National Appliance and Equipment Energy Efficiency Program

Analysis of Potential for Minimum Energy Performance Standards

for

Self-Contained Commercial Refrigeration

Prepared for the Australian Greenhouse Office

by

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- greenhouse modelling
- design of energy efficiency strategies
- implementation and management of energy efficiency programs
- energy information and advisory services
- green pricing schemes
- energy sector micro-economic reform
- low energy planning and building design
- environmental impacts of energy generation technologies and fuels

CONTENTS

Glossary 2

Executive Summary 2

1. Purpose 7

2. Scope 7

3. Product Description 8

4. Energy Consumption Summary: All Products 11

5. Scope for Energy Efficiency 14

6. Identification of Stakeholders 17

7. Market Profile 19

8. Industry Links 22

9. Standard Development 25

10. Appropriate MEPS for Australia ... 27

11. Greenhouse Reduction Potential ... 34

12. Economic Implications ... 36

13. Other Programs ... 37

14. Implementation ... 40

15. References ... 41

Appendix A: Australian Standard ... 42

Appendix B: British Standard, EU Standard & Other Programs ... 43

Appendix C: International Organisation for Standardisation ... 47

Appendix D: Canadian Standards ... 47

Appendix E: United States Standards ... 54

Appendix F: South African Standard ... 57

Appendix G: Japanese Standard ... 58

Appendix H: Mailing List (Interested parties) ... 58

Appendix I: Adjustment of Overseas Performance Standards for Australian Voltages ... 62

Appendix J: Equivalent energy performance levels to the Canadian Standard for Refrigerated display cabinets, C657-95, achieved under Australian test conditions, as specified in AS1761. ... 62

GLOSSARY

Air-Cooled Condenser.

A refrigeration system component which condenses refrigerant vapour by rejecting heat to air mechanically circulated over its heat transfer surface causing a rise in the air temperature. Desuperheating and sub-cooling of the refrigerant may occur as well.

Air-Cooled Heat Reclaim Condenser.

A heat transfer device which condenses refrigerant vapour, in the process of rejecting the heat of condensation to air, causing a rise in the air temperature. Desuperheating and/or sub-cooling of the refrigerant may occur as well. This condenser may be a separate condenser, the same as, or a portion of the air-cooled condenser.

Bubble Point.

Refrigerant liquid saturation temperature at a specified pressure.

Compressor Saturated Discharge Temperature.

For single component and azeotrope refrigerants, it is the saturated temperature corresponding to the refrigerant pressure at the compressor discharge. For zeotropic refrigerants, it is the arithmetic average of the dew point and bubble point temperatures corresponding to refrigerant pressure at the compressor discharge. It is usually taken at or immediately downstream of the compressor discharge service valve (in either case on the downstream side of the valve seat), where discharge valves are used.

Dew Point.

Refrigerant vapour saturation temperature at a specified pressure.

Coefficient of Performance (COP)[W/W].

A ratio of the cooling capacity in Watts [W], to the total power input in Watts [W] at any given set of rating conditions.

Energy Efficiency Ratio (EER).

A ratio of the cooling capacity in Btu/h [W] to the total power input in watts [W] at any given set of rating conditions.

Evaporatively-Cooled Condenser.

A refrigeration system component which condenses refrigerant vapour by rejecting heat to a water and air mixture mechanically circulated over its heat transfer surface, causing evaporation of the water and an increase in the enthalpy of the air. Desuperheating and sub-cooling of the refrigerant may occur as well.

Heat Reclaim Coefficient of Performance (COP).

A ratio calculated by dividing the net heat reclaim capacity (W) by the total power input to the unit.

Integrated Part Load Value (IPLV).

A single number part-load efficiency figure of merit calculated per the method described in 5.3 referenced to Standard Rating Conditions.

Net Heat Reclaim Capacity.

A quantity defined as the mass flow rate of the condenser water multiplied by the difference in enthalpy of water entering and leaving the heat reclaim condenser, expressed in Btu/h [kW].

Net Refrigerating Capacity.

A quantity defined as the mass flow rate of the evaporator water multiplied by the difference in enthalpy of water entering and leaving the cooler, expressed in Btu/h or tons [kW].

Non-Standard Part Load Value (NPLV).

A single number part-load efficiency figure of merit calculated per the method described in 5.3 referenced to conditions other than IPLV conditions. (For units that are not designed to operate at ARI Standard Rating Conditions.)

Power Input per Ton (kW/Ton).

A ratio of the total power input to the unit, including controls, in kW to the net refrigerating capacity in tons at any given set of rating conditions. 1 ton refrigeration (TR) = 3.52kW.

Published Ratings.

A statement of the assigned values of those performance characteristics, under stated rating conditions, by which a unit may be chosen to fit its application. Such ratings shall be based on a series of tests that support the applicable range of the product with the refrigerant specified in the ratings. Published ratings consist of the standard rating(s), part load ratings and application ratings, whether published in catalogues or by computer output and shall apply to all units of like nominal size and type (identification) produced by the same manufacturer.

Water-Chilling Package.

A factory-designed and prefabricated assembly (not necessarily shipped as one package) of one or more compressors, condensers and evaporators, with interconnections and accessories, designed for the purpose of cooling water. It is a machine specifically designed to make use of a vapour compression refrigeration cycle to remove heat from water and reject the heat to a cooling medium, usually air or water. The refrigerant condenser may or may not be an integral part of the package.

Water-Cooled Condenser.

A heat transfer device, which utilises refrigerant-to-water heat transfer means, causing the refrigerant to condense and the water to be heated. Desuperheating and sub-cooling of the refrigerant may occur as well.

Water-Cooled Heat Reclaim Condenser.

A heat transfer device, which utilises refrigerant-to-water heat transfer means, causing the refrigerant to condense and the water to be heated. Desuperheating and sub-cooling of the refrigerant may occur as well. This condenser may be a separate condenser, the same as, or a portion of the water-cooled condenser.

EXECUTIVE SUMMARY

This report covers major 'self-contained' commercial refrigeration technologies and products currently used in Australia. These are systems which have integral components and are designed to plug into an available electricity supply. They are typically mass produced rather than designed for a specific end-user. This category includes the following:

- Self-contained display cases in Supermarkets, Clubs, Pubs & Hotels, Butchers, and other food preparation and service industries;
- Self-contained glass door merchandisers;
- Self-contained reach in freezers and refrigerators;
- Self-contained refrigerated food displays;
- Self-contained ice making and ice storage equipment;
- Self-contained refrigerated beverage vending machines;
- Self-contained ice cream displays;
- Self-contained cold water dispensers.

The scope of this study has not included industrial refrigeration equipment such as that used in food processing, abattoirs and dairies.

Remote refrigeration systems are covered in an additional report [MEA, 2000]. These systems comprise compressors and condensing equipment for cooling rooms or large spaces, such as cool storage rooms, or for providing refrigeration services to other locations, for example supermarket display cases. A feature of these systems is that they are designed for the specified task and comprise a number of components which are selected and purchased individually.

Market Profile

The following table shows the estimated of annual sales and the existing population of the various technologies covered in this report.

Table E1: Market Profile Summary, Self-Contained Commercial Refrigeration

PRODUCT	ANNUAL MARKET	EXISTING STOCK	Life Span (years)
Display Cases	6,000	36,000	6
Glass Door Merchandisers	10,000	170,000	8
Reach in Refrigerators	3,500	32,000	9
Reach in Freezers	4,000	36,000	9
Ice Making Equipment	4,500	45,000	10
Refrigerated Vending Machines	13,300	120,000	9
Ice Cream Displays	10,000	60,000	6
Cold Water Dispensers	32,000	300,000	9

There are approximately 260 refrigeration suppliers in Australia with most specialising in a small number of sub markets. A large quantity of components and finished products are imported.

Standards

The Current Australian Standard AS 1731 – 1983, which is in the process of being revised, only includes frozen food retail cabinets. The new draft standard is based on the British Standard BS EN 441 and will cover both retail chiller and freezer cabinets, including display cases in supermarkets, reach in freezers and refrigerators, merchandisers and ice cream cases.

The new draft prescribes a methodology for undertaking energy consumption tests but at the moment does not include energy performance standards. It is our understanding that it will not cover:

- Supermarket equipment, excluding cabinets;
- walk-in storage (cool rooms) and freezer rooms;
- ice making and ice storage equipment;
- refrigerated beverage vending machines; or
- cold water dispensers.

Available information suggests that many of the technologies discussed in this report are already subject to standards, test methodologies and minimum energy performance levels in one or more other countries. The exception to this is cold water dispensers. Canada has the most extensive range of standards covering commercial refrigeration products, all prescribing test methodologies and minimum energy performance standards. South Africa has a single energy performance standard for refrigerated display cabinets. MEPS for commercial refrigeration products are being actively considered in Europe and the US.

In addition, several countries have voluntary programs, including the US Energy Star Program for ice-makers and water coolers, and the soon to be launched program for reach in refrigerators and freezers. In Europe, a commercial refrigeration labelling program has been proposed, a certification program is run by the industry association, and in Holland there is a subsidy program to encourage efficient supermarket refrigeration. The UK operate an ‘enhanced capital allowance scheme’ to allow the full value of investment in energy efficient commercial refrigeration to be set against tax in the first year.

A number of countries are currently examining strategies to reduce energy consumption from commercial refrigeration, including the development of energy performance standards.

Recommendations

Commercial refrigeration is estimated to currently consume 6,400GWh of electricity per year, projected to be increasing by 4.8% per annum. This represents greenhouse emissions of over 6.3 Mt CO_2-e in 2000, rising to 11.6 Mt CO_2-e in 2015.

Energy consumption by **self-contained** commercial refrigeration technologies is estimated at approximately 2,200 GWh in 2000, with greenhouse emissions of nearly 2.2 Mt CO_2-e. By 2015, consumption is estimated to have grown to 3,600 GWh, and emissions to 3.2 Mt CO_2-e.

The features of the market for self-contained commercial refrigeration which suggest that market intervention by way of mandatory MEPS is an appropriate strategy include:

- Consumption is spread across a large number of users: 72% of this consumption is shared amongst over 55,000 end-users.
- Users of most vending machines, beverage merchandisers, ice cream displays, ice storage and cold water dispensers, responsible for around 71% of total consumption by self-contained technologies, do not purchase the units. These are owned by beverage, ice cream, ice and bottled water suppliers and are made to their specifications. Since users pay for the electricity consumed, there is little or no cost incentive for the owners to purchase more energy efficient units. Most users have little market power and little awareness or information of the savings potential available.
- Technically feasible improvements with a payback under 5 years could save approximately 40% of self-contained commercial refrigeration consumption, with large savings available at very small additional costs to the manufacturer.

- The strong international market in commercial refrigeration products suggest that the levels of energy performance adopted by Australia should be approximately equivalent to those used in major markets elsewhere.

Given the large and growing contribution to greenhouse emissions made by commercial refrigeration, of which more than one third come from self-contained technologies, and the considerable potential for cost effective efficiency improvements, there is reason for Government to play a role in this sector.

Commercial Refrigerated Display Cabinets and Merchandisers

It is recommended that Australian MEPS are based on the Canadian standard C657-95, which prescribes the maximum energy consumption per unit length for a range of refrigerated cabinet types.

It is also recommended that the new Australian standard (based on BS EN 441) is adopted as the test methodology. The following table shows the SEC values contained in C657-95 translated to the approximate equivalent values under the new Australian test conditions, for climate class 3.

Table E2: Recommended Energy Performance Standard for Refrigerated Display Cabinet and Merchandisers

Class	Description	Evaporating Temp.(°C)	Specific Energy Consumption
			Proposed Australia (kWh/m/day)
Class 1:	low temperature multideck, two or more air curtains	-35	38.6
		-30	38.0
Class 2:	medium temperature multideck, single air curtain, length of air curtain 1.0-1.5m. Cabinet height 1.9-2.1m and depth 0.8-1.2m.	-10	22.6
		-5	19.5
Class 3:	medium temperature multideck, single air curtain, length of air curtain 0.8-1.0m. Cabinet height 1.0-1.4m and depth 1.0-1.2m.	-10	15.6
		-5	12.8
Class 4:	low or medium temperature closed multideck, single air curtain behind glass door. Cabinet height 2.0-2.1m and depth 1.0-1.2m.	-30	22.6
		-5	17.8
Class 5:	low temperature, well type self service cabinet, open or closed, with horizontal air curtain, length of air curtain 0.75-0.85m or 1.0-1.2m. Product loading depth 0.3-0.45m	-35	20.9
		-30	17.5
Class 6:	medium temperature single deck self service cabinet with single air curtain, length of air curtain 0.75-0.9m. Cabinet height 0.8-1.01m at the back and 0.7-0.9m at the front. Depth 1.0-1.2m.	-10	11.7
		-5	9.2
Class 7:	medium temperature single deck wall or island type self service cabinet with a perforated product shelf. Class 7 cabinets are dividing into three subclasses on the basis of the width of the display area:		
	a. narrow: 0.75-1.02m	-10	12.4
		-5	9.6
	b. medium: 1.03-1.27m	-10	17.3
		-5	14.6
	c. wide: 1.28-1.65m	-10	18.4
		-5	15.3
Class 8:	low or medium temperature cabinet with a flat or curved front glass and a sliding door service access to the rear. Height 1.25-1.4m, depth 0.95-1.2m. Class 8 cabinets are dividing into two subclasses on the basis of their evaporator coil arrangements:		
	a. fan coil.	-25	17.5
		-5	6.0
	b. gravity coil.	-10	6.4
		-5	3.2

It is recommended that further investigation should be undertaken during the formulation of the Australian standard to determine appropriate classes in the Australian market, and appropriate equivalent energy performance standards.

In addition, consideration should be given as to whether the test methodology should be simplified to include only one class, eg. Class 3 which equates to the design conditions for most stores.

Food Service Refrigerators and Freezers

The recommended MEPS is based on the Canadian standard C827-98 for commercial refrigerator, refrigerator-freezer, and freezer cabinets. This standard prescribes the annual energy consumption for a range of products, based on the refrigerator volume.

Table E3: Recommended Energy Performance Standard for Commercial Refrigerators and Freezers

Description	Annual Energy Consumption (AECmax), kWh/y
Refrigerators – Solid Doors	
Reach-in	59 V + 1010
Reach-in Wine Cooler	51 V + 300
Milk or beverage type	31 V + 450
Worktop table/undercounter	87 V + 780
Refrigerators – Glass Doors	
Reach-in	118 V + 2020
Reach-in Wine Cooler	102 V + 600
Milk or beverage type	62 V + 900
Worktop table/undercounter	174 V + 1560
Freezers – Solid Doors	
Reach-in	172 V + 930
Ice-cream cabinet	86 V + 1270
Worktop table/undercounter	367 V + 2200
Freezers – Glass Doors	
Reach-in	334 V + 1860
Ice-cream cabinet	172 V + 2540
Worktop table/undercounter	734 V + 4400
Refrigerator-Freezers – Solid Doors	
Reach-in	92 AV + 1900

Since there is no existing Australian test methodology for these products, it is recommended that ASHRAE 117 is used as the test methodology in Australia.

Vending Machines

The recommended MEPS is based on the Canadian standard C804-96 for self contained vending machines that actively cool or heat, or both. This prescribes the maximum daily energy consumption for a range of products, where C is the machine capacity in number of cans.

Table E4: Recommended Energy Performance Standard for Vending Machines

Class	Description	Max Daily Consumption (E_{dmax}) kWh
A	Packaged beverage	Edmax < 8.66 + 0.009 x C
B	Post-mix beverage	8.0
C	Chilled non-perishable food	14.0
D	Cold perishable food	
	Gross Volume <300L	10.5
	Gross Volume >300L	14.0
E	Frozen food	14.0
F	Hot food that is stored cold	17.0
G	Frozen food or snack	12.0
H	Cold beverage or snack	8.0
J	Cold perishable food/snack	10.5
K	Hot beverage	
	<10L	4.5
	>10L	6

Since there is no existing Australian test methodology for these products, it is recommended that C804-96 and ASHRAE 21.1–1997 be used as the test methodology in Australia.

Automatic Ice-Makers and Ice Storage Bins

The recommended MEPS is based on the Canadian standard C-742-94 for automatic ice-makers and ice storage bins. This prescribes the maximum input energy per kg ice produced or stored.

Table E5: Recommended Energy Performance Standards for Ice-Makers and Ice Storage Bins

Ice-Makers	Batch automatic ice-makers (cubers)	Input Energy
	Air-cooled	
	23 < capacity < 150 kg/d	1630 – 6.008 x capacity, kj/kg
	150 < capacity < 1000 kg/d	807.2 – 0.5229 x capacity, kj/kg
	Water-cooled	
	23 < capacity < 150 kg/d	1234 – 4.381 x capacity, kj/kg
	150 < capacity < 1000 kg/d	621.8 – 0.2985 x capacity, kj/kg
	Continuous automatic ice-makers (flakers)	
	Air-cooled	
	23 < capacity < 300 kg/d	875.2 – 1.122 x capacity, kj/kg
	300 < capacity < 1000 kg/d	538.6 kj/kg
	Water-cooled	
	23 < capacity < 300 kg/d	740.5 – 0.8976 x capacity, kj/kg
	300 < capacity < 1000 kg/d	471.2 kj/kg
Ice Storage		**Minimum storage effectiveness**
	Capacity < 100 kg	0.7
	100 < Capacity < 200 kg	0.75
	Capacity > 200 kg	0.8

Since there is no existing Australian test methodology for these products, it is recommended that C-742-94 and ASHRAE 29 be used as the test methodology in Australia.

Adjustment for Australian Electrical Supply Conditions

The standards recommended above are based on those currently used in Canada, where electricity supply has a nominal voltage of 115 volts. To ensure equivalent standards, it is recommended that Australian MEPS levels should be raised by 6% in order to account for the supply voltage of 240 volts.

Additional Activities

Consideration should be given to types of programs which provide information to specifiers and end-users of refrigeration products in order to stimulate the selection of energy efficient products. Recommended programs include:

- Energy performance labelling schemes for:
  - refrigerated display cases; a cost-benefit analysis should be undertaken of the labelling options identified, and industry approached to run a listing of the performance of products.
  - food service refrigerators and freezers; based on the US EPA Energy Star criteria under development, together with a publicly available listing of conforming products.
  - ice making and ice storage equipment, based on the US EPA Energy Star criteria under development, together with a publicly available listing of the performance of products.
  - cold water dispensers, based on the US EPA Energy Star criteria under development, together with a publicly available listing of the performance of products.
- A 'best practice' program between government and a leading manufacturer of refrigerated beverage vending machines should be implemented as an alternative to labelling at this time.
- In addition, we suggest that the UK Capital Allowance Program should be monitored once it is operational to determine whether a similar approach could be taken in Australia in due course, particularly if other programs prove insufficiently effective.

Greenhouse Gas Reduction Potential

Emissions from self-contained commercial refrigeration technologies are estimated to rise to 3.2 Mt CO_2-e. by 2015. Some benefit will be gained by the introduction of MEPs on lighting ballasts, due for implementation in 2002, estimated at 225 kt CO_2-e per annum by 2015.

Based on the technical potential examined during this study, the additional greenhouse gas reduction potential is 1.5 Mt CO_2-e per annum by 2015.

To estimate the impact of the proposed MEPS on greenhouse emissions requires information on the performance of the range of products currently available on the market, however sufficient information has been unobtainable. After consideration of overseas experience, it has been assumed that MEPs will achieve 30% of the technical potential savings, ie. approximately 450 kt CO_2-e by 2015.

1. PURPOSE

The Australian Greenhouse Office as part of the National Appliance and Equipment Energy Efficiency Program (NAEEEP) has commissioned this report. The purpose of this report is to explore the potential for energy and greenhouse savings through improvements to self-contained commercial refrigerating equipment used in retail and service businesses in Australia.

2. SCOPE

This report describes the major commercial refrigeration technologies and products currently used in Australia and their characteristics. Only technologies which are defined as 'self-contained' are covered by the report. These are systems which have integral components and are designed to plug into an available electricity supply. They are typically mass produced rather than designed for a specific end-user. This category includes the following:

- Self-contained display cases in Supermarkets, Clubs, Pubs & Hotels, Butchers, and other food preparation and service industries;
- Self-contained glass door merchandisers;
- Self-contained reach in freezers and refrigerators;
- Self-contained refrigerated food displays;
- Self-contained ice making and ice storage equipment;
- Self-contained refrigerated beverage vending machines;
- Self-contained ice cream displays;
- Self-contained cold water dispensers.

Not included are refrigeration equipment used in processing industries, such as abattoirs and dairies.

The report examines the current market for these technologies and identifies developments which may have a significant influence on energy consumption and greenhouse emissions. It describes existing energy standards applying to self-contained commercial refrigeration technologies in Australia, and those in force overseas, together with relevant test methodologies. Significant programs other than regulation, such as labelling, are also identified.

Based on these findings, the report makes recommendations for Australian minimum energy performance standards for the following products:

- Self-contained Commercial Refrigerated Display Cabinets and Merchandisers;
- Self-contained Food Service Refrigerators and Freezers;
- Self-contained Vending Machines;
- Self-contained Automatic Ice-Makers and Ice Storage Bins.

3. PRODUCT DESCRIPTION

For the purposes of this study, there are two major categories of commercial refrigeration systems. This report focuses on **Self-Contained Systems**: those which have integral components and are designed to plug into an available electricity supply. They are typically mass produced rather than designed for a specific end-user. This category includes refrigerator vending machines, deli cases, food and beverage merchandisers, ice machines and water coolers.

The following section describes in more detail the major product categories with self-contained refrigeration systems. While this is not exhaustive, it covers those products responsible for the majority of refrigeration energy consumption within this category in Australia.

The second category is **Remote Systems:** those comprise compressors and condensing equipment for cooling rooms or large spaces, such as cool storage rooms, or for providing refrigeration services to other locations, for example supermarket display cases. A feature of these systems is that they are designed for the specified task and comprise a number of components which are selected and purchased individually. This category is the subject of a separate report [MEA, 2000], and is not considered in depth in this report. However, information is provided where appropriate for the purpose of comparison.

3.1 GLASS DOOR MERCHANDISERS

These are glass fronted cabinets for displaying and selling goods, primarily packaged beverages, and refrigeration is supplied by compressor usually located at the bottom of the unit and powered from standard power point. They are used in supermarkets, most food vending establishments, service stations, leisure facilities and some public places. Beverage supply companies provide these merchandisers to the vendor. They are therefore designed to maximise sales volume and to present product attractively and at an appropriate temperature. The vendor is responsible for energy running costs.

Units typically comprise of one 1/3 hp compressor, two evaporator fans and one condenser fan. Heat is rejected into the surrounding environment. Most units have integral lighting for product and logo display, provided by one 20W or 40W T-12 fluorescent lamp and one 20W incandescent bulb. The majority of units are single door, which are either triple glazed, or double glazed using a low emissivity coating. Case insulation is approximately 11/2 inches thick and provided by blown polyurethane foam.

3.1.1 Energy consumption

Industry sources estimated that the average annual consumption of a glass door merchandiser is approximately 4,500 kWh. The distribution of this consumption by component is shown in the following table.

Table 1: Distribution of Energy Consumption in Glass Door Merchandisers

Compressor	Evap. Fans	Condenser Fans	Antisweat Heaters	Electric Defrost	Lights
43%	24%	6%	-	-	27%

Source: US DoE, 1996

3.2 REACH IN FREEZERS AND REFRIGERATORS

These are solid door freezers and refrigerators commonly used in restaurants and cafés, and other food preparation and facilities for the storage of foodstuffs. They may be vertical or horizontal ('coffin' type).

Freezers have a ½ hp compressor, one evaporator fan and one condenser fan. Cases and doors are typically made of stainless steel and contain 2 to 21/2 inches of blown polyurethane insulation. Anti-sweat heaters are included in the door surround to prevent condensation and freezing of the seal, and a 600W electric defrost heater is located next to the evaporator coil. Most units have integral lighting in the form of one 25W incandescent lamp switched to operate when the door is open.

Reach-in Refrigerators are similar in construction to freezers, except that the most common version has two doors. Typically a 1/3 hp compressor is used, and these larger units may have two integral 25W lamps to supply illumination.

3.2.1 Energy consumption

No information is currently available on the average consumption of Australian products, therefore consumption data for US products has been used. Typical annual electricity consumption is estimated to be 5,200 kWh for single-door freezers, and 4,300 kWh for refrigerators.

The distribution of total consumption by component is shown in the following table.

Table 2: Distribution of Energy Consumption in Reach-in Refrigerators and Freezers

	Compressor	Evap. Fans	Condenser Fans	Antisweat Heaters	Electric Defrost	Lights
Freezer: One Door	67.0%	3.4%	8.9%	14.3%	6.3%	0.1%
Refrigerator: Two Door	58.0%	9.7%	11.9%	20.1%	-	0.3%

Source: US DoE, 1996

3.3 REFRIGERATED FOOD DISPLAYS

Refrigerated food displays are used in food retail outlets to display and facilitate the serving of foodstuffs. Typically they are used in delis, supermarkets, sandwich bars, and similar outlets for the display of cheeses, meats and prepared dishes.

Most products comprise a metal chest housing the compressor, condenser and fans, with one or more display counters above this and surrounded by a glazing. The glazing protects the foodstuff but allows staff to handle the refrigerated products through an opening on one side, which may be closeable by means of a sliding glazed screen. Often the service side of the unit is simply unglazed to allow for easy access. Units typically have integrated lighting to increase the visibility of the food on display.

3.3.1 Energy consumption

No authoritative information is currently available on the typical consumption of Australian products, however industry sources have suggested that an average annual value of 3,650 kWh/yr is appropriate.

We estimated that the distribution of total consumption by component is as shown in the following table.

Table 3: Distribution of Energy Consumption in Refrigerated Food Displays

Compressor	Evap. Fans	Condenser Fans	Antisweat Heaters	Electric Defrost	Lights
43%	24%	6%	-	-	27%

Source: Author's Estimate

3.4 Ice Making and Ice Storage Equipment

A number of types of equipment are used to make ice cubes, flake ice and crushed ice. Typical applications include ice storage in food preparation and display, for ice sales to customers, fish storage on boats, and for drinks in food retailing.

Ice-makers are often located above an insulated storage box and are specified by their nominal capacity, defined as the weight of ice produced per 24 hours. Typically the capacity of ice machines range between 110 kg/24 hrs and 650 kg/24hrs. Condenser size varies in proportion to the capacity, ranging from 1/3 hp units to 3 hp.

Water consumption can be a significant cost factor, since excess water is used to flush impurities away from the evaporator and other surfaces. Unless this is done, scale build-up of deposited impurities can be considerable.

3.4.1 Energy consumption

The output, and therefore the energy consumption of ice-makers varies considerably, although larger units tend to be more energy efficient partly because larger compressors have higher efficiencies, and partly because larger units have proportionately smaller surface areas through which to transfer heat. A typical ice maker with an output of around 230 kg/day will consume approximately 5,000 kWh per year.

The distribution of total consumption by component is shown in the following table.

Table 4: Distribution of Energy Consumption in Ice-Makers

Compressor	Condenser Fans	Water pump	Solenoid
90.2%	8.1%	1.6%	0.1%

Source: US DoE, 1996

3.5 Refrigerated Beverage Vending Machines

These units are made to the specifications of beverage suppliers for the purpose of retailing cold drinks, usually in the form of cans or bottles, to customers. They include a dispensing mechanism so that customers can obtain drinks by the insertion of coins into the mechanism. The large majority are supplied and owned by beverage suppliers.

Vending machines typically have two-doors, an insulated inner door opening into the refrigerated storage area and the outer door housing the logo and lighting equipment. Refrigeration supplied by a 1/3 hp compressor, one evaporator fan and one condenser fan.

Case insulation is approximately 11/4 inches thick and provided by blown polyurethane foam. Illumination is provided by two 40W T-12 fluorescent tubes, using a common ballast.

3.5.1 Energy consumption

The majority of units are either imported, or closely based on foreign products. In the absence of any data on Australia products, US figures have been used. These suggest average annual electricity consumption is between 2,800 kWh and 3,200 kWh.

The distribution of total consumption by component is shown in the following table.

Table 5: Distribution of Energy Consumption in Refrigerated Vending Machines

Compressor	Evap. Fans	Condenser Fans	Lighting	Dispensing Mechanism
47%	12%	4%	37%	-

Source: US DoE, 1996

3.6 ICE CREAM DISPLAYS

These are freezer display cabinets for retailing ice cream and other impulse frozen confection products, usually with a transparent top lid. The large majority are supplied and owned by ice cream suppliers.

Typically these units comprise an insulated box and a 1/3 hp compressor, located at the bottom rear of the chest. Generally no lighting is provided.

3.6.1 Energy consumption

Industry sources estimate that total annual consumption for an ice-cream display is approximately 1,000 kWh.

3.7 COLD WATER DISPENSERS

This category, sometimes called water bubblers, comprise both refrigerated mains connected and bottled water units, primarily used in the commercial sector. Units have an inbuilt condenser and compressor, and small water storage facility, generally with between 0.5 to 2 litres capacity. Large centralised units with up to 135 litre storage are also available. Depending upon the required output, compressors vary in size from 1/16 hp to 1/3 hp output, and are usually powered by connection to a nearby mains socket.

The major difference between types of cold water dispensers is that bottled dispensers are not connected to the mains water supply, but usually are fed by an inverted plastic water bottle. These types also have a small water storage tank for cold water.

Some water dispensers have the capacity to provide hot water in addition to cold water. A separate storage tank with an electrical resistance heating element enables the production of boiling water through a separate outlet. For the purposes of this report, the hot water capacity of these units is not discussed further.

3.7.1 Energy consumption

The energy consumption of cold water dispensers varies with demand and the capacity of each unit. The estimated annual consumption ranges between 300 kWh and 1,600 kWh. For the purposes of this report, an average annual consumption of 500 kWh per unit has been assumed.

4. ENERGY CONSUMPTION SUMMARY: ALL PRODUCTS

This section summarises the total energy consumption by self-contained commercial refrigeration systems in Australia. In the absence of authoritative data, a number of approaches have been taken to estimate total consumption for this study.

The first method used is based on business types with quantifiable refrigeration loads. Typical energy consumption from self-contained products has been estimated for each business type, and this has been multiplied by the number of each category of business in Australia. The assumptions used are shown in Table 6. In addition, to account for other businesses which have a minor refrigeration load, a further 10%

of all refrigeration consumption has been added. This method provides an estimated total consumption of 2,260 GWh/yr.

It should be noted that the total energy consumed by self-contained products is estimated to be approximately 36% of the total commercial refrigeration consumption, including remote technologies.

The second method used is based on the stock of refrigeration products. Estimates of typical consumption per product have been made (see previous Section), and these multiplied by the total stock of each product provided by industry sources where possible. As above, in order to account for other self-contained products, a further 10% of all self-contained refrigeration consumption has been added. This method provides an estimated total consumption of 2,190 GWh/yr. See table below.

4.1 By Business Type

It is estimated that all major business types employ self-contained units, even in those cases where the majority of refrigeration is provided by remote technologies, such supermarkets. The average consumption by business type is provided below. The number of business types is derived from information provided by ABS and a number of trade associations [ABS, 2000]

Table 6: Total Energy Consumption by Business Type: Self-Contained Commercial Refrigeration

-	Av Energy Consumption per Business	Total Energy Consumption Per Business Type	% of Total Commercial Refrigeration (self-contained and remote)
-	kWh/a	GWh/a	-%
Supermarkets: Lg	46,850	65.7	5.0%
Supermarkets: Md	95,707	134.2	30.0%
Supermarkets: Sm	25,000	35.0	44.6%
Clubs:Lg	19,446	41.4	10.0%
Clubs:Sm	31,114	66.2	40.0%
Grocery Stores	9,000	54.2	27.9%
Take-aways	19,850	365.8	100.0%
Service Stations: Lg	60,447	242.1	40.0%
Service Stations: Sm	19,800	79.3	100.0%
Bottle Shops	19,551	36.4	30.0%
Fresh Meat, Fish & Poultry	9,000	49.6	17.2%
Pubs	18,280	105.3	30.0%
Café's Restaurants	24,109	518.2	51.2%
Institutions	58,304	260.9	100.0%
Other	0	205.4	36.1%
-	-	**2,259.6**	**36.1%**

It should be noted that consumption is spread over approximately 80,000 individual businesses across Australia. Particularly intensive categories include supermarkets, service stations and institutions.

As shown in Table below, Cafes and Restaurants, Take Away outlets, Institutions and Large Service Stations account for approximately 60% of the total energy consumed by self-contained commercial refrigeration technologies.

Table 7: Total Energy Consumption by Business Type, Self-Contained Commercial Refrigeration

Business Type	Percentage
Café's Restaurants	22%
Take-aways	15%
Institutions	12%
Service Stations: Lg	11%
Supermarkets: Md	6%
Pubs	5%
Services Sfations: Sm	4%
Supermarkets: Lg	3%
Clubs: Sm	3%
Fresh Meat, Fish & Poultry	2%
Grocery Stores	2%
Supermarkets: Sm	2%
Clubs: Lg	2%
Bottle Shops	2%
Other	9%

4.2 By Product Type

Estimates of energy consumption by product type are identified in the previous Section, derived from product literature and industry sources. The stock of each product have been estimated based on discussions with the industry (further details are provided in Section 7). This method provides a figure for total consumption of 2,190 GWh per annum, which is only 3% less than that calculated on the bases of business types, in Section 4.1.

As shown in the table below it is estimated that glass door merchandisers use the largest proportion of energy consumed by self-contained refrigeration technologies (39%). Glass door merchandisers and drinks vending machines together account for approximately 57% of total energy consumed by self-contained refrigeration technologies.

Table 8: Total Energy Consumption by Product Type, Self-Contained Commercial Refrigeration

Product Type	Percentage
Glass Door Merchandisers	49%
Drink Vending Machines	13%
Reach-in Freezer	10%
Refrigerated Food Displays	10%

4.3 By End-Use Refrigeration Components

Based on examples from the US for the allocation of consumption by product type to components within refrigeration systems, the total consumption of components used by self-contained technologies in Australia has been calculated.

Table 9 shows that compressors account for over half of all consumption, with lighting using approximately 20% of total consumption.

Table 9: Total Energy Consumption by Refrigeration Components, Self-Contained Commercial Refrigeration

Component	Percentage
Compressor	53%
Lights	20%
Evap. Fans	16%
Condenser Fans	7%
Antisweat Heaters	3%
Electric Defrost	1%

4.4 Energy Consumption Trends by Product

Section 3 of this report includes information on average energy consumption by product category in 2000.

Since no authoritative historical information has been forthcoming on previous consumption trends, it has not been possible to estimate future trends on this basis. It is noteworthy that a recent study for the UK Government suggested that there was little reason to factor in future savings due to naturally occurring technology improvements [Tait, 2000]. While we have no firm evidence to dispute this assumption, we consider that the high level of imported products in Australia is more likely to lead to in increased product efficiency. This may, for example, occur as a result of overseas regulations stimulating technological improvements imported into Australia.

As a result, we have assumed an annual efficiency improvement of 0.5% for each product category for the period 2000 to 2015. We recognise that this approach may underestimate the total energy consumption due to commercial refrigeration, and the impact of energy saving measures.

5. Scope for Energy Efficiency

The following measures are generally applicable to all self-contained products. The impact of these measures will, however, vary between products. Where measures are appropriate for particular products, these are indicated below.

5.1 Applicable to Most Products

5.1.1 High Efficiency Fan Motors

Most fans used are of the single-phase shaded-pole type, which are relatively inefficient compared to permanent split capacitor (PSC) or electronically commutated (ECM) types. As shown in Table 10, switching from shaded-pole type to PSC type motors can result in savings of 50% - 60%. Savings of 70% - 80% can be achieved by switching to ECM type motors.

Table 10: Comparative Energy Consumption of Different Types of Electric Motors

Motor Output (W)	Shaded-Pole (W)	PSC (W)	ECM (W)
6	40	15	8.5
9	53	21	12.5
15	75	33	20.5
20	90	42	27
25	110	51	33

Source: US DoE, 1996

It should be noted that there is a significant cost increase associated with ECM motors at the present time, which make them prohibitive. Since PSC type motors are considerable cheaper, and the bulk of savings can be gained from switching from shaded pole to PSC motors, this appears a more feasible development.

In addition to reduced consumption on fans, switching to more efficient motors reduces the compressor load leading to further energy savings, estimated to be approximately 60% of the motor savings.

5.1.2 High Efficiency Fan Blades

Typical fan blades used in refrigeration systems have an efficiency rating of around 40%. This could be improved by better design, resulting in savings of approximately 15% of fan power at low additional cost.

5.1.3 Insulation

Reduced thermal losses through the cases can be achieved by increasing the thickness of the insulation used and by using better insulating materials. Increases to the overall case dimensions are often limited by available space, so that any increase in the thickness of insulation will impact on the interior storage space available for storage.

Alternative or additional reductions may be achieved by replacing the blown polyurethane with better insulation material or improving the blowing techniques.

5.1.4 Lighting

Units typically use 38mm fluorescent lamps and magnetic ballasts. Heat emitted from lighting adds to the refrigeration loads, therefore by reducing lighting losses, compressor loads can also be reduced. It should be noted that MEPs for ballasts are to be introduced in 2002, which will lead to reductions in this area, estimated to be equivalent to around 25% of lighting consumption. Further savings could be achieved by using T-8 or T-5 tubes.

5.1.5 High Efficiency and Variable Speed Compressors

The typical compressor has an overall efficiency of 45%-48%, using an induction motor with an efficiency of around 70%. Higher efficiency motors (up to 98%) are now available, which together with variable speed drives, offer significant improvements.

5.2 Reach-in Freezers

Appropriate measures also include:

5.2.1 Hot Gas Defrost

Instead of using an electric resistance coil to ensure evaporator coils do not get covered in ice layers, the discharge gas from the compressor is piped through to the evaporator.

5.2.2 Hot Gas Anti-Sweat Heating

Instead of using an electric resistance coil to ensure door gaskets do not freeze, a hot gas line is run from the compressor to the door frame.

5.2.3 Anti-Sweat Heater Controls

Use of anti-sweat heaters, in order to prevent condensation build-up and freezing of door gaskets, can be controlled by switches responding to local dewpoint or humidity conditions. Appropriately placed sensors enable dewpoint measurement, and the heater to be switched off when not required.

5.2.4 Liquid Suction Heat Exchangers

Use of a heat exchanger in order to cool the refrigerant flow to the evaporator may also achieve savings. Gas leaving the evaporator is passed through the heat exchanger, providing subcooling to the entering liquid.

5.2.5 Defrost Control

In many instances, defrost is initiated by a simple timer control. Savings can be achieved by initiating defrost automatically on the basis of either the air temperature drop across the coil, or detection of frost build-up.

5.3 Ice Machines

Appropriate measures also include:

- Higher efficiency capacitor start compressors: these increase compressor efficiency from around 45% to between 50% and 55%.
- Reduced Ice Meltage: Caused by ice sitting on the plate exposed to the warm evaporator. Good design can reduce energy consumption by 5%.
- Mechanical Assist Defrost.
- Pre-cooling incoming water, using the cold drain water and a heat exchanger.

5.4 Working Fluids

Refrigerants are the ***working fluids*** in refrigeration systems. They absorb heat from one space, such as a cold room, and reject heat into another space, such as the outdoors. The absorption and rejection processes are generally evaporation and condensation respectively.

CholoroFluoroCarbons (CFC's) and HydroCholoroFluoroCarbons (HCFC's) have been the dominating working fluids in refrigeration systems since the 1950's. Due to the ozone depleting properties of these and other man-made fluids containing chlorine and/or bromine the Montreal Protocol was established in 1987 to effect an schedule for the reduction and phase-out in production and consumption of ozone depleting substances. In recent years the most pressing issue has been the search for new and environmentally acceptable working fluids that can replace the CFC's and HCFC's. Ammonia, a natural working fluid, has had a continuing use in the industrial and commercial refrigerant market because of its known properties and ability for cold room applications but needs competent specialist to install, operate and maintain

Most of the alternative working fluids are new, ***synthetic compounds***, namely HydroFluoroCarbons (HFC's), which have little or no ozone-depleting potential (ODP). Although these new compounds have been extensively tested with regard to toxicity, flammability etc., they are foreign to nature. Widespread use of these fluids will always include *a risk* of unforseen global environmental effects, as has already been experienced with the CFCs and HCFCs. The HFCs have relatively strong greenhouse gases with Greenhouse Warming Potentials (GWP) ranging from 1,300 to 3,800 for the most common HFCs.

Natural working fluids – The main alternative to the HFCs is to apply naturally occurring and ecologically safe substances, such as ammonia, hydrocarbons, carbon dioxide, water and air. As a result, all uncertainties and potential negative effects on the global environment will be eliminated. However, some of the natural working fluids are either flammable or toxic, and the growing acceptance of the TEWI (Total Equivalent Warming Impact) as the measure of a working fluid's contribution to global warming, is placing greater emphasis on applying natural working fluids are to build safe and reliable systems which are able to compete with conventional HFC systems with regard to energy efficiency and first costs.

5.5 Summary of Energy Saving Potential

The following table shows the estimated energy saving potential by product (the "technical potential"), based on overseas experience and discussions with the industry in Australia. This is not necessarily the maximum potential saving, but is limited to measures with a probable payback equal or under five years.

Table 11: Summary of Energy Saving 'Technical Potential', Self-Contained Commercial Refrigeration

Technology	Maximum Energy Saving Potential (%) *
Glass Door Merchandisers	40%
Reach-in Freezer	40%
Reach-in Refrigerator	40%
Refrigerated Food Displays	40%
Ice Maker	10%
Refrigerated Vending Machine	40%
Ice Cream Displays	20%
Cold Water Dispensers	30%

6. IDENTIFICATION OF STAKEHOLDERS

This section identifies organisations which are considered stakeholders in commercial refrigeration. Those stakeholders which are common to all applications and products are listed first. Stakeholders for particular products are then listed separately.

6.1 All Categories

- Electricity utilities;
- Site owners;
- Commercial Refrigerators Manufacturers Association;
- Australian Retailers Association;
- Retail Confectionery and Mixed Business Associations;
- Australian Supermarket Institute;
- Australian Association of Convenience Stores;
- National Association of Retail Grocers of Australia (representing small operators);
- Refrigeration Air Conditioning Contractors Association (RACCA);
- Australian Soft Drink Association;
- Commonwealth/State/Territory energy agencies.

6.2 Display Cases, Glass Door Merchandisers & Refrigerated Food Displays

Supermarket Chains

Manufacturers

- Austral;
- Orford;
- Williams;
- Spillsbury Windsall;
- Arcus (WA);
- Fridgright;
- McAlpine Hussmann.

Importers

- Skope (NZ);
- Kingloc (Caravelle, Ital);
- Comcool;
- Bakers (WA).

Hospitality providers

Installers

6.4 Refrigerated beverage vending machines

Manufacturers

- Currently no Australian manufacturer supplying machines, however All Purpose Vending Australia has prototype ready for production

Importers

- Coca-Cola
- Dixi Narco (local representative in Australia)
- Vendo (local office)
- Royale
- Cavalier

Soft drink suppliers

Site owners (30% are estimated to be Government owned sites)

6.5 Ice-Makers

Manufacturers

- Stuart Ice-Makers

Packaged Ice Manufacturers/distributors

- Bells Pure Ice

Users

- Hotels, Restaurants, Clubs and Takeaway Food Chains

6.6 Ice cream displays

Ice cream suppliers

Manufacturers/Importers of cabinets

- Streets
- Nestles/Peters
- Cadbury

Retailers

6.7 Cold water dispensers

Manufacturers

- Aqua Cooler
- Billi Integrated Systems

Suppliers

- Neverfail
- Clear Water
- The Water Shop

7. MARKET PROFILE

There are approximately 260 refrigeration suppliers in Australia with most specialising in a small number of sub-markets. In addition, a large quantity of components and finished products are imported. These are discussed further in the Industry Links Section. This Section provides information on the current stock, and the market for refrigeration products in Australia.

7.1 Glass Door Merchandisers

The current stock of merchandisers is estimated to be 170,000 units.* (*AGO estimate from consultation with the industry Table 12 below shows the approximate ownership by beverage suppliers.

Table 12: Stock of Glass Door Merchandisers

Existing Merchandiser ownership	Nos
Coca-Cola	104,550
Cad-Schweppes	23,800
Pepsico	15,300
All others	18,530
Total	**170,000**

Source: Industry

Industry sources estimate that the annual market for merchandisers is 10,000 units, however, based on an average lifespan of eight years, the market would be expected to be more than double this figure.

Table 13: Distribution of Market for Glass Door Merchandisers

Merchandiser manufactures	% of annual market
Orford	40%
Williams	5%
Spillsbury Windsall	2%
Arcus (WA)	2%
Newsystems (VIC)	2%
250 other small manufacturers	4%
Subtotal	**55%**
Importers	
Skope (NZ)	15%
Kingloc (Caravelle, Ital)	15%
Bakers (WA)	5%
McAlpine Hussman	5%
Comcool	5%
Subtotal	**45%**

Source: Industry

7.2 Reach-in Freezers and Refrigerators

Based on the number of end-use applications for these products, it has been estimated that the total stock is approximately 32,000 (refrigerators) and 36,000 (freezers). Industry sources suggest that the average lifespan of these products is 9 years, indicating an annual market of 3,500 and 4,000 respectively.

7.3 Refrigerated Food Displays

The current level of annual sales of refrigerated food displays is estimated to be 6,000 units, based on industry sources. Products tend to be retired before reaching the end of their useful life for aesthetic reasons, because of new ownership and a total refit, and some units are refurbished and resold. As a result the typical life of a unit is only approximately 5 years. It is estimated that the stock of units is approximately 30,000 units.

7.4 Ice Making and Ice Storage Equipment

Industry sources estimate an annual market of 4,500 units and a total stock of 45,000, with imports in 1999 totalling 3,850 units. Typically less than 10% of products are manufactured in Australia. The average life of units is approximately 10 years.

7.5 Refrigerated Beverage Vending Machines

The current stock of merchandisers is estimated to be 120,000 units, based on industry sources. Table 14 below shows the approximate ownership by beverage suppliers.

Table 14: Stock of Refrigerated Beverage Vending Machines

Existing Vending Machine ownership	Nos
Coca-Cola	100,000
Schweppes/Cottees, Pepsi, Others	20,000
Total	**120,000**

Source: Industry

Industry sources estimate that the annual market for refrigerated vending machines is 13,000 units, and that the average lifespan is between eight and ten years.

7.6 Ice cream displays

Industry sources have estimated the total stock of ice cream displays at 60,000 units. These generally have a lifespan of six years, suggesting an annual market of around 10,000 units. The ownership profile is provided in the table below.

Table 15: Stock of Ice Cream Displays

Existing Stick Ice Cream Displays ownership	Quantity (%)
Streets	30,000 (50%)
Nestles/Peters	21,000 (35%)
Cadbury	9,000 (15%)
Total	**60,000 (100%)**

Source: Industry

7.7 Cold Water dispensers

Based on industry sources, it is estimated that the stock of cold water dispensers is approximately 300,000 units, with an annual turnover of 32,000 units. However, it should be noted that approximately 70% of units are rented. The average lifespan of a unit is between eight and ten years.

Mains connected units comprise 10% of the stock and turnover, with the remaining made up of bottled water units. Products with heating capacity are estimated to comprise only 1% of the market.

Most products are imported from the US, Korea or Malaysia, with Aqua Cooler and Billi Integrated Systems amongst the largest Australian manufacturers. Neverfail and Clear Water are the major suppliers with probably over 50% of the market.

7.8 Sales Trends of Self-Contained Products

Most industry sources confirm that sales have grown substantially over the past 5-10 years and consider it likely this trend will continue.

The estimated rate of both historical and projected growth varies between different product categories however there is considerable agreement on the factors that are currently causing increases in sales. The relative impact of these factors varies for each product type, and in some cases there are geographical or other issues which play a role. In general, the drivers for increased sales include:

- Growth in the overall volume of refrigerated food sales;
- An increase in the choice of refrigerated foods (product lines) available on the market. A specific example is the advent of the flavoured milk market;
- An increase in the number of producers of refrigerated foods;
- An increased focus on health issues in food retail, including an increase in policing of existing regulations regarding the temperature for storage and display of foodstuffs.

Further issues which may have a future impact on refrigeration consumption include pressure from foodstuff product manufacturers to:

- Expand the number of frozen products generally available;
- Supply chilled bottled drinks in supermarkets.

Industry sources suggest that these factors will continue to drive increases in sales for most commercial refrigeration products by at least 10% per annum. Ice-makers, vending machines and ice cream displays may be approaching saturation and their growth is estimated to be substantially lower. The table below shows the estimates used for product sales growth in the period 2001-2015, divided into two periods. It is considered likely that growth will tend to slow towards the end of this period, as available outlets and space becomes constrained.

Table 16: Estimated Growth Rates, 2001-2010, Self-Contained Commercial Refrigeration

Technology	Growth Rate 2001-2009	Growth Rate 2010-2015
Glass Door Merchandisers	9%	5%
Reach-in Freezer	7%	5%
Reach-in Refrigerator	7%	5%
Refrigerated Food Displays	8%	5%
Ice Maker	1%	1%
Refrigerated Vending Machine	1%	1%
Ice Cream Display	2%	1%
Cold Water Dispensers	9%	6%

These estimates are similar, though slightly more conservative, to those produced by the UK Government for refrigerated retail display cabinets [Tait, 2000]. Annual growth from 1985 to 1995 was recorded at over 25% in the UK; and is predicted to fall from 15% pa in 1997 to 2% by 2010.

8. INDUSTRY LINKS

8.1 Imported Products, 1999 Imports

Table 17: Number of Imported Commercial Refrigeration Products

Category	Quantity
Refrigerator freezing chests, cabinets, display counters, show-cases and similar refrigerating or freezing furniture	5,977
Refrigerating or freezing chests, cabinets, display counters, show-cases and similar refrigerating or freezing furniture (excl. refrigerators)	6,657
Other refrigerating or freezing chests, cabinets, display counters, show-cases and similar refrigerating or freezing furniture	21,367
Ice-making machines	3,853
Automatic beverage-vending machines, incorporating heating or refrigerating devices	2,640

Based on information on the estimated market in Australia for each product type, the proportion of imports has been calculated and is shown in the following table. Note the first category includes some remote system products.

Table 18: Estimated Proportion of Imported Commercial Refrigeration Products

Category	Total Sales	Imports (1999)	% Imports
Refrigerator & freezing chests, cabinets and displays	50,750	34,001	67%
Ice making Machines	4,500	3,853	86%
Drink Vending Machines	13,000	2,640	20%

8.1.3 Country of Origin and historical Trends for Imports

The following tables show the major country of origin for imported products, together with import supply trends, for most product categories [ABS 1999].

Table 19: Country of Origin for Imported Refrigerator Freezing Chests, Cabinets, Display Counters, Show-cases and similar Refrigerating or Freezing Furniture.

Country	Percentage
China	23%
Finland	6%
Germany	9%
Italy	11%
New Zealand	29%
Thailand	6%

Table 20: Country of Origin for Imported Refrigerating or Freezing Chests, Cabinets, Display Counters, Show-cases and similar Refrigerating or Freezing Furniture (excl. Refrigerators)

Country	Percentage
Denmark	69%
Italy	8%
USA	16%

Table 21: Country of Origin for Other Imported Refrigerating or Freezing Chests, Cabinets, Display Counters, Show-cases and similar Refrigerating or Freezing Furniture

Country	Percentage
China	13%
Denmark	39%
Hong Kong	5%
Italy	17%
Thailand	6%
USA	6%

Table 22: Import Trends for Commercial Refrigeration Cabinets

Year	Totals
1989	3897
1990	5637
1991	20935
1992	20665
1993	11987
1994	8337
1995	10590
1996	12304
1997	11278
1998	14592

Table 23: Country of Origin for Imported Ice-making Machines

Country	Percentage
China	2%
France	2%
Italy	36%
Japan	15%
Spain	2%
UK	3%
USA	39%

Table 24: Import Trends for Ice-making Machines

Year	Totals
1989	2342
1990	2251
1991	1914
1992	1864
1993	1546
1994	1865
1995	2539
1996	2201
1997	3422
1998	3304
1999	3853

Table 25: Country of Origin for Imported Automatic Beverage-Vending Machines, incorporating Heating or Refrigerating Devices

Country	Percentage
Italy	7%
Japan	8%
USA	84%

Table 26: Import Trends for Automatic Vending Machines

Year	Totals
1989	6721
1990	5155
1991	8141
1992	10831
1993	8993
1994	9116
1995	6793
1996	9411
1997	4518
1998	3109
1999	2640

9. STANDARD DEVELOPMENT

9.1 Current Australian Standards

Standards Australia advises that there are no standards applying to refrigeration technologies or products which currently include an energy performance standard.

AS 1731-1983, "Frozen Food Retail Cabinets" applies to refrigerated cabinets for the retail sale of packaged frozen foods. It provides for two climate classes, for use where the ambient temperature will not exceed 25°C (e.g. a naturally mild climate or a fully and continuously air-conditioned store) and for use where the ambient temperature may exceed 25°C but will not exceed 32°C. It specifies requirements for construction and performance and prescribes uniform procedures for determining the performance and capacities of such cabinets. Further details are included in Appendix A.

This Standard is currently being re-drafted by Standards Australia/Standards New Zealand Committee ME/8, *Refrigerated Display Cabinets*. It has been put forward to the International Standards Organisation (ISO) that they should similarly adopt this Standard.

The current drafts are made up of a twelve-part series, based on British Standards BS EN 441 (see Appendix B), and covers retail chiller cabinets as well as retail freezer cabinets, using either self-contained or remote refrigeration technologies. It is our understanding that, without further extension of its scope, it will not cover:

- ice-making and ice storage equipment;
- refrigerated beverage vending machines; or
- cold water dispensers.

The draft standard prescribes a methodology for undertaking energy consumption tests for units with or without integral condenser units (Part 9). It provides for six climate classes. However, no energy performance standard is prescribed for either self-contained or remote cabinets.

Part 2 describes the information requirements of the marking plate, to be attached to each cabinet. There is currently no requirement to include energy consumption information with each product on the marker plate.

The current drafting process of this standard provides an opportunity to include requirements for energy performance standards and consumption information for these important categories of products.

9.2 Summary of International Standards and other Programs

A number of countries have implemented standards for commercial refrigeration products.

9.2.1 Canadian Standards

Canada has standards applicable to the following self-contained products:

- Commercial Refrigerated Display Cabinets and Merchandisers (C657-95),
- Food Service Refrigerators and Freezers (C827-98),
- Ice-Makers (C743-98) and
- Vending Machines (C804-96).

These all prescribe minimum energy performance standards and test methodologies, often with reference to ASHRAE testing methods. In all cases, these energy standards are expressed in terms of energy consumption over a certain period (day, year) relating to the unit as a whole or per unit length or volume. In the case of ice-makers, energy consumption per unit output is measured. More details on the Canadian Standards are provided in Appendix D.

9.2.2 United States

Although the United States does not currently have minimum energy performance standards, there are a number of national standards applicable to commercial refrigeration technologies, which provide energy consumption test methodologies. These have been developed by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) and the American National Standards Institute (ANSI), and cover open and closed refrigerated cabinets and beverage vending machines.

See Appendix E for further information.

The Commercial Refrigeration Manufacturers Association (CRMA), through the Air-Conditioning and Refrigeration Institute has been appointed by ANSI to serve as the Secretariat for an international subcommittee responsible for refrigeration systems standards (ISO TC 86/SC3, "Testing and Rating of Factory-made Refrigeration Systems).

One of the responsibilities of ISO TC 86/SC3 is to standardise methods for testing and rating the performance of factory-made systems which use a refrigeration cycle to remove heat from solids, liquids and gases. This includes commercial ice-makers and commercial water-coolers as well as mobile refrigeration systems, but does not include household refrigeration appliances, unitary equipment and commercial refrigerated display cabinets (which are covered by TR86 Subcommittees SC5, SC6 and SC7).

It is understood that energy performance standards are likely to be part of the development of these international standards.

9.2.3 South African

South Africa has a standard applicable to commercial refrigerated food display cabinets (SABS 1406:1998), including frozen food storage (Type A), fresh food and liquids (Type B) and ice-cream storage (Type C). The standard sets a test methodology and a minimum energy performance standard, based on the gross capacity of the cabinet. The same energy performance standard applies to all cabinet types. See Appendix F for further details.

9.2.4 European and International Standards

EN441 (1995, updated in 1999) has now been issued as a Europe-wide standard for the comprehensive testing of refrigerated display cabinets, and is very widely used throughout the industry. This Standard specifies terminology, general mechanical and physical requirements, test conditions as well as installation, maintenance and users guide for refrigerated display cabinets for the sale and/or display of food products. This Standard does not cover refrigerated vending machines or cabinets intended for use in catering or similar non-retail appliances.

Part 9 of EN 441 specifies the method of measuring the consumption of electrical energy for refrigerated display cabinets. See Appendix B for further details. This Standard and its associated series are currently being used as the bases for the draft to replace the current Australian Standard AS 1731—1975.

Other test methodologies for commercial refrigerated cabinets include ISO 1992-6 which is summarised in Appendix C.

It should be noted that the EC has indicated that commercial refrigeration equipment will be the subject of minimum energy performance standards or negotiated agreements for energy efficiency [CEC, 2000]. No details are currently available on the which of these approaches will be adopted but there is a commitment to proceed with standards if voluntary programs are not agreed with the industry.

9.3 Voluntary Programs

9.3.1 United States

The Federal Energy Management Program has procurement guidelines for ice-makers, which identify recommended and best available performance, in terms of energy used per unit output. In addition, the Energy Star program is currently in the process of developing guidelines for three new areas involving commercial refrigeration. These are automatic commercial ice-makers, water coolers, and reach-in refrigerators and freezers.

See Appendix E for further information.

9.3.2 European Labelling & Financial Incentive Programs

A technical methodology to determine energy labels for integral and remote cabinets has been defined, drawing upon data generated by the existing operational EN441 testing standard. This has been proposed as the basis for a Europe-wide labelling scheme. Characteristics tested include Refrigeration Electrical Energy Consumption (REC kWh/day) and Direct Electrical Energy Consumption (DEC with 12 hour lighting kWh/day)

The Dutch Government has an operational subsidy scheme for retail refrigeration called STIMECK, which gives subsidies towards cabinets achieving A or B ratings according to the assessment method described above. The majority of cabinets rated under this scheme are understood to be remote.

The UK Government has recently announced an enhanced capital allowance scheme for introduction in 2001, for application to a range of energy efficiency improvements including commercial refrigeration. Under the scheme, companies investing in eligible energy efficiency technologies are able to claim 100% of expenditure against tax in the first year of investment.

Further information is contained in Appendix B.

9.4 Alternative Greenhouse Impact Test Methodologies

The Total Equivalent Warming Impact (TEWI) has been developed as a method of quantifying the total global warming effect of a refrigeration system. TEWI can be used to provide an indication of which of two or more options for refrigeration systems is the most environmentally-friendly in terms of global warming, for the same application. TEWI is not appropriate for comparing refrigeration systems for different applications.

To calculate a 'TEWI factor', the direct impact of any released refrigerant is added to the indirect effect from the energy consumed over the lifetime of the plant. A key point raised by TEWI analysis is thus that the energy consumption of a refrigeration system is usually as, if not more, significant than the effects of the refrigerant itself on the environment. The TEWI system is more appropriate for remote systems than for those products with self-contained refrigeration technology.

9.5 Summary

There are several well-established national and international test methodologies for energy consumption of refrigerator and freezer cabinets (both self-contained and remote). Test methodologies also exist for food service refrigerators and freezers, ice-makers, beverage vending machines.

Apart from Canada, few other countries have as yet applied minimum energy performance standards to many commercial refrigeration products, although these are being actively considered in Europe and the US.

In addition, there is a trend towards voluntary standards, information, marketing and incentive programs for a wide range of commercial refrigeration products.

Evidently at the present time there is a thorough examination of ways to reduce energy consumption from commercial refrigeration technologies, being undertaken worldwide. It is considered that this will result in the development of energy performance standards over the next year or so, which would at that time represent world's 'best practice'. While this should not delay the initiation of a development process for Australian standards, this process should include the monitoring of overseas initiatives in the field of commercial refrigeration.

10. Appropriate MEPS for Australia

10.1 Background

It is estimated that energy consumption due to all commercial refrigeration is currently at least 6,370 GWh in Australia, and predicted to rise by an average of 4.8% per annum to 2015. This represents greenhouse emissions of over 6.3 Mt CO_2-e in 2000, rising to 11.6 Mt CO_2-e in 2015, and considerable expenditure by Australian businesses.

Energy consumption by self-contained commercial refrigeration technologies is estimated at approximately 2,200 GWh in 2000, with greenhouse emissions of nearly 2.2 Mt CO_2-e. By 2015, consumption is estimated to have grown to 3,600 GWh, and emissions to 3.2 Mt CO_2-e.

Key features of the market for commercial refrigeration are:

- Consumption is spread across a large number of users: 72% of this consumption is shared amongst over 55,000 end-users.
- Users of most vending machines, beverage merchandisers, ice cream displays, ice storage and cold water dispensers, responsible for around 71% of total consumption by self-contained technologies, do not purchase the units. These are owned by beverage, ice cream, ice and bottled water suppliers and are made to their specifications. Since users pay for the electricity consumed, there is little or no cost incentive for the owners to purchase more energy efficient units. Most users have little market power and little awareness or information of the savings potential available.
- A large proportion of finished refrigeration products are imported. Most Australian made products use imported components, such as compressors.
- Technically feasible improvements with a payback under 5 years could save approximately 40% of self-contained commercial refrigeration consumption, with large savings available at very small additional costs to the manufacturer.
- However most users have almost no market power, and little awareness or information of the savings potential available.

These factors suggest that market intervention, by the way of MEPs, is warranted, particularly where there are split incentives, and for markets involving a large number of end-users. There is also a good case for other types of programs aimed at introducing advanced technologies to the marketplace, and promoting these to customers.

10.2 Approach to Setting MEPS

The strong international market in commercial refrigeration products and design services suggest that the levels of energy performance adopted by Australia should be approximately equivalent to those used in major markets elsewhere. By moving towards harmonisation, any cost implication should be minimised.

Where new energy performance standards are to be based on overseas levels, and there exist an Australian test methodology, the levels will need to be adjusted to take into account any differences between the test methodology used overseas, and that used here.

Where no Australian test methodology currently exists in Australia, both the energy performance level and test methodology should be based on overseas practices.

There is no reason to delay the process of standards development in Australia with regard to commercial refrigeration products, however, considering the state of standards development in the US and Europe, on-going monitoring of these countries should be incorporated. This will enable Australia to adopt equivalent standards to those used in other major markets.

Further adjustment may need to be made to energy performance levels adopted by Australia to account for differences in the voltage and frequency of electricity supply between Australia and other countries.

10.3 Recommendations

It is recommended at this stage that Australia should adopt the following energy performance standards and test methodologies. If, during the consultation or committee stages, new overseas standards are developed, consideration should be given as to whether these are more appropriate.

10.3.1 Commercial Refrigerated Display Cabinets and Merchandisers

The recommended minimum energy performance standard is based on the Canadian standard C657-95.

Refrigerated display cabinets are categorised into 8 classes as shown in the table below. For each class, values for the specific energy consumption (SEC) are provided at two evaporating temperatures, where the SEC is the total daily energy consumption associated with operating a unit length of the cabinet (the unit is 1 ft = 0.3048 m).

This establishes a boundary line, and conforming products must have a performance which exceeds the levels indicated by this line.

The test methodologies specified in C657-95 are ANSI/ASHRI 117 for closed cabinets and ANSI/ASHRI 72 for open cabinets, tested at ambient temperatures 23.9 C dry bulb, 17.8 C wet bulb. Specified operating temperatures for tests are -20 C for low-temp applications and 2 C for med-temp applications.

The existing Australian Standard AS 1731-1983 is currently being re-written to cover the equivalent products to C657-95, and provides an energy consumption test methodology. The SEC values contained in C657-95 and shown below are therefore required to be translated to the approximate equivalent values under Australian test conditions.

A preliminary translation has been undertaken and is included in Appendix J. The column presenting the proposed Australian standards in the following tables, show the values for Climate Class 3 only. Information relating to other climate classes is contained in Appendix J.

Table 27: Energy Performance Standard for Refrigerated Display Cabinet and Merchandisers

Class	Description	Evaporating Temp.(°C)	Specific Energy Consumption	
			Canadian (kWh/ft/day)	Proposed Australia (kWh/m/day)
Class 1:	low temperature multideck, two or more air curtains, length of air curtain 1.0-1.3m	-35	11.3	38.6
		-30	11.1	38.0
Class 2:	Medium temperature multideck, single air curtain, length of air curtain 1.0-1.5m. Cabinet height 1.9-2.1m and depth 0.8-1.2m.	-10	6.4	22.6
		-5	5.5	19.5
Class 3:	Medium temperature multideck, single air curtain, length of air curtain 0.8-1.0m. Cabinet height 1.0-1.4m and depth 1.0-1.2m.	-10	4.4	15.6
		-5	3.6	12.8
Class 4:	low or medium temperature closed multideck, single air curtain behind glass door. Cabinet height 2.0-2.1m and depth 1.0-1.2m.	-30	6.6	22.6
		-5	5	17.8
Class 5:	low temperature, well type self service cabinet, open or closed, with horizontal air curtain, length of air curtain 0.75-0.85m or 1.0-1.2m. Product loading depth 0.3-0.45m	-35	6.1	20.9
		-30	5.1	17.5
Class 6:	Medium temperature single deck self service cabinet with single air curtain, length of air curtain 0.75-0.9m. Cabinet height 0.8-1.01m at the back and 0.7-0.9m at the front. Depth 1.0-1.2m.	-10	3.3	11.7
		-5	2.6	9.2
Class 7:	Medium temperature single deck wall or island type self service cabinet with a perforated product shelf. Class 7 cabinets are dividing into three subclasses on the basis of the width of the display area:			
	a. narrow: 0.75-1.02m	-10	3.5	12.4
		-5	2.7	9.6
	b. medium: 1.03-1.27m	-10	4.9	17.3
		-5	4.1	14.6
	c. wide: 1.28-1.65m	-10	5.2	18.4
		-5	4.3	15.3
Class 8:	low or medium temperature cabinet with a flat or curved front glass and a sliding door service access to the rear. Height 1.25-1.4m, depth 0.95-1.2m. Class 8 cabinets are dividing into two subclasses on the basis of their evaporator coil arrangements:			
	a. fan coil.	-25	5.1	17.5
		-5	1.7	6.0
	b. gravity coil.	-10	1.8	6.4
		-5	0.9	3.2

It should be noted that the class descriptions provided above are based on common products in the Canadian market. Further investigation should be undertaken during the formulation of the Australian standard to determine appropriate classes in the Australian market, and appropriate equivalent energy performance standards.

In addition, consideration should be given as to whether it is appropriate to maintain six climate classes within the test methodology, or whether this should be simplified to the one class, eg. Class 3 which equates to the design conditions for most stores.

10.3.2 Food Service Refrigerators and Freezers

The recommended minimum energy performance standard is based on the Canadian standard C827-98 for commercial refrigerator, refrigerator-freezer, and freezer cabinets that are intended for storage or holding food products and other perishable merchandise.

The following table prescribes the maximum Annual Energy Consumption for a range of products, where V is the refrigerator volume measured in ft^3. The adjusted volume (AV) is equal to the refrigerator volume plus 1.63 times the freezer volume.

Table 28: Energy Performance Standard for Commercial Refrigerators and Freezers

Description	Annual Energy Consumption (AECmax), kWh/y
Refrigerators – Solid Doors	
Reach-in	59 V + 1010
Reach-in Wine Cooler	51 V + 300
Milk or beverage type	31 V + 450
Worktop table/undercounter	87 V + 780
Refrigerators – Glass Doors	
Reach-in	118 V + 2020
Reach-in Wine Cooler	102 V + 600
Milk or beverage type	62 V + 900
Worktop table/undercounter	174 V + 1560
Freezers – Solid Doors	
Reach-in	172 V + 930
Ice-cream cabinet	86 V + 1270
Worktop table/undercounter	367 V + 2200
Freezers – Glass Doors	
Reach-in	334 V + 1860
Ice-cream cabinet	172 V + 2540
Worktop table/undercounter	734 V + 4400
Refrigerator-Freezers – Solid Doors	
Reach-in	92 AV + 1900

There is no existing Australian test methodology for these products. The test methodology used in Canada is ASHRAE 117 for self-contained refrigerators and freezers, with the following test conditions.

Table 29: Test Conditions for Measuring the Energy Performance of Commercial Refrigerators and Freezers

Ambient Temp	Initial Product Test Temp (C)
24 C dry-bulb	Refrigerator, fresh food: 3.3 C
10 C wet bulb	Freezer: -17.8 C
	Reach-in wine cooler: 7.2 C
	Ice cream cabinet: -20.6 C

It is recommended that ASHRAE 117 is used as the test methodology in Australia, and that the test conditions specified are the same as those in the table above.

10.3.3 Vending Machines

The recommended minimum energy performance standard is based on the Canadian standard C804-96 for self contained vending machines that actively cool or heat, or both.

The following table prescribes the maximum Daily Energy Consumption for a range of products, where C is the machine capacity in number of cans.

Table 30: Energy Performance Standard for Vending Machines

Class	Description	Max Daily Consumption (E_{dmax}) kWh
A	Packaged beverage	Edmax < 8.66 + 0.009 x C
B	Post-mix beverage	8.0
C	Chilled non-perishable food	14.0
D	Cold perishable food	
	Gross Volume <300L	10.5
	Gross Volume >300L	14.0
E	Frozen food	14.0
F	Hot food that is stored cold	17.0
G	Frozen food or snack	12.0
H	Cold beverage or snack	8.0
J	Cold perishable food/snack	10.5
K	Hot beverage	
	<10L	4.5
	>10L	6

There is no existing Australian test methodology for these products. The test methodology used in Canada is contained within C804-96 with reference to ASHRAE 21.1-1997. Product tests are conducted at an ambient temperature of 32^{o}C +/- 1 for Types A-J, and at 10^{o}C +/- 1 for Type K. Internal temperatures for different product types under test conditions are shown below.

Table 31: Internal Temperatures for Vending Machines under Test Conditions

Class	Product Temp (C)
A	1 +/- 1
B	1 +/- 1
C	16 +/- 2
D (<300L)	4 +/- 1
D (>300L)	4 +/- 1
E	-19 +/- 1
F	-9 +/- 1
G	-19 +/- 1
H	1 +/- 1
J	4 +/- 1
K (<10L)	94.5 +/- 2
K (>10L)	94.5 +/- 2

It is recommended that C804-96 and ASHRAE 21.1–1997 are used as the test methodology in Australia, and that the test conditions specified are the same as those in the table above.

10.3.4 Automatic Ice-Makers and Ice Storage Bins

The recommended minimum energy performance standard is based on the Canadian standard C-742-94 for automatic ice-makers and ice storage bins, referring to products with an ice production/storage capacity of between 23 and 1000 kg/day.

The following table prescribes the maximum Input Energy per kg ice produced or stored, for a range of product sizes, where the capacity is defined as 0.8 X Vm X 481 and Vm is the internal volume (m^3) ignoring baffles.

Storage effectiveness (e_s) is defined over a 24 hour period as $(W_1 - M_2 - 6M_4)/(W_1 - M_2) \times 100\%$, where;

M_2 = melted ice weight from hour 0 to 2 (kg)

M_4 = melted ice weight from hour 2 to 6 (kg)

W_1 = initial weight of ice (kg)

Table 32: Energy Performance Standards for Ice-Makers and Ice Storage Bins

Ice-Makers	Batch automatic ice-makers (cubers)	Input Energy
	Air-cooled	
	23 < capacity < 150 kg/d	1630 – 6.008 x capacity, kJ/kg
	150 < capacity < 1000 kg/d	807.2 – 0.5229 x capacity, kJ/kg
	Water-cooled	
	23 < capacity < 150 kg/d	1234 – 4.381 x capacity, kJ/kg
	150 < capacity < 1000 kg/d	621.8 – 0.2985 x capacity, kJ/kg
	Continuous automatic ice-makers (flakers)	
	Air-cooled	
	23 < capacity < 300 kg/d	875.2 – 1.122 x capacity, kJ/kg
	300 < capacity < 1000 kg/d	538.6 kJ/kg
	Water-cooled	
	23 < capacity < 300 kg/d	740.5 – 0.8976 x capacity, kJ/kg
	300 < capacity < 1000 kg/d	471.2 kJ/kg
Ice Storage		**Minimum storage effectiveness**
	Capacity < 100 kg	0.7
	100 < Capacity < 200 kg	0.75
	Capacity > 200 kg	0.8

There is no existing Australian test methodology for these products. The test methodology used in Canada is contained within standard C-742-94 with reference to ASHRAE 29. Product tests are conducted at an ambient temperature of 32°C, with a condenser inlet temperature for ice-makers of 32°C and an initial ice temperature of 0°C for ice storage bins.

It is recommended that C-742-94 and ASHRAE 29 are used as the test methodology in Australia, and that the test conditions specified are the same as those described above.

10.3.5 Adjustment for Australian Electrical Supply Conditions

The standards recommended above are based on those currently used in Canada, which has a nominal electricity supply voltage of 115 volts. Products designed for use in Australia operate at a nominal supply voltage of 240 volts.

Commercial refrigeration products operating at 240 volts result in fewer losses than the same products operating at 115 volts, and therefore some adjustment should be made to the levels used in Canada in order for the standards to be equivalent.

Enginuity Pty Ltd has calculated that Australian standards should be raised by approximately 6% in order to account for the difference in electricity supply voltages. See Appendix I for an example of calculations.

There will also be some difference resulting from the different frequency of supply in Australia (50Hz) and Canada (60Hz). The impact of these differences will vary for each mechanical device (compressor), and it has not been possible at this stage to quantify the effect without considerable product testing. We therefore suggest that no adjustment is made to the proposed standards to account for frequency differences.

11. GREENHOUSE REDUCTION POTENTIAL

11.1 Greenhouse Emissions

The total greenhouse emissions in 2000 due to self-contained commercial refrigeration are estimated to be 2.19 Mt CO_2-e. Assuming average sales growth rates and average energy consumption per product category described in previous sections, emissions due to commercial refrigeration is estimated to rise to 3.2 Mt CO_2-e by 2015, as shown in the following table.

The introduction of minimum energy performance standards for lighting ballasts in 2002 will have some impact on direct consumption. Lights currently consume over 560 GWh per annum in all commercial refrigeration products, and it is estimated that ballasts will reduce lighting consumption in products entering the market after 2002 by 10% to 15%.

There will be an additional in-direct impact due to reduced heat losses from lights in commercial refrigeration, and an overall reduction in lighting consumption of 20% has been assumed in order to account for this in-direct effect. The impact of this is estimated to be a reduction of annual emissions in 2015 by 225 kt CO_2-e in self contained products, as shown in the table below, which have a relatively high proportion of lighting consumption.

MEPs on motors apply to three-phase units and are not stringent for smaller products, such as those used in commercial refrigeration systems. Since three-phase motors comprise only a small part of the market in the refrigeration sector, the impact of MEPs on motors is considered negligible.

Table 33: Business As Usual Emissions and Reduction due to MEPS for Lamp Ballasts, Self-Contained Commercial Refrigeration

Year	Business As Usual (BAU) CO2-e (kt CO2-e)	BAU with Ballast MEPS CO2-e (kt CO2-e)
2000	2,185.9	2185.9
2001	2,175.1	2175.1
2002	2,179.4	2168.7
2003	2,197.9	2176.0
2004	2,229.6	2196.0
2005	2,273.8	2228.0
2006	2,330.1	2271.5
2007	2,398.1	2326.1
2008	2,477.6	2391.6
2009	2,568.6	2467.8
2010	2,661.2	2545.2
2011	2,763.1	2631.1
2012	2,867.8	2719.3
2013	2,976.2	2810.7
2014	3,088.3	2905.2
2015	3,204.9	3003.5

11.2 Potential for Greenhouse Savings

Based on the technical potential for energy efficiency described in previous sections, should all new sales by 2005 switch to products which provide this level of savings the estimated annual greenhouse reduction would be around 110 kt CO_2-e. By 2015 the total estimated reduction in annual emissions would be approximately 1,500 kt CO_2-e, as shown in the following table.

Table 34: Technical Potential for Greenhouse Gas Reduction in Commercial Refrigeration, Self-Contained Commercial Refrigeration

Year	BAU - Technical Potential for Savings kt CO2-e	Business As Usual - Ballast MEPS kt CO2-e
2000	2,185.9	2185.9
2001	2,175.1	2175.1
2002	2,168.7	2168.7
2003	2,176.0	2176.0
2004	2,196.0	2196.0
2005	2,119.3	2228.0
2006	2,048.7	2271.5
2007	1,983.5	2326.1
2008	1,922.9	2391.6
2009	1,866.4	2467.8
2010	1,807.3	2545.2
2011	1,750.4	2631.1
2012	1,690.9	2719.3
2013	1,629.3	2810.7
2014	1,565.4	2905.2
2015	1,499.6	3003.5

It should be noted that this after this period (ie. 2015) the majority of the product stock would have been introduced after the implementation of the proposed energy performance standards and therefore the quantity of new annual emission savings would decrease.

The allocation of potential savings by product category is shown in the table below.

Table 35: Distribution of Estimated Technical Potential Greenhouse Savings, Self-Contained Commercial Refrigeration

Product	Percentage
Glass Door Merchandisers	49%
Drink Vending Machines	13%
Refrigerated Food Displays	10%
Reach-in Freezer	10%
Reach-in Refrigerator	7%
Cold Water Dispensers	6%
Stick Ice Cream	3%
Ice making Machines	2%

11.3 Estimated Impact of Minimum Energy Performance Standards

The previous section identified the technical potential for savings in the self-contained commercial refrigeration sector. The minimum energy performance standards recommended are not designed to meet this technical potential, but to ensure that the worst performing products are naturally replaced by products with an improved performance.

To estimate the impact of the proposed standards on greenhouse emissions requires information on the performance of a range of products currently available on the market, tested under the proposed test conditions. Since most products are not required to undergo energy performance tests in Australia, this information is not available.

In the absence of this information, and after consideration of overseas experience, it has been assumed that MEPs will achieve 30% of the technical potential savings, ie. approximately 450 kt CO_2-e by 2015 (see table below).

Table 36: Annual Greenhouse Savings, Estimated Impact of MEPS

Year	BAU - MEPS (est) kt CO2-e	BAU - Ballast MEPS kt CO2-e
2000	2,185.9	2185.9
2001	2,175.1	2175.1
2002	2,168.7	2168.7
2003	2,176.0	2176.0
2004	2,196.0	2196.0
2005	2,195.4	2228.0
2006	2,204.7	2271.5
2007	2,223.3	2326.1
2008	2,251.0	2391.6
2009	2,287.4	2467.8
2010	2,323.8	2545.2
2011	2,366.9	2631.1
2012	2,410.8	2719.3
2013	2,456.3	2810.7
2014	2,503.2	2905.2
2015	2,552.3	3003.5

Further examination of the level of savings likely to be achieved would be possible with the supply of product specific information from the industry. Alternatively, sample products could be independently tested. It is recommended that the scope for information sharing be pursued during the consultation process with the refrigeration industry in Australia.

12. Economic Implications

Information received from suppliers of refrigeration systems and units indicates a very low demand for the higher energy efficient equipment. This makes manufacturers of current generation high-energy efficient components reluctant to invest resources to obtain further efficiency gains. In part this is due to the fact that many units are not owned by the purchasing organisations. Until demand is stimulated, business as usual advances in energy efficiency are likely to be lower than required by the Government.

At the same time, considerable savings are feasible, often with minimal additional cost and achieving excellent payback periods. As a result, Australian businesses and consumers are currently being disadvantaged by bearing considerable energy costs over and above those which would be expected in an efficiently operating market.

These circumstances would appear to justify Government market intervention in the form of mandatory minimum energy performance standards for the various types of commercial refrigeration equipment.

In view of the fact that a large proportion of products are imported, either as components for finished products, and the international trend towards greater efficiency in refrigeration products, the impact on manufacturers is likely to be low, particularly given sufficient lead times to adapt.

13. OTHER PROGRAMS

MEPS are designed to remove the worst performing products from the market, however they do not in themselves promote 'best practice'. In view of the substantial greenhouse savings to be made through adoption of the best performing technologies currently in the marketplace, it is recommended that programs in addition to MEPS are considered.

13.1 Information Programs

Currently there is no information provided on commercial refrigeration products which indicate their energy performance to specifiers and end-users of refrigeration products. This is despite advice from industry sources that there is considerable variation in performance between products within most product categories. Although some self-contained products are purchased by major organised with considerable expertise in refrigeration, for example ice cream and beverage retailers, many are purchased by small retailers with little or no understanding of the performance of products, or the potential differences in performance between products.

As a result, we believe that consideration should be given to programs which provide information to specifiers and end-users of refrigeration products in order to stimulate the selection of energy efficient products.

13.1.1 Types of Labelling Programs: Options for Australia

In general terms, the options for Australia with regard to refrigerated display cabinets appear to include the following:

1. The development of a mandatory labelling program for all products, which takes the proposed MEPS as the lowest level and includes a number of steps.
2. The development of a voluntary labelling program, as above, which is likely to be adopted by manufacturers which have the most energy efficient products.
3. The development of a simplified labelling program, similar to Energy Star, which defines and identifies 'high efficiency' products. Such a program could be mandatory or voluntary.
4. The development of a listing of the performance of products measured using the Australian standard, and made available to customers, for example via a website.
5. Waiting for the implementation of a labelling program elsewhere, on which we could base an Australian program.

There are clearly cost ramifications to each of these options, although without a cost-benefit analysis we are not in a position to comment on this issue. However, we make the following general observations:

- In addition to variations in costs of each proposal, the distribution of costs amongst stakeholders may also vary for each proposal.
- A mandatory program will require the development of standard procedures and algorithms, and enactment in legislation. A voluntary program would require the same framework to be developed but would not require legislation.
- Because any program implemented overseas is likely to need to be 'Australianised', option five is more likely to defer costs, rather than save them.

13.1.2 Suitable Products

In deciding which products might be appropriate for labelling, the following considerations have been taken into account:

- Labelling is best suited where there is a range in the performance of available products;
- Labels are likely to have the most impact on products which are predominantly purchased by customers who are currently uninformed;
- There is more reason to implement 'other programs' in cases where no MEPS have been recommended.

The suitability for labelling of the range of products considered in this report are discussed below.

13.1.3 Self-contained Display Cases

Programs for display cases have been considered at some length in the report on remote commercial refrigeration technologies [MEA, 2000]. There is little reason why similar products using self-contained refrigeration technology should be treated differently and hence we suggest that the following recommendations made in MEA 2000 should also apply:

"That the Government proceed with the intention of developing an information or labelling program.

"That the industry is asked to respond to the specific proposal of operating a listing for remote commercial display cabinets, providing information on energy consumption under standard test conditions. This listing would be undertaken by the industry and promoted on an appropriate website. We note that links could be made with www.energyrating.com.au.

"That a cost-benefit analysis is undertaken of the labelling and information options identified above, (excluding option 4 if the industry provides a negative response) together with any further options put forward by the industry."

13.1.4 Self-contained Food Service Refrigerators and Freezers

This category includes the following product ranges: glass door merchandisers, reach in freezers and refrigerators, refrigerated food displays (closed), and ice cream displays.

Many of these products are purchased by smaller businesses and which would benefit from information on the performance of products. In addition, a label would provide some competitive advantage to manufacturers who produced more efficient products.

The Canadian standard, C827-98, already provides a benchmark for 'high efficiency' products, and at this stage it appears that the US EPA will adopt this as the criteria for Energy Star commercial refrigeration products. Although this will not provide as much useful performance information as a rating scheme with a number of steps, the adoption of an equivalent program in Australia would have the advantage of harmonising with these markets. It is also likely that such a program would be implemented more quickly and at lower cost.

It is therefore recommended that the Energy Star proposal currently under development is investigated further and the high efficiency criteria contained in C827-98 examined to see how these can be adapted for use in Australia. It is suggested that this is pursued following further consultation with the industry.

We consider that mandatory labelling will be more effective than a voluntary program, and is warranted in view of the large size of this market and the contribution to greenhouse emissions. However, an alternative which could be considered is a trial of for voluntary period, moving to a mandatory program if results prove insufficient.

We also recommend that, whether mandatory or voluntary, a listing of conforming 'high efficiency' products should be made available to customers, for example via a website.

13.1.5 Self-contained Ice Making and Ice Storage Equipment

Ice makers are purchased by a wide variety of end-users, many of whom are small businesses with little knowledge of their running costs or performance. Industry suggests that there is considerable variation in the performance of products and scope for improvement.

The overall contribution of ice-makers to energy consumption and greenhouse emissions is small, suggesting that the development of substantial new programs will probably not be warranted. As a result, we consider that options worth considering include the adoption of an equivalent to the Energy Star program under development in the United States, or a listing of the performance of products in the marketplace.

At this stage the Energy Star criteria has not been finalised, and it is not known how it will relate to the MEPS proposed for Australia. We therefore recommend that progress with Energy Star for Ice Makers is monitored closely and considered for adoption in Australia once further information is available.

We also recommend that a listing of products is made available to customers, which identifies the performance of products tested using C-742-94 and ASHRAE 29. Participation in this should be voluntary.

13.1.6 Self-contained Refrigerated Beverage Vending Machines

The majority of beverage vending machines are manufactured for large beverage suppliers and provided to retail outlets. The retailers have little influence on the selection of technology, despite the fact that they pay for the energy consumed by vending machines. There is some variation in the performance of vending machines.

While a performance label may provide some incentive to manufacturers of the poorer performing units to match their competitors, this will not necessarily be the most efficient means to achieve this. In addition, we no of no other labelling program for vending machines, which could be easily adapted for Australia. This would mean that the decision to implement labelling for these products would result in a lengthy development period.

We therefore consider that a ‘best practice’ program between government and a leading manufacturer may be a better alternative.

13.1.7 Self-contained Cold Water Dispensers

The market for cold water dispensers is significant and growing. At the present, we are not aware of any country that has introduced MEPS for these products and none have been recommended for Australia. As a result, we consider it important that other programs are implemented to reduce emissions from this subsector.

The only labelling program currently being considered elsewhere for these products is the Energy Star program in the United States. Although this is still under development and may not be finalised for another 12 months, it is considered that adapting this will still involve a shorter lead time than if Australia were to begin developing it’s own labelling program.

It is therefore recommended that the Energy Star proposal currently under development is investigated further to see how this can be adapted for use in Australia as a mandatory requirement. If this turns out not to be suitable, it is suggested that the alternative, the development of a specific Australia labelling program, should be pursued following further consultation with the industry.

We also recommend that the industry is approached with regard to establishing a public listing of products, which identifies the performance of products.

13.2 Financial Incentives

The Dutch STIMECK scheme and the UK capital allowance facility (to be implemented in 2001) are the only programs we are aware of which provide financial incentives for investment in the commercial refrigeration area.

The STIMICK scheme is operated by the Electricity Utilities partly in recognition of the benefits for load management which can be obtained through improvement to commercial refrigeration. In Australia many areas face network constraints during the summer daytime due to loads from commercial customers. In some cases, refrigeration makes a significant direct and indirect contribution to these loads. As network operators become increasingly aware of these constraints and the costs of augmenting the network, the option of meeting demand through demand management is a strategy being actively considered by network operators and electricity retailers.

We suggest that further exploration of the potential for utilities to provide incentives for demand management activities in general, and in the field of commercial refrigeration in particular, is warranted. One approach would be the Government to work with the Electricity Supply Association of Australia (ESAA) or individual utilities on a trial program to assess the costs and benefits to all parties in refrigeration load management. Such a trial could also involve a major supermarket chain.

Clearly there is no evidence yet of the effectiveness of the proposed capital allowance facility, and it should be noted that commercial refrigeration products are only one set of eligible products amongst many. The changes to the tax system which would be required to implement this program, and similar programs, are unlikely to be cost-effective for less than a number of product categories.

At this stage we do not recommend a similar approach, although we suggest that the UK program should be monitored once it is operational to determine whether a similar approach could be taken in Australia in due course, particularly if other programs prove insufficiently effective.

14. IMPLEMENTATION

14.1 MEPS Timetable

It is understood that NAEEEC proposes to recommend to ANZMEC the following target timeframe for the introduction of MEPs, giving industry an appropriate period of notice to undertake any necessary modifications to production procedures. This proposed timeframe may be modified to take into account specific circumstances that may arise not foreseen at this time.

14.1.1 Development Stage	Timetable
Following the publication of this initial plan and a desk-top review of the energy impacts of mandatory and / or voluntary measures, the following steps will occur: An industry expert will work to refine the initial MEPs proposals under a steering committee including industry stakeholders . Cost/benefit analysis of potential legislative options. Industry and stakeholder consultation on potential legislative proposals. Development of Australian and New Zealand Standards for inclusion in regulations. Ministerial approval required before introduction of any new regulations.	Commenced from July 2000 and completed by July 2002
14.1.2 Notification Stage	
Period of notification will depend on the level of manufacture undertaken in Australia. Longer periods would apply if Australian industry required to undertake substantial development or re-tooling	The Australian standard will be published by July 2002 containing the MEPs levels and the MEPs will come into effect from July 2005
14.1.3 Duration Stage	
This is the 'stability period' in which no changes to regulations are made (ie MEPs levels unchanged).	Commenced from July 2005 and scheduled for reconsideration by July 2010

14.2 Strategy for public consultation

We understand that stakeholder participation in the process will be mainly through having representation on the project steering committee that NAEEEC has established, together with involvement in the normal consultation process undertaken during the Regulatory Impact Statement process.

15. REFERENCES

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ABS, 2000	pers.com. Information provided on number of businesses by type.
BIS, 2000	*Market Analysis of Refrigerators and Freezers.* Commissioned for NAEEEC.
CEC, 2000	*Action Plan to Improve Energy efficiency in the European Community*. Communication from the Commission to the Council, The European Parliament The Economic and Social Committee and the Committee of the Region. Brussels, June 26th 2000.
Elefson, 1995	*Energy Labelling of Supermarket Refrigerated Cabinets.* TNO Institute of Environmental Sciences, Energy Research and Process Innovation, The Netherlands report R95-164.
MEA, 2000	*Analysis of Potential for Minimum Energy Performance Standards for Remote Commercial Refrigeration*. Prepared for the Australian Greenhouse Office and the National Appliance and Equipment Energy Efficiency Program by Mark Ellis & Associates. October 2000.
Pers. Com. EPA, 2000	Rachel Schmeltz, US EPA, November 2000.
Tait, 2000	*Overview of Commercial Refrigeration in the United Kingdom*. A sector review paper on Projected Energy Consumption for the Department of the Environment, Transport and the Regions.
US DOE 1996.	*Energy Savings Potential for Commercial Refrigeration Equipment – Final Report*. Produced by Arthur D Little Inc.
Van Der Sluis, 1999	*Experience with a Voluntary Energy Labelling Scheme For Refrigerated Display Cabinets*. Presentation to the 20th International Congress of Refrigeration, IIR/!!F, Sydney 1999. SM Van Der Sluis, TNO-MEP, Department of Refrigeration and Heat Pump Technology, Netherlands.

APPENDIX A: AUSTRALIAN STANDARD

A.1 AS 1731-1983: Frozen food retail cabinets

A.1.1 Scope

This Standard specifies requirements for frozen food retail cabinets, as defined in Clause 1.4.5. It specifies requirements for construction and performance and prescribes uniform procedures for determining the performance and capacities of such cabinets.

A.1.2 Abstract

Applies to refrigerated cabinets for the retail sale of packaged frozen foods. It provides for two climate classes, for use where the ambient temperature will not exceed 25°C (e.g. a naturally mild climate or a fully and continuously air-conditioned store) and for use where the ambient temperature may exceed 25°C but will not exceed 32°C.

Performance requirements and methods of test are specified, together with other requirements relating to construction, volume and area ratings, and markings. The Standard prescribes an electrical energy test methodology for refrigerated cabinets only, whether it has an integral condenser or a remote condenser.

This Standard was prepared by the Association's Committee on Frozen Food Retail Cabinets to supersede AS 1731—1975, which had itself superseded the original AS B220—1966. AS B220 had been published in response to a request by the Council of Australian Food Technology Associations, and had drawn largely upon BS 3053 and draft DIN 8954.

It is currently being re-drafted by Standards Australia/Standards New Zealand Committee ME/8, *Refrigerated Display Cabinets*. The Current Drafts are made up of a twelve-part series, based on British Standards BS EN 441. Public comment on these documents closed on 31 October 1999

It has been put forward to the International Standards Organisation (ISO) that they should similarly adopt this Standard.

Status: Current

Published: 7 March 1983

Pages: 16

APPENDIX B: BRITISH STANDARD, EU STANDARD & OTHER PROGRAMS

B.1 BS EN 441-9 Refrigerated display cabinets

EN441 (1995, updated in 1999) is a European standard in twelve parts. It has now been issued as a Europe-wide standard for the comprehensive testing of refrigerated display cabinets, and is very widely used throughout the industry.

This Standard specifies terminology, general mechanical and physical requirements, test conditions as well as installation, maintenance and users guide for refrigerated display cabinets for the sale and/or display of food products.

This Standard does not cover refrigerated vending machines or cabinets intended for use in catering or similar non-retail appliances.

Part 9 of EN 441 specifies the method of measuring the consumption of electrical energy for refrigerated display cabinets

This Standard and its associated series are currently being used as the bases for the draft to replace the current Australian Standard AS 1731—1975.

It is equivalent, or though not technically similar to the following ASHRAE standards in the USA:

- ANSI/ASHRAE Standard 72-1983 Method of testing open refrigerators for food stores;
- ANSI/ASHRAE Standard 117-1986 Method of testing self-service closed refrigerators for food stores.

These two standards were compared with EN441 at a meeting of the IIR Sub-commission D1 'Refrigerated Display Cabinets' on 31 March 1998. Amendments to EN441 are now being mooted.

The proposed SAVE energy labelling scheme (Elefson 1995) (see below) makes use of some of the results of testing done under EN441 to provide its basic technical data.

B.2 Energy Labelling & Other Programs

B.2.1 Labelling

A technical methodology to determine energy labels for integral and remote cabinets has been defined (Elefson 1995). The proposed methodology draws upon data generated by the existing operational EN441 testing standard and requires no additional testing, simply arithmetic on the results. EN441 is used throughout the European cabinet manufacturing industry.

The Dutch Government have an operational subsidy scheme for retail refrigeration called STIMECK, which gives subsidies towards cabinets achieving A or B ratings according to the Elefson assessment method, modified according to an amendment agreed with EUROVENT/CECOMAF. It is understood that the majority of products in this scheme are designed for remote systems [Van Der Sluis, 1999]. As a result this is not discussed further here, but details are contained in [MEA, 2000].

The most often heard criticism of the EN441 testing is that it only involves study of the cabinet itself, whereas in the case of a remote cabinet the whole plant affects efficiency. The British Refrigeration Association and large retailers have developed the TEWI (Total Equivalent Warming Impact) factor for quantifying the impact of the whole plant. They advocate TEWI as a more appropriate framework, whilst recognising that it needs further developing. (See below).

The proposed scheme attempts to rank cabinets according to their inherent efficiency, as would be achieved by running them all with a 'standard' remote plant. However, it has been shown that for any given remote plant, the relative efficiency of cabinets will remain the same (ie E-rated cabinet is less efficient than a B-rated cabinet, no matter how good or bad the remote plant). The labels would therefore still perform a useful role in decision-making.

B.2.2 EUROVENT Certification

European Association of Air Handling and Refrigerating Equipment Manufacturers includes fifteen National Associations from the following eleven countries :

- Belgium: FABRIMETAL
- Finland: AFMAHE, FREA
- France: UNICLIMA
- Germany: FG ALT im VDMA
- Great Britain: FETA
- Italy: COAER, ANIMA
- Netherlands: NKI, VLA
- Norway: NVEF
- Spain: AFEC
- Sweden: KTG, SWEDVENT
- Turkey: ISKID

- ***THE PURPOSE OF EUROVENT CERTIFICATION***

The purpose of Eurovent Certification Programmes is to create a common set of criteria for rating products. Through specification of certified products, the engineer's tasks are made easier, since there is no need for carrying out detailed comparison and performance qualification testing.

Consultants, specifiers and users can select products with the assurance that the catalogue data is accurate.

- ***COMMON REFERENCE IN EUROPE***

The importance and reliability of the European Air Conditioning Industry are clearly demonstrated by the very existence of the voluntary certification programmes established and administered by Eurovent.

Comparison of product performances by third party testing based on well-defined procedures ensures healthy, solid competition within a market, which is open to all manufacturers.

- ***BENEFITS OF CERTIFICATION***

The Eurovent Certification provides clear benefits for selection of products and their performance. The end users may have confidence that equipment will operate in accordance with design specifications, the energy cost will be correctly predicted and therefore the supplied product will correspond to the initial investment.

For manufacturers, the Eurovent Certification programmes create a common platform for competition on equal terms based on comparable data.

Finally the image and integrity of the all industry is improved and a better confidence between manufacturers and specifiers is established.

- ***CERTIFICATION PROCEDURES***

Participants present performance and construction data for all products or for selected ranges within the scope of the programme. This data is evaluated by the Eurovent Certification Company and certain number of units are selected for testing. If results are satisfactory then products or ranges are listed in the Eurovent Directory. All products are subject to regular random testing to verify compliance with catalogue data.

- ***INDEPENDENT LABORATORIES***

Performance testing in the scope of Eurovent Certification is carried out by independent laboratories under contract with Eurovent.

- ***WHAT HAPPENS WHEN THE PERFORMANCE CHARACTERISTICS OF THE TESTED PRODUCTS ARE FOUND OUTSIDE OF THE ALLOWED TOLERANCE?***

If a product characteristics falls below value claimed in the catalogue by more than specified allowed tolerance, the participant will be required to rerate not only the tested model but all products in the same basic product range. Participants may otherwise decide to withdraw the product from the market.

- ***HOW TO IDENTIFY EUROVENT CERTIFIED PRODUCT?***

Certified products or ranges are listed in the Eurovent Directories, specification sheets, literature and, where appropriate, advertising display the Eurovent Certification Logo.

The Certification Logo guarantees that products have been submitted to independent checking and that they have been accurately rated.

- ***SCOPE OF THE PROGRAMME***

This programme concerns the Vertical Chilled Multi-deck (VC2) and Semi-vertical (VC1) Refrigerated Display Cabinets.

- ***DEFINITIONS***

Refrigerated Display Cabinets: Cabinet cooled by a refrigerating system which enables chilled and frozen foodstuff placed therein for display to be maintained within prescribed temperature limits.

Internal fitting type: HNLS : Horizontal Non Lighted Shelves & HLS : Horizontal Lighted Shelves ; TNLS : Tilted Non Lighted Shelves & TLS : Tilted Lighted Shelves ; MNLS : Mirror and tilted Non Lighted Shelves & MLS : Mirror and tilted Lighted Shelves (available for vertical only).

Number of shelves: The bottom shelf (well) and the mirror are not taken into account in this number.

M-package temperature class: Classification in test room climate class 3 : 3H2 (-1; +10), 3H1 (+1; +10), 3M2 or 3M1, according to EN441-6 : 1994 (where H class is substitute by H2 and H1 as above defined).

Average heat extraction rate 75% (W): According to EN441-12 : 1997 ; 4,1 NOTE 1, measurement based on 75 % of stabilised period between two defrosts, and mean running time figure to take into account day (12 h) and night (12 h) figures for a complete day if night covers are used.

For cycling running, the measurement frequency of 20' precised in note 2 of EN441-12 ; 4.1 must be respected.

At evaporating temperature (°C): According to EN441-12 : 1997 ; 4,1 NOTE 1, measurement based on 75 % of stabilised period between two defrosts.

REC (kWh/day): Refrigeration Electrical Energy Consumption according to Eurovent/Cecomaf Recommendation for energy consumption evaluation of remote refrigerated display cabinets REC 05 (December 1997).

DEC with 12 h lighting (kWh/day): Direct Electrical Energy Consumption according to EN441-9 : 1994 and Eurovent/Cecomaf Recommendation for energy consumption evaluation of remote refrigerated display cabinets REC 05 (December 1997).

TDA (m²): Total Display Area according to Eurovent/Cecomaf Recommendation for energy consumption evaluation of remote refrigerated display cabinets REC 05 (December 1997).

- ***REFERENCES***

Verification of performance characteristics are carried out in accordance with the European Standard EN 441.

EN 441-1 : 1994 and EN 441-1/A1 : 1995 - Terms and definitions

EN 441-3 : 1994 - Linear dimensions, areas and volumes

EN 441-4 : 1994 - General test conditions

EN 441-5 : 1996 - Temperature test

EN 441-6 : 1994 - Classification according to temperatures

EN 441-8 : 1994 - Water vapour condensation test

EN 441-9 : 1994 - Electrical energy consumption test

EN 441-12 : 1997 - Measurement of the heat extraction rate of the cabinets when the condensing unit is remote from the cabinet

Eurovent/Cecomaf Recommendation REC 04 : Standardisation of refrigerated display cabinets - Standard test report - June 1997

Eurovent/Cecomaf Recommendation REC 05 : Energy consumption evaluation of remote refrigerated display cabinets - December 1997

CEN/TC44 N 106 June 1999 General test conditions and test room definition

- ***CERTIFIED CHARACTERISTICS***

The following dimensional and performance characteristics are certified :

- M-package temperature class (H2 , H1 , M2 , M1)

- Refrigeration electrical energy consumption (REC)

- Direct electrical energy consumption (DEC)

- Total display area (TDA)

B.2.3 STIMECK: Dutch subsidy program for supermarket refrigeration [Tait 2000]

The Dutch subsidy scheme covers supermarket refrigeration, including the cooling plant and cabinets. The scheme was set up by three electricity distribution companies, together with NOVEM (the Dutch Energy Agency).

These parties have contracted TNO (a Dutch technological institute) and a small engineering firm to set up a scheme for subsidising energy conservation in supermarket refrigeration. The scheme stems from the targets set for the electricity distribution companies to save energy. They have funding for this aim, which originates from a special tax on electricity. There are guidelines which allow the distributors to subsidise energy saving by DFL 150 (A$ 207) per ton of CO_2 saved (one year basis), which amounts to about DFL 0.08 (A$ 0.11) per kWh.

TNO has implemented two frameworks which are both being used:

i) A subsidy on a range of technological measures that can be applied to save energy

ii) A subsidy on energy saved relative to a benchmark set for supermarkets

The subsidy under framework (i) is quite straightforward; if you buy night-covers, electronic expansion valves, strip curtains, evaporative condensers efficient cabinets etc. you can get a fixed amount of subsidy per kW of capacity to which the saving devices apply. 'Efficient cabinets' are defined as those earning energy label A or B according to the SAVE project methodology (Elefson 1995). TNO keeps a list of all options (and equipment models) that are eligible for subsidy.

The subsidy on option (ii) is more complicated. For a supermarket a reference consumption is set (depending on the refrigerated display areas). The energy consumption of the installation is calculated (not measured) by TNO, and the subsidy of DFL 0.08 / kWh saved is given for all savings relative to the reference.

The whole scheme is now regionally administered. Requests for subsidy must be made by supermarkets to the energy distribution companies. Each energy distribution company will select the ten best requests in their region (with the help of TNO), and subsidise these. Each distribution company has set aside a budget of about DFL 150.000 (A$ 206,850) for this pilot phase.

B.2.4 UK Enhanced Capital Allowance Scheme

The UK Government has recently announced an enhanced capital allowance scheme for introduction in 2001, for application to a range of energy efficiency improvements including commercial refrigeration. Under the scheme, companies investing in eligible energy efficiency technologies are able to claim 100% of expenditure against tax in the first year of investment. Eligible refrigeration technologies include:

- Evaporative condensers;

- Liquid pressure amplification systems;
- Automatic air purging systems;
- Refrigeration control systems with energy saving features, including electronic expansion valves, balanced port valves, defrost controls and pro-active controllers;
- Night blinds and strip curtains for retail display cabinets;
- Automated permanent refrigerant leak detection systems;
- Absorption cooling equipment driven by CHP heat.

B.3 Total Equivalent Warming Impact (TEWI)

This is a method of quantifying the total global warming effect of a refrigeration system. TEWI can be used to provide an indication of which of two or more options for refrigeration systems is the most environmentally-friendly in terms of global warming, for the same application. TEWI is not appropriate for comparing refrigeration systems for different applications.

To calculate a 'TEWI factor', the direct impact of any released refrigerant is added to the indirect effect from the energy consumed over the lifetime of the plant. A key point raised by TEWI analysis is thus that the energy consumption of a refrigeration system is usually as, if not more, significant than the effects of the refrigerant itself on the environment.

Since leakage reduces energy efficiency as well as releasing chemicals into the environment, control of leakage is very effective at improving the TEWI rating of a system. It is essential to control refrigerant leakage to minimise costs and environmental damage.

APPENDIX C: INTERNATIONAL ORGANISATION FOR STANDARDISATION

ISO 1992-6: Commercial refrigerated cabinets: methods of test: part VI: electrical energy consumption test

Applicable to commercial refrigerated cabinets intended for sale and/or display of food products. The electrical energy consumption test shall be made in accordance with part 2 of ISO 1992 and on ambient conditions corresponding to the climate class(es) for which the cabinet lighting shall be on continuously during test.

Published: 1974

International Relationships:

BS 6148 PART6- 1981, EQV* NS 4628-1979, NEQ * D74-010(1987/AFNOR)

APPENDIX D: CANADIAN STANDARDS

D.1 C300-M91 CAN/CSA Capacity Measurement and Energy Consumption Test Methods for Refrigerators, Combination Refrigerator-Freezers, and Freezers General Instruction No 1

This Standard applies to refrigerators, combination refrigerator-freezers, and freezers, as defined in clause 3 of C300-M91, that are electrically operated on a 60Hz alternating current, with a nominal supply of 115 V. ***The majority of appliances covered by C300-M91 are likely to be for residential applications.***

This Standard covers definitions, methods for computing volumes and shelf areas, methods for determining volumes of special feature, performance test procedures, methods of determining energy consumption with associated energy factors, and specifies maximum energy consumption limits.

The requirements in this Standard are not applicable to electrically operated refrigerators employing an absorption refrigeration system.

The energy consumption limits in this Standard apply only to refrigerators and combination refrigerator-freezers with a capacity of up to 1100 L (39ft^3), and to freezers with a capacity up to 859 L (30 ft^3).

Refrigerators, combination refrigerator-freezers and freezers were prescribed as a regulated product under the *Energy Efficiency Regulations* which came into effect on February 3,1995. Natural Resources Canada (NRCan) is now proposing to amend these Regulations to establish minimum efficiency levels that are identical to those that were published in the U.S. *Federal Register* on April 28, 1997 and which will be implemented in the U.S. on July 1, 2001.

D.2 C827-98: Energy Performance Standard for Food Service Refrigerators and Freezers

This Standard applies to commercial refrigerator, refrigerator-freezer, and freezer cabinets that are intended for storage or holding food products and other perishable merchandise.

This Standard applies to

- Manufacturer's standard catalogue-type equipment;
- Closed cabinets of a unitary, self contained type;
- Commercial refrigerated storage cabinets, regardless of their shape, size or configuration (except as noted below), including

  reach-in cabinets;

  roll-in or roll-through cabinets;

  pass through cabinets;

  reach in wine coolers;

  fish or poultry files;

  ice cream cabinets;

  milk or beverage cabinets;

  milk or beverage and ice cream cabinets;

  preparation tables

  worktop tables; and

  undercounter cabinets;
- closed refrigerated cabinets, regardless of what the door(s) of the closed cabinets are made of, provided that the closed cabinets are designed for holding and storing food products;
- both permanently connected and cord-connected equipment;
- cabinets equipped with or designed to work with electrically driven, mechanical, vapour compression systems charged with one of the refrigerants listed in Group A1 of CSA Standard B52;
- refrigeration equipment designed for storage temperatures either above or below freezing temperatures, or both in separate compartments; and
- freezers.

This Standard **does not** apply to

- open-type refrigeration cases designed for use without doors;
- remote-condensing commercial refrigerators and freezers;
- walk-in refrigerators and freezers, water coolers, refrigerated vending machines, or ice-making machines;
- soft serve, slush, and shake-dispensing freezers and extruders.

Products must meet the energy performance standards ("Standard Efficiency") as shown in the following tables. The second performance level "High Efficiency", defines products which can claim to be high efficiency units. All products are required to be clearly labelled with the average energy consumption of the unit achieved under specified test conditions, and whether it claims to be a standard or high efficiency unit.

Table D1: Maximum Annual Energy Consumption: Refrigerators – Solid Doors

Type	Annual Energy Consumption (AEC_{max}), kWh/y	
	Standard Efficiency	High Efficiency
Reach-in	59 V + 1010	54 V + 470
Reach-in Wine Cooler	51 V + 300	47 V + 10
Roll-in or Roll-through	*	*
Pass-through	*	*
Milk or beverage type	31 V + 450	28 V + 260
Preparation Table	*	*
Worktop table/undercounter	87 V + 780	79 V + 210

Note: V is the refrigerator volume measured in ft^3 .
** insufficient product data available*

Table D2: Maximum Annual Energy Consumption: Refrigerators – Glass Doors

Type	Annual Energy Consumption (AEC_{max}), kWh/y	
	Standard Efficiency	High Efficiency
Reach-in	118 V + 2020	108 V + 940
Reach-in Wine Cooler	102 V + 600	94 V + 20
Roll-in or Roll-through	*	*
Pass-through	*	*
Milk or beverage type	62 V + 900	56 V + 520
Preparation Table	*	*
Worktop table/undercounter	174 V + 1560	158 V + 520

Note: V is the refrigerator volume measured in ft^3 .

Table D3: Maximum Annual Energy Consumption: Freezers – Solid Doors

Type	Annual Energy Consumption (AEC_{max}), kWh/y	
	Standard Efficiency	High Efficiency
Reach-in	172 V + 930	156 V + 1270
Roll-in or Roll-through	*	*
Pass-through	*	*
Ice-cream cabinet	86 V + 1270	78 V + 755
Preparation Table	*	*
Worktop table/undercounter	367 V + 2200	334 V + 400

Note: V is the refrigerator volume measured in ft^3 .
** insufficient product data available*

Table D4: Maximum Annual Energy Consumption: Freezers – Glass Doors

Type	Annual Energy Consumption (AEC_{max}), kWh/y	
	Standard Efficiency	High Efficiency
Reach-in	334 V + 1860	312 V + 2540
Roll-in or Roll-through	*	*
Pass-through	*	*
Ice-cream cabinet	172 V + 2540	156 V + 1510
Preparation Table	*	*
Worktop table/undercounter	734 V + 4400	668 V + 800

Note: V is the refrigerator volume measured in ft^3 .
** insufficient product data available*

Table D5: Maximum Annual Energy Consumption: Refrigerator-Freezers – Solid Doors

Type	Annual Energy Consumption (AEC_{max}), kWh/y	
	Standard Efficiency	High Efficiency
Reach-in	92 AV + 1900	84 AV + 1160
Reach-in Wine Cooler	*	*
Milk or beverage and ice-cream	*	*
Preparation Table	*	*
Worktop table/undercounter	*	*

** insufficient product data available*

Note: Adjusted volume (AV) is equal to the refrigerator volume plus 1.63 times the freezer volume.
Volume is measured in ft^3 .

D.3 C743-98: Performance of Automatic ice-makers and Ice Storage Bins

Applies to factory-assembled automatic ice-makers that have a standard capacity rating of between 23 and 1000 kilograms per day (kg/d), including self-contained and split-system machines that produce cubed, flaked, crushed or fragmented ice, in either a batch or continuous process. Ice-makers installed in household refrigerators, refrigerator-freezers or freezers, automatic ice-dispensing machines and cold-plate drink dispensers are excluded.

The minimum energy performance standard is shown in Table D6 below.

Test Standard: CAN/CSA-C742-98

Published: 1998

Table D6: Canadian Minimum Energy Performance Standard: Ice-Makers

PRODUCT CLASS	MAXIMUM ENERGY INPUT kilojoules (kJ)/day December 31, 1998
Batch automatic ice-makers (cubers)	
▪ Air-cooled	
23 ² capacity < 150 kg/d	1630 – 6.008 x capacity, kJ/kg
150 ² capacity ² 1000 kg/d	807.2 – 0.5229 x capacity, kJ/kg

▪ Water-cooled	
23 ≤ capacity < 150 kg/d	1234 – 4.381 x capacity, kJ/kg
150 ≤ capacity ≤ 1000 kg/d	621.8 – 0.2985 x capacity, kJ/kg
Continuous automatic ice-makers (flakers)	
▪ Air-cooled	
23 ≤ capacity < 300 kg/d	875.2 – 1.122 x capacity, kJ/kg
300 ≤ capacity ≤ 1000 kg/d	538.6 kJ/kg
▪ Water-cooled	
23 ≤ capacity < 300 kg/d	740.5 – 0.8976 x capacity, kJ/kg
300 ≤ capacity ≤ 1000 kg/d	471.2 kJ/kg

Requirements for the energy efficiency report, as listed in Schedule IV of the Regulations

- type of product (automatic ice-maker);
- brand name;
- model number;
- manufacturer;
- name of the organisation or province that carried out the ice-maker verification and authorised the verification mark that will be affixed to the ice-maker;
- capacity in kilograms of ice per day;
- product category (one cabinet or split-system);
- product process type (batch or continuous);
- the product cooling mechanism (air-cooled or water-cooled); and
- the input energy rating in kj/kg (kWh/100 lb).

D.4 C657-95: Energy Performance Standard for Commercial Refrigerated Display Cabinets and Merchandisers

This standard applies to refrigerated display cabinets, both self-contained and with remote compressors. These are categorised in eight classes, as follows:

Class 1: low temperature multideck, two or more air curtains, length of air curtain 1.0-1.3m

Class 2: medium temperature multideck, single air curtain, length of air curtain 1.0-1.5m. Cabinet height 1.9-2.1m and depth 0.8-1.2m.

Class 3: medium temperature multideck, single air curtain, length of air curtain 0.8-1.0m. Cabinet height 1.0-1.4m and depth 1.0-1.2m.

Class 4: low or medium temperature closed multideck, single air curtain behind glass door. Cabinet height 2.0-2.1m and depth 1.0-1.2m.

Class 5: low temperature, well type self service cabinet, open or closed, with horizontal air curtain, length of air curtain 0.75-0.85m or 1.0-1.2m. Product loading depth 0.3-0.45m

Class 6: medium temperature single deck self service cabinet with single air curtain, length of air curtain 0.75-0.9m. Cabinet height 0.8-1.01m at the back and 0.7-0.9m at the front. Depth 1.0-1.2m.

Class 7: medium temperature single deck wall or island type self service cabinet with a perforated product shelf. Class 7 cabinets are dividing into three subclasses on the basis of the width of the display area:

a. narrow: 0.75-1.02m

b. medium: 1.03-1.27m

c. wide: 1.28-1.65m

Class 8: low or medium temperature cabinet with a flat or curved front glass and a sliding door service access to the rear. Height 1.25-1.4m, depth 0.95-1.2m. Class 8 cabinets are dividing into two subclasses on the basis of their evaporator coil arrangements:

a. fan coil.

b. gravity coil.

The standard provides a test procedure, which draws heavily on ANSI/ASHRAI–72. Required minimum energy performance standards for each class are expressed in kWh/ft/day and are provided in the following table.

Table D7: Energy Performance Standard for Commercial Refrigerated Display Cabinets and Merchandisers

Class	Subclass	Evaporating Temp.(°C)	Standard Rating (kWh/ft/day)
1		-35	11.3
		-30	11.1
2		-10	6.4
		-5	5.5
3		-10	4.4
		-5	3.6
4		-30	6.6
		-5	5.0
5		-35	6.1
		-30	5.1
6		-10	3.3
		-5	2.6
7	Width: 0.77-1.02 m	-10	3.5
		-5	2.7
	Width: 1.03-1.27 m	-10	4.9
		-5	4.1
	Width: 1.28-1.55 m	-10	5.2
		-5	4.3
8	Fan	-25	5.1
		-5	1.7
	Gravity	-10	1.8
		-5	0.9

D.5 C804-96: Energy Performance of Vending Machines

Applies to self contained vending machines that actively cool or heat, or both, including:

- refrigerated post mix soft drinks

- refrigerated packaged beverages
- hot products that have been stored in a cooled space
- cold products that have been stored in a cooled space
- bulk hot beverages
- other types of vending machines

The minimum energy performance standard is shown in Table D8 below.

Table D8: Canadian Energy Performance Standard for Vending Machines

Category			Max Daily Consumption (E_{dmax}) kWh
A	Packaged beverage		Edmax < 8.66 + 0.009 x C
B	Post-mix beverage		8.0
C	Chilled non-perishable food		14.0
D	Cold perishable food	Gross Volume <300L	10.5
		Gross Volume >300L	14.0
E	Frozen food		14.0
F	Hot food that is stored cold		17.0
G	Frozen food or snack		12.0
H	Cold beverage or snack		8.0
J	Cold perishable food/snack		10.5
K	Hot beverage	<10L	4.5
		>10L	6

C = machine capacity in number of cans

APPENDIX E: UNITED STATES STANDARDS

E.1 Federal Energy Management Program (FEMP)

The **US Department of Energy (DOE)** Federal Energy Management Program also encourages government procurement of energy efficient Ice-Makers. Recommended efficiency levels are included in the table below.

Table E1: Federal Energy Management Program, Guidelines for Procurement of Ice-Makers

Product Type	Ice Harvest Rate[2] (lbs per 24 hrs.)	Energy Consumption[3] (per 100 lbs. Ice)	
		Recommended	Best Available
Ice-Making Head[4]			
Air-Cooled	101-200	9.4 kWh or less	8.6 kWh
Air-Cooled	201-300	8.5 kWh or less	7.9 kWh
Air-Cooled	301-400	7.2 kWh or less	7.1 kWh
Air-Cooled	401-500	6.1 kWh or less	5.8 kWh
Air-Cooled	501-1000	5.8 kWh or less	5.4 kWh
Air-Cooled	1001-1500	5.5 kWh or less	5.1 kWh
Water-Cooled	201-300	6.7 kWh or less	5.9 kWh
Water-Cooled	301-500	5.5 kWh or less	4.7 kWh
	501-1000	4.6 kWh or less	3.8 kWh
	1001-1500	4.3 kWh or less	4.1 kWh
	> 1500	4.0 kWh or less	3.7 kWh
Self-Contained[5]			
Air-Cooled	101-200	10.7 kWh or less	9.5 kWh
Water-Cooled	101-200	9.5 kWh or less	7.5 kWh
Water-Cooled	201-300	7.6 kWh or less	7.2 kWh
Remote Condensing[6]			
Air-Cooled	301-400	8.1 kWh or less	7.9 kWh
Air-Cooled	401-500	7.0 kWh or less	6.1 kWh
Air-Cooled	501-1000	6.2 kWh or less	5.4 kWh
Air-Cooled	1001-1500	5.1 kWh or less	4.6 kWh
Air-Cooled	> 1500	5.3 kWh or less	4.9 kWh

Notes

1. This Recommendation covers machines generating 60 grams (2 oz.) or lighter ice cubes, and does not cover flaked, crushed or fragmented ice-makers.

2. The ice harvest rate (capacity) is the amount of ice produced in 24 hours.

3. Based on ARI Standard 810-95.

4. Ice-making head units do not contain integral storage bins, but are generally designed to accommodate a variety of bin capacities. Storage bins entail additional energy use not included in the reported energy consumption figures for these units.

5. Self-contained units contain built-in storage bins.

6. Remote condensing units transfer the heat generated by the ice-making process outside of the building (comparable to split system air conditioners).

E.2 Energy Star Program

Energy Star is a voluntary program between the US EPA, DOE and product manufactures, aimed at achieving market transformation. It encourages the manufacture, promotion and use of efficient products, using the Energy Star to identify conforming products in the marketplace.

Energy Star criteria are currently under development for three new product areas relating to commercial refrigeration. These are:

- Automatic Commercial Ice-Makers
- Water Coolers
- Reach in Refrigerators and Freezers

E.2.1 Automatic Commercial Ice-Makers

US research indicates the following:

- There are about 1 million automatic commercial ice-makers in the US, of which 60% are air cooled and 40% water cooled. These machines consume an estimated 8 TWh per year.
- American businesses spend over US$600 million annually to power these machines.
- There is currently a range of efficiencies amongst automatic ice-makers.
- The savings potential is estimated at 1.7 TWh per year, equivalent to saving US$136 million.

As a result, the EPA is currently consulting with industry before launching their new program.

E.2.2 Draft Bottled Water Dispenser Specification (December 22, 1999)

EPA research indicates that in the US,

- Annual electricity expenditure on water coolers is approximately $300 million;
- Annual electricity consumption is over 4 TWh;
- 60% of daily cold only dispenser consumption and 90% of hot and cold dispenser consumption is due to standby losses.

As a result the EPA has developed the following draft guidelines for consultation.

Definitions: Below is a brief description of a bottled water dispenser and its common energy consumption characteristics as relevant to the ENERGY STAR Program.

- Bottled Water Dispenser: A free standing device whose purpose is to dispense water from removable 4 to 5-gallon plastic bottles commonly positioned on top of the unit.
- Standby Energy Consumption: Heating or cooling losses associated with keeping the water in the tank hot or cold and ready for use.

EPA Comments: Above are brief descriptions of common energy consumption characteristics for bottled water dispensers that EPA has observed in tests conducted by/for EPA. To achieve the maximum energy savings without compromising product performance, the ENERGY STAR specification will focus on standby energy consumption. In EPA tests, we found that standby losses account for the majority of bottled water dispenser energy use. Reducing standby losses is a cost-effective and feasible option for achieving substantial energy savings.

Qualifying Products: For the purposes of this Program, bottled water dispensers include the following:

- Cold Only Units: These units dispense either cold water only, or both cold and room-temperature water, sometimes referred to as "Cook and Cold" units.
- Hot and Cold Units: These units dispense both hot and cold water. Some units may have a third room temperature tap. Units will have an electric resistance heater and a refrigeration cycle.

EPA Comments: EPA's interest in developing energy-efficiency guidelines for bottled water dispensers is driven by the following considerations: 1) a large and stable installed product base, 2) evidence of considerable energy consumption due to standby losses, 3) the potential for more energy-efficient design based on engineering analysis and manufacturer feedback, and 4) low-cost options for reducing standby energy consumption.

Efficiency Specifications for Qualifying Products: Only those products listed in Section 2 that meet the specifications outlined in table E2 below may qualify as ENERGY STAR compliant.

Table E2: Draft Criteria for ENERGY STAR®-compliant bottled water dispensers (Version 1.0)

Product Category	ENERGY USE UNDER TEST CONDITIONS
Cold only	$\leq$ 0.13 kW-hours/day
Hot and Cold	$\leq$ 1.20 kW-hours/day

EPA Comments: Based on a technical review of existing products and discussions with manufacturers, EPA feels that the specifications listed above for bottled water dispensers are challenging, reasonable, and technology-neutral. EPA estimates that the above specifications constitute an average reduction in standby energy consumption of roughly 30% for cold only units and roughly 40% for hot and cold units. As proposed, EPA recognises that there are no models currently on the market that meet the specification. Testing conducted by/for EPA indicates the following:

- *Within the above categories, there is only a slight range in energy consumption among product models*
- *Current design practices result in significant standby losses, which account for the majority of the product energy consumption*
- *Given the magnitude of standby losses and the small range in efficiencies among the models, EPA cannot justify setting a standard based on currently available product models.*
- *EPA estimates that the majority of energy savings opportunities focus on reducing standby losses and that several low-cost design options exist that when implemented can meet the proposed specification.*

Test Criteria: Test conditions as described below will focus on overall standby losses with no water being withdrawn during the testing procedure.

a. Power Measurement: The energy use shall be measured as the total true power (kilowatt-hours) consumed in one 24-hour period.

b. Starting Conditions: Before starting the energy measurements, the unit should be at operating conditions, with water temperatures as defined in item (f) below.

c. Water Withdrawal: No water may be withdrawn from the units during the test.

d. Timer Usage: If the unit has an integral, automatic timer, during the test the timer can be set to turn off the unit for not more than 10 hours.

e. Ambient Temperature: Ambient air and water temperature must be at 70^{o} ± 2^{o} F.

f. Dispensed Water Temperatures: Cold water temperature shall not exceed 49^{o} F and hot water temperature shall be at least 165^{o}F. These temperatures shall be measured at the time the respective function, compressor, or heating element turns on.

g. Dispenser Location: The unit must be no more than 6 inches from a wall, with the wall being a minimum of seven feet high and extending horizontally a minimum of two feet from each side of the unit.

h. Air Flow: Airflow around the unit must be natural; no artificial means of increasing the airflow are allowed. Airflow created by methods integral to the unit itself, such as internal fans, is permitted.

E.2.3 Reach in Refrigerators and Freezers

Although the EPA has indicated its commitment to consultation on proposed guidelines for reach-in refrigerators and freezers, draft guidelines have not yet been fully developed for this range of products. At this stage consultation with the industry has been undertaken on the basis that the Canadian Standard, C827-98, may form the basis for the Energy Star requirement [pers. com. EPA, 2000].

APPENDIX F: SOUTH AFRICAN STANDARD

F.1 SABS 1406:1998 - Commercial refrigerated food display cabinets

Specifies requirements for three types and two climate classes of commercial refrigerated display cabinet for the storage, for sale, of frozen and fresh foods, and liquids in containers, and intended for operation on a three-phase 440 V power supply or on a single-phase power supply not exceeding 250 V phase to neutral.

The energy requirements of this standard are as follows:

F.1.1 Energy Consumption

When a cabinet is tested in accordance with 9.22, the power consumed shall not exceed 0.42 W.h/l of the gross capacity.

F.1.2 Test Conditions

Ensure that defrosting trays, shelves and other fittings are in their normal positions, and that all containers are empty.

Ensure that the voltage and frequency of the a.c. power supply does not differ by more than 1.0% from the specified voltage and frequency.

Use alternating current (where relevant) of nominal frequency 50Hz, and of substantially sine waveform.

Test a three-phase motor that is suitable for both single-phase or three-phase operation, under the most favourable conditions.

Shield the cabinet under test from any air current of velocity exceeding 0.25 m/s.

Operate the cabinet under test for 24 hour at an ambient temperature of 20 ^{o}C +/- 2 ^{o}C before starting any test.

Conduct the tests at a relative humidity in the range 45% to 75%.

F.1.3 Energy Consumption Test

If the temperature controller of the cabinet under test is manually adjustable, set it at its lowest temperature setting and disconnect the heating elements (if any) in accordance with the manufacturer's instructions.

Operate the cabinet until the stable operating conditions have been reached, and from the time of the first convenient cut-in of the temperature controller, measure, by means of a suitable kilowatt-hour meter, the energy consumed over 24 h.

Check for compliance with 8.12

Published: 1998

APPENDIX G: JAPANESE STANDARD

G.1 JRA 4032-1993: Commercial refrigerators, refrigerator-freezers and freezers

Published: 1993

Awaiting further information from Standards Australia.

APPENDIX H: MAILING LIST (INTERESTED PARTIES)

H.1 Organisations

Australia New Zealand Food Authority

Boeing House, 55 Blackall Street , BARTON ACT 2600

Ph: +61-2-6271 2222, Fax: +61-2-6271 2278

Postal Address: PO Box 7186, Canberra Mail Centre, ACT 2610 Australia.

email: info@anzfa.gov.au

Website: www.anzfa.gov.au

Australian Food and Grocery Council

Executive Director, Locked Bag 1, Kingston ACT 2604

Australian Greenhouse Office

John Gorton Building, GPO Box 621, Canberra ACT 2601

Telephone: +61 2 6274 1888, Facsimile: +61 2 6274 1795

Website: www.greenhouse.gov.au

Australian Industry Group

Nation Manager Trade Policy, GPO Box 817, Canberra ACT 2601

Australian Institute of Refrigeration Air Conditioning and Heating

The Director, James Harrison House, 52 Rosslyn Street, West Melbourne VIC 3003

Greenchill Technology Association Inc

PO Box 558, Katoomba, NSW 2780.

Ph: 02-4782-6639

Website: www.greenchill.org

Institute of Refrigeration Heating & Air Conditioning Engineers of New Zealand

The Secretary, PO Box 11130, Ellerslie, Auckland NEW ZEALAND

Website: www.irhace.org.nz

Refrigeration & Air Conditioning Companies Association (New Zealand)

The Secretary, PO Box 12737, Auckland 1135 NEW ZEALAND

Refrigeration & Air Conditioning Contractors Association of Australia

The Secretary, 485 Princes Highway, St Peters NSW 2044

The Australian Institute of Refrigeration Air Conditioning and Refrigeration Inc.

Postal address: AIRAH National Office, James Harrison House, 52 Rosslyn Street, West Melbourne, Victoria 3003, Australia

Ph: +61 3 9328 2399, Fax: +61 3 9328 4116

Website: www.airah.org.au

Vehicle Air Conditioning Specialists of Australasia

President, 30-32 Lexton Road, Box Hill VIC 3128

H.2 Manufacturers

Commercial Refrigeration Manufacturers Association of Australia

The Secretary, PO Box 156, Wamberal NSW 2260

H.3 Individual Manufacturers

Frigrite Kingfisher Pty. Ltd.

P.O. Box 499, Braeside, Victoria 3195, Australia

Ph: 61-3-9584-2711, Fax: 61-3-9584-5624

Tyler Refrigeration Corporation

1329 Lake Street, Niles, MI 49120

Ph: (800) 992-3744, (616) 683-2000, Fax: (616) 684-9802

Email: tylercorp@tylerrefrigeration.com

ComCool Refrigeration PTY LTD

Unit A, 30-34 Hilly Street, Mortlake, N.S.W. 2137

Ph: +61 2 9743 1294, Fax: +61 2 9743 1404

Email: *comcool@comcool.com.au*

Website: www.comcool.com.au

Far North Air Conditioning & Refrigeration Services

Showroom: 135 Lyons St, CAIRNS Queensland, 4870

Ph: (07) 40312222, Fax: (07) 40312183

A/H: (0418) 773197

Pager: 132222 - pager 4014753

Email: fnac@c130.aone.net.au

Website: www.fnac.com.au

Stuart Ice-Makers

23 Arkley St, Bankstown, NSW 2200

Tel: 02 9709 4077 Fax: 02 9796 2880

Orford Pty Ltd A.C.N. 009 790 265 trading as Orford Refrigeration

Head Office, 75 Vacy Street, Toowoomba Queensland AUSTRALIA 4350

P.O. Box 6085 Toowoomba West Queensland AUSTRALIA 4350

Ph: (07) 4639 9000, Fax (07) 4638 5326

Email: mail@orford.com.au

Website: www.orford.com.au

James N Kirby Pty Limited

Ph: +61 2 9774 7155

email webmaster@kirbyjn.com.au

Tri Tech Pty Ltd

Nevin Dr. Thomastown VIC 3074

Ph: 03 9465 0122, Fax 039464 1327

Whitechurch Refrig & Air Conditioning Pty Limited

31A McCoy St, Myaree WA 6154

Ph: 08 9330 1133, Fax 08 9330 2959

H.4 Regulators

NSW Ministry of Energy and Utilities

Tim Aldrich, PO Box 536, St Leonards NSW 2065

Ph: 02 9901 8837, Fax 02 9901 8403

Office of the Chief Electrical Inspector

Chairman, Electrical Approvals, 3/4 Riverside Quay, Southbank VIC 3006

PO Box 262, Collins Street West V 8007

Ph: 03 9203 9700, Fax: 03 9686 2197

Office of Chief Electrical Inspector

Michael Grubert, PO Box 262, Collins Street West VIC 8007

Ph: 03 9203 9741, Fax: 03 9686 2197

Department of Mines and Energy

Electrical Safety Branch, 61 Mary Street, Brisbane QLD 4000

PO Box 194, Brisbane QLD 4001

Ph: 07 3237 0239, Fax: 07 3237 0229

Department of Mines and Energy

Energy Division, Level 19, 30 Wakefield Adelaide SA 5000

Ph: 08 8226 5500, Fax: 08 8226 5523

Power and Water Authority

Chief Electrical Inspector, 4th Floor JAPE Building, 18-20 Cavenagh Street, Darwin NT 0800. GPO Box 1921, Darwin NT 0801

Ph: 08 8924 711, Fax: 08 8927 212

Office of Energy

Technical and Safety Division, 20 Southport Street, Leederville WA 6007

Ph: 08 9422 5200, Fax: 08 9422 5244

Hydro-Electric Commission

Chief Electrical Inspector, 4 Elizabeth Street, Hobart TAS 7000. GPO Box 355D, Hobart TAS 7001

Ph: 03 623 05855, Fax: 03 622 33279

Department of Urban Services

GPO Box 158, Canberra ACT 2601

Ph: 02 6207 5111, Fax: 02 6207 6229

H.5 Testing Interests

The most likely source of Testing Laboratory interest would be those typical of commercial refrigerators and through certification bodies such as.

QAS
Homebush - Head Office

1 The Crescent, Homebush, NSW 2150 Sydney Australia

Toll Free: 1300 360 314

Ph: (612) 97464900, Fax: (612) 9746 8460

Email: customerservice@qas.com.au

NATA

7 Leeds Street, Rhodes NSW 2138

Ph: +61 2 9736 8222, Fax: +61 9743 5311

H.6 Retailers

Australian Retailers Association

Executive Director, 132 Grenfell Street, Adelaide SA 5000

Individual retailer representation can be achieved through any of the major retailers throughout Australia. Some of these include:

- Woolworths
- Coles
- Franklins
- Jewel

H.7 Consumers

Australian Consumers Association

57 Carrington Road, Marrickville NSW 2204

Ph: 02 9577 3333, Fax 02 9577 3377

This Group would best be covered through consumer associations such as the ACA..

APPENDIX I: ADJUSTMENT OF OVERSEAS PERFORMANCE STANDARDS FOR AUSTRALIAN VOLTAGES

Calculations have been undertaken based on CAN/CSA – C827-98

In the following examples, a 1 cubic metre product has been used as the example.

Table I1: Calculations for Voltage Adjustment

-	Refrigerators – Solid Doors	-	Refrigerators – Glass Doors	-	Freezers – Solid Doors	-	Freezers – Glass Doors	
Canadian Std	59V+1010	-	118V+2020	-	172 V + 930	-	334 V + 1860	
1cu m product (kWh/yr)	1069	-	2138	-	1102	-	2194	-
At 115 volts	-	-	-	-	-	-	-	-
Amps/yr	9.30	-	18.59	-	9.58	-	19.08	-
Losses (I^2R)	86.41	x R1	345.64	x R1	91.83	x R1	363.98	x R1
	-	-	-		-	-	-	-
At 240 volts	-	-	-		-	-	-	-
Amps/yr	4.45	-	8.91	-	4.59	-	9.14	-
Losses (I^2R)	19.84	x R2	79.36	x R2	21.08	x R2	83.57	x R2
R2/R1	1.73	-	1.73	-	1.73	-	1.73	-
losses	34.32	x R1	137.29	x R1	36.47	x R1	144.58	x R1
	-	-	-	-	-	-	-	-
Difference in losses	52.09	-	208.35	-	55.35	-	219.40	-
% difference in losses	60.3%	-	60.3%	-	60.3%	-	60.3%	-
Motor losses (@10%)	6.0%	-	6.0%	-	6.0%	-	6.0%	-

APPENDIX J: EQUIVALENT ENERGY PERFORMANCE LEVELS TO THE CANADIAN STANDARD FOR REFRIGERATED DISPLAY CABINETS, C657-95, ACHIEVED UNDER AUSTRALIAN TEST CONDITIONS, AS SPECIFIED IN AS1761.

Preliminary Analysis:

The following tasks were performed:

- MEPS values converted to metric units for each unit category of equipment specified in the CAN standard;
- MEPS values adjusted for different climate class ambient temperatures specified under AS1761 test conditions.

The following are assumed to be the same in the Canadian and Australian tests:

- Evaporator temperatures (as specified in the CAN standard);
- Internal (storage) Temperatures (as specified in the CAN standard);
- Cabinet Types (as specified in the CAN standard);
- Temperature differential between the condenser and ambient air is 7^0C (different values can be modelled);
- Energy consumption by the compressor(s) account(s) for 60% of total energy consumed by the unit.

Methodology:

Ambient temperature adjustments for heat gain are based on the ratios between the internal to external temperature differentials, noting that internal temperatures are assumed to be the same for both countries. The heat gain loading is therefore:

(internal - ambient Can) / (internal - ambient Aus)

The COP changes from Can to Aus are based on an idealised carnot engine, where the COP under a particular condition is defined as:

(Tevap) / (Tcond – Tevap) (all temperatures are in K)

Where: Tevap = Evaporator temperature

Tcond = Condenser temperature

Therefore, the change in COP expected for the change in ambient temperature is estimated to be:

(Tcond Aus – Tevap) / (Tcond Can – Tevap)

noting that Tevap is the same for both cases and that temperatures are in degrees K.

Since 60% of energy consumed is due to the operation of the compressor, the ratio of energy consumed =

(0.6 x heat gain differential) / ((COP change) + (1 - 0.6))

The results are shown in the following table.

Table J1: Canadian Standards for Refrigerated display cabinets under Australian test conditions

AS1761 Climate	Climate 1	Climate 2	Climate 3	Climate 4	Climate 5	Climate 6
	MEPS	MEPS	MEPS	MEPS	MEPS	MEPS
C657-95 Product Categories	kWh/m/d	kWh/m/d	kWh/m/d	kWh/m/d	kWh/m/d	kWh/m/d
AS1761 Ambient Temp (^{0}C)	16	22	25	30	40	27
Class 1:	26.8	34.4	38.6	46.1	63.0	41.6
Class 1:	26.0	33.8	38.0	45.6	62.9	41.0
Class 2:	10.8	18.3	22.6	30.8	50.8	25.8
Class 2:	9.0	15.6	19.5	27.0	45.4	22.4
Class 3:	7.4	12.6	15.6	21.2	34.9	17.7
Class 3:	5.9	10.2	12.8	17.7	29.7	14.6
Class 4:	15.5	20.1	22.6	27.1	37.4	24.4
Class 4:	8.2	14.2	17.8	24.5	41.2	20.3
Class 5:	14.4	18.6	20.9	24.9	34.0	22.4
Class 5:	11.9	15.5	17.5	21.0	28.9	18.8
Class 6:	5.6	9.4	11.7	15.9	26.2	13.3
Class 6:	4.3	7.4	9.2	12.8	21.4	10.6
Class 7: narrow	5.9	10.0	12.4	16.9	27.8	14.1
Class 7: narrow	4.4	7.7	9.6	13.3	22.3	11.0

Class 7: medium	8.3	14.0	17.3	23.6	38.9	19.7
Class 7: medium	6.7	11.6	14.6	20.1	33.8	16.7
Class 7: wide	8.8	14.9	18.4	25.1	41.3	21.0
Class 7: wide	7.0	12.2	15.3	21.1	35.5	17.5
Class 8: coil	11.8	15.5	17.5	21.1	29.5	18.9
Class 8: coil	2.8	4.8	6.0	8.3	14.0	6.9
Class 8: gravity	3.0	5.1	6.4	8.7	14.3	7.3
Class 8: gravity	1.5	2.6	3.2	4.4	7.4	3.7