


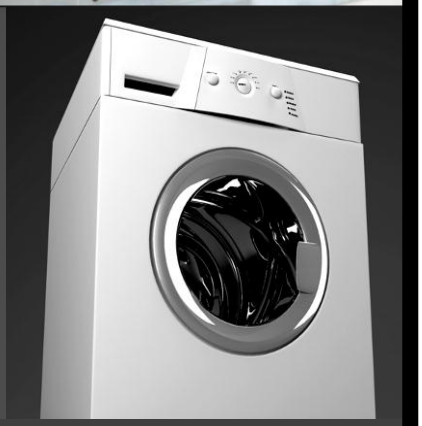

Scoping Study for Commercial Refrigeration Equipment

Mapping and Benchmarking Project

Results

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BY

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in Partnership with
The Collaborative Labeling and Appliance Standards Program (CLASP)

Contents

Summary Report

1 Introduction

CLASP completed a cooling study in 2011, the first in a series intended to provide an international comparison of energy efficiency performance and policy measures for various appliances. The CLASP study provides policy makers and energy efficiency program managers with tools for comparing the efficiency of common air conditioning (AC) products under different test procedures that are currently used in major world economies. The objectives of the study are to lay the foundation for strong and comparable energy performance requirements at the global level and to pull the market towards higher levels of AC efficiency.

CLASP is now planning further studies for commercial refrigeration equipment and lighting products. In order to maximize efficiency in its studies, CLASP has conducted a scoping study to define the work that will be needed for the benchmarking of commercial refrigeration equipment – these include beverage vending machines, walk-in coolers, and reach-in coolers. The study covers the following countries and economies: Australia, Canada, Denmark, European Union, Italy, Japan, Korea, New Zealand, South Africa, United Kingdom, and the USA (Federal, California, Washington State). Not all countries are covered for every aspect of the study; inclusion depends on whether a country has standards and labeling (S&L) activities for a given product and whether information is available.

Mapping and Benchmarking projects can be challenging, and it is often not easy to find an approach that results in information that is directly beneficial to policy makers and program managers in a variety of countries, all at a different stage of S&L policy development. Most mapping and benchmarking projects have also experienced challenges due to incomparability of products in different parts of the world, different approaches to testing and lack of or unavailability of critical data.

This report describes the findings of the scoping study. It includes this summary report, which provides an overview of product definitions, main test procedures and comparability issues for the commercial refrigeration products covered, as well as an overview of the needs identified by S&L program managers in various countries. The report further includes three sections providing detailed information on Reach-in coolers (Section A), Cold vending machines (Section B), and Walk-in cold rooms (Section C).

2 Definition of Product Classes

This report covers Reach-in coolers, Cold vending machines and Walk-in coolers. For this report, these products are defined as follows:

- **Reach-in cooler**: Is a non-household cabinet whose primary function is to store foodstuffs in one or more compartments or recesses accessible by reaching (but not stepping) into the cabinet, which is cooled at between -18 and +5°C, using any energy using refrigeration system
- **Cold vending machine:** self-contained refrigerated systems designed to accept consumer payments or tokens to dispense pre-packed beverages and/or food at between 2°C and 12°C without on-site labor/intervention
- **Walk in cooler:** an enclosed, refrigerated space, sufficiently large to be stepped into, but no larger than 3,000 square feet (279 m^2) capable of storing foodstuffs at temperatures from +5°C (41°F) to -18°C (-0.4°F)

3 Identification of International and National Test Procedures, and Initial Comparison

This analysis identifies several international and national test procedures for the products covered. Most national test procedures considered or in use for national S&L programs are based on a limited number of international test procedures. These include:

For **Reach-in coolers**:

- Over 10 separate standards are identified for retail display cases/cabinets (RDC) and commercial/professional service cases/cabinets/refrigerators/freezers (CSC) coolers, however most of the market within the scope of this study is covered by ASHRAE 72 or ISO 23953
- AHRI standards are performance-rating standards that refer to ASHRAE 72 for the test method. These include AHRI 1200 and AHRI 1320
- ISO 23953:2005 replaces EN441:1995 and key test methods remain the same
- The ASHRAE standard 72:2005 combines both previous version ASHRAE 117 (open type) and ASHRAE 72 (closed) together eliminating the need for two individual standards
- Energy Star and the California Energy Commission (CEC) refer to ASHRAE 72
- Test standards by country are included in Section A of the report and are fully referenced. Section A also includes a detailed comparison of ASHRAE 72:2005 and ISO 23953:2005

For **Cold vending machines**:

- The key test standard is ASHRAE 32.1, which underpins minimum efficiency performance standards (MEPS) (incl. proposed) and/or labeling in USA, California, Canada, Australia and New Zealand. This commonality renders comparison easier
- Manufacturers marketing in Europe make voluntary use of the Energy Measurement Protocol (EMP), developed by the European Vending Association (EVA)
- The other key test standard identified is Japan's *JIS B8561: 2007*
- Test standards by country source are included in Section B of the report: these are fully referenced
- ASHRAE 32.1 (2004) is used in Australia and New Zealand (draft MEPS), Canada (MEPS), US (DoE MEPS), Energy Star (labeling), and California (MEPS). It is likely that the EU will regulate similarly for vending machines, but no details are available
- Section B of the report includes a detailed comparison of ASHRAE 32.1, EMP and JIS B8561

For **Walk-in coolers**:

- Regulations are in place in the USA only. Draft regulations in the EU and policy recommendations in Australia and New Zealand are insufficiently developed to allow proper comparisons since test standards are absent
- However, similar technical improvement measures are in place/proposed, which are summarized in Section C of the report

Comparability of test results is needed to benchmark energy performance among economies. Test results are typically based on the test procedures in place in an economy, and differences between procedures need to be taken into account in order to compare results. The report discusses the characteristics of the test procedures to allow for a detailed discussion of differences and how these might affect measured energy performance.

4 Potential Issues in Test Result Comparison

In order to compare test results between economies, the impact of test procedure differences on measured energy performance needs to be identified. This typically requires a detailed engineering analysis of and comparative testing among test procedures. The report discusses the main differences between key international test procedures and how these might affect comparability of test results.

Potential Issues for **Reach-in Coolers**:

The impact of key differences between ASHRAE 72 and ISO 23953 is difficult to quantify, when comparing efficiencies derived from each. A study to evaluate results with changes in key requirements would be beneficial in understanding the relative impact. This could be done first with the same sample tested utilizing each of the two key standards. Additional testing to evaluate the impact of specific criteria would also be needed. This could be accomplished with back-to-back tests while changing each of the key criteria individually. Changes equal to the maximum deviation (between the test procedures) would allow each specification to be evaluated independent of the others. Key specifications may include:

- Air velocity, direction and speed
- Ambient temperature
- Internal temperature
- Door opening frequency, duration, angle
- Loading material, number of measurement sensors, and load levels

Potential Issues for **Cold Vending Machines**:

The impact of key differences between ASHRAE 32.1, EVA-EMP and JIS B8561 is difficult to quantify, when comparing efficiencies derived from each. A study to evaluate results with changes in key requirements would be beneficial in understanding the relative impact. It should be noted that EVA-EMP is not used for regulatory purposes, and is therefore probably less relevant from a benchmarking perspective.

As with reach-in coolers, reconciliation of test efficiencies making use of the different tests could be achieved by testing various products under the relevant test procedures. This could be done first with the same sample tested utilizing each of the two key standards. Additional testing to evaluate the impact of specific criteria would also be needed. This could be accomplished with back-to-back tests while changing each of the key criteria individually.

Potential issues for **Walk-in Cold Rooms:**

There is no known comparison of test results under the established or draft test procedures. At the moment, the only relevant fully established test procedure is the DOE procedure – which includes a calculated rating of performance, not an actual test. It is expected that the draft EU test procedure will be updated soon, as part of an update of the EU Working Document.

Given that walk-in cold rooms are not actually tested as a complete assembly, a comparison of performances would largely be limited to a theoretical assessment of differences in calculations and assumptions in the various procedures. This could be done between the DOE procedure and the EU draft procedure, once updated. Potential issues between comparisons may include:

- The impact of basic model definitions
- Validation of the model used to calculate U factors from limited test data
- Leakage of full assembly

- Heat gain from full assembly

5 Identification of Country Needs

The mapping component of CLASP's benchmarking studies includes comprehensive research on the market characteristics of the countries under study to establish product characteristics, compare market sizes and trends, and identify the energy performance of products offered on the market. As a result of this analysis, it also identifies what are the most relevant products or product categories to be included in the remaining components of the study: benchmarking and testing.

This component also includes a review of existing standards and labeling initiatives and its characteristics which will support the selection of test methods and ratings to be compared in the benchmarking component.

For this scoping study, CLASP Global Research identified potential countries to be included in the scope of the mapping task and consequently in the overall benchmarking project, and assessed what were the countries' needs from a benchmarking study like the one proposed. The following section describes these results.

Selection of countries under study

The following criteria was considered when selecting a list of countries under study: 1) CLASP regions of operation (China, India, the EU and the US); 2) those countries where there are S&L policies implemented or under consideration, as they will serve as levels for benchmarks.

An initial research on CLASP's Global S&L Database and the review of most recent activities implemented by countries for commercial refrigeration equipment resulted in the following list of countries of interest:

- Australia
- Canada
- China
- EU
- Korea
- Japan
- Mexico
- New Zealand
- United States

The initial mapping of the status of S&L policies in some of the countries above also showed that:

- Australia is starting the process to revise and update existing regulations for refrigerated display cabinets scheduled to be completed by 2014.
- Canada just completed the revision for self-contained commercial refrigerators, freezers and refrigerators-freezers and it is considering working on new regulations for ice-cream freezers and walk-in refrigeration.
- The EU is in the process of finalizing the regulatory process. A consultation forum was held on 2010 to discuss proposed requirements for commercial refrigerators and freezers (TREN LOT 12) and the Impact Assessment is underway. Another consultation forum held on January 2012 discussed the requirements for service cabinets, walk-in cold rooms, chillers, ice makers, ice cream and milk-shake machines (ENTR LOT 1). Following that, a final web-based consultation was launched; the Final regulation publication is expected by 2012 to be adopted in 2013.

- United States is finalizing the regulatory process expected to be completed by 2012-2013. The new requirements will enter into force in 2015 for commercial refrigeration equipment, walk-in coolers and freezers and in 2016 for automatic commercial ice makers.
- Other countries where regulation exists without further activities scheduled: Mexico, Korea, New Zealand, Japan, and Brazil.

Identification of country needs

The team developed a questionnaire in order to assess what were the needs of different countries from a benchmarking analysis for commercial refrigeration equipment (CRE). We queried policy makers and S&L program managers in several countries (Brazil, China, EU, and Korea) about what type of information they would find useful from the various components of a benchmarking study.

The responses generally fall in two categories: 1) countries where the information needs are greater; in this case, research that can bring new information about market characteristics, performance levels, test procedures and others is required and deemed as very relevant (i.e., Brazil, China and Korea); and, 2) countries where the S&L policy implementation process is already at an advanced stage and new information can have low impact into the process unless it is very targeted (i.e., EU).

A topic that seems to be of interest for both groups is the comparison of the test procedures and EE metrics used in various countries, as test procedures for each product category not only depend on the type of equipment but also on safety and health regulations applicable for each country. This is due to the variety of foodstuff to be cooled/stored, and of use patterns (i.e., a cabinet that is meant to store wet fish in a supermarket in Canada needs to comply with Canadian regulation for fish storage which may be different from a cabinet that is meant to store beverages in a restaurant in Italy, with Italian regulations for beverage storage).

Countries that do not have S&L policies for commercial refrigeration equipment also pointed out the relevance of knowing best practices and international test procedures applicable for different equipment types, which can help in the decision making process of S&L implementers.

Additional information that some countries would find useful is the likely impact of S&L policies on the final price of the products on the market.

6 Discussion and Conclusions

A mapping and benchmarking study for commercial refrigeration equipment needs to address several knowledge gaps in order to provide a good overview of energy performance levels and requirements across economies. Several economies have introduced S&L for **reach-in coolers**, and some data are available about the energy performance of products on the market. There are two primary test procedures in use, and there is, so far, no reliable way to compare measurements obtained with these two procedures. The IEA 4E Mapping and Benchmarking Annex recently completed a study on **cold vending machines**, which provides a good starting point for further analysis. Some relevant economies are not covered in the IEA 4E study, and there is not a reliable way to compare measurements obtained with the two primary test procedures in use. Little is known about **walk-in cold rooms**. Only one economy has introduced standards for this product group, and two other economies are preparing standards but haven't completed these yet. Energy performance of walk-in cold rooms is not tested but calculated, and there are no reliable ways to compare calculation results between the procedures in place or under development for the three economies.

Overview of knowledge Gaps
This study identified knowledge gaps that could be addressed by a mapping and benchmarking study for the product classes covered:

Reach-in Coolers

1. Complete information about existing MEPS and Labels;
2. Efficiency of sales and stocks;
3. Cost-benefit data and potential national impacts of efficiency improvements;
4. Comparability of test results between ASHRAE and ISO test procedures.

Cold Vending Machines

1. Gaps in the scope of the IEA 4E analysis:
   - More recent information
   - Countries not covered (e.g. China, Japan, India)
   - Variations in annual energy consumption for machines of the same capacity
   - Variations in machine efficiency/annual consumption in conjunction with policy development, e.g. labeling/MEPS.
   - Assessing cold food/snack machines separately
2. Efficiency of sales and stocks;
3. Cost-benefit data and potential national impacts of efficiency improvements;
4. Comparability of test results between ASHRAE and ISO test procedures.

Walk-in Coolers

1. Walk-in coolers are not tested; their energy performance is calculated based on the component characteristics;
2. As far as could be established, no comprehensive testing has been done to establish how accurately these calculations agree with measured energy performance;
3. There are virtually no data available for two new energy performance metrics under development;
4. Test metrics could be compared theoretically or empirically, both with substantial challenges.

Based on the above, CLASP selected the elements of a full benchmarking study for commercial refrigeration equipment to be launched in December 2012.

Section A.
Detailed Results for Reach-in Coolers

7 Definition of relevant product classes or categories

Reach-in cooler: Is a non-household cabinet whose primary function is to store foodstuffs in one or more compartments or recesses accessible by reaching (but not stepping) into the cabinet, which is cooled at between -18 and +5°C, using any energy using refrigeration system.

Summary of products included:

- **RDC coolers: retail display cases/cabinets – integral and remote**
- **CSC coolers: commercial/professional service cases/cabinets/refrigerators/freezers (including 'roll-in' and 'pass through') – integral and remote**

7.1 Discussion

- The above definition is sufficiently broad to include products which, while technically distinct in some areas, contain enough commonalities to warrant coverage in a single mapping and benchmarking study. Essentially, it is intended to cover commercial refrigerators and/or/freezers, and retail display refrigerators and freezers.
- Non-household: the definition is intended to exclude household cooling appliances, which are generally covered by other test standards.
- Primary function – cold storage: While the product has the capability to cool down foodstuffs to the desired or set temperature, this is not its primary function, as it is for a blast cooler/ chiller/cabinet[1]. Blast coolers are tested to different conditions and while current/draft MEPS and/or labeling of blast coolers is present in some countries[2], these products are tentatively excluded from this scope.
- Foodstuffs: this distinction is intended to exclude products used in specialist applications such as laboratories, for the storage of pharmaceuticals etc.
- Access: reach-in, not step-in compartment/s: this distinction is intended to exclude walk-in cool/cold rooms covered separately in this study, and open top preparation tables/'saladettes[3]'. However it includes 'roll-in' coolers, which allow wheel-mounted racks to be rolled in to the cooling compartment.
- Temperature: the range -18 and +5°C is intended to include refrigerators and freezers, but exclude products used to store food at higher temperatures, such as wine coolers (~10-14°C or 50-57°F).

[1] Blast coolers are essentially designed to rapidly cool (but not store) foodstuffs, down to cold or freezing temperatures
[2] Draft proposals under EU ENTR Lot 1 Refrigerating and freezing equipment- blast cabinets (Dec 2011)
[3] Essentially refrigerated table tops, used for food preparation

- 'Energy-using' refrigeration system. The great majority of products identified in this study are likely to use a vapour-compression refrigeration system[4]. Limiting a mapping and benchmarking study scope to products using this system could also limit any potential discussion of technical improvement options. However other active cooling systems are available, e.g. absorption[5] or evaporative[6] systems: both are viable off-grid applications, and are more common in developing countries[7]. Also, ENERGY STAR and the California Energy Commission do not define their reach-in coolers products this rigidly. Instead they essentially limit the cooling system to one that uses energy (see 7.6.1 and 7.6.2).
- The above points conclude discussion of the definition chosen for reach-in coolers. However products falling within this require further division before making fair comparisons of energy efficiency and/or energy consumption:
    - Purpose: technically, products can be divided depending on whether they perform a customer facing/ merchandising function, or a 'back room' catering/commercial storage function. The former necessitates open view and ease of access by customers to products within the cooler. These coolers are variously referred to as retail display cases or cabinets (**hereafter RDC coolers**), and are technically identified as being either open-fronted, open topped wells, or glazed[8]. Commercial service/professional cabinets/refrigerator/freezers (**hereafter CSC coolers**) are not for customer use and typically contain solid doors or drawers[9].
- **RDC coolers**: for the purposes of measuring energy efficiency or consumption, further definitions and distinctions can be made, however these are determined by the test standard employed, which vary among the countries within scope. See sections 8, 9 and 10. Key considerations include:
    - Location of condensing unit: RDC coolers, can be divided into those that contain the condenser within the unit – variously referred to as 'self-contained' 'plug-in' or 'integral', and those that are connected to a central, remote condensing unit, generally capable of providing condensed refrigerant to multiple remote RDC coolers – variously referred to as 'remote' or 'external' RDCs. Remote RDC coolers are common (but not limited) to supermarkets, and include a variety of configurations usually linking 10-40 RDCs to the remote condensing unit. Increasingly (in Europe at least) these systems are using a variety of refrigerants, including low-global-warming-potential (low-GWP) options. Plug-in RDC coolers are generally found in convenience stores and gas station forecourts, but are also used by some large supermarket chains.
    - Temperature: products are tested at different temperatures – largely whether they are intended to cool or freeze foodstuffs.
    - Means of access, and cooler profile: RDC coolers may be open-fronted, open wells, or have sliding or hinged, top or front opening glazed doors. Profile may be vertical or horizontal. All such configurations may be included in scope.
- **CSC coolers**: as with RDC coolers, the way in which CSCs break down into product sub-categories depends on the test standard employed. Key considerations include:

[4]In simple terms, the vapour-compression cycle converts (evaporates) a refrigerant that is partially in a liquid state, into a vapour, which creates a cooling effect for refrigerating purposes: the refrigerant is then pumped back into a semi liquid state (condensed), which releases heat on the outside of the refrigerated enclosure, ready to be converted to vapour again

[5] Absorption cooling: essentially uses heat instead of an electric pump to drive the vapour-compression cycle

[6] Evaporative cooling: essentially makes use of the cooling effect of evaporation (best in low relative humidity)

[7] http://www.altenergy.org/Glossary/cool.html

[8] Other transparent materials may also be used

[9] Occasionally they contain glazed doors: care will be needed to avoid defining such products as RDC coolers, if/when addressed more fully in a mapping and benchmarking study

- Location of condensing unit: it is far more common for CSC coolers to be of the self-contained/integral/plug-in type. However in its proposals, the EC included both integral and remote types. Both fall within the scope of this study.
- Temperature: products are tested at different temperatures – largely whether they are intended to cool or freeze foodstuffs.
- Means of access, and cooler profile: CSC coolers may be accessed using sliding or hinged, top or front opening glazed or solid doors, or by drawers. Coolers may be so-called 'pass-through' varieties, which contain doors on opposite sides of the cabinet. Profile may be vertical or horizontal (including under-counter). All such configurations may be included in scope.
- Internal (cooled) volume.

- Scope is also intended to exclude the following products:
  - Ice-makers, ice cream machines and water chillers
  - Open top preparation tables and 'saladettes'
  - Cabinets that carry out food processing and not just storage function (e.g. bakery cabinets that chill, heat and humidify)
- Detailed definitions by country sources follow: these are fully referenced.

Table 1 Key product variations – reach-in coolers

Product	Open	Glazed	Solid	frozen	chilled	Integral	Remote
RDC	Yes	Yes	No	Yes	Yes	Yes	Yes
CSC	No	Yes	Yes	Yes	Yes	Yes	Yes

7.2 Australia and New Zealand[10]

Refrigerated Display Cabinets (RDCs) are products that are specifically designed to store and display-for-sale chilled and/or frozen foodstuffs. They allow the foodstuff stores in the cabinet to be either directly viewed through an opening in the cabinet or through transparent doors, lids or covers that:

- Are normally kept closed but can be opened to access the contents;
- Allow the contents of the cabinet to be viewed when closed;
- Enable users to access the contents of any part of the interior without stepping inside the refrigerated space.

Refrigerated Service Cabinets (RSCs) are products that are specifically designed to store, but not display-for-sale, chilled and/or frozen foodstuffs. They are normally fitted with predominantly solid-faced lids, drawers or doors that:

- Are normally kept closed, but can be opened to access contents;
- Obscure the majority of the contents of the cabinet from view when closed;

[10] Australia: http://www.energyrating.gov.au/products-themes/refrigeration/commercial-refrigeration/meps/; New Zealand: http://www.eeca.govt.nz/node/1316

- Enable users to access the contents of any part of the interior without stepping inside the refrigerated space.

7.3 Canada

Self-contained commercial refrigerators and freezers[11], that:

- Have cabinet doors, cabinet drawers or no doors;
- Are designed for the storage of food, beverages or ice;
- Have a self-contained refrigeration system that requires an energy input; and
- May have one or more interior lights to illuminate the contents.

Explicitly excluded from the regulations are:

- Buffet tables
- Preparation tables
- Walk-in refrigerators and freezers

7.4 Korea

Definition – Commercial Refrigerator[12]

"Commercial electric refrigerator-freezer of storage volume 300L ~ 2000L with the cooling system of less than 1000W electric power consumption by KS C ISO 15502. Exclude the freezer only, the showcase, the table type, and the specified type".

7.5 European Union

7.5.1 EU Ecodesign Consultation on non-household storage cabinets (2012 - verbatim)[13]

A non-household refrigerated storage cabinet is defined as:

An insulated cabinet integrating at least one condensing unit and one or more compartments accessible via one or more doors and/or drawers, intended for the storage but not the display and sale of refrigerated or frozen foodstuffs and intended for non-household purposes. It is cooled by one or more energy-consuming processes.

This includes the following categories:

- Category VC: Vertical chilled cabinets

[11] http://oee.nrcan.gc.ca/commercial/equipment/selfcontained-refrigerators-freezers/7194
[12] http://www.kemco.or.kr/new_eng/pg02/pg02100200_2.asp
[13] "Stakeholder consultation on possible ecodesign requirements for professional refrigeration: non-household storage cabinets impact assessment study" (June2012); Tait Consulting for EC:
http://www.taitconsulting.co.uk/Ecodesign_Consultation.html
Proposed requirements are updated in:
http://www.taitconsulting.co.uk/Ecodesign_Consultation_files/Adhoc_Intro_Storage_cabinets_2012-06-18.pdf:
Minimum requirements are graduated by 3 tiers: tier 1 is 1 yr after entry into force, tier 2 is 2 yrs after entry and tier 3 is 4 yrs after entry into force.

- Category VF: Vertical freezer cabinets
- Category HC: Counter, horizontal and under-counter chilled cabinets
- Category HF: Counter, horizontal and under-counter freezer cabinets
- Category FF: Fridge freezer cabinets
- Category CHEST: Non-household chest freezers

It is envisaged that the same requirements may be applied to storage cabinets with transparent doors (which are intended for the storage, but not the sale and display of foodstuff, and are therefore usually located in storage areas, back shops, professional kitchens, etc. and not in retail areas)

Excluded from the scope:

- Cabinets operating with a remote condensing unit
- Open cabinets
- Open top preparation tables and saladettes
- Cabinets that carry out food processing and not just storage function (e.g. bakery cabinets that chill, heat and humidify)
- Serve-over counters and any other form of cabinet primarily intended for display and sale of foodstuff

Notes on special provisions and exemptions:

- Semi-professional cabinets (not designed for climate class 4 conditions[14]) may be made subject to standard testing and requirements, or may be considered for testing at climate class 3 conditions with calculated adjustment of energy consumption to simulate climate class 4 conditions for use in a comparable energy label and minimum requirements.
- Built-in, roll in and roll-through cabinets and fridge freezers may be exempted until review of the regulation due to inadequate data to set standards at present.
- Non-household static air cabinets under consideration to be subject to the labeling and minimum energy efficiency requirements of household refrigerators from January 2016.
- Non-household chest freezer cabinets proposed to be subject to the labeling and minimum energy efficiency requirements of household refrigerators from July 2014.
- Storage cabinets fitted with transparent doors are under consideration for exclusion from these regulations (and inclusion with Lot 12 display cabinets in due course), or possible inclusion with storage cabinets under certain special provisions.
- Heavy duty cabinets (defined as those that can meet temperature requirements under climate class 5 conditions) are proposed to be subject to the same requirements of performance and testing as standard cabinets but are under consideration for possible exemption from Tier 2 and/or Tier 3 requirements.
- Under-counter cabinets are under consideration for inclusion along with other horizontal cabinets, despite their more challenging usage conditions from an energy efficiency perspective. This is because of the principle that users should be made aware of any higher consumption of such cabinets at the point of purchase via a comparable energy label, and that such cabinets could be designed to meet the minimum requirements without excessive cost.

[14] Climate class 4 (most widely used for testing CSC coolers): +30ºC and 55% relative humidity (RH); Climate class 3: +25ºC/60% RH; and, Climate Class 5: +27ºC/70% RH.

7.5.2 *European Commission DG TREN Lot 12: Commercial refrigerators and freezers*[15]

The study considers the following factors when determining the definition of reach-in cooling products (verbatim):

Functionality

For a coherent analysis and facilitate the comparison it is suggested to analyze the products having similar functionality.

The functionality of a refrigerator or a freezer being "to cool or freeze food and store it at the proper temperatures", some other products, which could have been considered as well, can be excluded because of a different functionality such as to "produce chilled water (chillers), to freeze water into ice (ice makers) or to make ice cream (ice cream and milk-shake machines). "

It had been previously noticed that these products were also out of the classification based on design criteria.

End Use

This study focuses on the products designed for commercial use and the products designed for industrial and/or domestic use shall be excluded, for example cold rooms.

Availability of test standards

The products normally tested with standards for commercial cabinets only could be considered and this leads to the exclusion of products tested with standards for household/industrial appliances such as wine cellars.

7.5.3 *European Commission DG ENTR Lot 1 Preparatory Study: refrigerating and freezing equipment*[16]

Service cabinets/commercial refrigerated cabinets – Definitions

"Commercial refrigerated cabinets are designed for the storage, but not the sale of, chilled or frozen foodstuff. A service cabinet is a refrigerated enclosure (with a gross internal volume of 100 – 1200 liters) containing goods which are accessible via one or more doors and/or drawers. The sizes of the products are based around the Gatronorm standard and are used in a nondomestic environment"

[15] Bio Intelligence Service for European Commission (DG TREN, Dec 2007); *Preparatory studies for ecodesign requirements of EuPs Lot 12: Commercial refrigerators and freezers, final report.* (p I-10)
http://www.ecofreezercom.org/documents_1.php.

[16] Bio Intelligence Service for European Commission (DG ENTR, May, 2011); *Preparatory study for Ecodesign requirements of EuPs: Lot 1 Refrigerating and freezing equipment; Summary document; Final report;.*
http://www.ecofreezercom.org/documents_1.php

Classification

Table 2 Service cabinet classification

Type (commercial, either plug-in or remote)	Orientation	Access
Refrigerator	Vertical	1 door*
		2 door or more*
	Horizontal	1 door*
		2 door or more*
	Open top preparation counter**	
Freezer	Vertical	As for vertical refrigerators
	Horizontal	As for horizontal refrigerators
	Chest***	
Refrigerator-freezer	Vertical	As for vertical refrigerators
	Horizontal	As for horizontal refrigerators

* Or with combination of drawers; ** Also known as 'saladettes' – not included in ENTR lot 1; *** freezers and 1 door only

7.5.4 United Kingdom: Enhanced Capital Allowance Scheme[17]

Covers 3 product categories:

- Single door commercial cabinets
- Double door commercial cabinets
- Under counter and counter commercial service cabinets with solid doors or drawers

Definition:

Be designed to store chilled or frozen foodstuffs, whilst maintaining them within prescribed temperature limits.

Be fitted with solid-faced lids, drawers or doors that:

- Are normally kept closed, but can be opened to access the contents
- Obscure the contents of the cabinet from view when closed
- Enable users to access the contents of any part of the interior without stepping into the refrigerated space

[17] http://etl.decc.gov.uk/etl/find/ - see Commercial service cabinets

Be a 'plug in' type cabinet with an integral refrigeration system (i.e. incorporating a compressor and condensing unit).
Have a gross internal volume of 400 to 600 liters (single door commercial cabinets); 1300 liters (double door commercial cabinets); and 150 to 800 liters (under counter and counter commercial service cabinets with solid doors or drawers) where the gross internal volume is as defined in Section 3.6 of BS EN 441-1: 1995.

Be CE marked.

7.5.5 United Kingdom: Market Transformation Programme[18]

Commercial service cabinets

- "A commercial service cabinet is essentially a refrigerator used in commercial catering. They are widely used in all types of catering establishments from small cafes and restaurants through to pubs and hotels.
- "They are also used in retail establishments such as convenience stores, garage forecourts and supermarkets where models equipped with glass doors are frequently employed as merchandising units.
- "They differ from domestic refrigerators in size and robustness of construction, and are usually equipped with a digital temperature display.
- "Cabinets are designed to perform two basic functions:
    - Chilled storage of food: The cabinet is maintained at temperatures from +1 to +5°C (34 to 41°F)
    - Frozen storage of food: The cabinet is maintained at temperatures from –15 to – 18°C (5 to -0.4°F)

- "They consist of three principal types:
    - Single door cabinets with internal capacity between 400 to 600 liters (0.4 to 0.6 m3)
    - Double door cabinets with internal capacity of about 1300 liters (1.3 m3)
    - Under the counter cabinets with internal volume from 200 to 800 liters. (0.2 to 0. 8 m3)

- "This (…) covers all cabinets described above for the storage of perishable foodstuffs. It excludes specialized cabinets designed for the storage of specialized goods such as pharmaceutical products."

Retail Display Cases

- "Refrigerated display cases (RDCs) are sales units designed to enable a customer to self-serve chilled or frozen foodstuffs.
- "There are two generic types of RDCs: plug-in and remote cases.
- "Plug-in cases are equipped with a dedicated refrigeration system that is contained within the case envelope and are mostly used in locations such as convenience stores and garage forecourts, although some supermarkets use multiple plug-in cases in place of a central system.
- "Remote cases are connected via a pipe network to a central refrigeration system which draws refrigerant vapor from the case and supplies it with condensed refrigerant liquid. These systems are mostly used in supermarkets and discount stores[19], with between 10 and 40 cases within a system.
- "Generally cases display food under two conditions, frozen ('low temperature) and chilled ('high and medium temperature'). There are various configurations of cases used for both temperatures. These are:

[18] BC CR01-04: http://efficient-products.defra.gov.uk/spm/download/document/id/889; p1-2
[19] These demarcations are not rigid. Some corner stores use remote cases and central refrigeration systems, and some large supermarkets chains have experimented with using plug-in cases.

- Vertical open fronted: food is displayed on tiered shelving from waist to head height. Used for both chilled and frozen food but chilled use predominates.
- Horizontal open top: food is contained in an insulated well at waist height and accessed by the customer from above. May be open or covered by a sliding cover. Mostly used for frozen food.
- Glass door cases: these are vertical cases currently used for frozen food although their use is being proposed for chilled food. The food is stored in a case behind a triple glazed glass door which is opened by the customer.

- "The Preparatory Study for the Eco-design of EuPs – Lot 12[20] has identified two representative generic cases: a vertical chilled multi-deck case and a horizontal well-type freezer. The chilled multi-deck is representative of the medium temperature cases modeled in this study and the well-type freezer is representative of the low temperature cases modeled."

7.5.6 Denmark Go Energi Scheme[21]

Requirements established by the Danish Energy Saving Trust based on schemes in the UK, tested in accordance with EN441 or DS/EN ISO 23953, climate class 4.

Covers four product categories of commercial fridges and freezers: cabinet with single door (0-319L), cabinet with single door (320-719L), cabinet with double door, and refrigerated counters.

Fridges should be classified in temperature class M1 (+5 °C) and freezers in temperature class L1 (-18 °C).

7.6 USA

7.6.1 Energy star: Commercial Refrigerators and Freezers

Definitions and relevant terms [22](verbatim):

A. Commercial Food-grade Refrigerator: A refrigeration cabinet designed for storing food products at temperatures above 32 degrees Fahrenheit (F)(0ºC) but no greater than 40 degrees F (4.4ºC) and intended for commercial use.

B. Commercial Food-grade Freezer: A refrigeration cabinet designed for storing food products at temperatures of 0 degrees F (-17.8ºC) and intended for commercial use.

C. Refrigeration Cabinet: A refrigerator or freezer used for storing food products at specified temperatures, with the condensing unit and compressor built into the cabinet, and designed for use by commercial or institutional facilities, other than laboratory settings. These units may be vertical or chest configurations and may contain a worktop surface.

[20] Preparatory Study for the Eco-design of EuPs – Lot 12 Commercial Refrigerators and Freezers Final Report December 2007.
[21] http://www.savingtrust.dk/publications/guidelines/purchasing-guidelines
[22] Definition from ANSI/ASHRAE Standard 72-2005, Method of Testing Commercial Refrigerators and Freezers, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. 2005. Appears to deal with RDCs, but only glass, not open-fronted (to be expected): integral/remote distinction not made here.

D. Closed Refrigerator: A display or holding refrigerator where product is accessible for removal by opening or moving doors or panels

E Solid Door Cabinet: A commercial food-grade refrigerator or freezer in which all outer doors on all sides of the unit are solid doors. These doors may be sliding or hinged.

F Glass Door Cabinet: A commercial food-grade refrigerator or freezer in which all outer doors on at least one side of the unit are glass doors. These doors may be sliding or hinged.

G. Mixed Solid/Glass Door Cabinet: A commercial food-grade refrigerator or freezer in which all outer doors on at least one side of the unit are a combination of solid and glass doors. A unit which has all glass doors on one side and a combination of solid and glass doors on another is considered a glass door cabinet.

H Solid Door: Less than 75% of the front surface area is glass.

I. Glass Door: Greater than, or equal to, 75% of the front surface area is glass.

J. Worktop Surface: A solid working surface. The working surface may be a cutting board, a stainless steel work surface, or a stone slab. This surface cannot add to the total energy consumption of the unit.

K. Chest Configuration: An enclosed refrigeration cabinet to which access is gained only through a top-opening door.

Qualifying Products: For the purposes of ENERGY STAR, only those products that meet definitions 1.A through 1.G, above, are eligible for qualification. Examples of product types that may be eligible for qualification include: reach-in, roll-in, or pass-through units; merchandisers; under-counter units; milk coolers; back bar coolers; bottle coolers; glass frosters; deep well units; beer-dispensing or direct draw units; and bunker freezers.

Drawer cabinets, prep tables, deli cases, and open air units are not eligible for ENERGY STAR under this Version 2.0 specification.

7.6.2 California Energy Commission[23]

Commercial refrigerators, refrigerator-freezers, and freezers (verbatim)

Scope - exclusions: commercial refrigerators, commercial refrigerator-freezers, and commercial freezers with total refrigerated volume exceeding 85 ft^3 (2.4 m^3); except that walk-in refrigerators and walk-in freezers are not excluded.

Definitions:

"Commercial freezer" means a freezer that is not a federally regulated consumer product.

[23] California Energy Agency (2006): *Appliance Efficiency Regulations; CEC-400-(2006)-002-REV2 – Definitions: p8-11verbatim:* Does not appear to deal with remote units (integral / self contained only); does not deal with door type – not clear if covers RDCs therefore.

"Commercial refrigerator" means a refrigerator that is not a federally regulated consumer product.

"Commercial refrigerator-freezer" means a refrigerator-freezer that is not a federally regulated consumer product and that has one or more sources of refrigeration requiring an energy input.

Where:

"Freezer" means a cabinet that is designed as a unit for the freezing and storage of food, beverages, or ice at temperatures of 0º F (-18 ºC) or below and that has a source of refrigeration requiring an energy input.

"Refrigerator" means a cabinet that is designed for the refrigerated storage of food, including but not limited to solid food and wine, beer, and other beverages, at temperatures above 32º F (0 ºC), and that has a source of refrigeration requiring an energy input. It may include a compartment for the freezing and storage of food at temperatures below 32º F (0 ºC), but it does not provide a separate low temperature compartment designed for the freezing and storage of food at temperatures below 8º F (-13.3 ºC).

"Refrigerator-freezer" means a cabinet that:

(1) Consists of two or more compartments with at least one of the compartments designed for the refrigerated storage of food, including but not limited to solid food and wine, beer, and other beverages, at temperatures above 32º F (0 ºC);

(2) Has at least one of the compartments designed for the freezing and storage of food or ice at temperatures below 8º F (-13.3 ºC) that may be adjusted by the user to a temperature of 0° F (-18 ºC) or below; and

(3) Has a source of refrigeration requiring an energy input.

"Self-contained freezer" means a freezer that has the condensing unit mounted in or on the freezer cabinet.

"Self-contained refrigerator" means a refrigerator that has the condensing unit mounted in or on the refrigerator cabinet.

Other relevant definitions:

"Pass-through cabinet" means a commercial refrigerator or commercial freezer with hinged or sliding doors on both front and rear of the refrigerator or freezer.

"Roll-in or roll-through cabinet" means a commercial refrigerator or commercial freezer that allows wheeled racks of product to be rolled into or through the refrigerator or freezer.

8 Identification of international and national test procedures

8.1 Discussion

- Over 10 separate standards are identified for RDC and CSC coolers, however most of the market within the scope of this study is covered by ASHRAE 72 or ISO 23953.
- Test standards by country source are included below. These are fully referenced.

Table 3 International and national test standards (energy consumption/efficiency) – reach in coolers

Standard	Description	Where used	Reference
BS EN 441:1995/1996 – refrigerated display cabinets	Calculates: net volume; total electricity consumption; test room conditions; temperature classifications; climate classification and; loading: for EC, largely[24] superseded by ISO 23953	UK ECA scheme, Danish Go Energi	Actual standard not freely available[25]
DS/EN ISO 23953 – refrigerated display cabinets, under review for suitability to CSCs/service cabinets[26]	Specifies requirements for the construction, characteristics and performance; test conditions and methods for checking that the requirements have been satisfied; classification of the cabinets, their marking and the list of their characteristics to be declared by the manufacturer.	Danish Go Energi (climate class 4), Eurovent voluntary certification/labeling	Actual standard not freely available[27]. Definitions/energy calculations replicated & discussed in Lot 12 Preparatory study pI-18 and Annex I-4
ISO 1992-3	'Commercial refrigerated cabinets - Methods of test'	Unknown – possibly EU but may be replaced by ISO 23953	Actual standard not freely available[28]
ANSI/ASHRAE Standard 117-1992, Method of Testing Closed Refrigerators	For self-contained commercial refrigerators and freezers with doors or drawers	Canada: voluntary/mandatory standards; USA, Washington State, California: mandatory standards (see Table 4 for adjustments); USA:	Actual standard not freely available[30]
ANSI/ASHRAE 72-1998, Method of Testing Open Refrigerators	For self-contained (integral) and remote commercial refrigerators and freezers with no doors or drawers. Procedure for pass through and roll-through variants:		

[24] EC draft regulation refers to EN441 for internal storage volume.
[25] http://www.standardsdirect.org/standards/standards1/StandardsCatalogue24_view_13985.html
[26] Bio Intelligence Service for European Commission (DG ENTR, May, 2011); *Preparatory study for Ecodesign requirements of EuPs: Lot 1 Refrigerating and freezing equipment; Summary document; Final report; p12*
[27] http://engineers.ihs.com/document/abstract/XCVTIBAAAAAAAAAA
[28] http://www.iso.org/iso/iso_catalogue/catalogue_ics/catalogue_detail_ics.htm?csnumber=6734&ics1=97&ics2=130&ics3=20

Standard	Description	Where used	Reference
	see Table 5 for exceptions	Energy Star voluntary label see supplement[29]	
ARI/AHRI 1200 – 2006: "Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets"	"This standard establishes definitions, test requirements, rating requirements, symbols, minimum data requirements for published ratings, marking and nameplate data and conformance conditions. It enables the measurement and comparison of energy consumption for remote commercial refrigerated display merchandisers; remote commercial refrigerated storage cabinets; self-contained commercial refrigerated display merchandisers; and self-contained commercial refrigerated storage cabinets"[31]	US	
AHRI 1320	Applies to the following refrigerated display merchandisers and storage cabinets, provided that the cases are designed and equipped to work with electrically driven medium temperature, single phase secondary cooling systems: remote commercial refrigerated display merchandisers as well as open and closed commercial refrigerated display merchandisers	USA	AHRI[32]
AS 1731.14-2003 Refrigerated display cabinets	To establish compliance with MEPS: remote and plug-in refrigerated display cases.	New Zealand, Australia. Initially aligned with EN 441 which has been replaced by ISO 23953	AS 1731.14-2003 Refrigerated display cabinets - Minimum energy performance standard (MEPS) requirements (Commercial Refrigeration)[33]
KS C ISO 15502	Commercial Refrigerator	Korea	http://www.ke

[30] http://www.ashrae.org/
[29]http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/freezers/Draft_2_ES_Supplement_to_ASHRAE_72.pdf
[31] Waide, Navigant (2011) for CLASP: *Opportunities for success and CO2 savings from Appliance energy efficiency harmonisation:* Part 2: an assessment of test procedures and efficiency metrics, p101
[32]http://www.ahrinet.org/App_Content/ahri/files/standards%20pdfs/ANSI%20standards%20pdfs/ANSI.AHRI%20Standard%201320%20%28I-P%29-2011.pdf
[33] http://infostore.saiglobal.com/store/Details.aspx?ProductID=243908

Standard	Description	Where used	Reference
			mco.or.kr (actual standard not freely available[34])
SANS 60335-2-89(2003): part 2-89:	Commercial Refrigerator: std appears to be identical to the EN standard of the same code.	South Africa	
DIN 18872-1:	"Equipment for commercial kitchens – Refrigeration technology equipment - Part 1: Refrigerators and refrigerated counters, Requirements and testing"	Germany	Reference in in Lot 12 Preparatory study p I-16-17
DIN 18872-3	"Equipment for commercial kitchens – Refrigeration technology equipment – Part 3: Refrigerated display cases for food distribution, Requirement and testing" which include a section on the energy consumption (chapter 7).	Germany	
NF AC D40-003	Test protocol for blast cabinets: note Blast cabinets tentatively outside of scope of reach-in coolers	UK: suggested in draft EU MEPS proposals under ENTR Lot 1	

Table 4 With-door temperature adjustments

Type	Integrated Average Product Temperature in ° F
Refrigerator Compartment	38 ± 2
Freezer Compartment	0 ± 2

8.2 ANSI/ASHRAE Exceptions for pass through and roll-through variants

The following exceptions apply to both standards: the back (loading) doors of pass-through and roll-through refrigerators and freezers shall remain closed throughout the test, and the controls of all appliances shall be adjusted to obtain the following product temperatures:

Table 5 ANSI/ASHRAE Exceptions - pass through and roll-through

Type	Integrated Average Product Temperature in °C
Refrigerator compartment	3.3 + 1.1

[34] http://www.kemco.or.kr/nd_file/kemco_eng/MKE_Notice_2010-124.pdf

Freezer compartment	-17.8 + 1.1
Wine chiller	7.2 + 1.1
Ice Cream Cabinet	-20.6 + 1.1

Source: Natural resources Canada: http://oee.nrcan.gc.ca/regulations/10392

9 Initial comparison of test procedures

9.1 Discussion

- Of the standards identified in section 8 above, an initial comparison of the two key methods is shown in Table 6 below.
- ISO 23953:2005 replaces EN441:1995 and key test methods remain the same.
- The ASHRAE standard 72:2005 combines both previous version ASHRAE 117 (open type) and ASHRAE 72 (closed) together eliminating the need for two individual standards.
- Energy Star and CEC refer to ASHRAE 72.

Table 6 Initial comparison of test procedures – reach-in coolers

Product parameter/standards	**ASHRAE 72:2005**	**ISO 23953:2005**
Test room conditions		
Ambient temperature: Drybulb	Single condition 24.0 C	8 climate classes EN441 defined 6. Class 3 shown: 25.0 C
Ambient temperature: Wetbulb %humidity	Single condition 18.0 C (56%) calculated	8 climate classes EN441 defined 6. Class 3 shown (19.4 C) calculated 60%
Ambient: temperature gradient	2 C / m	2 C / m
Ambient: location & no. of sensors	Two points defined TA highest point (open) TB geometric center (closed)	One midway along length of cabinet. Two sensors for Island type one each side
Radiant Heat (RH): room	Minimum 800 lux	600 +/- 100 lux

Product parameter/standards	ASHRAE 72:2005	ISO 23953:2005
lighting	300mm from center of door opening	1m from floor
RH: from walls, support equipment, etc	Not less than 21.2 C	+/- 2 C of ambient
RH: emissivity (wall color)	Gloss white facing the display area	Light Gray walls
Air velocity	< 0.25 m/s	(0.1 – 0.2) m/s
Power Voltage	+/- 4% of rated	+/- 2% of rated
Power Frequency	+/- 1% of rated	+/- 1% of rated
Loading		
Measurement Material type	Sponge Material with 50% propylene glycol mix. Minimum 473ml plastic container. Sensor located in geometric center of container.	ISO M packages Oxyethylmethylcellulose/water/salt mixture Sensor located geometric center of package
Filler Material	Simulated Filler same as measurement pack or with similar characteristics Typically wooden blocks are used having density > 480 kg/m3	Same as measurement pack without sensors
% loading	70% -90% of usable volume	Essentially 100% loaded - to Load Limit
Loading temperature	Not defined typically preconditioned to nominal compartment temperature	Same as nominal operating temperature
Volume Determination	AHAM HRF1 ASHRAE 72 includes informative Appendix	ISO 23953-2
Duration of Test	24 hours	12 hour minimum for samples with night covers or designed with lighting that is switched off at night. 24 hours

Product parameter/standards	ASHRAE 72:2005	ISO 23953:2005
		for all others.
Stability Criteria	Stable when back to back 24 hour periods have less than 0.2 C deviation for each measurement package.	Stable when all measurement packages are within +/- 0.5 deviation for the prior 24 hour test period.
Measurement Package Locations	Standard includes detailed instructions and figures for measurement package placement Typically 4 per shelf left/right front back. Open type typically left/right, front/back at upper and lower vertical load limits.	Standard includes detailed instructions and figures for measurement package placement Typically 4 per shelf left/right front back. Open type typically left/right, front/back at upper and lower vertical load limits, and typically at vertical center for larger equipment.
Door opening regime		
Frequency	6 times/hour for total of 8 consecutive hours	6 times/hour for total of 12 consecutive hours.
Door angle	Fully opened not less than 75 degrees	Fully opened > 60 degrees with min of 4 seconds opened
Duration of opening	6 seconds	6 seconds, at start of opening cycle first the first door opening shall be open for 3 minutes.

10 Identification of potential issues in test result comparisons

10.1 Summary

The impact of key differences between ASHRAE 72 and ISO 23953 is difficult to quantify, when comparing efficiencies derived from each. A study to evaluate results with changes in key requirements would be beneficial in understanding the relative impact. This could be done first with the same sample tested utilizing each of the two key standards. Additional testing to evaluate the impact of specific criteria would also be needed. This could be accomplished with back-to-back tests while changing each of the key criteria individually. Changes equal to the maximum deviation (between the test procedures) would allow each specification to be evaluated independent of the others. Key specifications may include:

- Air velocity, direction and speed
- Ambient Temperature
- Internal Temperature
- Door opening frequency, duration, angle
- Loading material, number of measurement sensors, and load levels.

10.2 Detailed discussion

Several issues exist that impact test results and test result comparisons. Differences in the test method specifications as noted in Section 9 can lead to differences in energy consumption measurements:

- The determination of Volume can influence the results. This includes:
    - Gross vs. Net
    - Usable Volume
    - Multiple Compartments

- Sample stability can influence test results. This includes:
    - criteria to confirm steady state operation
    - test duration
    - ending test based on compressor start/stop
    - ending test based on defrost cycle termination
    - adequate and repeatable defrosting

- Door opening can influence test results. This includes:
    - frequency of door opening
    - angle of opening
    - duration of opening

- Test room condition and design can influence test results. This includes:
    - ambient conditions
        - temperature
        - humidity
        - temperature gradient
        - measurement location and number of ambient sensors

    - radiant heat
        - room lighting
        - radiant heat from walls, support equipment, etc.
        - emissivity (wall color)

    - air velocity
        - direction
        - velocity (maximum or within a set range)

- Loading can influence test results. Generally speaking the highest energy consumption for steady-state tests is an empty refrigerator. This includes:
    - load material type
    - configuration of load material
    - percentage of loading

- Setup of samples that incorporate remote condensers can influence test results, including:

- Length of interconnect tubing
- Size and type of interconnect tubing
- Ambient conditions and/or secondary fluid conditions

Section B.
Detailed Results for Cold Vending Machines

11 Definition of relevant product classes or categories

Cold vending machine: self-contained refrigerated systems designed to accept consumer payments or tokens to dispense pre-packed beverages and/or food at between 2°C and 12°C without on-site labour/intervention

11.1 Discussion

- The above definition is intended to be sufficiently broad as to include most of the product data and country sources identified below. A common test standard (see sections 12 and 13) underpins most of these sources, making benchmarking easier; however there is variation in sub-product classes.
- Temperature range. Beverage machines are often designed to vend at 2.2°C[35]. Machines that vend at lower temperatures (frozen foods) are relatively rare and related data identified is limited to two classes of the Canadian MEPS. Machines that vend at higher temperatures (ambient/heated) are typically non-refrigerated, although a small minority of machines provides both heated and cooled food. Sales data of this kind has not been sourced, however both Canada MEPS and Japan Top Runner include classes for machines that vend both hot and cold beverages – related data may be available directly from the relevant authority or trade body. Access to European Vending Association (EVA) data may enable to expand scope to cover such products. Thus there is potential to expand the above definitions to capture wider temperature ranges.
- Payment. Intended to exclude products which do not require some form of payment in exchange for the product vended – thus excluding some water and other beverage (soda) dispensing machines. MEPS and/or labeling programs exist for water and/or beverage dispensers in USA, Canada, Taiwan, Hong Kong, South Korea, and Australia. China has a test procedure, at least. While not within the scope as defined above, this product category may warrant further investigation, due to apparent availability of data and due to the size of related markets
- Packaging: data/standards have yet to be found on machines which vend products that are not packaged and do *not* require on-site labor/intervention: As described in the bullet above on payment, unpackaged beverage machines that do required onsite intervention (e.g. hot/cold beverage dispensers) could be considered: machines dispensing into a cup/similar are found in many restaurants and fast-food outlets, likely with high throughput/loads compared to vending machines as defined. Consequently these dispensers may occur in sufficient numbers and consume sufficient energy to warrant a widening of scope of cold vending mapping and benchmarking.

[35] According to ASHRAE 32.1: IEA 4E vending machines – product definition p 5

- Self-contained: all definitions found below relate to self-contained/plug-in/integral units. Remote units[36] are highly unlikely to occur and are excluded from scope.
- Detailed definitions by country source follow: these are fully referenced.

11.2 International definitions: International Energy Agency (IEA) – 4E Mapping and benchmarking study[37]

A mapping and benchmarking study was carried out for the IEA 4E (published May 2011), to identify product scope, country coverage, depth of analysis, and opportunities for further work building on its findings.

The study contains 5 documents: one addresses definition of vending machines, and there are four partner documents. Each deals specifically with these products in one of the following countries/regions: Australia (and to some extent New Zealand), the EU, USA and Canada.

11.2.1 Definition

The 4E Definition[38] document defines and discusses key features relating the energy consumption of cold vending machines. Table 7 provides a definition and overview.

Table 7 Simplified product categorization matrix

Definition and Scope	Self-contained refrigerated systems designed to accept consumer payments or tokens to dispense pre-packed beverages (cans/bottles/food packets) at between 3°C and 12°C without on-site labor intervention.(p1)	
Type	Beverage (can, bottle)	Food/snack (spiral, carousel, other)
Capacity	Number of cans / bottles / snacks that can be stored in the carousel (units). Or (for food/snack only): Internal volume of refrigerated storage space (liters) (This allows dividing products into size categories small, medium, large)	
Other characteristics to be noted:	Storage temperature Ambient temperature during test Whether for indoor or for outdoor use Capability of automatically switching into a low power mode Presence of usage sensor or timer to enable low power modes Refrigerant used Glass fronted or solid (i.e. whether or not the product can be seen from the outside)	

The points below summarize key outputs of the IEA 4E study:

- The focus is on *beverage* vending machines, but also includes descriptions of snack/food vending machines, and combined beverage/food vending machines.

[36] I.e. machines connected to a separate, remote condensing unit
[37] IEA 4E Mapping and Benchmarking; Product definition: Vending machines (May 2011)
[38] Ibid.

- Country-specific time-series analysis presents new beverage (+snack in EU) vending machine unit annual energy consumption based on variations in machine capacity, and separately for Australia, estimated total energy consumption of the stock.
- Estimated dedicated *beverage* vending machine share of total cold vending machine sales are shown to vary by geographical market – between 30% (EU) and 75% (Australia). Thus there is scope to build on the data discovered from beverage vending machine, and to obtain data relating to the energy performance of snack and mixed food/beverage cold vending machines.
- The 4E study excludes:
    - Hot and cold beverage vending machines that dispense into a cup
    - "Point of use" water dispensers, for which water is dispensed from a bottle/reservoir or mains water source
    - Non-refrigerated vending machines

  Thus there is scope to include these product types in future CLASP studies

- Analysis in the study does not include variations in energy performance based on design options indicated by Table 7.

Scope for the CLASP mapping and benchmarking study to build upon the 4E study includes:

- Update the analysis
- Widen scope to include other countries (e.g. China, Japan)
- Assess variations in annual energy consumption for machines of the same capacity
- Assess variations in machine efficiency/annual consumption in conjunction with policy development e.g. labeling/MEPS.
- Assess cold food/snack machines separately
- Assess refrigerant options in terms of TEWI[39] analysis
- All developments will be subject to data availability

11.3 Australia and New Zealand

General Description[40]

"Refrigerated vending machines are self-contained machines that accept payment prior to dispensing selected food or beverages stored in the machine to the consumer. Vending machines are typically placed in high-use public areas, either inside or outside buildings, to maximize product turnover.

"These machines plug into a conventional 240V power supply.

"Broadly, vending machine types can be categorized as follows:

- Refrigerated machines for vending beverages;
- Refrigerated machines that heat food from cold or frozen, prior to vending;
- Refrigerated machines that vend frozen or chilled food;
- Refrigerated machines that vend both beverages and snacks;

[39] Total equivalent warming impact: an indicator combining direct global warming emissions (e.g. refrigerant leakage) and indirect emissions (from energy use)

[40] Ministerial Council on Efficiency forming part of the National Framework for Energy Efficiency and New Zealand Energy Efficiency and Conservation Authority: Minimum Energy Performance Standards: refrigerated vending machines. Report 2004/11; p2 - verbatim

- Non-refrigerated machines that vend snacks;
- Non-refrigerated machines that vend hot beverages; and
- Combination machines that vend hot and cold beverages and chilled snacks".

11.4 Canada

Regulatory definition[41]:

- Refrigerated beverage vending machine
  - A self-contained system designed to accept consumer payments and dispense only bottled, canned or other sealed beverages

- Snack and refrigerated beverage vending machine
  - A self-contained system that is designed to accept consumer payments and dispense packages of solid non-refrigerated food and bottled, canned or other sealed refrigerated beverages, and has a vendible capacity of no more than 100 beverages

11.5 European Union

11.5.1 *European Commission: Preparatory studies for Ecodesign requirements of EuPs: Lot 12 Commercial refrigerators and freezers*[42]

The study contains detailed descriptions of drum, can/bottle, and spiral vending machines. Summaries are provided below (ref: pIV-31) - further details available in the Study.

- Spiral machines: 55-60% of EU market share:
  - "In a spiral vending machine, drinks (cans or bottles) and food are lined up on shelves, and segregated by one or two spirals depending on the size of the product. When a shopper selects a product, a motor causes the spiral to rotate, moving the full line of the chosen product forward one revolution so that the front item falls off into the delivery station. This kind of vending machine has a glass door to present products to the customer".
- Can and bottle machines: 30% of EU market share:
  - "There are two full height hinged doors on the can vending machine. An inner door which is insulated, gives access to the refrigerated space where cans, snacks or bottles are stored. An outer door, generally in acrylic, houses the logo and its associated lighting equipment for display purposes. The latter, also contains the electronic controls that allow customers to purchase and receive goods. Cans and bottles machines typically show a smaller energy consumption than spiral machines due to a better insulation (acrylic door vs. glass door). In the refrigerated compartment, cans and bottles are set in feeder stack columns. Lower products are sold first… where the can or the bottle falls to the access area with a dispensing slide".
- Drum machines: 10-15% of EU market share:
  - "As for spiral machines, drum vending machines have a glass door to present products. Drums are stacked up on shelves and products are set in each compartment. The product is provided to the customer either by an access area in the lower place of the appliance, like for

[41] http://oee.nrcan.gc.ca/regulations/products/3335
[42] http://www.ecofreezercom.org/documents_1.php - verbatim

other vending machines, or by a lateral slot. In the latter case, the shopper rotates the drum to present the product in front of the slot".

- Base case spiral vending machine[43]:
  - "A spiral vending machine with a glass door, operating 24 hours a day for 8.5 years enabling to contain 288 cans and maintaining product temperature around 3 °C. The lights are turned on 24 hours a day".

11.5.2 United Kingdom

In its 2009 evaluation of vending machines, the UK Government used the following definition, based on ENERGY STAR and the European Vending Association definitions[44].

"Self-contained refrigerated systems designed to accept consumer payments or tokens to dispense food and/or drink at appropriate temperatures without on-site labor intervention."

- Products modeled include: can/carton/bottle machines and snack/food machines.

11.5.3 European vending association (EVA)

"The EVA EMP was designed to cover all food and drink machines, cold and hot, refrigerated or not. For all machines, the energy consumption is measured in stand-by situation and vending situation. For cooled machines, the energy consumption after reloading is also measured"[45].

11.6 USA

ENERGY STAR[46]:

- Refrigerated beverage vending machines: "a self-contained system designed to accept consumer payments and dispense bottled, canned and other sealed beverages at appropriate temperatures without on-site labor intervention"
- Indoor Vending Machine: "A machine intended for placement inside a building and not subjected to the effects of weathering. These machines are marked 'For Indoor Use Only' in accordance with UL Standard 541 Refrigerated Vending Machines."
- Outdoor Vending Machine: "A machine intended for placement outdoors and subjected to the full effects of weathering. These machines are marked 'Suitable for Outdoor Use' or 'Suitable for Protected Locations' in accordance with UL Standard 541 Refrigerated Vending Machines."
- Rebuilt Refrigerated Beverage Vending Machine: "A UL Listed or Classified model that has been previously in use and subjected to various degrees of retrofitting, remanufacturing, refurbishing, repairing, or reconditioning for resale or reuse."

[43] Used in life cycle assessment (LCA): Page V-70-79
[44] BNCR VM 01: see http://efficient-products.defra.gov.uk/spm/download/document/id/880, p1
[45] http://www.vending-europe.eu/en/standards_protocols/eva-emp.html
[46] Definitions below from Energy Star Program requirements for refrigerated vending machines: Eligibility requirements Version 2.0

12 Identification of international and national test procedures

12.1 Discussion

- The key test standard is ASHRAE 32.1, which underpins MEPS (incl. proposed) and/or labeling in USA, California, Canada, Australia and New Zealand. This commonality renders comparison easier.
- Manufacturers marketing in Europe make use voluntarily of the Energy Measurement Protocol (EMP), developed by the European Vending Association (EVA).
- The other key test standard identified is Japan's *JIS B8561: 2007*
- Test standards by country source follow: these are fully referenced.

Table 8 National and international test standards

Standard	Description	Where used	Reference
ASHRAE 32.1 (2004)	Definition of a vending machine – storage temperature (chilled); Methods of Testing for Rating Vending Machines for Bottled, Canned, and Other Sealed Beverages	US DoE MEPS, Energy Star, California energy Commission, Australia and N Zealand[47], Canada	Interpretation see footnote[48] , and see section 12.2 below (actual standard not freely available)
Test Protocol for the Measurement of Energy Consumption in Vending & Dispensing Machines, Version 3.0	Used by European Vending Association, Brussels, for use in presenting performance data to customers, and also for a voluntary energy labeling scheme in Europe	Europe – voluntary labeling	Energy measurement[49], temperature measurement (actual standard not freely available)
JIS B8561: 2007	Hot and cold vending machine test procedures. Subject to Top Runner standards	Japan	Extracts of test procedure available[50]
CAN/CSA-C804:96	Canada Standard Association: "energy performance of vending machines" – test may actually relate to ASHRAE 32.1 (above)		Reference in Lot 12 Preparatory study p I-33

[47] Part 1 of the regulation AS/NZ 4864.2:2008 sets out the test procedure which is identical to the ASHRAE procedure (according to IEA 4E vending report – Australia p5)

[48] http://www.ashrae.org/standards-research--technology/standards-interpretations/interpretation-to-standard-32-1-2010; http://china.lbl.gov/sites/china.lbl.gov/files/International_Review_for_Selected_2010_Standards_final.pdf from p56

[49] http://www.vending-europe.eu/en/standards_protocols/eva-emp.html

[50] http://www.eccj.or.jp/top_runner/pdf/tr_vending_machines_may2007.pdf from p55 and http://www.google.co.nz/url?sa=t&rct=j&q=jis%20b8561%3A%202007&source=web&cd=5&ved=0CFoQFjAE&url=http%3A%2F%2Fwww.freestd.us%2Fsoft%2F124402.htm&ei=VV32T4bxMu-wiQfZsKD9Bg&usg=AFQjCNE2_n3zn_JuMxSRUOyg3g3S183LNg

12.2 Test comparisons – detailed - ASHRAE 32.1

The following information is from the IEA 4E Mapping and Benchmarking Study (May 2011) on Vending Machines, p7-8.

"The ASHRAE test methodology has been adopted by the USA EPA for ENERGY STAR, California Energy Commission for state MEPS, Canada and Australia. The European Vending Association methodology has not been adopted by any national schemes, nor is there much public domain product performance information available that is based upon this methodology (based on UK study during 2009). Hence it is proposed to adopt the ASHRAE test methodology for this analysis. Should any significant datasets be identified using other methodologies, normalization will have to be considered.

Energy efficiency metrics (i.e. specific consumption) are not generally used in the sector. However, for the purposes of this analysis and energy efficiency comparison, the following metrics will be used:

- Energy efficiency of beverage (can/bottle) vending machines in kWh per 300 cans per day.
- This uses the lowest likely capacity of machine (300 cans) as the baseline, with larger machines credited for their higher capacity.
- Energy efficiency of snack/drink machines either in kWh per liter of refrigerated volume per day, or in kWh per 300 snack items per day, depending upon which capacity metric is available.

Capacity

"Capacity of beverage (bottle/can) and snack/drink vending machines is generally measured in number of cans/bottles or packets of food/snack that the machine's carousel can store. For example a beverage machine may hold 650 cans. It is also preferable to determine the size of the bottle/can that can be accommodated – whether 355 ml (common in USA), 330 ml (Europe), 0.5 liter bottle or other as this could influence the overall size of the machine, and so it's refrigerated volume and heat losses, etc.

Alternatively for some snack/drink vending machines capacity can be measured in liters of refrigerated storage space. The volume of space used for dispensing the product would not be included in this, nor would any volume associated with payments or product selection as per the European Vending Association energy measurement protocol.

From IAE 4E Vending – Australia (p7):
"Results for one product in 2002 supported the assumption that there is no significant difference in energy consumption results from ANSI/ASHRAE 32.1-1997 (11.4 kWh/24h) and CAN/CSA-C804-96 (11.6kWh/24h). For one product the energy consumption was tested with the light on and then off, giving rise to a significant difference in energy consumption.

An important distinction of product type that also defines the ambient temperature in which it is tested is whether it is designed to be placed outside and fully weatherproof or only indoors. Ambient temperature (defined by usage location) affects the energy consumption of the machine – consumption rises (or falls) by around 3% for each additional (or reducing) degree Celsius of ambient temperature above the internal storage temperature of the machine. The ASHRAE 32.1 test standard and AS/NZ 4864.1:2008 require a different test temperature and humidity depending on whether the product is intended for indoor or outdoor use."

12.3 Test comparisons – detailed - LBL comments[51]

"The U.S. Energy Star program follows the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) test procedure as published in ASHRAE Standard 32.1-2004.This test procedure has since been adopted by Canada, Australia and the U.S. for the MEPS program. Australia has its own national standard of AS/NZS 4864 but directly references the ASHRAE standard. The ASHRAE test procedure mandates an indoor ambient temperature of 23.9°C (75°F), outdoor ambient temperature of 32.2°C (90°F) and average beverage temperature of 2.2°C (36°F) for both types of machines. With a much more complex set of target standards for different types of vending machines, Japan has its own test procedure in the reference standard of JIS B8561: 2007. This test procedure uses a lower ambient temperature of 15°C (59°F) and requires that hot beverages reach an average temperature of 55°C (131°F) and cold canned or bottled beverages be at 4°C. (39.2°F)".

13 Initial comparison of test procedures

13.1 Discussion

- ASHRAE 32.1 (2004) is used in Australia and New Zealand (draft MEPS), Canada (MEPS), US (DoE MEPS), Energy Star (labeling), and California (MEPS). It is likely that the EU will regulate similarly for vending machines, but no details are available.
- The European Vending Association (EVA) uses its own test procedure (voluntary labeling/certification) in Europe – the Energy Measurement Protocol (EMP), and the test standard used in Japan is JIS B8561: 2007 (MEPS)
- The key comparisons identified therefore, are between ASHRAE 32.1, EMP and JIS B8561

Table 9 Initial comparison of test procedures – vending machines

Product parameter/standard	ASHRAE 32.1	EVA - EMP	JIS B8561
Scope	Cold beverage only	All Types 6 Categories Category #1 can/bottle	Cold Only Hot Only Hot and Cold Also covers beverage dispensed into paper cups
Volume	Vendible capacity # cans	Not defined	Internal Volume
Energy Metric	kWh/day based on number of	kWh	kWh/year

[51] Ernest Orlando Lawrence Berkeley National Laboratory, China Energy Group (2010) *Comparison of Test Procedures and Energy Efficiency Criteria in Selected International Standards & Labeling Programs for Clothes Washers, Water Dispensers, Vending Machines and CFLs;* LBNL-3505E

Product parameter/standard	ASHRAE 32.1	EVA - EMP	JIS B8561
	vendible cans		based on internal volume
Stability/operating cycle tested	24 hours verified by two consecutive 6 hour segments with energy consumption within 2 %	24 hours	24 hours
Test room conditions			
Indoor Ambient: temperature	*23.9°C (75°F)*	*25.0°C (77°F)*	*15.0°C (59°F)*
Outdoor Ambient: temperature	*32.2°C (90°F)* *Informative appendix B identifies a tropical condition of 40.6C*	*32.0°C (89.6°F)*	No specific temperature defined for outdoor use
Ambient: humidity	65 +/- 5% @ 32.2C ambient 45 +/- 5% @ 23.9 C ambient	65 +/- 5% @ 32.0°C ambient 60 +/- 5% @ 25.0°C ambient	Not defined
Loading			
Average beverage temperature	*2.2°C (36°F)*	Factory Settings	Cold: *4°C. (39.2°F); hot: 55°C (131°F)*
Pull down Power Consumption included?	*None*	Yes Defined as Reloading and Pull Down to be completed immediately after the idle state test.	Yes Considers power used based on loading every 14 days. WA: energy consumption in 24 hours after startup WB: energy consumption in 24 hours following WA WF: energy consumption of lighting per day Energy consumption per day: Wd Wd = (WA + WB × 13)/14 + WF

Product parameter/standard	ASHRAE 32.1	EVA - EMP	JIS B8561
			Annual energy consumption = Wd × 365
Dispensing	*None*	Yes – defined as the vending state test. Record energy used vending 2/min until 50% remaining	None for cans/bottles
Low power mode considered?	No not directly within the standard method of test however standards that reference ASHRAE 32.1 consider low power mode, load management and/or lighting management.	Included within test measurements	Lighting is measured independently and reported. Based on 12 hours/day usage Default power savings settings shall be included in test.

14 Identification of potential issues in test result comparisons

14.1 Summary

The impact of key differences between ASHRAE 32.1 EVA-EMP and JIS B8561 is difficult to quantify, when comparing efficiencies derived from each. A study to evaluate results with changes in key requirements would be beneficial in understanding the relative impact. It should be noted that EVA-EMP is not used for regulatory purposes, and is therefore probably less relevant from a benchmarking perspective.

As with reach-in coolers, reconciliation of test efficiencies making use of the different tests could be achieved by testing various products under the relevant test procedures. This could be done first with the same sample tested utilizing each of the two key standards. Additional testing to evaluate the impact of specific criteria would also be needed. This could be accomplished with back-to-back tests while changing each of the key criteria individually.

14.2 Detailed discussion

Several issues exist that impact test results and test result comparisons. While all tests measure energy consumption over the 24 h cycle:

- The conditions in which measurements are taken vary:
  - Ambient temperature

  - Humidity,
  - State (steady – no dispensing, or cycling – dispensing, pull-down energy consumption[52])
- The characteristics of the product or cooling load vary:
  - Foods vs. beverage,
  - Set or target temperature
  - Definition of volume

[52] i.e. that required to reduce the product's temperature to the set temperature (*c.f.* maintaining the set temperature)

Section C.
Detailed Results for Walk-in Cold Rooms

15 Definition of relevant product classes or categories

Walk in cooler: an enclosed, refrigerated space, sufficiently large to be stepped into, but no larger than 3,000 square feet (279 m^2) capable of storing foodstuffs at temperatures from +5°C (41°F) to -18°C (-0.4°F)

15.1 Discussion

Definitions of walk in coolers for the purpose of standards and labeling appear limited to the USA and the EU (draft). Thus the purpose of the above definition is to be sufficiently broad as to at least include both 'products'.

15.2 European Union

15.2.1 European Commission

The EC is currently in the process of developing Ecodesign measures for walk in coolers. Current Working Documents[53] define a Walk in Cold Room and further critical elements in the following way (WD p1-2, verbatim):

- A 'walk-in cold room' is a refrigerated enclosure intended for the storage of chilled and/or frozen foodstuff or other perishable items, accessible via at least one door, and which is large enough to let somebody walk in it.
- 'Operating temperature' means the target storage temperature which is intended to be maintained within the walk-in cold room.
- 'Medium operating temperature' means any temperature above -2°C (28.4°F), with reference point at +5°C (M1 temperature class).
- 'Low operating temperature' means any temperature below -2°C (28.4°F), reference point at -18°C (-0.4°F), (L1 temperature class).
- For the definition of the 'storage volume' or 'internal volume' for the purpose of determining whether a walk-in cold room falls into the scope of the present Regulation, two options are proposed:
    - Option 1: "net storage volume containing foodstuff within the load limit", in m^3 and rounded to three decimal places. This would correspond to the shelf base area multiplied by the

[53] European Commission (Dec 2011) Working document on possible Commission Regulations implementing Directive 2009/125/EC with regard to professional refrigeration products; Brussels, 09.12.2011;Part 3 – Walk in cold rooms

loading height. The measurement method would be that of EN441 used for professional refrigerated cabinets
    - Option 2: "gross storage volume", in m^3 and rounded to three decimal places. This would correspond to the internal dimensions of the cold room, measured from floor to ceiling and from left to right (total height*width*length). The measurement method could be that of EN ISO 10211
- It is intended that the proposed Regulation will cover any walk-in cold room of a storage volume smaller than 400m^3 (14,126 ft^3). This includes:
    - Walk-in cold rooms which are prefabricated kits
    - Customized walk-in cold rooms which are built from separate insulating panels, and assembled and charged with refrigerant in-situ by qualified professionals
    - Walk-in cold rooms which are used as corridors, working rooms or areas where food and other stuff is processed
    - Walk-in cold rooms operating at medium and low temperatures
- In addition, it is intended to include in the scope of the proposed Regulation walk-in cold rooms of less than 400m^3 (14,126 ft^3) which are leant or standing directly against at least one exterior wall (with no cladding between the refrigerated space and the exterior wall). In this instance, "exterior wall" means a façade wall in direct contact with the outdoor climate. These cold rooms may form part of the building and may have load-bearing walls. Therefore, they may fall into the scope of national Building Codes. This implies a risk of duplication of legal requirements at product and building level. However, the risk of "holey cheese" legislation was considered more serious, as illustrated below. Besides, many national Building Codes do not cover refrigerated buildings.
- Definitions in terms of MEPS are limited to:
    - Insulation: walls, floors, windows, doors and thermal bridges (joints)
    - Generic requirements: ingress of ambient air; installation of customized cold rooms

15.2.2 United Kingdom – Market Transformation Programme[54]

A walk-in cool room (WICR) is an insulated enclosure that is used predominately for the storage of perishable food, but may also be used for other goods that require cold storage such as pharmaceutical products.

- WICRs are broadly of two types:
    - Chilled storage: The cold space is maintained at temperatures from +1°C to +10°C at varying levels of humidity
    - Frozen storage: The cold space is maintained at temperatures from -25 °C to - 20°C. Humidity is normally high but not critical to storage.

- The size of cool rooms generally varies from about 10 m^3 in the case of large restaurant or small high street food store, to many thousands of cubic meters in the case of refrigerated storage facilities such as supermarket distribution centers and refrigerated warehouses. WICRs in the upper band of 100 to 400 m^3 are found only in very large supermarkets or food processing plants. The vast majority of WICRs are below 20 m^3 in volume and used in a wide range of establishments from pubs and restaurants, to high street stores, garage forecourts and supermarkets.

- MTP modeling covers WICRs up to 400 m^3:
    - Small chillers up to 20 m^3
    - Medium chillers 20 to 100 m^3

[54] BNCR CR01 Walk-in Cool Rooms Government Standards Evidence Base 2009: Key Inputs: p1-2 (verbatim)

- Large chillers 100 to 400 m^3
- Small freezers up to 20 m^3
- Medium freezers 20 to 100 m^3
- Large freezers 100 to 400 m^3

- The WICRs considered are assumed to have the following characteristics:
  - They are assembled on site from factory-made modular insulating panels.
  - They are located inside a building rather than outside.
  - Cooling is provided by basic refrigeration systems consisting of single or multiple condensing units and forced air evaporators[55], with the condensing unit located adjacent to the room either inside or outside the building.

15.3 USA

The Energy Independence and Security Act of 2007 (EISA[56])

- EISA Section 312(a): Defines the terms 'walk-in cooler' and 'walk-in freezer' to mean: "an enclosed storage space refrigerated to temperatures, respectively, above, and at or below 32 degrees Fahrenheit (0°C) that can be walked into, and has a total chilled storage area of less than 3,000 square feet…(b) The terms 'walk-in cooler' and 'walk-in freezer' do not include products designed and marketed exclusively for medical, scientific, or research purposes."

16 Identification of international and national test procedures

Table 10 International and national test standards (energy consumption/efficiency) – Walk in coolers

Standard	Description	Where used	Reference
EC Working Document	Calculation of linear thermal bridge	EC – Working Document (WD)	See section 15.2.1
	Calculation of punctual thermal bridge		
EN 441	Calculation of net storage volume		Referred to in WD, p1 (actual standard not freely available[57])

[55] The exception to this being use in supermarkets where WICRs are usually connected to a central station cooling plant or "pack"
[56] Document found here: http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf
[57] http://www.standardsdirect.org/standards/standards1/StandardsCatalogue24_view_13985.html

Standard	Description	Where used	Reference
EN ISO 10211	Calculation of gross storage volume		Actual standard not freely available[58]
references of ETAG021 Series C (to be translated into EN standard)	U, ψ (linear thermal bridge) and χ (punctual thermal bridge) values of walk-in cold rooms which are prefabricated kits		WD, p4 (actual std not freely available[59])
References of ETAG016 and EN14509 (to be translated into EN standard)	U values of customized walk-in cold rooms		WD, p4, and ETAG 16[60]
DTU45-1 (French) (to be translated into EN standard)	Generic requirements on proper installation of customized walk-in cold rooms		WD, p4 (actual std not freely available[61])
EN13215 / EN13771 (remote condensing units) and PAS 57:2003 (refrigeration systems)	Method for measuring the cooling capacity, power input and coefficient of performance (COP) of the refrigeration unit or system serving the walk-in cold room: to serve as basis of new harmonized standard	EC – Working Document (WD)	WD, p4 (actual standards not freely available[62])
ANSI/AHRI Standard 1250P (I-P) (2009)	Performance rating of walk in coolers and freezers: refrigeration systems	USA	AHRI[63]
NFRC-100 – 2010	Procedure for Determining Fenestration Product U Factors: for doors, windows, display panels		NFRC[64]
ASTM C1363-05	Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus: floor and		Not freely available[65]

[58]http://www.google.co.nz/url?sa=t&rct=j&q=en%20iso%2010211&source=web&cd=1&sqi=2&ved=0CFkQFjAA&url=http%3A%2F%2Fwww.iso.org%2Fiso%2Fhome%2Fstore%2Fcatalogue_tc%2Fcatalogue_detail.htm%3Fcsnumber%3D40967%26utm_source%3DISO%26utm_medium%3DRSS%26utm_campaign%3D

[59]http://ec.europa.eu/enterprise/newapproach/nando/index.cfm?fuseaction=notification.html&ntf_id=156862&version_no=6

[60] http://www.eota.be/ckfinder/userfiles/files/Public%20-%20Endorsed%20ETAGs/part3-05-february.pdf

[61] http://www.eyrolles.com/BTP/Livre/dtu-45-1-isolation-thermique-des-batiments-frigorifiques-et-des-locaux-a-ambiance-regulee-3260050847186

[62] http://www.standardsdirect.org/standards/standards4/StandardsCatalogue24_view_25656.html

[63]http://www.ahrinet.org/App_Content/ahri/files/standards%20pdfs/ANSI%20standards%20pdfs/ANSI.AHRI%20Standard%201250%20(I-P)-2009.pdf

[64] http://www.nfrc.org/documents/NFRC100A-2010.pdf

[65] http://www.astm.org/Standards/C1363.htm

Standard	Description	Where used	Reference
	non-floor panels, floors, ceilings, walls		
DIN EN 13164:2009	Thermal insulation products for buildings – Factory made products of extruded polystyrene XPS foam: degradation factor for floor and non-floor panels		Not freely ANSI[66]
DIN EN 13165:2009	Thermal insulation products for buildings - factory made rigid polyurethane PUR foam: degradation factor for floor and non-floor panels		ANSI[67]
US Dept. of Energy	Test procedures for Walk in coolers and freezers		See Final Rule[68]

17 Initial comparison of test procedures;

17.1 Discussion

- Regulations are in place in the USA only. Draft regulations in the EU and policy recommendations in Australia and New Zealand are insufficiently developed to allow proper comparisons since test standards are absent.
- However, similar technical improvement measures are in place/proposed, which are summarized in the table below.

Table 11 Elements subject to minimum specifications

Option	USA	Draft EU	Recommended Australia and New Zealand
Insulation: U values or R values: walls, floors ceiling, doors, glazing	Yes	Yes	Yes
Thermal Bridges	No	Yes	No
Door closers/similar	Yes	No	No

[66] http://webstore.ansi.org/RecordDetail.aspx?sku=DIN+EN+13164:2009
[67] http://webstore.ansi.org/RecordDetail.aspx?sku=DIN+EN+13165:2009
[68] http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/wicf_tp_final_rule_2011_04_15.pdf

Option	USA	Draft EU	Recommended Australia and New Zealand
Motors (Fan)	Yes	No	Yes
Anti-sweat	Yes	No	Yes
Door and envelope seals/air tightness	No	No	Yes
Defrost controls	No	No	Yes
Compressors	No	No	Yes
Lighting	Yes	No	Yes

18 Identification of potential issues in test result comparisons

18.1 Summary

There is no known comparison of test results under the established or draft test procedures. At the moment, the only relevant fully established test procedure is the DOE procedure – which includes a calculated rating of performance, not an actual test. It is expected that the draft EU test procedure will be updated soon, as part of an update of the EU Working Document.

Given that walk-in cold rooms are not actually tested as a complete assembly, a comparison of performances would largely be limited to a theoretical assessment of differences in calculations and assumptions in the various procedures. This could be done between the DOE procedure and the EU draft procedure, once updated. Potential issues between comparisons may include:

- The impact of basic model definitions
- Validation of the model used to calculate U factors from limited test data
- Leakage of full assembly
- Heat gain from full assembly