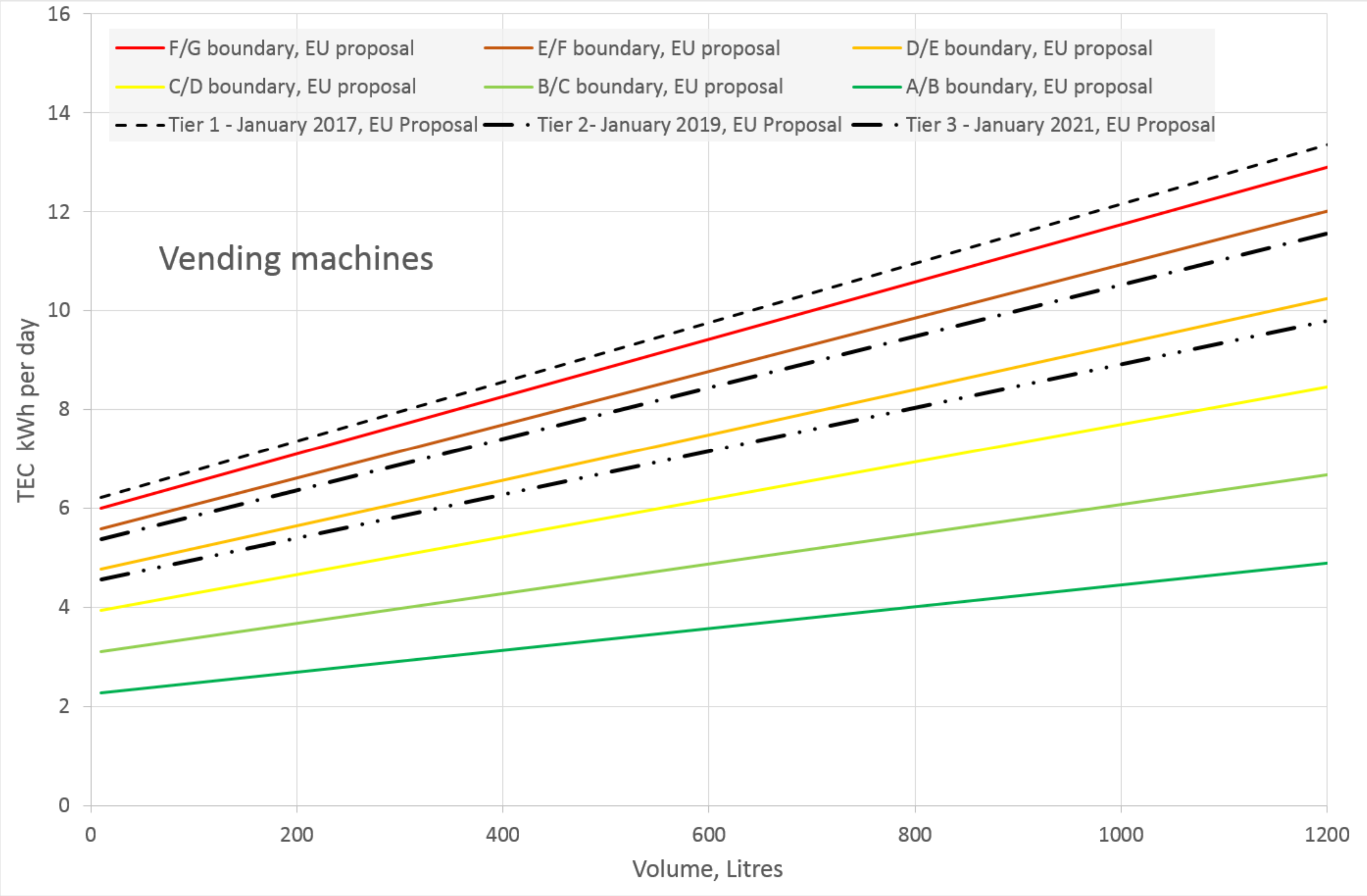


Figure 13. EU proposed MEPS and energy label classes for vending machines.

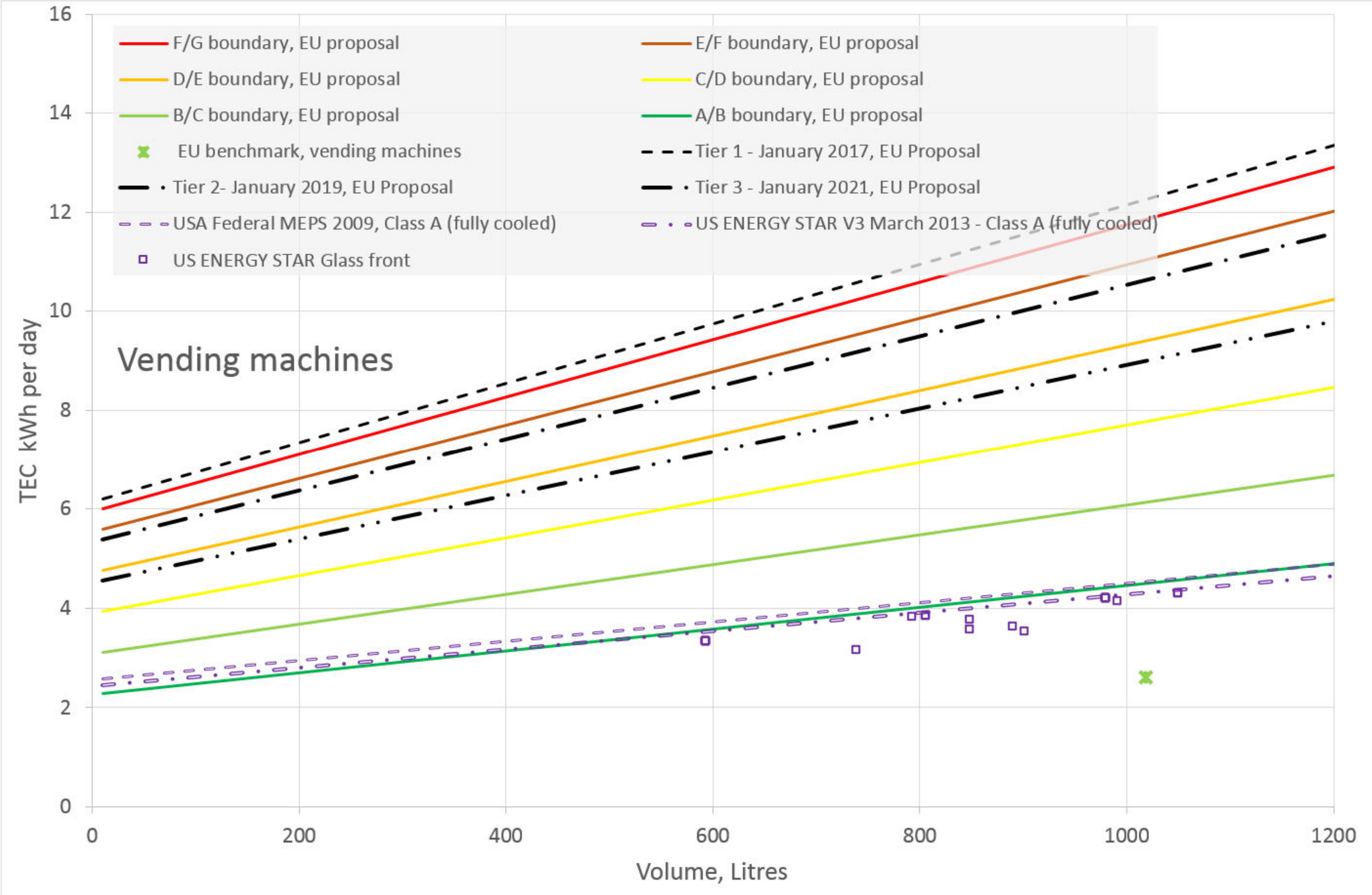


Figure 14. EU proposed MEPS and energy label classes for all vending machines, compared with requirements for US Class A vending machines under ENERGY STAR V3 (2013) and US federal MEPS of August 2012. Also showing ENERGY STAR qualified glass front products from 2014, the EU regulation benchmark product from the Working Document, and an example test result using the draft EU test method (CEN TC59X WG11).

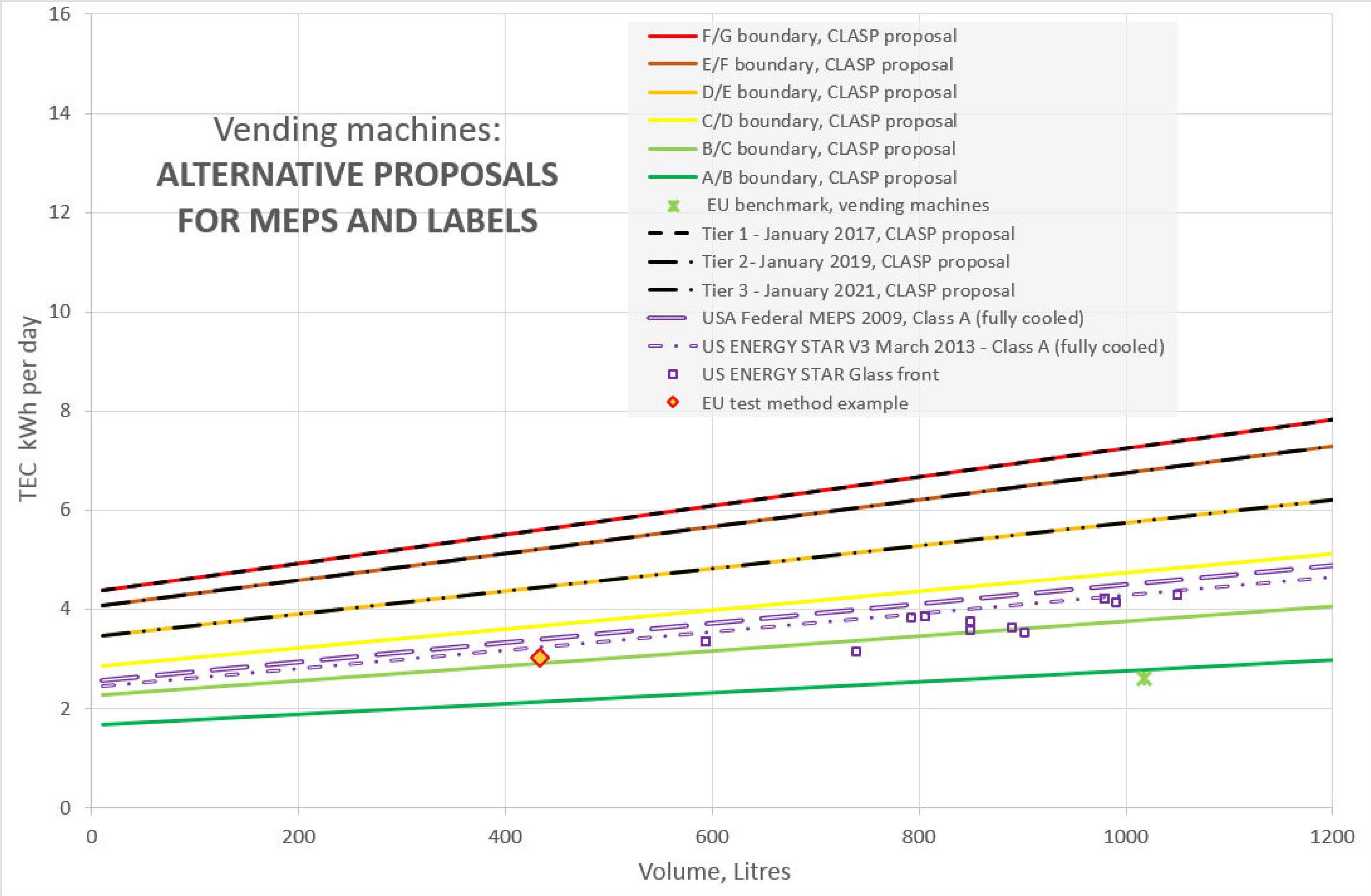


Figure 15. Alternative proposal for MEPS and energy label classes for EU vending machines, compared with requirements for US Class A vending machines under ENERGY STAR V3 (2013) and US federal MEPS of August 2012. Also showing ENERGY STAR qualified glass front products from 2014, the EU regulation benchmark product from the Working Document, and an example test result using the draft EU test method (CEN TC59X WG11).

Annex 1: Normalisation methodology report for retail display cabinets from RD&T

Refrigeration Developments and Testing Ltd

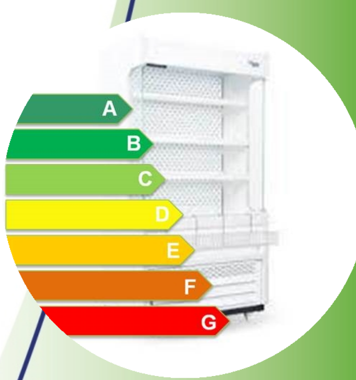
Normalisation methodology used to convert between European, American and Australian test standards

This report has been prepared by: *Judith Evans (Director)*

Date of report: 15 August 2014

File reference number: RDT643

File title: Normalisation methodology 15.08.14 v5



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Normalisation methodology

Worldwide the most commonly used test standards to assess energy used in commercial refrigerators are ISO EN 23953:2005, ANSI/ASHRAE 72-2005 and AS 1731 (2010). There are some significant differences between these standards and their methods to assess energy performance (Table 1). In particular ANSI/ASHRAE 72-2005 is quite different in many respects to ISO EN 23953:2005 and AS 1731 (2010). To be able to compare cabinet energy performance equally, data need to be normalised to one test methodology. To achieve this comparability test, data from ANSI/ASHRAE 72-2005 and AS 1731 (2010) were normalised to be comparable with ISO EN 23953:2005. A further normalisation was then carried out to enable ISO EN 23953:2005 to be compared with data from ISO EN 23953:2005 + amd. 2012. This report described the methodology used to achieve this normalisation.

Based on the differences between test standards and the feasibility of being able to normalise data, the following factors were normalised:

1. Ambient climate class temperature and humidity.

   A sensitivity analysis was carried out to assess the impact of the greater tolerance in relative humidity allowed in ANSI/ASHRAE 72-2005 compared to the other test standards.

2. Door openings.
3. Cabinet lighting.
4. Calculation of refrigerated energy consumption for remote cabinets.
5. Temperature classification.

In all cases data was normalised to a 24 hour test period. In addition cabinets such as bottle coolers and ice cream freezers were assessed as energy use per unit volume rather than area.

Methodology

Cabinets were normalised in 2 stages:

1. Normalised for test conditions and calculation methods for energy consumption. All cabinets were normalised initially to ISO EN 23953:2005. During the normalisation, cabinets were normalised for climate class temperature and humidity, door openings, cabinet lighting and calculation of refrigerated energy consumption (for remote cabinets).
2. Cabinet were normalised for temperature classification. All chilled cabinets were normalised to the M2 classification (all ‘m’ packs equal to or greater than -1°C and equal to or less than 7°C) and all freezer cabinets to the L1 classification (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).

Data derived from the Eurovent Certification Scheme was also subject to an adjustment to convert it back to an approximation of EN 23953 ambient and operational conditions (climate class 3).

Details of these normalisation adjustments are provided in the following sections.

Table 1. Differences between the test standards and the importance of the differences.

	ISO EN 23953:2005	AS 1731 (2010)	ISO EN 23953:2005 + amd. 2012	ANSI/ASHRAE 72-2005	Whether difference is important	Whether normalised Y/N
Climate classes	25°C, 60%RH	25°C, 60%RH	25°C, 60%RH	24°C, 55.4% RH	Difference in temperature and RH between ANSI/ASHRAE 72-2005 and other standards likely to be important	Y
Air flow (ms^{-1})	0.1-0.2	0.1-0.2	0.1-0.2	<0.25	Air flow in ANSI/ASHRAE 72-2005 likely to have impact on open fronted cabinets but almost impossible to normalise without detailed information in individual cabinets	N
Climate measuring point	1 or 2 point(s)	1 or 2 point(s)	1 or 2 point(s)	2 points	Position of monitoring point may have impact, however almost impossible to normalise without detailed information in individual cabinets	N
Control of air temperature in test(°C)	±1	±1	±1	±1.0 mean, individual points ±2.0°C	Unlikely to be important	N
Temperature gradient allowed	Vertical temperature shall not exceed 2 K/m, no more than 6 K between the temperature at floor and ceiling	Vertical temperature shall not exceed 2 K/m, no more than 6 K between the temperature at floor and ceiling	Vertical temperature shall not exceed 2 K/m, no more than 6 K between the temperature at floor and ceiling	0.6°C/305 mm	Larger temperature gradient allowed in Ashrae but almost impossible to normalise quickly and simply	N
Control of air humidity in test (%)	±3 at climate class 3	±3 at climate class 3	±3 at climate class 3	±6.8% mean, individual points ±13.8% (measured as wet bulb)	Large differences between EN and Ashrae. Impossible to normalise without detailed information in individual cabinets	Sensitivity analysis to see effect
Lighting (lux)	600±100 at 1 m height (fluorescent lighting). Emission spectrum within infrared field shall not include peaks of a value of more than 500 W/5 nm/lm	600±100 at 1 m height (fluorescent lighting). Emission spectrum within infrared field shall not include peaks of a value of more than 500 W/5 nm/lm	600±100 at 1 m height (fluorescent lighting). Emission spectrum within infrared field shall not include peaks of a value of more than 500 W/5 nm/lm	Fluorescent, not < 800 lux in front of cabinet under test	Could have impact on horizontal cabinets but almost impossible to normalise quickly and simply	N
Size	Parallelepiped. Defined distanced around and above cabinet	Parallelepiped. Defined distanced around and above cabinet	Parallelepiped. Defined distanced around and above cabinet	Not defined	Could have impact but almost impossible to normalise quickly and simply	N

	ISO EN 23953:2005	AS 1731 (2010)	ISO EN 23953:2005 + amd. 2012	ANSI/ASHRAE 72-2005	Whether difference is important	Whether normalised Y/N
Wall construction	Minimum insulation level equivalent to 60 mm of rigid polyurethane foam ƛ= 0,03 W/m °C)	Minimum insulation level equivalent to 60 mm of rigid polyurethane foam ƛ= 0,03 W/m °C)	Minimum insulation level equivalent to 60 mm of rigid polyurethane foam ƛ= 0,03 W/m °C)	Not defined	Could have impact but almost impossible to normalise quickly and simply	N
Wall emissivity	Light grey (e.g. NCS 2706-G90Y or RAL 7032) emissivity 0,9-1 at 25°C	Painted in a colour with an emissivity between 0.9 and 1 at 25°C, e.g., light grey	Light grey (e.g. NCS 2706-G90Y or RAL 7032) emissivity 0,9-1 at 25°C	Gloss white wall or panel (>21.2°C) in front of cabinet	Could have impact but almost impossible to normalise quickly and simply	N
Floor	Concrete or of thermally equivalent material (sufficiently insulated to ensure external climatic conditions do not affect the floor temperature)	Concrete or of thermally equivalent material (sufficiently insulated to ensure external climatic conditions do not affect the floor temperature)	Concrete or of thermally equivalent material (sufficiently insulated to ensure external climatic conditions do not affect the floor temperature)	Not defined	Could have impact but almost impossible to normalise quickly and simply	N
Room calibration	Detailed cross sectional records of temperature, humidity and air flow at climate class 3	Detailed cross sectional records of temperature, humidity and air flow at climate class 3	Detailed cross sectional records of temperature, humidity and air flow at climate class 3	None	Could have impact but almost impossible to normalise quickly and simply	N
Test packs	Tylose ± filler packs	Tylose ± filler packs	Tylose ± filler packs	Fillers (approximating food product)	Could have impact but almost impossible to normalise quickly and simply	N
Number of 'M' packs in typical 2.5 m multi-deck	12 per shelf, 18 in well (2012 standard: 12 in well)	12 per shelf, 18 in well	12 per shelf, 18 in well (2012 standard: 12 in well)	6 per shelf, 6 in well	Could have impact but almost impossible to normalise quickly and simply	N
Temperature measurement	Geometric centre of 'M' packs	Geometric centre of 'M' packs	Geometric centre of 'M' packs	Inside simulators (sponge material soaked in 50/50±2% mixture propylene glycol and distilled water in 473 mL container)	Could have impact but almost impossible to normalise quickly and simply	N

	ISO EN 23953:2005	AS 1731 (2010)	ISO EN 23953:2005 + amd. 2012	ANSI/ASHRAE 72-2005	Whether difference is important	Whether normalised Y/N
Loading	Prescribed loading pattern with air gaps from rear to front of cabinet between test packs	Prescribed loading pattern with air gaps from rear to front of cabinet between test packs	Prescribed loading pattern with air gaps from rear to front of cabinet between test packs	Zones within the cabinet that would store food	Could have impact but almost impossible to normalise quickly and simply	N
Stabilisation period prior to test	Each sensor temperatures at the corresponding points on the temperature curve agree within ±0.5°C during a period of 24 h	Each sensor temperatures at the corresponding points on the temperature curve agree within ±0.5°C during a period of 24 h	Each sensor temperatures at the corresponding points on the temperature curve agree within ±0.5°C during a period of 24 h	Steady state achieved average temperature of simulators changes by < 0.2°C from one 24 h period of the refrigeration period or refrigerant cycle to the next Refrigerant vapour controlled within 14 kPa (±2 psi) during last ¾ of running cycle	Could have impact but almost impossible to normalise quickly and simply	N
Door/lid openings	Initial 3 minute door opening, followed by 6 s every 10 minutes for 12 h. Open to > 60° angle.	Initial 3 minute door opening, followed by 6 s every 10 minutes for 12 h. Open to > 60° angle.	Initial 3 minute door opening, followed by 6 s every 10 minutes for 12 h for freezers, 15 s every 10 minutes for chillers. Open to > 60° angle. Sliding doors to 80%	8h, hinged doors opened to angle of >75°, sliding doors fully opened. Fully open for 6 s, 6 times/h	Potentially large impact, need to normalise	Y
Lighting	On continuously or on for 12 hours out of 24	Continuous or on 1 h before and off 1 h after door opening test in closed door cabinets	On continuously or on for 12 hours out of 24	Not defined	Potentially large impact, need to normalise	Y

	ISO EN 23953:2005	AS 1731 (2010)	ISO EN 23953:2005 + amd. 2012	ANSI/ASHRAE 72-2005	Whether difference is important	Whether normalised Y/N
Test duration (h)	12 h for cabinets switched off at night, 24 h for all other cabinets. Test should be extended if temperature test performance not maintained due to icing	Not < 12 h for cabinets intended to be switched off at night. Not < 48 h for closed refrigerated cabinets under stable< less than 24 h for all other cabinets under stable conditions	12 h for cabinets switched off at night, 24 h for all other cabinets. Test should be extended if temperature test performance not maintained due to icing	24 h after steady state conditions (further 24 h period to check ice build up)	Normalise all data to 24 hours	Y
Starting point for test	None defined	None defined	None defined	Immediately after a defrost or for cabinets with doors 3 hours after the start of a defrost	Could have impact but almost impossible to normalise quickly and simply	N
Temperature classification	L1, L2, L3, M1, M2, H1, H2, S	L1, L2, L3, M1, M2, H1, H2, S	L1, L2, L3, M1, M2, H1, H2, S	Integrated Average Product temperature: Ice cream -15.0±2.0°F (-9.4±0.1°C), Low temperature 0.0±2.0°F (-17.8±0.1°C), Medium temperature 38±2.0°F (3.3±0.1°C), Application product temperature – other temperatures allowed	Large impact, need to normalise	Y

	ISO EN 23953:2005	AS 1731 (2010)	ISO EN 23953:2005 + amd. 2012	ANSI/ASHRAE 72-2005	Whether difference is important	Whether normalised Y/N
Control of refrigerant liquid pressure/temperature (remote cabinets)	Not >10°C above the specified test room temperature	Not >10°C above the specified test room temperature	Not >10°C above the specified test room temperature	Maintained within 26.7±2.8°C	Could have impact but almost impossible to normalise quickly and simply	N
Control of refrigerant suction pressure	None	None	None	See stabilisation	Could have impact but almost impossible to normalise quickly and simply	N
Integral cabinets	Measured directly (DEC)	Measured directly (DEC)	Measured directly (DEC)	Measured directly (TDEC)	No impact	N
Remote cabinets	DEC of components and heat extraction (Φ_{run}, $\Phi_{24\text{-}def}$, Φ_{24} and Φ_{75}), Combined to calculate TEC	DEC of components and heat extraction (Φ_{run}, $\Phi_{24\text{-}def}$, Φ_{24} and Φ_{75}), Combined to calculate TEC	DEC of components and heat extraction (Φ_{run}, $\Phi_{24\text{-}def}$, Φ_{24} and Φ_{75}), Combined to calculate TEC	CDEC either measured or calculated. Uses COP look up table. Calculates energy/m length of cabinet.	Large impact, need to normalise	Y
Time interval	Temperatures checked every 1 min, refrigerant mass flow rate, inlet/outlet temperature and inlet and suction pressure shall be 20 s	Readings should be taken with a frequency of 20 to 60 s	Temperatures checked every 1 min, refrigerant mass flow rate, inlet/outlet temperature and inlet and suction pressure shall be 20 s	<3 mins	Could have impact but almost impossible to normalise quickly and simply	N
Cabinet area/volume	TDA (area)	TDA (area)	TDA (area)	TDA (area)	Similar methods, differences could be normalised but would need knowledge of individual cabinet construction	N
Efficiency	TEC/TDA	TEC/TDA	TEC/TDA	CDEC/TDA or CDEC/volume	Need to convert EN TDA to volume if relevant	Y

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Stage 1 normalisation

Cabinets were normalised using a spreadsheet model. Remote and integral cabinet types shown in Table 2 were assessed in the normalisation. For each cabinet type the normalisation was based on a baseline where energy associated with the refrigeration system and with other components was split. For a remote cabinet the energy of the refrigeration system is termed REC (Refrigerated Energy Consumption) and the energy of the electrical components is termed DEC (Direct Energy Consumption). For a chiller REC was assumed to be 87.5% and DEC 12.5% of the total energy consumption (TEC). For freezers REC was assumed to be 60% and DEC 40% of TEC. These figures were based on limited data from Eurovent. It should be noted that if more information on the REC and DEC of individual cabinets was available the data could be normalised with greater accuracy. The normalisation procedure was based on the input of the following information:

1. Test room air temperature (°C)
2. Test room relative humidity (%)
3. Assumed cabinet 'internal' mean temperature (5°C for chillers, -18°C for freezers)
4. Assumed cabinet 'internal' RH (%) (assumed to be 80%)
5. Ambient pressure (mbar) (assumed to be 1013 mbar)
6. Lights on (time per 24 hours)
7. Change to infiltration due to doors (% increase/decrease)

The cabinet REC was split according to the % heat loads on the cabinet (infiltration, conduction, radiation, lights, fans, defrost, anti-sweat heaters) and the DEC split according to the % of the direct energy components (defrost, anti-sweat heaters, lights, fans). The division of heat loads and DEC for each cabinet type is shown in Table 2.

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Table 2. Division of heat loads and DEC for each cabinet type normalised according to ISO EN 23953:2005.

	VC1	VC2	VC3	VC4	HC1	HC3/4	HC5/6	HF3/4	VF4	HF5/6	YF3	YF4
Heat load (%):												
Infiltration	80	65	88	40	40	50	30	20	23	15	18	15
Conduction	3	5	3	15	15	5	20	15	15	20	18	20
Radiation	8	15	5	15	25	30	29	38	37	40	39	39
Lights	6	10	2	15	10	5	5	6	6	7	6	7
Fans	3	5	2	9	10	10	10	7	5	7	6	7
Defrost	0	0	0	0	0	0	0	10	10	6	8	7
ASH	0	0	0	6	0	0	6	4	4	5	5	5
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
DEC (i.e. % of power)												
Defrost	0	0	0	0	0	0	0	30	27	25	25	20
Anti-sweat heaters	0	0	0	10	0	0	10	20	43	20	20	20
Lights	15	15	10	15	10	10	10	10	10	10	15	15
Fans	85	*85*	*90*	*75*	*90*	*90*	*80*	40	*20*	*45*	*40*	*45*
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Using a 'baseline' cabinet (tested to ISO EN 23953:2005) the impact of changing ambient temperature and humidity, cabinet lighting, door openings and calculation of refrigeration energy could be assessed.

Normalisation of refrigeration energy (REC)

Infiltration

The model compared the air temperature and humidity inside and outside of the cabinet in ISO EN 23953:2005 to those in an alternative test standard and calculated the % heat load due to infiltration for the alternative test standard. The sensible and latent heat for the infiltrated air was calculated and the infiltration heat load for the alternative test standard cabinet calculated.

For test conditions where door openings were different from the baseline cabinet the % increase in infiltration was calculated. The impact of door openings was calculated using an iterative Gosney and Olama[1] equation, where the temperature and humidity of the air inside the cabinet changes with time due to transient infiltration:

[1] Gosney, W.B. and Olama, H.A.L. Heat and enthalpy gains through cold room doorways. Proc. Inst. of Refrig. 1975:72;31-41.

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$$q = 0.221A(h_i + l_r - h_r)\rho_r\left(1 - \frac{\rho_i}{\rho_r}\right)^{0.5}(gH)^{0.5}F_m$$

Where

q = heat through infiltration (W)

A = Area of cold store door (m^2)

h_i = Enthalpy of ambient air ($kJ.kg^{-1}$)

l_r = Latent heat of refrigerated air ($kJ.kg^{-1}$)

h_r = Enthalpy of refrigerated air ($kJ.kg^{-1}$)

ρ_r = Density of refrigerated air ($kg.m^{-3}$) calculated from $\rho = p / R T$ (where p = pressure in Pa (assumed to be 100,000), T = temperature in K and R = universal gas constant (287))

ρ_i = Density of ambient air ($kg.m^{-3}$)

g = Acceleration due to gravity (9.81 $m.s^{-2}$)

H = Height of cold store door (m)

$F_m = (2/(1+(\rho_r/\rho_i)^{0.333}))^{1.5}$

Conduction

The % change in heat load from the ISO EN 23953:2005 to the alternative test standard cabinet due to conduction was calculated based on the temperature difference between inside and outside the cabinet.

Radiation

The % change in heat load from the ISO EN 23953:2005 to the alternative test standard cabinet due to radiation was calculated from the Stefan Boltzmann equation based on the temperature inside and outside the cabinet.

Lighting

The heat load due to lighting was calculated based on the level of lighting in the ISO EN 23953:2005 to the alternative test standard cabinet.

Fans

Fans in the ISO EN 23953:2005 and the alternative test standard cabinet were assumed to be identical power.

Defrosts

The latent heat infiltrated into the cabinet was used to calculate heat load from defrosts for the ISO EN 23953:2005 and the alternative test standard cabinet. An assumption was made that all condensed moisture was frozen onto the evaporator and that defrosting thawed all the ice on the evaporator.

Anti-sweat heaters

An assumption was made that use of anti-sweat heaters was directly related to moisture in the ambient air. Therefore the moisture in the ambient air was compared for the ISO EN

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23953:2005 and the alternative test standard cabinet to calculate a % difference in the heat loads for the 'standard' and 'new' cabinets.

All heat loads were calculated as % of total and power used. The power used by each component of the overall heat load were totalled and converted to kWh/24h for the 'new' cabinet. This figure could then be compared to the 'standard' cabinet and a %v increase or decrease in refrigerated energy calculated.

Recalculation of CEC

Adjustment of REC in ISO EN 23953:2005 and AS 1731 (2010) to CEC in ANSI/ASHRAE 72-2005 was based on a % difference between the 2 calculation methods:

For ISO EN 23953:2005 and AS 1731 (2010):

$$REC_{RC} = Q_{tot}\ x\ \frac{T_c - T_{mrun}}{(0.34\ x\ T_{mrun})}$$

Where T_c = constant condensing temperature of T_c = 308.15 K (35°C)

T_{mrun} = evaporating temperature (K)

0.34 = Carnot efficiency

For ANSI/ASHRAE 72-2005:

$$CEC = [\left(\frac{Q_n}{L}\right).(t - t_{dt})]/(COP.1000)$$

Where:

CEC = Compressor Energy Consumption (kW·h/m per day)

Q_n = load (W)

L = length of unit (m)

t = time (h)

t_d = defrost time (h)

COP derived from look up table

If a 1 m cabinet is compared using the above equations the REC is on average 40.9% higher than the CEC for a chilled cabinet (over the evaporating range -13.9 to -3.9°C). For a freezer the REC is on average 34.5% higher than the CEC (over the evaporating range -36.1 to -27.8°C). There percentage adjustments were included in the spreadsheet to convert the 'new' cabinet CEC to REC. It should be noted that for conversions from ANSI/ASHRAE 72-2005 to ISO EN 23953:2005 the cabinet length needs to be taken into account.

For integral cabinets energy is measured directly. Based on a Carnot efficiency the difference between ISO EN 23953:2005 / AS 1731 (2010) and ANSI/ASHRAE 72-2005 is approximately 2% (based on a test room and condensing temperature that is 1°C lower in ANSI/ASHRAE 72-2005). For integral cabinets a further 2% increase in energy was added to conversions between ISO EN 23953:2005 / AS 1731 (2010) and ANSI/ASHRAE 72-2005.

Recalculation of DEC

Similar principals were used to those described above to recalculate DEC for defrosts, anti-sweat heaters, lights and fans.

Stage 2 normalisation

For normalising between temperature classifications, data from Eurovent was used to convert ISO EN 23953:2005 data between different temperature classifications. The Eurovent data for different cabinet types was used to create graphs of average ‘m’ pack temperature in the cabinet against TEC/TDA. Using a regression of the data the TEC/TDA at alternative mean cabinet temperatures could then be calculated. An example of the relationship for open fronted integral and remote cabinets is shown in Figure 1.

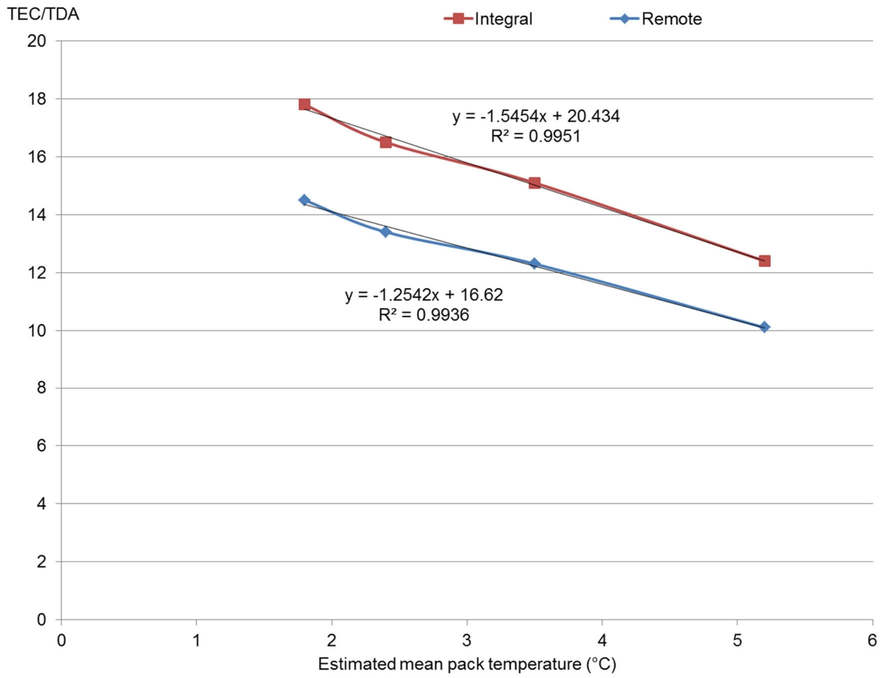

Figure 1. Relationship from Eurovent data on mean cabinet ‘m’ pack temperatures against TEC/TDA.

Normalisation of Eurovent data

Eurovent data were presented as energy usage in store conditions. For equal comparison with other data sets the Eurovent store energy data was converted back to climate class 3 test room conditions using the same methods as described for the stage 1 normalisation.

Eurovent do not publish information on the exact store conditions used for the conversions. Therefore the following assumptions were made:

1. Store conditions were assumed to be 21°C and 50% RH. These were selected based on information from Mousset and Libsig (2013)[2].
2. Cabinet lighting was on for 12 hours per day.
3. Average heat loads for chillers and freezers from Table 2 were used in the calculations.
4. Cabinet temperatures at store conditions were 1°C lower than at test room conditions.

Using these assumptions a figure to convert chillers and freezers from store to test room conditions was calculated.

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

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Conversions used for normalisation

The conversions used for normalisation are shown in Table 3 (stage 1 conversion to ISO EN 23953:2005), Table 4 (stage 2 conversion between temperature classifications) and Table 5 (for Eurovent store conditions to test room conditions).

Table 3. Stage 1 conversion for normalisation.

Change in test room conditions (temperature and RH), lighting, door openings, REC/CEC						
	REMOTE (TEC) kWh/day			**INTEGRAL (TEC) kWh/day**		
-ve means reduce figure by this value +ve means increase figure by this value	Ashrae to EN23953 :2005	AS 1731 (2010) to EN23953 :2005	EN23953 :2012 to EN23953 :2005	Ashrae to EN23953 :2005	AS 1731 (2010) to EN23953 :2005	EN23953 :2012 to EN23953 :2005
Chilled semi vertical (VC1)	45.3% x L	-6.7%	0.0%	3.0% x L	-7.2%	0.0%
Chilled vertical open (VC2)	39.0% x L	-9.6%	0.0%	-1.3% x L	-9.9%	0.0%
Chilled vertical roll in (VC3)	52.9% x L	-2.9%	0.0%	8.3% x L	-3.5%	0.0%
Chilled vertical door (VC4)	63.4% x L	-2.4%	-35.3%	9.7% x L	-2.4%	-33.3%
Chilled horizontal serve over (HC1)	37.8% x L	-9.1%	0.0%	-2.0% x L	-9.1%	0.0%
Chilled horizontal island open (HC3/4)	44.7% x L	-5.3%	0.0%	2.7% x L	-5.7%	0.0%
Chilled horizontal island lid (HC5/6)	55.2% x L	-0.9%	-29.1%	15.6% x L	-1.0%	-27.2%
Frozen horizontal island open (HF3/4)	29.6% x L	-7.1%	0.0%	0.4% x L	-3.6%	0.0%
Frozen FGD (VF4)	39.2% x L	-1.3%	0.0%	9.2% x L	2.3%	0.0%
Frozen horizontal island lid (HF5/6)	28.2% x L	-7.6%	0.0%	-0.9% x L	-4.5%	0.0%
Frozen HGD/well (YF3)	25.8% x L	-8.8%	0.0%	-0.8% x L	-4.6%	0.0%
Frozen HGD/well (with lid) (YF4)	29.1% x L	-1.7%	0.0%	7.9% x L	1.4%	0.0%

Where L=cabinet length (m) (Ashrae calculations are per metre length of cabinet and not for a whole cabinet as in EN/AS standards).

n.b. Calculations using the range in RH allowed in ANSI/ASHRAE 72-2005 (mean ±6.8%) altered the % corrections for a VC2 cabinet by ±6.3%.

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Table 4. Stage 2 conversion for normalisation between temperature classifications (TEC).

Cabinet type:	Conversion:	Integral	Remote
Chilled vertical open (VC1/2)	Ashrae to EN23953 M2	2.9%	2.9%
	EN23953 M1 to M2	-9.8%	-9.8%
	EN23953 H1 to M2	17.5%	24.4%
	EN23953 H2 to M2	14.7%	14.6%
	EN23953 M0 to M2	-17.5%	-17.4%
Chilled vertical roll in (VC3)	Ashrae to EN23953 M2	n/a	2.3%
	EN23953 M1 to M2	n/a	-7.8%
	EN23953 H1 to M2	n/a	13.8%
	EN23953 H2 to M2	n/a	11.7%
Chilled vertical door (VC4)	Ashrae to EN23953 M2	2.8%	2.9%
	EN23953 M1 to M2	-9.5%	-9.5%
	EN23953 H1 to M2	16.9%	17.0%
	EN23953 H2 to M2	14.2%	14.3%
	EN23953 M0 to M2	-11.4%	-11.4%
Chilled horizontal serve over (HC1)	Ashrae to EN23953 M2	1.6%	1.5%
	EN23953 M1 to M2	-5.3%	-5.1%
	EN23953 H1 to M2	9.3%	8.8%
	EN23953 H2 to M2	8.0%	7.6%
Chilled horizontal island open (HC3/4)	Ashrae to EN23953 M2	1.2%	n/a
	EN23953 M1 to M2	-4.1%	n/a
	EN23953 H1 to M2	7.0%	n/a
	EN23953 H2 to M2	6.1%	n/a
Chilled horizontal island lid (HC5/6)	Ashrae to EN23953 M2	1.6%	1.5%
	EN23953 M1 to M2	-5.3%	-5.1%
	EN23953 H1 to M2	9.3%	9.0%
	EN23953 H2 to M2	8.0%	7.7%
Frozen horizontal island open (HF3/4)	Ashrae to EN23953 L1	-4.1%	-4.2%
	EN23953 L2 to L1	4.7%	4.8%
	EN23953 L3 to L1	13.1%	13.2%
Frozen FGD (VF4)	Ashrae to EN23953 L1	-3.9%	-3.9%
	EN23953 L2 to L1	4.5%	4.5%
	EN23953 L3 to L1	12.5%	12.5%
Frozen horizontal island lid (HF5/6)	Ashrae to EN23953 L1	-4.1%	-4.2%
	EN23953 L2 to L1)	4.8%	4.8%
	EN23953 L3 to L1	13.1%	13.2%
Frozen HGD/well (YF3)	Ashrae to EN23953 L1	-1.6%	-1.5%
	EN23953 L2 to L1	1.8%	1.8%
	EN23953 L3 to L1	5.6%	5.4%
Frozen HGD/well (with lid) (YF4)	Ashrae to EN23953 L1	-1.4%	-1.4%
	EN23953 L2 to L1	1.6%	1.7%
	EN23953 L3 to L1	5.0%	5.2%

n.b. Mean temperatures for ISO EN 23953:2005 / AS 1731 (2010) and ANSI/ASHRAE 72-2005 were taken from the CLASP Commercial refrigeration equipment: mapping and benchmarking by Waide Strategic Efficiency Ltd, Saint Trofee and Cemafroid, January 2014.

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Table 5. Conversion used to normalise Eurovent store conditions to test room conditions.

+ve means increase figure by this value	Eurovent store conditions to EN23953:2005 climate class 3
Chilled cabinets	30.4%
Frozen cabinets	21.2%

Annex 2: Summary of evidence regarding use of open versus closed retail display cabinets

In February 2014 the UK Institute of Refrigeration hosted a debate entitled 'Are doors on fridges the best environmental solution for the retail sector?' An information paper supporting the debate[38] reviewed a substantial amount of evidence on this topic and includes evidence on most of the points listed below.

On the supporting side:

a) The IoR report implies that savings will be over one third and could range up to half or even three quarters in some circumstances. These sort of ratios are confirmed by examination of data from the RDC data sets (e.g. from California).

b) Payback for retrofitted doors appears to be around 1.5 years and it is likely that the marginal cost of purchasing a cabinet already fitted with a door will payback in less than this.

c) Presence of doors leads to less variability in product temperatures which has food safety and food quality benefits (IoR debate report, 2014).

d) Customer comfort is better with doors, reducing cold aisle effects and increasing the likelihood of customers spending longer looking at the products displayed.

On the downside:

a) The doors may impact sales by putting a barrier between customers and products. Evidence is limited and varied on this depending on the type of products being stocked/displayed: impulse purchases are affected more detrimentally; some goods customers like to handle to select; for some situations little or no impact has been shown.

b) It is possible that presence of the door could result in higher energy consumption: Eurovent has presented evidence[39] that once an opening frequency of 60 per hour was exceeded there is no energy advantage in having the door[40], noting that some food retailers have registered up to 250 door openings per hour although this was only during peak times.

Some major EU retailers have made substantial progress and ambitious objectives regarding wider use of doors. The Environmental Investigation Agency (EIA) has produced an annual report since 2009 regarding environmental progress on retail refrigeration and includes reporting use of doors on cabinets[41]. EIA reports that the Dutch retailer Royal Ahold has doors on about 80% of their store cooling; Tesco (UK) uses doors on fridges for all smaller stores and almost universally in Turkey, Hungary and Poland; Iceland (UK) stores have doors on 85% of all cabinets (the majority of which are freezer type for which doors make more economic sense); a handful of other major European retailers are either experimenting or actively installing cabinets with doors. On the other hand, Lidl and Marks & Spencer have not made any substantial move toward use of doors; ALDI Süd (Germany) and Coop Schweitz have ruled them out.

[38] The Institute Of Refrigeration, Are doors on fridges the best environmental solution for the retail sector? Background paper to IOR Debate by Judith Evans, RD&T. Presented before the Institute of Refrigeration on Thursday 6th February 2014.
[39] EPEE and EUROVENT Joint Position on the Implementing Measures for the Energy related Products (ErP) ENER Lot 12 of the EU Ecodesign Directive 2009/125/EC, Brussels, 15 July 2011, page 5.
[40] The act of opening the door swirls the air within the cabinet and entrains warm/moist air from the environment into the cabinet which directly increase the heat load. Sliding doors do not have the swirling effect and cause around 17% less infiltration, but are more difficult to seal effectively when closed.
[41] Chilling Facts V: RETAILERS ON THE CUSP OF A GLOBAL COOLING REVOLUTION, September 2013, Environmental Investigation Agency. www.eia-international.org.

France has by far the most ambitious programme towards adoption of doors with almost all of their major retailers, including two main groups of independents, signed up to a voluntary agreement to use doors in over 75% of their cabinets buy 2020. This agreement carries a financial incentive based on a form of white certificates: installing doors represents a substantial investment in energy efficiency and retailers signing up to the agreement will receive a *Certificat d'economie d'energie* as evidence of fulfilment of a retailers efficiency obligations[42]. Relevant businesses that do not earn such certificates are obliged to pay 2 cents per kWh into a public treasury fund.

[42] See http://www.developpement-durable.gouv.fr/-Certificats-d-economies-d-energie,188-.html.