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NATIONAL APPLIANCE AND EQUIPMENT ENERGY EFFICIENCY PROGRAM

Minimum Energy Performance Standards

ICE MAKERS AND ICE STORAGE BINS

PREPARED FOR

THE AUSTRALIAN GREENHOUSE OFFICE UNDER
THE NATIONAL APPLIANCE & EQUIPMENT ENERGY
EFFICIENCY PROGRAM

Minimum Energy Performance Standards - Ice Makers and Ice Storage Bins

Ice makers and ice storage bins are widely used in hospitality and service industries, and the market for these products is steadily increasing. There are an estimated 45,000 to 50,000 ice makers, and 20,000 ice storage bins in commercial use in Australia today. Approximately 90% of ice makers are imported, while local manufacture comprises a higher proportion of ice storage bins – probably in the region of 50%.

Commercial ice makers consume approximately 250GWh of electricity every year, with small and medium sized ice makers responsible for almost 80% of this. This equates to an estimated 240 ktCO_2-e of greenhouse gas emissions in 2003, which does not include the effect of the extra load that ice makers place on air-conditioning systems. Given current sales growth rates, annual energy consumption by ice makers may reach 950GWh by 2020 without intervention.

There is significant variation in the energy consumed by ice makers in Australia. It is apparent that higher capacity ice makers tend to be more efficient than lower capacity machines, and that water-cooled models are more efficient that air-cooled ones. Ice storage bins are non-refrigerated and the great majority consume no power, however their effectiveness does influence the demand for ice.

The appropriate combination of ice maker and storage bin for specific applications also influences the overall efficiency of ice production.

With increased sales of more efficient models, and technical improvements in general refrigeration systems, it is feasible that ice maker energy consumption can be reduced by 15 – 20% with a 2 – 3 year payback. However there seems to be little market interest in or knowledge of these potential savings.

Given this lack of market incentive to improve product efficiency, and the significant growth rate predicted for ice makers and storage bins in Australia, NAEEEC considers the introduction of efficiency standards for ice makers a priority.

STAKEHOLDER COMMENT

NAEEEC invites comments from any interested person or organisation on the measures proposed in this study. Comments should be directed to energy.rating@greenhouse.gov.au by 31 December 2004. Information sessions for industry participants can be arranged during the comment period if requested.

Electronic copies of profiles and full reports released for public discussion can be obtained from www.energyrating.gov.au

INTERNATIONAL HARMONISATION

In keeping with Australian Government policy of matching world's best regulatory practice, NAEEEC plans to introduce energy performance requirements in ice maker standards which are equivalent to North America standards. NAEEEC has examined the regulations in Canada (which apply MEPS to ice makers and ice storage bins) and California (which has ice maker MEPS due for introduction in 2006). After consideration of these levels, Australia plans to adopt MEPS levels for ice makers equivalent to those proposed in California, and MEPS for ice storage bins equivalent to those in Canada.

Existing energy performance test methods for ice makers and ice storage bins are all technically equivalent, and generally based on ARI 810 (ice makers) and ARI 820 (ice storage bins), prepared by the Air-conditioning and Refrigeration Institute in the US. The ISO test method for ice makers and ice storage bins, which is currently in draft form, is also technically identical to ARI 810 and 820.

Ice makers consume varying amounts of water depending upon the design of the machine; so the introduction of energy performance regulations provides an opportunity to also promote water conservation. NAEEEC considers that the introduction of a water consumption labelling program would not be as effective as setting a level for the maximum amount of potable water consumed per unit of ice manufactured.

NAEEEC PLAN

NAEEEC proposes to introduce efficiency regulations for ice makers and ice storage bins, with key components as follows:

- minimum energy performance standards (MEPS) should be implemented for commercial ice makers with an ice harvest rate up to 2,500 kg/24hrs, applying to all new products sold from October 2006;
- ice maker MEPS should be equivalent to those due for implementation in California from 1/1/2006, as shown in the following table:

TABLE 1: PROPOSED AUSTRALIAN MEPS LEVELS FOR ICE MAKERS

Product class	Type	Ice harvest rate (kg/24 hrs)	Maximum energy consumption (kWh/45kg ice)
Ice making head	Air-cooled	< 200	10.26 - 0.0086H
		≥ 200	6.89 - 0.0011H
	Water-cooled	< 230	7.80 - 0.0055H
		≥ 230	5.58 - 0.0011H
Self-contained	Air-cooled	< 80	18.0 - 0.0469H
		≥ 80	9.80
	Water-cooled	< 90	11.40 - 0.0190H
		≥ 90	7.60
Remote condensing	Air-cooled	< 450	8.85 - 0.0038H
		≥ 450	5.10

- factory-made ice storage bins should also be regulated for heat loss by MEPS, as follows:

TABLE 2: PROPOSED AUSTRALIAN STORAGE EFFECTIVENESS RATINGS APPLYING TO ICE STORAGE BINS

Product class	Capacity (kg)	Minimum storage effectiveness (%)
Ice storage bins	less than 70	60
	70 to 99	70
	100 to 200	75
	greater than 200	80

- potable water consumption of ice makers should not exceed 22.5 litres/10 kg ice (27 gals/100 lbs), but no limits should be set for condenser water consumption;
- high efficiency levels should be set for promoting the best performing ice makers, as shown in Table 3, and consideration should be given to establishing a similar high efficiency category for ice storage bins once further data becomes available;

TABLE 3: PROPOSED AUSTRALIAN 'HIGH EFFICIENCY' LEVELS FOR ICE MAKERS

Product class	Type	Ice harvest rate (kg/24 hrs)	Maximum energy consumption (kWh/45kg ice)
Ice making head	Air-cooled	< 200	8.64 - 0.0086H
		≥ 200	4.96 - 0.0011H
	Water-cooled	< 220	7.04 - 0.0055H
		≥ 220	4.96 - 0.0011H
Self-contained	Air-cooled	< 75	16.00 - 0.0469H
		≥ 75	8.00
	Water-cooled	< 90	9.92 - 0.0190H
		≥ 90	6.56
Remote condensing	Air-cooled	< 450	8.22 - 0.0038H
		≥ 450	4.50

- An additional requirement for high efficiency products should be that potable water consumption will not exceed 12 litres/10 kg ice (15 gals/100 lbs) for all ice makers.
- 'High efficiency' levels should be used as the basis for stage 2 MEPS levels, proposed for introduction no later than October 2010.
- MEPS and high efficiency levels should be published in a new Australian Standard based on the ARI 810 and ARI 820 test methods. Once published, the Australian test methods should be proposed as the new ISO international test methods.

NAEEEC recommends the following timetable for the introduction of MEPS for ice makers and ice storage bins, which allows two years between release of the MEPS proposal and its implementation to ensure adequate market preparation.

TABLE 4: PROPOSED TIMETABLE FOR IMPLEMENTATION OF MEPS FOR ICE MAKERS

Item	Date
Consultation with Industry	Oct 2004 – April 2005
Publication of Draft Standard	Sept 2005
Regulatory Impact Statement	Sept 2005-April 2006
Implementation of MEPS	Oct 2006

IMPACT OF MEPS

With adoption of these proposed measures, it is estimated that annual energy consumption in 2020 should be reduced by 260 GWh, with a corresponding reduction in annual greenhouse emissions of 200 ktCO_2-e. The total cumulative savings in greenhouse gas emissions from 2006 – 2020 is estimated to be 1.2 MtCO_2-e.

NAEEEC MEMBERS

The Commonwealth, New Zealand, and all State and Territory governments are part of NAEEEC. Representatives are senior officials from various government agencies and statutory authorities or persons appointed to represent those bodies.

The *Australian Greenhouse Office (AGO)* is the Australian Government agency responsible for monitoring the National Greenhouse Strategy in cooperation with State and Territory Governments and with the support of local government, industry and the community. The AGO chairs NAEEEC and other members provide support for its activities.

The NSW *Ministry of Energy and Utilities* (incorporated within the Department of Energy, Utilities and Sustainability since 1 January 2004) provides policy advice to the NSW Government and operates a regulatory framework aimed at facilitating environmentally responsible appliance and equipment energy use. The Ministry is represented on the Energy Efficiency and Greenhouse Working Group, through which the appliance and equipment related elements of the National Greenhouse Strategy are being progressed.

The NSW *Sustainable Energy Development Authority* was established in February 1996 with a mission to reduce the level of greenhouse emissions in New South Wales by investing in the commercialisation and use of sustainable energy technologies.

The *Office of the Chief Electrical Inspector* is the Victorian technical regulator responsible for electrical safety and equipment efficiency. Its mission is to ensure the safety of electricity supply and use throughout the State. The corporate vision of the Office is to demonstrate national leadership in electrical safety matters and to improve the superior electrical safety record in Victoria. The Office's strategic focus is to ensure a high level of compliance is sustained by industry with equipment efficiency labelling and associated regulations.

The *Sustainable Energy Authority* was established in 2000 by the Victorian Government to provide a focus for sustainable energy in Victoria. The Authority's objective is to accelerate progress towards a sustainable energy future by bringing together the best available knowledge and expertise to stimulate innovation and provide Victorians with greater choice in how they can take action to significantly improve energy sustainability.

The *Electrical Safety Office*, Department of Industrial Relations, is the Queensland technical regulator responsible for electrical safety and appliance and equipment energy efficiency. The office ensures compliance with electrical safety and efficiency regulations throughout Queensland.

The *Department of Energy* is the lead agency with regard to sustainable development within the Queensland energy sector and is involved in a range of activities that reflect the importance of a sustainable approach. These activities involve developing and evaluating policies and initiatives through flexible and responsible decision making that allows economic, environmental and social outcomes from the energy sector to be maximised.

The Western Australian electricity regulator *Energy Safety* (a Division of the Department of Consumer and Employment Protection) is responsible for the technical and safety regulation of the electrical industry in WA. This includes the safety of consumers' electrical installations and appliances and the auditing of appliances and equipment to check compliance with energy efficiency and prescribed safety requirements.

The Western Australian *Sustainable Energy Development Office* promotes more efficient energy use and increased use of renewable energy to help reduce greenhouse gas emissions and increase jobs in related industries.

The *Office of the Technical Regulator* seeks to ensure the coordinated development and implementation of policies and regulatory responsibilities for the safe, efficient and responsible provision and use of energy for the benefit of the South Australian community.

The Tasmanian Government's interest is managed by the Department of Infrastructure, Energy and Resources' *Office of Energy, Planning and Conservation (OEPC)*. The OEPC provides policy advice on energy related matters including energy efficiency. Its web site is www.dier.tas.gov.au/energy/indext.html.

Electricity Standards and Safety is the technical regulator responsible for electrical safety throughout Tasmania. Regulatory responsibilities include electrical licensing, appliance approval and equipment energy efficiency.

The Australian Capital Territory's interest is managed by the *Energy Policy Unit, Economic Management Branch*, Department of Treasury. The primary function of this Unit is to provide the ACT Government with advice on National and Territory energy related matters including energy efficiency.

The *Department of Infrastructure, Planning and Environment* is responsible for the administration of regulations in the Northern Territory regarding various aspects of safety, performance and licensing for goods and services including electrical appliances.

The *Energy Efficiency and Conservation Authority (EECA)* is the principal body responsible for delivering New Zealand's National Energy Efficiency and Conservation Strategy (NEECS). EECA's function is to encourage, promote and support energy efficiency, energy conservation and the use of renewable energy sources.

Analysis of Potential for Minimum Energy Performance Standards

Ice Makers and Ice Storage Bins

Prepared for

The Australian Greenhouse Office and NAEEEC under the National Appliance & Equipment Energy Efficiency Program

By

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Final Draft Report

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1. Introduction

This report was commissioned by the National Appliance and Equipment Energy Efficiency Committee (NAEEEC) to explore the potential for energy and greenhouse savings through improvements to ice makers and ice storage bins in Australia.

NAEEEC is the administering body for the National Appliance and Equipment Energy Efficiency Program (NAEEEP) which comprises representatives from the following government agencies:

- State and Territory regulatory agencies responsible for administering the mandatory energy efficiency labeling and performance standards called into legislation in their respective jurisdictions; and
- Commonwealth, State and New Zealand agencies with a mandate to encourage sustainable energy use and reduce greenhouse gas emissions.

NAEEEC reports to the Ministerial Council on Energy (MCE) through the Energy Efficiency and Greenhouse Gas Working Group. The NAEEEC is administered by the Australian Greenhouse Office.

The activities of NAEEEP flow from the requirements in the National Greenhouse Strategy (NGS 1998) to improve the energy efficiency of energy-consuming household appliances, and industrial and commercial equipment.

In 2001 the Australian Greenhouse Office flagged its intentions to introduce MEPS for commercial refrigeration equipment, with the publication of the following reports:

- *Minimum Energy Performance Standards for Remote Commercial Refrigeration*, the plan by the National Appliance and Equipment Energy Efficiency Committee, March 2001;
- *Minimum Energy Performance Standards for Self-Contained Commercial Refrigeration*, the plan by the National Appliance and Equipment Energy Efficiency Committee, March 2001.

In the latter report, the AGO proposed to match the MEPS levels contained in the Canadian standard for ice makers and ice storage bins.

A subsequent discussion paper: *Minimum Energy Performance Standards for Ice Makers and Ice Storage Bins – Self-contained* [MEA 2001] highlighted the fact that ice makers and ice storage bins are specifically excluded from the Australian standard for commercial refrigeration products (AS 1731-2000). It also reported that international standards treat ice makers independently from other commercial refrigeration products.

The purpose of the 2001 discussion paper was to further examine the test methods and standards applicable to ice makers and ice storage bins, and recommend options for the setting of appropriate MEPS. At that time, the best available efficiency levels for ice makers and ice storage bins were set out in the Canadian standard. It was noted however that most Australian models were likely to comfortably meet these MEPS levels, and there could be a case for introducing more stringent MEPS.

The objective of this document is to further advance the MEPS process for these products, and provide updated information relating to ice makers and ice storage bins in Australia, in order to facilitate informed decision-making. Key information presented herein includes:

- current ice maker and ice storage bin technology;
- current market and stock figures, as well as an assessment of market trends;
- international standards applicable to ice makers and ice storage bins;
- energy consumption figures for ice makers;
- analysis of the potential to reduce energy consumption and greenhouse emissions;
- recommendations for setting efficiency levels.

2. Product Description

2.1 GENERAL DESCRIPTION

Commercial ice makers produce bulk quantities of ice for use in the hospitality industry (hotels, restaurants, etc), fresh food industries, hospitals and other industries. The major components of ice makers include the 'ice making head' which is the unit designed to manufacture ice, and the 'storage bin' where ice is held for further use. Ice makers which store ice in an integral storage bin are known as 'self-contained' ice makers, while those which use a separate storage bin are known as 'modular' ice makers.

Ice makers may further be categorized as either water or air-cooled depending upon the method used to cool the units' condenser. In addition, the ice making head may be defined according to whether it produces ice in a 'continuous' or a 'batch' process. These technologies are explained in more detail in Section 2.3. The ice making process is typically aligned to the type of ice produced, as discussed in Section 2.1.2.

In this report the term 'ice maker' will be used to refer to any unit incorporating the ice making head (including self-contained ice makers), and 'ice storage bin' will refer to the separate ice storage bins used in conjunction with modular ice makers.

2.1.1 ICE MAKERS

Ice makers are usually rated according to their capacity, or ice output per 24 hours (kg/day or lbs/day), which is determined at specific inlet water and ambient air temperatures. There is currently no universally adopted test method, and the capacity of ice makers can be rated under different test conditions, meaning that results may not be directly comparable.

Ice makers come in many sizes, ranging from small, self-contained units producing less than 20kg of ice per day, to modular units producing from 100 kg to more than 2 tonnes/day. Industrial 'flakers' (ice makers producing flaked ice) are available in Australia which produce up to 10 tonnes of ice per day, and even larger capacity machines are used overseas (e.g. 45 tonne). However the majority of ice machines sold in Australia have a capacity of no more than half a tonne. Machines producing more than half a tonne are generally for more specialized purposes.

As discussed above, the most common ice maker configurations are as follows.

Self-contained ice makers

These are all-in-one units, with the ice making head delivering ice into an integral storage bin or dispenser. They may be free-standing, benchtop or under-bench devices, and are generally smaller capacity (under 100 kg/day).

Note that the NAEEEC has previously used the term 'self-contained' to refer to refrigerated cabinets with integral components which are designed to plug into an available electricity supply [NAEEEC 2001]. While all ice makers in this report are considered to be self-contained in this more general sense, for the purposes of this report 'self-contained' will be used more specifically to refer to the all-in-one units described above.

Modular ice makers

These units consist only of an ice making head and require a separate ice storage bin or dispenser. The ice making head is generally supplied as a single unit, however remote (or split-system) models are also available where the condenser can be located separately from the ice making module.

- *ice making head units*: the ice making head (containing the ice making mechanism and condenser) comes as an individual unit which is usually mounted on top of a separate ice storage bin (different size bins can be used interchangeably). Ice falls from the ice maker through a hole in the top of the storage bin or dispenser. These units are generally medium to large capacity (50 kg to over 1 tonne per day). Individual ice makers can be stacked on top of each other, with ice falling straight through stacked units to the storage bin underneath.
- *remote condensing units*: heat or noise producing components such as the condenser, compressor and/or fan motor are placed in a separate location (such as the rooftop). As with ice

making head units, the ice making mechanism generally sits on top of the storage bin. They are generally medium to large capacity (over 300 kg/day). Although remote units tend to be more expensive, this cost may be offset by savings in building air conditioning energy use in the longer term (where the ice maker is located in an air-conditioned building).

There are also some compressed nugget ice maker models which have the ice making head situated remotely from the storage bin or dispenser. These units dispense ice into a long tube connected to the bin or ice dispenser, and have the advantage of removing the noise and heat producing components of the ice maker from the customer area.

2.1.2 ICE TYPES

Ice makers produce ice in a variety of shapes:

- *cubed*: clear pieces of ice of uniform shape and weight, with minimal liquid water content (shapes include cubic, rectangular, crescent, pillow and lentil-shaped). Ice shapes tend to vary with manufacturers because of differently shaped grids and indentations on the evaporator plate;
- *crushed*: rough fragments of ice produced by crushing larger ice chunks;
- *flaked/snow ice*: fine flakes or chips of soft, slushy ice (containing up to 20% liquid water). Flaked ice can be compressed into irregularly shaped chips (chiplets), or nuggets (see below);
- *nuggets*: nugget-shaped pieces of ice formed by extruding and freezing flake ice, ranging in form from an opaque, semi-hard nugget to a semi-clear, hardened (compressed) nugget.

Cubed ice makers are the most common in use, and make ice using 'batch process' technology. Crushed ice is also produced by this technology. Flake / snow ice and nugget ice are made using 'continuous process' technology.

2.1.3 ICE STORAGE BINS

The term ice storage bins refers to a range of free-standing ice storage devices which are insulated, non-refrigerated receptacles used for storing the ice produced by ice making equipment. These range from simple insulated storage boxes to more sophisticated ice dispensing and bagging bins.

These types of products may include mechanical dispensers and ancillary equipment such as automatic bagging facilities which consume power.

Ice merchandisers, used for the holding and/or display of bagged ice for sale, are considered commercial refrigerated cabinets and are therefore included in the scope of the series of Australian Standards AS1731-2003. These are therefore not considered further in this report.

The capacity of ice storage bins refers to the maximum storage weight (kg or lbs of ice) of the bin. Because the term 'capacity' has a different meaning for ice makers (kg/day output), discussion of ice storage bins will use the term 'storage capacity' to avoid confusion.

Ice bins are generally insulated with polyurethane (non-CFC and other types), and stored ice may last in the bins for days or even weeks (depending on the type of ice stored), with water draining from the machine as the ice melts.

Construction materials vary, with stainless steel exteriors and stainless steel or polyethylene liners being the most durable because they are non-corroding and non-contaminating. Other materials used for the exterior include plastic, painted steel and aluminium.

Storage bins generally have bin adaptors which can be changed to suit the model of ice maker mounted on top. These adaptor lids are mostly made from stainless steel or plastic.

In machines where ice is removed manually, the design of the access door is important. Variations include doors with rounded edges (to avoid user injury) and doors which lock open (for easy access) or have a multi-latch system (allowing the door to open to varying degrees). Access doors are commonly constructed of stainless steel or polyethylene.

Other design features include 'gates' to control ice flow and internal ice scoop holders.

Ice storage bin types are summarized as follows.

Top access bins

These are small to medium ice storage capacity bins (50 kg to 450 kg) with an access door at the top of the front panel from which ice is removed manually. The access door is usually sloped, so these bins are often referred to as 'slope front bins'.

These bins have a number of drawbacks, the most significant being that ice is deposited and removed from the top, meaning that stale ice accumulates in the bottom. These designs have a limited storage capacity because the access door cannot be sited beyond easy reach of the average adult.

Bottom access bins

Bottom access storage bins are a more sophisticated version of the top access ice storage bin. With a storage capacity ranging from 200 kg to over 2 tonnes, these units have an access door on the bottom of the front panel, therefore the bin can be much higher and still allow easy access when collecting ice. Larger models often have twin access doors.

Apart from improved storage capacity, these bins allow the oldest ice to be collected first and this ensures steady turnover and aeration of the ice. The main drawback of these bins is that the ice still needs to be removed manually.

Gravity-fed dispensing bins

These are elevated storage bins with a gravity-fed chute either at the base or bottom front panel of the bin. When a gate is opened, ice drops through the chute and dispenses directly into a specially designed ice storage cart (which fits underneath the bin) or other suitable receptacle. Storage capacity ranges from 200 kg to over 2 tonnes. Some models can be hooked up with an ice bagging device.

The advantage of these units, like other bottom access bins, is that ice turnover and aeration is good. Another advantage of these units is that ice dispenses efficiently and rapidly into an ice transport receptacle without the need for manual scooping or physical contact with the ice, reducing the chance of contamination. Furthermore, if the ice is dispensed into an ice storage cart, the ice can be wheeled to where the ice is required.

Mechanical dispensing bins

These are elevated bins similar to gravity-fed dispensing bins, however ice is dispensed mechanically from a front chute with the use of internal agitators and augers. Storage capacity ranges from under 100 kg to over 2 tonnes.

These bins deliver all the advantages of gravity-fed dispensing bins, as well as dispensing ice at a rapid rate. Mechanical dispensing bins are therefore ideal for ice bagging applications, and can be purchased with automatic bagging accessories which deliver bagged ice at rates of up to 10 bags per minute.

Models come with a range of features including an automatic agitation cycle to keep the ice loosened, and button, foot-pedal or coin activated operation.

2.1.4 ICE AND ICE/DRINK DISPENSING MACHINES

Ice and ice/drink dispensing machines are units which include an ice dispenser and often a water or beverage dispenser. They dispense cubed, crushed, flaked or nugget ice.

Units with an ice dispensing function only (most frequently small capacity, self-contained machines) differ from other ice machines only in that they have a simple ice dispensing action. Ice stored in the machine is dispensed in defined quantities by an actuating mechanism such as a lever.

Ice and drink dispensing machines are units which include an ice dispenser and a water or beverage dispenser. They are more complicated in function than ice dispensing units, and are discussed in more detail in Section 2.3.

Some domestic refrigerators have self-contained ice or ice/water dispensers, however these domestic ice makers are not within the scope of this document.

2.2 APPLICATIONS

The type of ice maker used depends not only on the quantity of ice required, but also the type of ice needed for the application.

Small capacity machines are commonly used in cafes, hotels/bars and food courts. These are generally self-contained free-standing, benchtop or under-bench units, and may have a small storage basket or bin with access door, or dispense ice or ice and beverages automatically.

Medium to large capacity machines are used in larger hotels, hospitals, supermarkets, fast food chain outlets and similar. These are generally modular units teamed with ice storage bins of varying size depending on demand. For example, businesses with slow turnover between mealtimes may choose a lower capacity ice maker with a larger storage bin, while other establishments with constant high demand for ice will need a higher capacity ice maker paired with a medium to large capacity storage bin depending on total volumes required. Irregular turnover (ie. slower on weekdays and heavy on weekends) can be managed by stacking several smaller ice makers on top of a storage bin, so individual ice makers can be turned off when not required.

The highest capacity machines are modular units used for large-scale industries, particularly food service and hospitality industries. Large volume ice cubers (up to 2 tonnes/day) are used for example in large hotels and small to medium size ice works. Very large volume flakers (up to 10 tonnes/day) are used for example by fishing co-operatives to supply fishing vessels.

Furthermore, larger establishments are likely to have a range of sized ice makers situated throughout their premises. For example hospitals often have one or more ice makers on each floor (usually smaller units), and larger capacity machines in other areas such as the kitchen.

Ice makers producing ice for consumption are usually sealed, sanitary units which minimize contamination. Where sanitation is of paramount importance (e.g. in hospitals), dispensing machines are used to avoid unnecessary contact with the ice.

As described in Section 2.1.2, there are different types of ice with varying characteristics depending on the applications they are used for. The main ice properties which influence customer choice are clarity, hardness, size, shape, melting/cooling speed and liquid displacement. Ice types are discussed in more detail below. The technology used for making different ice types is explained in Section 2.3.

2.2.1 CUBE ICE

Cube ice is the most popular type of ice because it is clear with a standard shape and size. It is used in many applications including the hospitality industry (hotels, cafés, restaurants), the fast-food industry, fresh food industries and hospitals. Cube ice is considered to be high-quality ice because it contains few impurities and minimal trapped air, making it harder, colder and slower melting than other types of ice. Cube ice is popular in bars because its clarity enhances the appearance of alcoholic drinks, and also because of its high displacement value (the cubes pack closely together, taking up maximum volume and making the drink appear larger than it is).

2.2.2 FLAKE ICE

Flake or snow ice is popular for packing or displaying perishable items because it is soft, easily molded and doesn't have rough edges which could bruise fresh produce. The high liquid water content of flake ice keeps fresh food hydrated, while it is cold enough to keep food cool without over-chilling it. Consequently, this type of ice is preferred for use in fresh food applications (supermarkets, greengrocers and fish markets). It is also used for industrial and scientific purposes (for example test tubes can sit firmly in flake ice without spilling).

2.2.3 CRUSHED AND NUGGET ICE

Crushed and nugget ice are used primarily for cooling drinks, for example in fast food store beverage dispensers. Nugget ice is substantially cheaper to make than cubed and crushed ice, and is often chosen in applications where appearance and displacement value are less important (for example the 'filler' characteristics of cube ice are less important when serving cheaper beverages).

Nugget ice has higher liquid water content than cube ice, and melts more quickly. Compressed nugget ice however has high cooling capacity and melts slowly, giving it some of the qualities of cube ice at a more affordable price. Nugget and compressed nugget ice are also easier to chew than cube ice because of their higher air and liquid water content. Nugget ice machines are often preferred by hospitals because this ‘chewability’ makes the ice more suitable for patients, and also because of the quieter operation of the machines.

2.3 TECHNICAL DESCRIPTION

2.3.1 ICE MAKING

The ice making process is similar for all ice makers, incorporating a refrigeration and water circulation system. However ice maker designs vary depending on the type of ice produced.

All ice makers use a conventional refrigeration system consisting of a compressor, a condenser and an evaporator:

- An electric motor drives the compressor, which compresses and therefore heats the refrigerant gas, then forces the hot gas through the narrow coiled tubing of the condenser. The gas condenses into a liquid, releasing heat into the surrounding air which is removed by either an air or water-cooling process.
- Liquid refrigerant from the condenser is piped to the evaporator, which comprises a series of heat-exchanging tubes mounted next to the ice making surface. When the refrigerant passes through the expansion valve in the evaporator, the liquid expands to become a gas, drawing in heat from the metal pipes and adjacent ice making surfaces.
- The vaporized gas then returns to the condenser and the cycle begins again.

Effective cooling of the condenser is critical to the efficient performance of the refrigeration system as a whole. Heat from the condenser is either dissipated into the surrounding environment (air-cooled), or is removed by a water-cooling process (water-cooled).

- **Air-cooled condensers** use fans to force air over the condenser tubes, and are suitable for ice makers used in locations with good ventilation and fairly cool ambient air temperature. To increase ventilation, condensers may be located on rooftops or other external positions, away from the ice making mechanism itself. The great majority of remote condensing units are air-cooled.
- In warmer or more confined conditions, **water-cooled condensers** are usually more suitable. They use an evaporative water process to cool the condenser. However this additional use of significant quantities of water will result in higher running costs and raises resource issues.

The majority of ice makers have integral air-cooled condensers, while some have integral water-cooled condensers or remote air-cooled condensers.

There are two main ice making technologies, batch processing (where ice is frozen and harvested in batches) and continuous processing (where fine snow-like ice is produced continuously). These processes are used in both self-contained and modular ice makers.

Batch processing ice makers

Batch processing ice makers have a water circulation system consisting of a water supply inlet, a water pump, a sump and a water purge drain:

- Water from the sump (where water collects at the base of the machine) is pumped in a stream over the chilled ice-making surfaces and ice begins to form. As the cooled water re-circulates, ice forms layer by layer on the ice making surface;
- After either the ice reaches a certain weight, or a set period of time has passed, a solenoid valve is triggered to initiate harvesting of the ice. This valve re-routes the hot gas from the condenser through the evaporator, rapidly heating the tubes and partially melting the surface of the ice, which falls away and is collected underneath;
- At the end of the ice making cycle, the system is refilled with fresh water (sometimes after a purge process) and the process begins again.

Fresh water flushing is common but not universal after each cycle. During the ice making process impurities become increasingly concentrated in the recycled water and regular flushing reduces the build up of lime and other impurities, increasing the lifetime of the ice maker.

Batch process ice makers produce cubed and crushed ice, however the technologies used for making each of these vary slightly.

- The simplest cubed ice makers have a large metal ice tray mounted vertically next to the evaporator. Water either runs over, or is sprayed onto, the chilled tray. Layers of ice build up gradually in the wells of the tray until cubes of the desired size are formed. The ice tray often has slanted cube cavities, so during harvesting the ice cubes slide out easily into a collection bin. There are variations on the evaporator tray design, for example the tray may also be mounted horizontally and water sprayed up against the tray.
- In crushed ice makers, the evaporator coils are inside of a large metal cylinder with water running over it. Ice gradually builds up where the water runs over the outside and inside surfaces of the cylinder, forming a large column of ice. When the cylinder is heated for harvesting the ice column falls into an ice crusher below. Ice crusher designs vary, and can produce crushed ice in larger, irregular chunks (crushed ice) through to finely crushed (flake-style) ice. Some machines also extrude finely crushed ice into nuggets.

Batched ice makers tend to be more noisy than continuous process ice makers in operation.

Continuous processing ice makers

Continuous processing is used for making very finely flaked (or snow) ice and nugget ice. In these machines, the evaporator tubing is generally wrapped around a metal barrel with water running over the inside surface. Ice forming on the inside walls is harvested continuously by a slowly rotating auger which scrapes the ice off and moves it to the top of the evaporator barrel. Designs vary, for example another design forms ice by running water over the outside surface of the evaporator cylinder, and an auger flakes ice from this surface and drops it into a holder.

Flake (and nugget) ice has a relatively high liquid water content, which is not always desirable. Some models squeeze water from the ice as it leaves the evaporator by passing it through an extruder, producing hard, dry flakes or nuggets. Other machines further remove excess water by compressing the extruded ice into hardened nuggets or chiplets.

Continuous process ice makers have a water circulation system with a water inlet valve, a sump, a water float and a pump. Inlet water runs into the sump and a water float closes the inlet water valve when the sump is full. Water is circulated over the evaporator surfaces by the water pump, and excess water drains back into the sump and is re-circulated.

These ice makers are quieter and typically use much less power than batch process machines.

2.3.2 ICE/DRINK DISPENSERS

Ice/drink dispensers are either self-contained or modular ice makers which include an ice and a drink dispensing mechanism. Ice and/or drinks are dispensed using an actuating device such as a lever, button or coin. The dispensing area includes a drain grill to contain spillages.

Simpler machines may dispense unchilled water and ice, while more complicated machines may dispense ten or more chilled ‘post-mix’ soft drinks with ice.

Ice/beverage dispensers

These so-called ‘post mix’ devices dispense ice and beverages on demand. Ice from the ice maker falls into a storage dispenser from which ice is delivered through one or more chutes. Syrup and carbonated or still water are dispensed through separate valves according to a pre-set ratio (hence ‘post-mix’).

The smallest machines have 4 valves and are usually self-contained benchtop or under-bench units, while larger machines such as those used in large fast-food outlets dispense through 20 or more valves. Some models (usually smaller and/or older) are filled manually with ice, however larger models generally have an automatic ice making function. These large machines may have a remote ice making unit or a top-mounted ice making head.

Ice/beverage dispensers have an additional energy load because the beverage lines must be cooled to deliver chilled drinks. This is accomplished either by a separate cooling system, or an integral cooling system using ice from the storage dispenser. While these latter devices tend to be cheaper, they use as much as half of the stored ice to cool the lines.

Ice/water dispensers

These are similar to ice/beverage dispensers except they dispense water instead of flavoured drinks. Most machines dispense water at room temperature together with ice, however some dispense chilled water and/or ice separately as required. They may have an integral or separate ice making mechanism, and come in a variety of configurations including benchtop, under-bench and free-standing models. Most ice and water dispensers produce nugget or compressed nugget ice. Units are available which store as little as 4 kg of ice, ranging through to about 300 kg.

Ice and water dispensers are popularly used in healthcare applications such as hospitals because there is no human contact with the ice between production and dispensing, reducing possible contamination. Also nugget ice is preferred in these applications because it is easy to chew but still has good cooling qualities.

2.3.3 OTHER ICE MAKER FEATURES

Water assisted ice harvesting

Some batch processing ice maker models use the heat of the incoming water supply to assist in the ice harvesting process. By using the inlet water at ambient temperatures to release the ice, the incoming water is slightly chilled in the process, requiring less subsequent chilling during the ice making cycle.

Water treatment

While ice makers generally operate from mains water supply, in some cases where the local water supply has a high concentration of chemicals, extra water filtration may be required. Some ice maker models designed to produce extra pure ice may filter mains water regardless of chemical content.

Cleaning

All ice makers must be periodically cleaned to remove built-up deposits and/or sediment. This typically involves emptying the machine of water/ice and circulating a cleaning solution by switching the controls to a cleaning mode. The ice maker must then make sufficient ice to remove the cleaning solution from the system. Some newer models of ice makers have an automated self-cleaning function making manual cleaning unnecessary.

3. Market Profile

3.1 SALES AND STOCK

Industry sources estimate that annual sales of commercial ice makers are in the range of 4,500 to 5,000 units. Of these, around 70-80% are self-contained models configured as either under-bench, benchtop or free-standing. The majority of modular units comprise ice making head models sold for use with a dispenser into the fast food industry.

For the purpose of this report, ice-makers have been classified as large, medium and small. The following table shows the definition and estimated market share of each category.

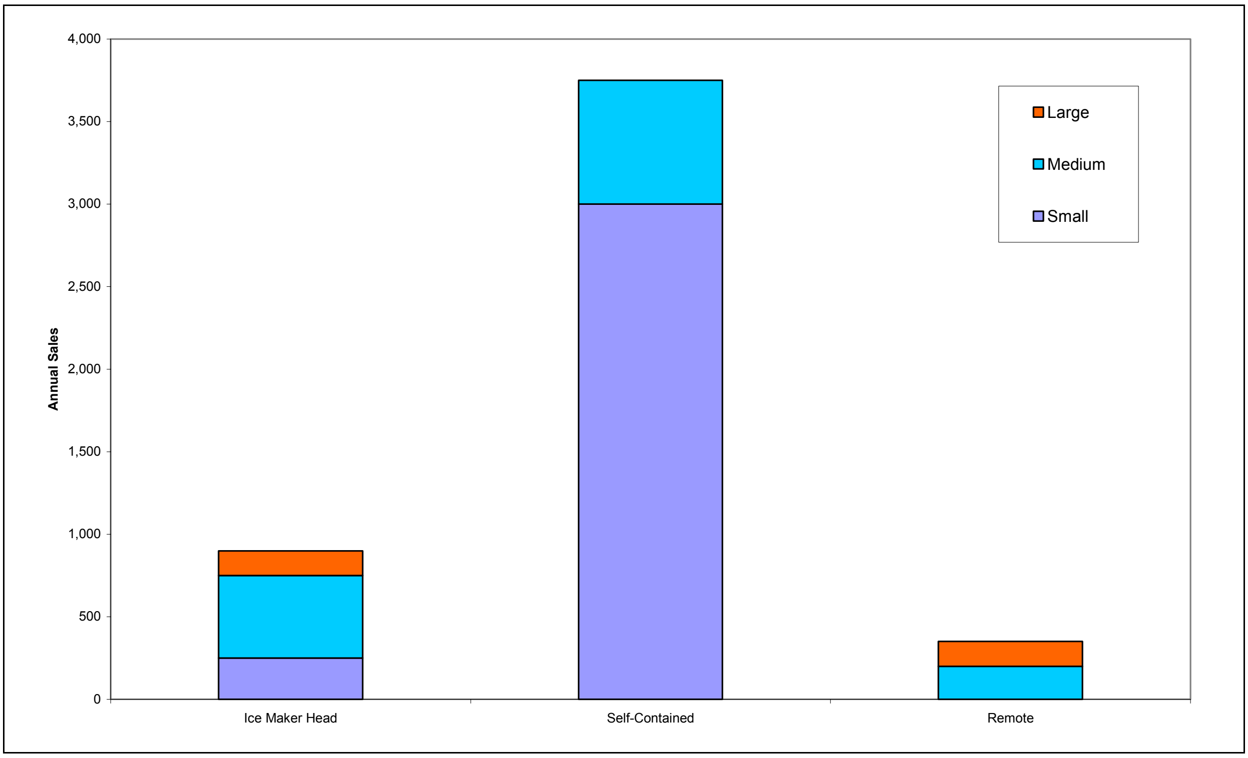
Table 1: Categories of ice-makers and estimated market share, Australia 2003

Size	Definition (ice harvest rate)	Market Share
Small	< 150 kg ice/24hrs	65%
Medium	150 to 400 kg ice/24hrs	29%
Large	> 400 kg ice/24hrs	6%
Total		100%

The estimated breakdown of ice maker sales in Australia, by type and size is shown in Figure 1.

Given that the average lifetime of units is around 10 years, it is likely that the total stock of ice makers in Australia is around 45,000 – 50,000 units and it is assumed that the breakdown of the stock is similar to that of the sales profile.

Figure 1: Estimated annual sales of ice-makers by type and size, Australia 2003



Annual sales of ice storage bins are estimated to be in the range of 1,300 – 1,500 units. These generally have a longer life than ice-makers and the stock is estimated to be approximately 20,000 units.

3.2 MARKET TRENDS

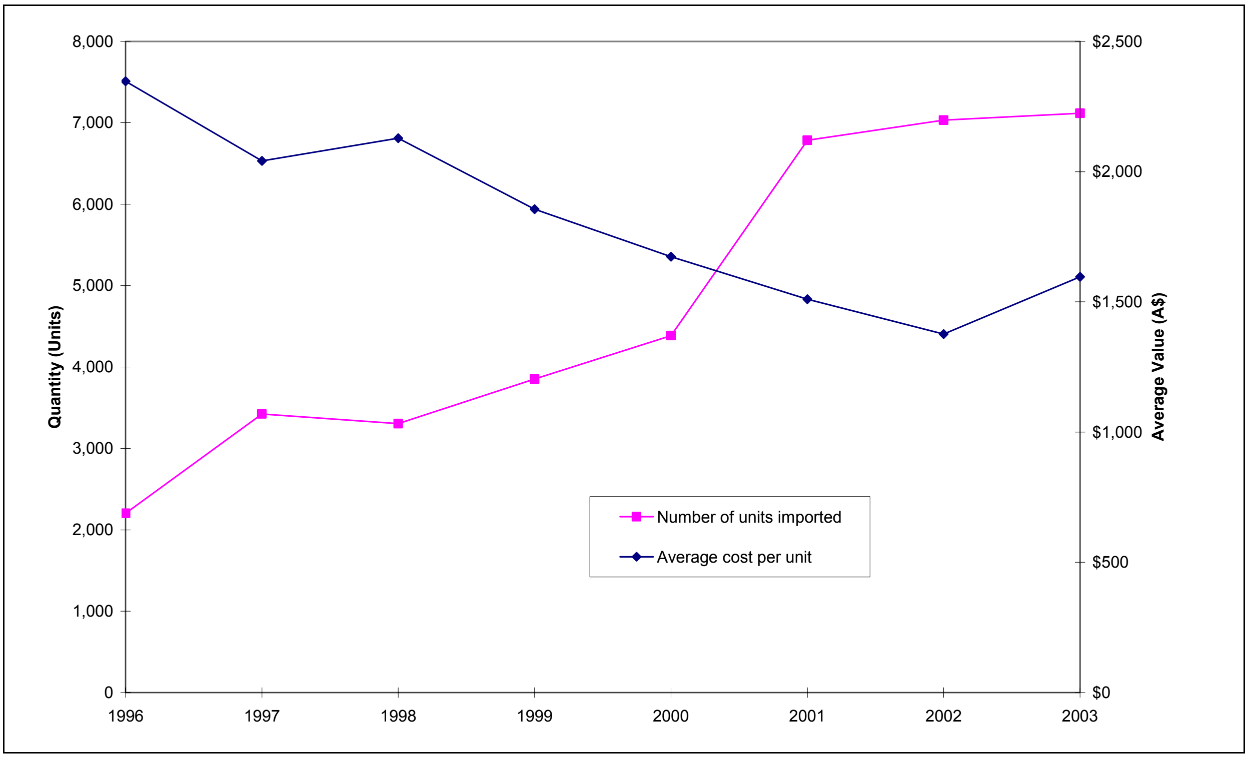
Industry currently estimates that 90% of ice makers are imported into Australia. ABS data suggest total imports in 2003 of over 7,000 ice makers. However this figure includes domestic ice-making machines such as those incorporated into some refrigerators, and therefore exaggerates products for the commercial market. It is not unreasonable for products intended for the domestic market to comprise 2,000 – 2,500 of this total, indicating that above industry estimates are accurate. It is also possible that some smaller ice-makers have not been included in the industry estimates.

Figure 2 shows the total number of ice-making machines imported since 1996, and their average unit value.

ABS data reveals that the total number of units imported doubled between 1996 and 2000, and there has been a 62% increase in the 3 years since then. Clearly a proportion of this growth is due to the influx of products for the domestic market, and the fall in average unit costs supports this, however industry has reported steady growth in the commercial market.

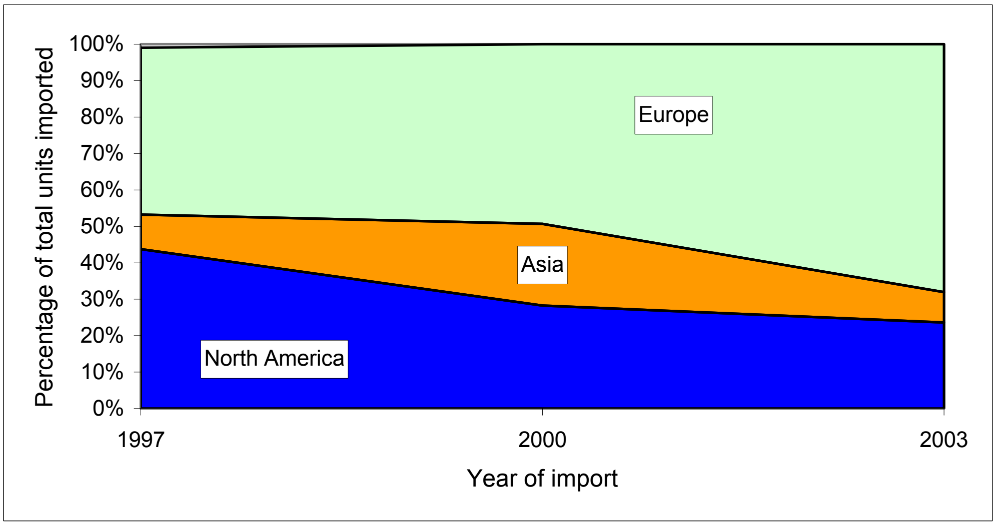
The estimated annual market growth of around 10% appears to be largely driven by demand from fast food outlets, and similar food and beverage suppliers.

Figure 2: Comparison of ABS statistics for ice-making machine imports (number imported vs average unit value [ABS 2004]



As shown in Figure 3, the proportion of ice makers imported from Europe has grown substantially since 1997; primarily from Italy and Germany (although it is thought that some of the products from Germany are domestic models). Europe has also provided a source of very low volume but large capacity machines to Australia.

Figure 3: Analysis of ABS ice-making machine import figures by region of origin



While approximately 90% of ice makers are imported, ice storage bins however are more likely to be manufactured in Australia. Storage bins are relatively simple, bulky objects and are therefore expensive to transport relative to their overall cost, particularly when they can be easily manufactured locally or sourced from independent manufacturers providing the bin only. It is estimated that approximately 50% of ice storage bins are manufactured in Australia. Those storage bins which are imported may be imported in a dismantled state and assembled locally.

3.2.1 INDUSTRY PROFILE

The majority of the Australian market is supplied by a relatively small number of companies, comprising either local manufacturers or distributors of imported products. The following table identifies the major players in the Australian market and the range of products that each supply.

Table 2: Major Australian importers, distributors and manufacturers of ice makers and ice storage bins

Company name	Brand	Type of ice maker	Approx size range
Frostline (importers and national distributors)	Hoshizaki	Predominantly self-contained. Sell cube, cubelet, crescent, top hat and flake ice machines.	22 ice maker models (23 – 600 kg capacity). Some industrial models over 3 tonnes.
Ice Master Systems (Australian importer and distributor)	Brema Ice Makers	Predominantly self-contained. Sell cube, flat cube, hollow cube, granular and flake machines.	27 ice maker models (21 – 1000 kg capacity); 8 storage bin models (120 - 400 kg ice storage capacity).
Ice Technologies Aust / Coast Distributors (Australian distributors)	Ice-O-Matic	Sell cube and flake ice machines; dispensers.	33 ice maker models (30 – 1200 kg capacity); 10 storage bin models (70 - 850 kg ice storage capacity).
IMI Cornelius (importers and national distributors)	Cornelius	Predominantly self-contained. Sell cube, flake and chunklet machines; dispensers.	48 ice maker models (18 - 500 kg capacity); 11 storage bin models (55 – 600 kg ice storage capacity).
Orford Refrigeration (importers and national distributors)	Manitowoc	Predominantly modular cube ice machines. Sell cube and flake machines, dispensers.	35 ice maker models (15 - 700 kg); 11 storage bin models (5 Manitowoc, 6 Orford brand; 68 - 345 kg ice storage capacity).
Scots Ice Australia (importers and national distributors)	Scotsman	Predominantly self-contained. Sell cube and flake machines; dispensers.	38 ice maker models (23 – 2300 kg capacity); 9 storage bin models (100 – 1500 kg ice storage capacity).
Stuart Manufacturing (Australian manufacturer and distributor/exporter)	Stuart Ice	Predominantly modular machines. Sell cube and flake machines, including large industrial flakers.	16 ice maker models (20 – 2000 kg capacity); industrial flaker machines up to 10 tonne capacity in Australia, and 45 tonne overseas); 13 models with optional storage bin (100 – 750 kg ice storage capacity).

4. Energy Consumption and Greenhouse Gas Emissions of Ice Makers

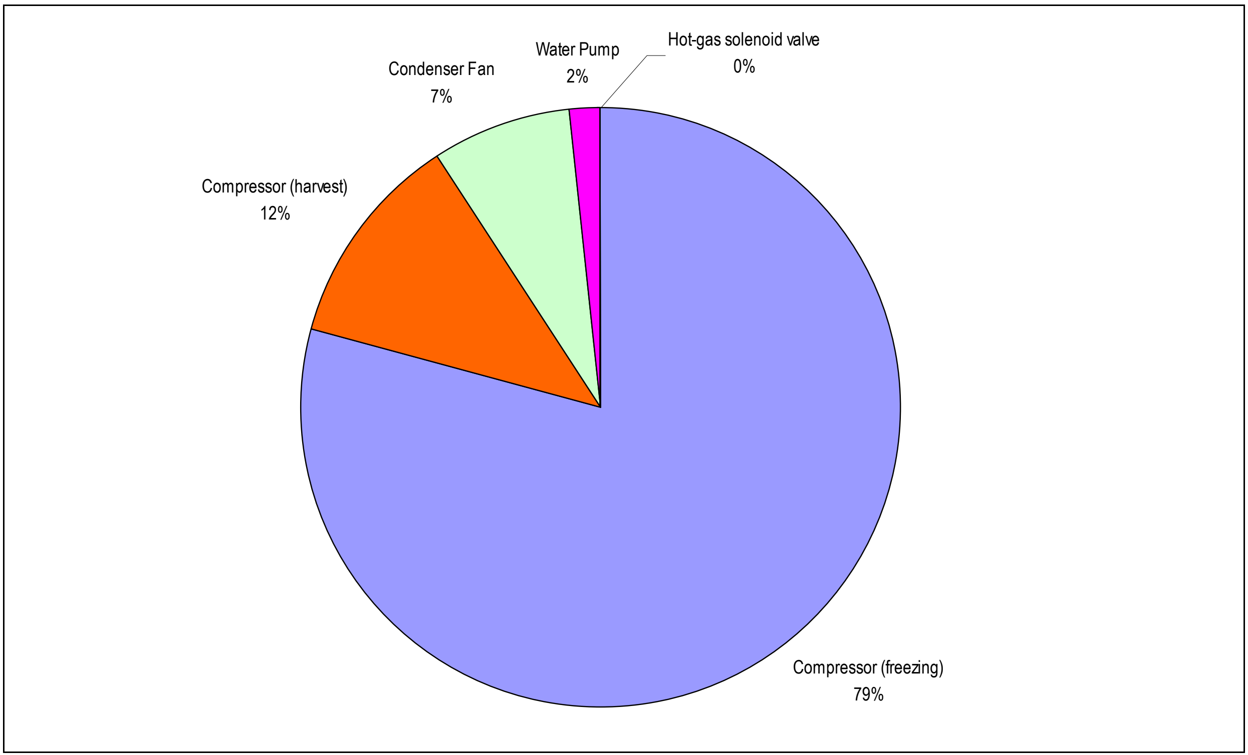
4.1 ENERGY CONSUMPTION ISSUES

4.1.1 ICE MAKERS

The following information and observations are based primarily, but not exclusively, on data published by ARI, the Air-conditioning and Refrigeration Institute in the United States (see Appendix 1). The ARI 2004 listing comprises the results of tests on over 449 ice-makers (and ice storage bins) conducted according to the test standard ARI 810 (see Section 6.3). Information provided for each model includes the ice harvest rate, the rate of energy consumption, the potable water consumption and, where relevant, the condenser water consumption.

The compressor is the component in ice makers responsible for by far the greatest proportion of energy consumption. Figure 4 shows the breakdown of consumption in a typical ice maker, where the energy used by the compressor comprises 90% of total energy used.

Figure 4: Typical distribution of energy consumption with ice makers by component



The following general points can be made in relation to the following figures concerning different types of ice makers (Figure 5 to Figure 7):

- Energy consumption increases significantly at low ice harvest rates for all types of ice makers;
- Air-cooled ice makers use the most energy—about 5.4 to 22.5 kWh per 45 kg (100lb) of ice;
- Water-cooled models are more efficient than air-cooled units, using 4.7 to 14.2 kWh per 45 lb (100lb) of ice.

Figure 5: Ice making head unit, water and air-cooled [ARI 2004]

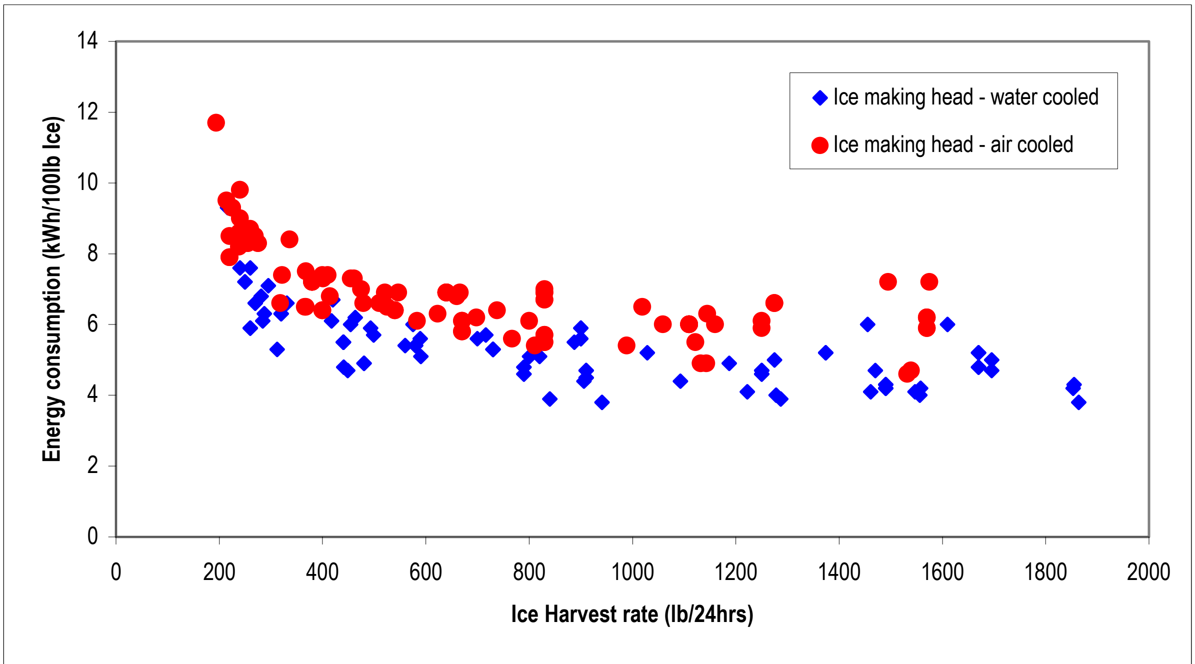


Figure 6: Remote conditioning unit, water and air-cooled [ARI 2004]

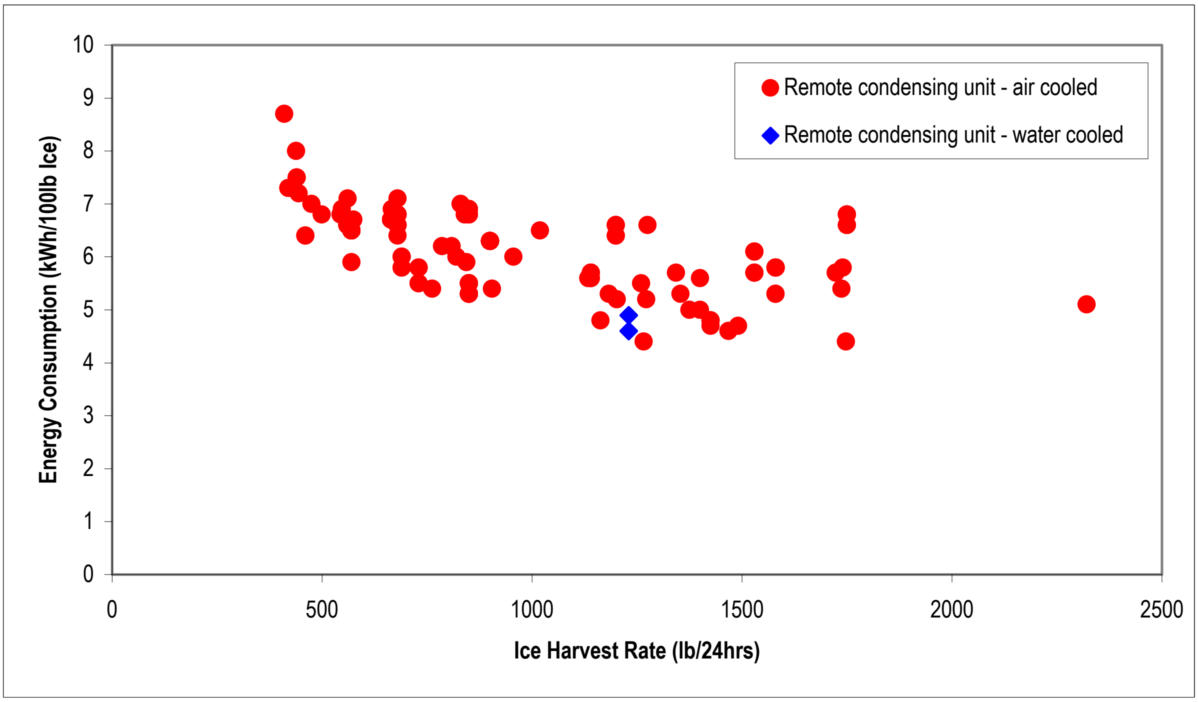
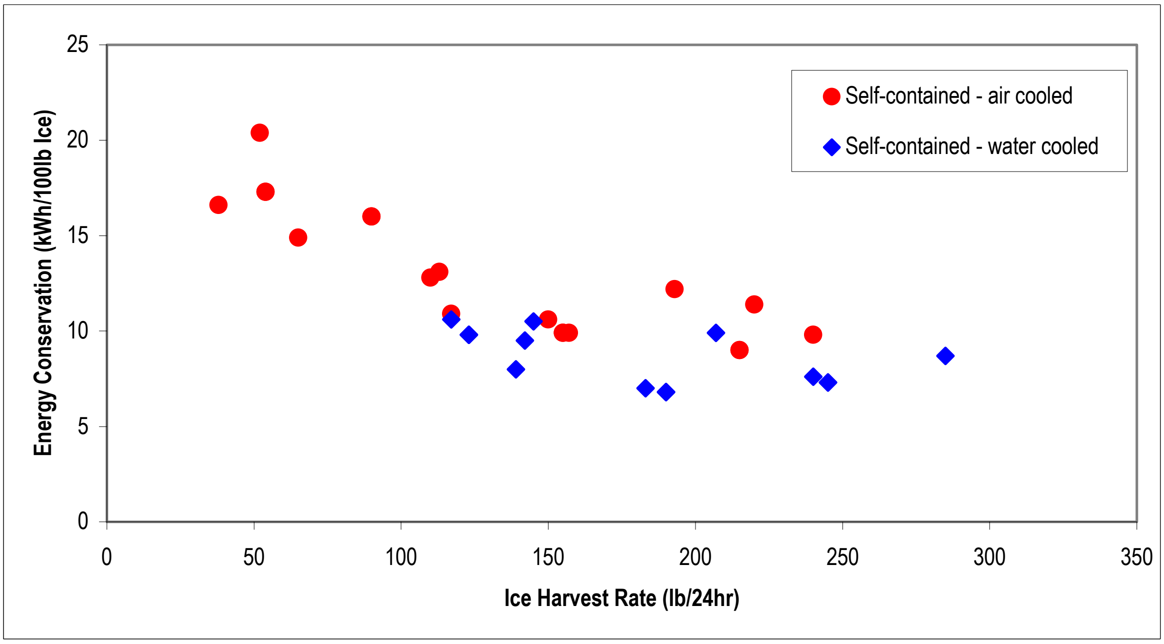


Figure 7: Self-contained ice maker, water and air-cooled [ARI 2004]



For the purposes of this report, the average annual energy consumption of each of the three sizes of ice makers is shown in Table 3. A similar set of categories was used in Section 3.

Table 3: Estimated annual energy consumption per unit

Size	Definition (ice harvest rate)	Energy consumption (kWh/yr)
Small	75 kg ice/24hrs	2,500
Medium	200 kg ice/24hrs	4,900
Large	600 kg ice/24hrs	14,600

These estimates are based on an average of 4,080 hours of use each year per machine. Clearly, the actual energy consumed will depend upon the number of hours in service and the ambient conditions. The latter has a significant impact on energy consumption, depending upon whether the ice maker is located within a conditioned environment or subject to high external temperatures and humidity.

However, it should be noted that models which reject waste heat into air conditioned environments will increase the load on air conditioning plants, thereby increasing total energy consumption. Remote air-cooled condensers and water-cooled units both avoid this issue.

4.1.2 ICE STORAGE BINS

While ice storage bins do not have active refrigeration components, they do have an indirect influence on energy consumption. A well insulated storage bin will be able to hold ice for a longer period of time than one which allows higher heat losses, and therefore will not require replenishing as frequently.

4.2 EQUIVALENT ENERGY CONSUMPTION

The data shown above is based on tests undertaken according to ARI 810, and under the US electricity supply conditions of 115 Volts and 60 Hz. Discussions with industry representatives in Australia indicate that imported ice makers are factory-fitted with new 230Volt/50Hz components before being shipped, and that these components are of equivalent specifications and performance to those they replace.

Most of the products on the ARI list are also available in Australia, either imported from North America or from elsewhere. It is therefore reasonable to assume that the performance of models on the ARI list reflects the performance of imported models, which comprise 90% of the current sales in this country.

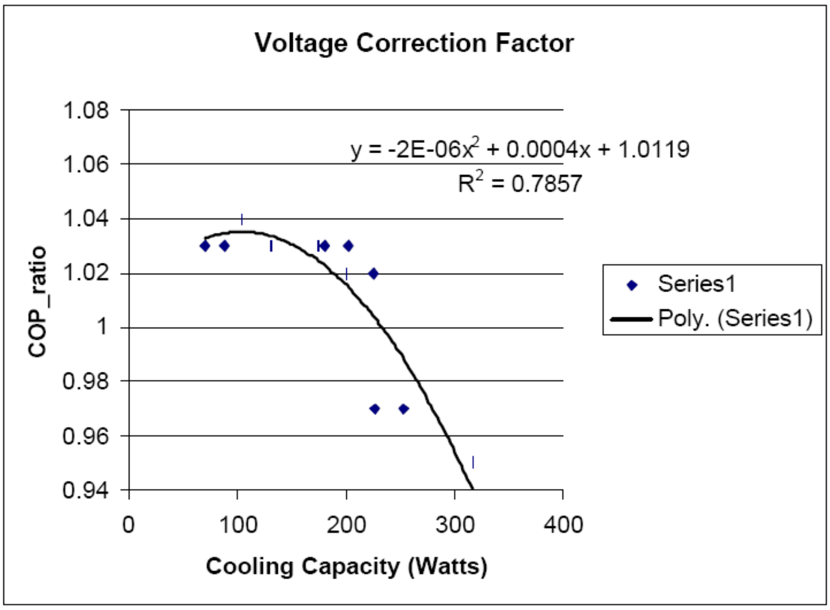
Representatives from the Australian refrigeration industry have suggested that there are inherent efficiency advantages in operating at either 115V/60Hz or 230V/50Hz, and that these should be acknowledged when translating overseas data for use in Australia.

To address this issue the Australian Greenhouse Office commissioned the Department of Mechanical Engineering at Auckland University in 2000 to examine the effects of voltage and frequency variation on the performance of compressors (and other accessories such as fans, heaters, timers, lights etc.) used in vapour compression refrigeration systems (Bansal 2001).

The following summarizes the findings of this report:

- Theoretically, with the same mass of the same quality steel, a higher frequency motor (US) will be more efficient than one operating at a lower frequency;
- For equivalent motors constructed to operate at 115V and 230V, the copper losses from each will be the same;
- Hydrodynamic (friction) losses are a more significant factor as compressors are scaled down. Thus for small compressors, 230V/50Hz versions are often more efficient than equivalent 115V/60Hz versions;
- The general conclusion resulting from a theoretical analysis and testing of several compressors is that **at lower cooling capacities** models operating at 220V/50Hz perform more efficiently than their equivalent 115/60Hz model, but worse at higher capacities;
- For compressors under 240W cooling capacity, 230V/50Hz models are between 0 - 3.5% more efficient;
- For compressors over 240W cooling capacity, 115V/60Hz models are between 0 - 5% more efficient;
- These effects are larger at the extremities of the capacity range, as shown in the following figure, which plots the conversion factor from 230V/50Hz to 115/60Hz.

Figure 8: Estimated conversion factor from 230V/50Hz to 115V/60Hz



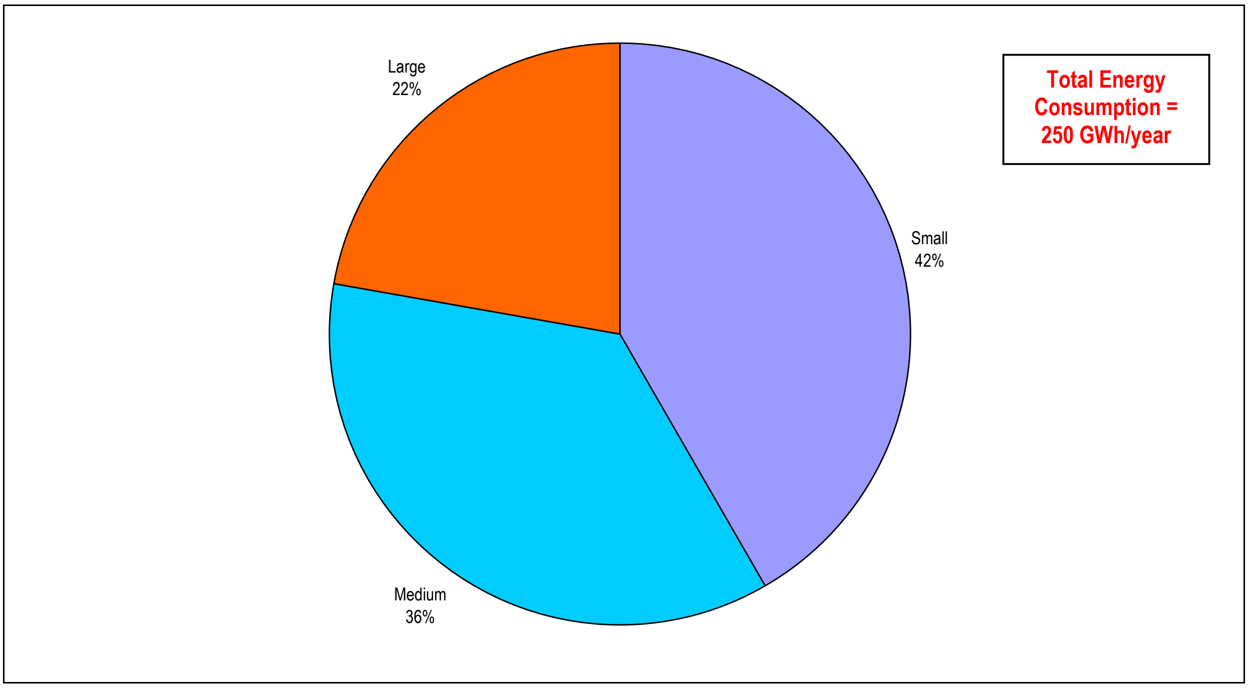
Where: $COP_{ratio} = COP_{(230V/50Hz)}/COP_{(115V/50Hz)}$

As can be seen from this, the total effect on the coefficient or performance (COP) of the compressor is extremely small, and would have a negligible effect when comparing the efficiency of equivalent models operating under the different electricity supply conditions.

4.3 Estimated Total Energy Consumption

Based on the data presented in this report, the estimated annual energy consumption of ice makers in Australia is approximately 250GWh. Small sized ice makers are estimated to be responsible for the largest percentage of this (42%), with medium sized ice makers consuming a futher 36% of the total.

Figure 9: Total energy consumption, ice makers Australia 2003.

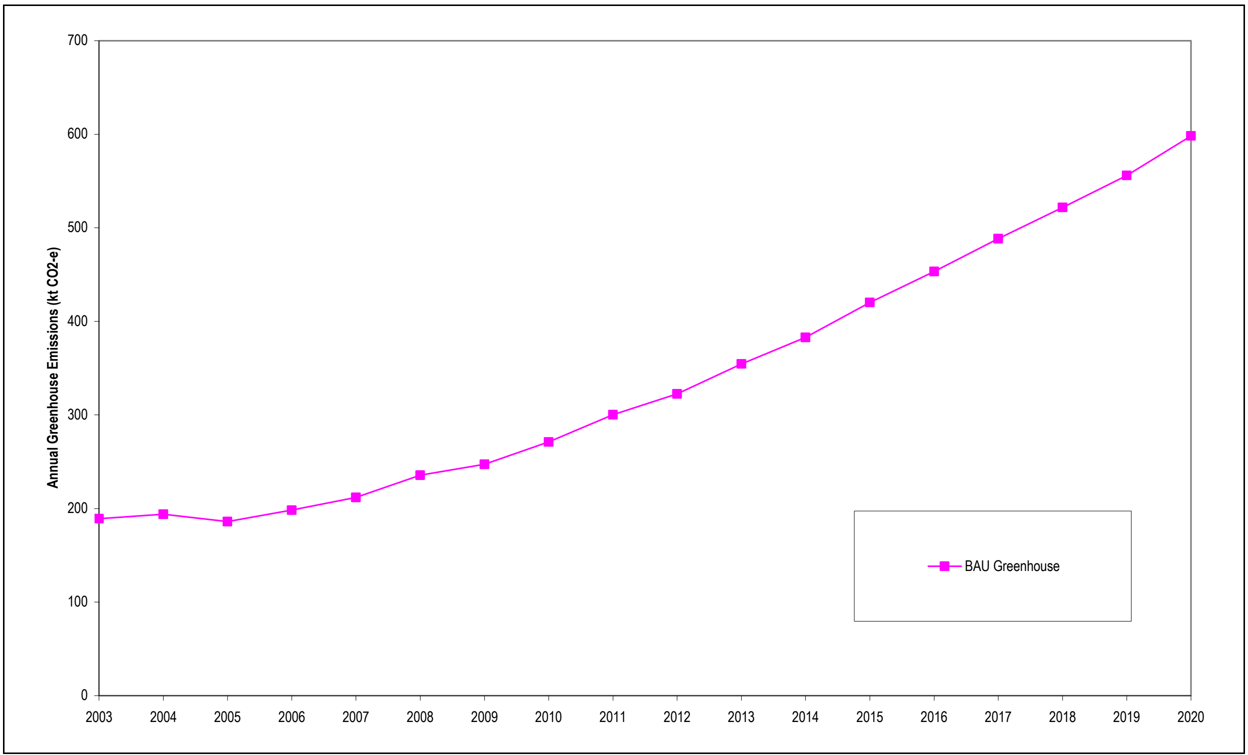


Predicted growth in the number of ice makers in service of between 5% and 8% per annum, is likely to lead to substantial increases such that, by 2020, annual energy consumption may reach 950GWh.

4.4 GREENHOUSE EMISSIONS

Direct emissions of greenhouse gases resulting from the electricity consumption of ice makers is estimated to be around 240 ktCO_2-e in 2003. Furthermore, emissions from increased air-conditioning loads in buildings where ice makers are used may comprise up to an additional one-third of this figure. The trend in greenhouse emissions is shown in Figure 10.

Figure 10: Estimated greenhouse emission trends, Australia 2003-2020



4.5 WATER CONSUMPTION

In addition to the water required to make usable ice, most ice makers consume water in cleaning cycles. Models with a water-cooled condenser use more water again.

Generally water consumption is measured in terms of the volume required per mass of ice produced, and potable water used for ice production is distinguished from the consumption of water for cooling purposes.

As can be seen in Figure 11, which shows water consumption for ice-makers listed by ARI, current models display a considerable range of potable water consumption. The lowest water consumption is around 13 gal/100lb ice, and the highest is 55 gal/100lb ice.

The trend line added to this figure indicates that the average water consumption per unit output does not depend to any great extent on the size of ice maker.

A number of factors influence water consumption, including: the type of technology used to produce different types of ice; the degree of water recycling; and the frequency of 'flushing through' with fresh water.

Figure 11: Potable water consumption, ARI 2004

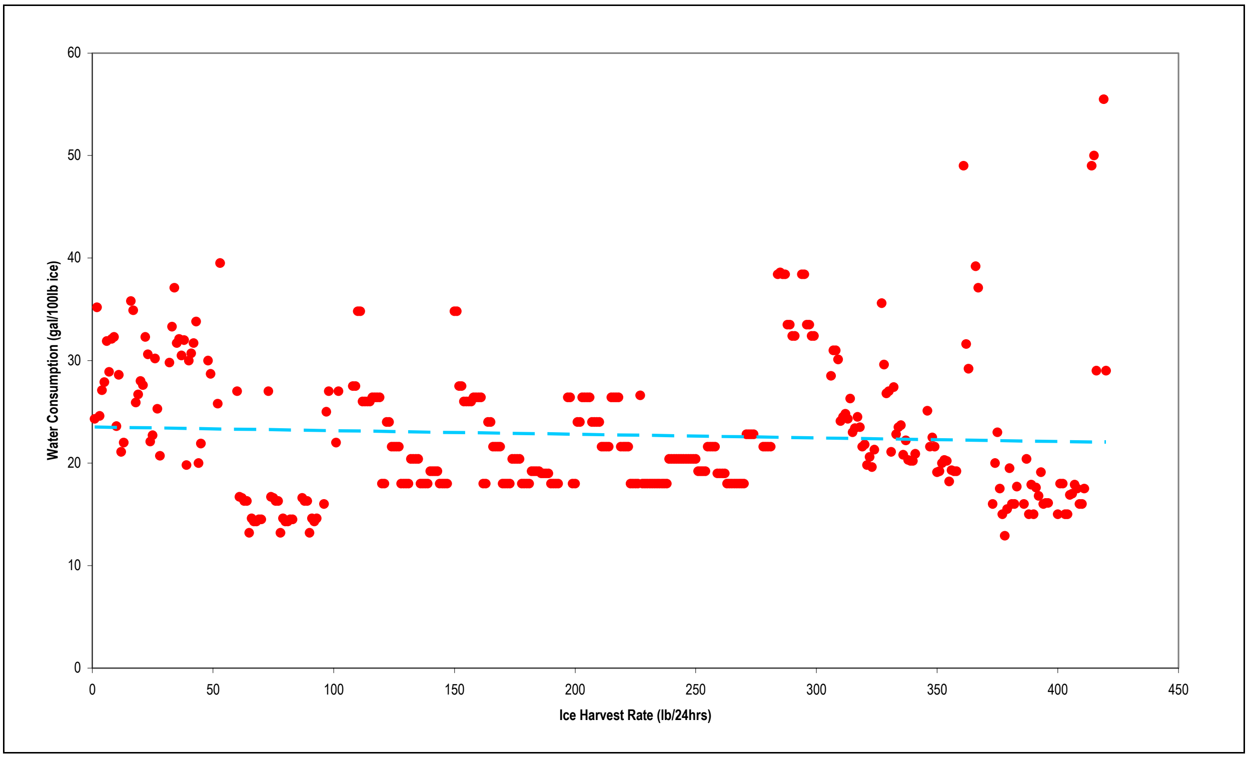
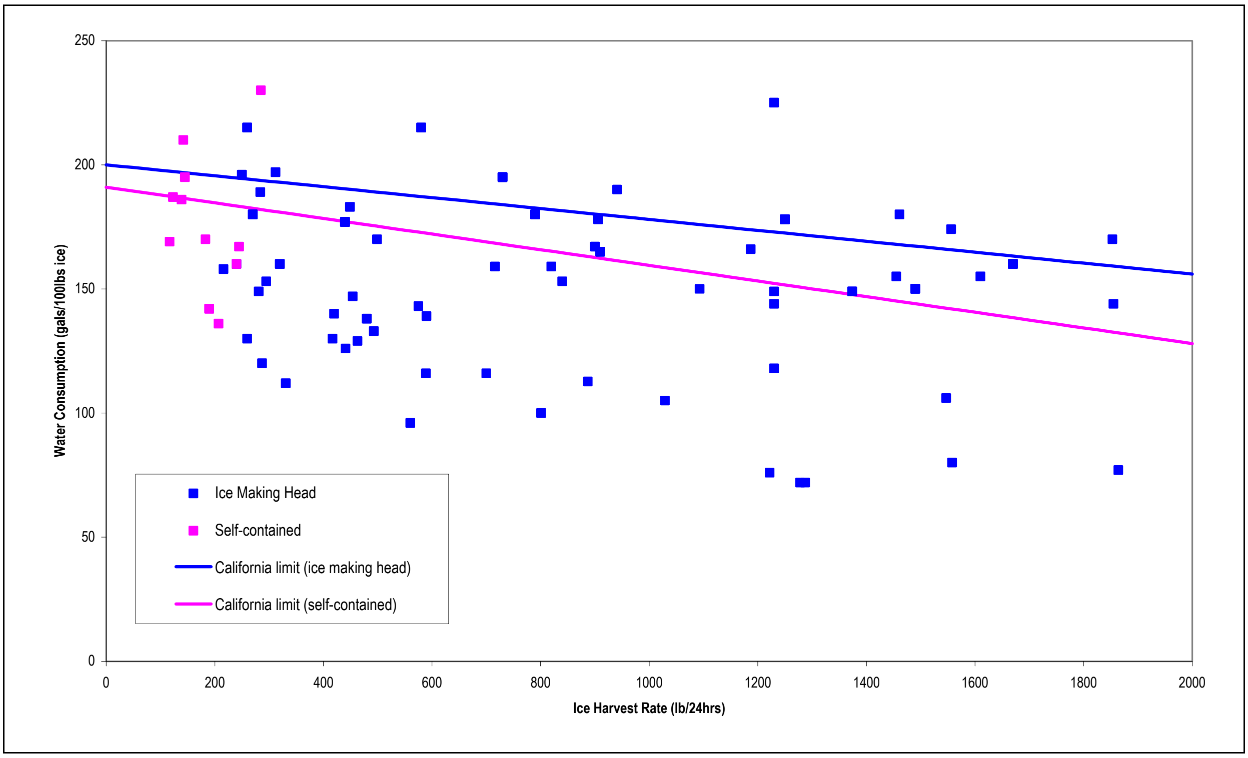


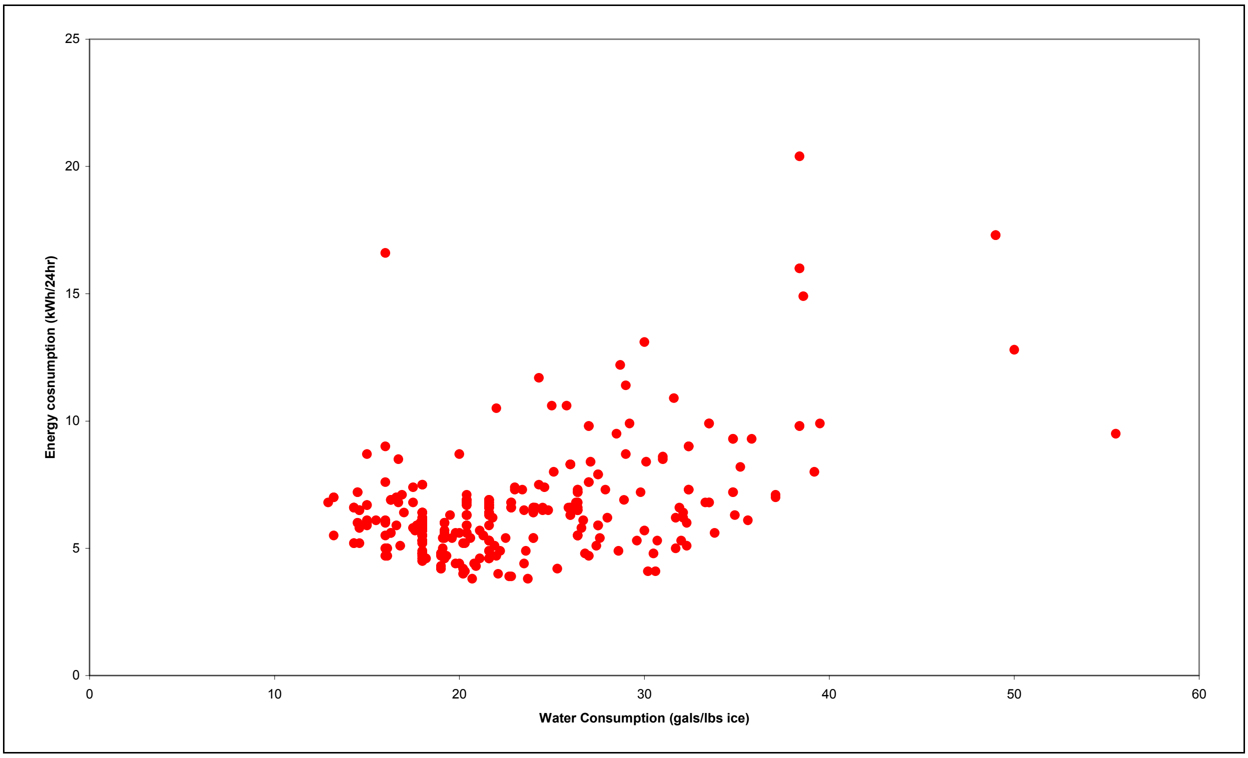
Figure 12 shows condenser water consumption for water-cooled ice makers listed by ARI, together with limits proposed for adoption in California (see section 6.2.1). Values range from 70 to 230 gal/100lb ice. The limits proposed by California suggest that the rate of water consumption falls slightly as the output of ice increases.

Figure 12: Condenser water use, ARI 2004



The energy used by water pumps is generally too small a fraction of total ice maker energy consumption to account for any correlation between the rate of water consumption and the rate of energy consumed. However, Figure 13 suggests that lower water consuming products also tend to be slightly more efficient. Since there is no obvious explanation for this, it may reflect different designs amongst companies and possibly a general aim to minimise resource use and resource costs.

Figure 13: Correlation between water consumption and energy consumption, ARI 2004



4.6 IMPROVING THE PERFORMANCE OF ICE MAKERS AND ICE STORAGE BINS

The performance of ice makers can be improved by a range of measures, some of which are applicable to most refrigeration systems. These typically include the use of:

- appropriate thermostatic controls, time-clocks and/or switches to control the operation of the ice maker;
- capacitor start compressors: these increase compressor efficiency from around 45% to between 50% and 55%;
- incoming water to help loosen ice rather than heating already chilled water;
- high-efficiency motors for the condenser fans, where relevant;
- high efficiency fan blades;
- mechanical assist defrost;
- a heat exchanger to pre-cool the incoming water, using the cold drain water;
- high insulation levels for ice storage bins;
- careful selection of the correct size of machine and bin. This is also important in producing ice efficiently. For example, to cope with irregular or intermittent high demand, multiple ice makers can be coupled with one bin, so that some machines can be turned off when not required.

While most of these measures are well understood within the commercial refrigeration industry and most are relatively inexpensive, customers may not be willing to incur the additional costs even when these pay for themselves in relatively short periods. Research in the United States suggests that savings of 15-20% are possible with a payback period of two years or less (US Dept of Energy 1996).

Such a situation, where customers are unwilling to invest in activities which would result in clear financial benefits is usually taken to be evidence of market failure, and justification for Government action such as regulation.

5. Australian Policies for Ice Makers

Australia currently has no policies with respect to the major categories of ice makers or storage bins described in this report, with the exception of the following products.

Commercial refrigeration cabinets are included in the scope of AS1731-2003, and this includes cabinets used for the sale and display of ice. Typically this would apply to bagged ice. Part 14 of AS1731-2003 describes the minimum energy performance standards for these products required from October 1, 2004. This standard also establishes the energy performance level required for any cabinet to be promoted as ‘high efficiency’.

Small ice makers included in chilled water dispensers may be covered by a new test and regulatory standard for Boiling and Chilled Water Dispensers. This work is being overseen by the Australian Standards Committee EL-20, and it is envisaged that a new standard will be published during 2005.

6. Overseas Policies for Ice Makers and Ice Storage Bins

There are a number of standards and policies applying to ice makers and ice storage bins in North America.

6.1 CANADA

The Canadian standard C742-98 specifies Minimum Energy Performance Standards for ice makers and ice storage bins as shown in Table 4 and Table 5 below. The standard applies to factory-assembled automatic ice-makers with 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.

It should be noted that the Canadian standard classifies ice makers by type (batch or continuous) rather than by technology type (ice making heads, self contained, etc).

Table 4: Canadian MEPS applying to ice makers

Product class	Type	Capacity (kg/day)	Maximum energy input (kJ/kg)
Batch automatic ice-makers (cubers)	Air-cooled	23 ≤ capacity < 150 kg/d	1630 – 6.008 x capacity
		150 ≤ capacity ≤ 1000 kg/d	807.2 – 0.5229 x capacity
	Water-cooled	23 ≤ capacity < 150 kg/d	1234 – 4.381 x capacity
		150 ≤ capacity ≤ 1000 kg/d	621.8 – 0.2985 x capacity
Continuous automatic ice-makers (flakers)	Air-cooled	23 ≤ capacity < 300 kg/d	875.2 – 1.122 x capacity
		300 ≤ capacity ≤ 1000 kg/d	538.6
	Water-cooled	23 ≤ capacity < 300 kg/d	740.5 – 0.8976 x capacity
		300 ≤ capacity ≤ 1000 kg/d	471.2

The Canadian standard also sets out storage effectiveness limits for ice storage bins, as shown in Table 5. Storage effectiveness is defined as ‘*a theoretical measure of the fraction of ice that under specific rating conditions would be expected to remain in the ice storage bin 24 hours after it is produced*’. This standard applies to factory-made manual scoop-out ice storage bins.

Table 5: Canadian storage effectiveness ratings applying to ice storage bins

Product class	Capacity (kg)	Minimum storage effectiveness (%)
Ice storage bins	less than 70	60
	70 to 99	70
	100 to 200	75
	greater than 200	80

6.2 UNITED STATES

6.2.1 UNITED STATES: CALIFORNIA ENERGY COMMISSION

Table 6 provides California's proposed energy requirements for ice makers, which are included in the proposed amendments to the Appliance Efficiency Regulations of California (Title 20, Division 2, Chapter 4, Article 4, Sections 1601 – 1608: May 12, 2004). These amendments will apply to commercial ice makers manufactured on or after January 1, 2006.

Table 6: California's proposed energy standards (MEPS) for ice makers

Product class	Type	Ice harvest rate (lbs/24 hrs)[1]	Maximum energy consumption (kWh/45kg ice)	Maximum water use (gallons/100 lbs ice)
Ice making head	Air-cooled	< 450	10.26 - 0.0086H[2]	Not applicable
		≥ 450	6.89 - 0.0011H	Not applicable
	Water-cooled	< 500	7.80 - 0.0055H	200 - 0.022H
		≥ 500	5.58 - 0.0011H	200 - 0.022H
Self-contained	Air-cooled	< 175	18.0 - 0.0469H	Not applicable
		≥ 175	9.80	Not applicable
	Water-cooled	< 200	11.40 - 0.0190H	191 - 0.0315H
		≥ 200	7.60	191 - 0.0315H
Remote condensing	Air-cooled	< 1000	8.85 - 0.0038H	Not applicable
		≥ 1000	5.10	Not applicable

[1] 1 lb = 0.45 kg; ice harvest rate = capacity
[2] H = harvest rate in hundreds of pounds per 24 hours.

Note that the maximum water use requirement in the above table refers to water used for condenser cooling only, and does not include potable water use.

6.2.2 UNITED STATES: FEDERAL ENVIRONMENT MANAGEMENT PROGRAM

The US Federal Environment Management Program (FEMP) provides efficiency recommendations and other resources for a range of products including ice making machines. Federal government agencies in the US are required to buy Energy Star labeled products or those in the top 25% efficiency range of their class, as well as products with low standby power. The FEMP recommended efficiency levels for ice makers are provided in Table 7. The Program covers machines generating 60 grams (2 oz) or lighter ice cubes, and does not cover flaked, crushed or fragmented ice makers.

Table 7: FEMP efficiency recommendation for ice makers

Product class	Type	Ice harvest rate (lbs/24 hrs)[1]	Energy consumption[2] (kWh/100 lbs ice)	
			Recommended	Best available
Ice making head[3]	Air-cooled	101 - 200	≤ 9.4 kWh	8.6 kWh
		201 - 300	≤ 8.5 kWh	7.9 kWh
		301 - 400	≤ 7.2 kWh	6.5 kWh
		401 - 500	≤ 6.1 kWh	5.8 kWh
		501 - 1000	≤ 5.8 kWh	5.4 kWh
		1001 - 1500	≤ 5.5 kWh	5.0 kWh
	Water-cooled	201 - 300	≤ 6.7 kWh	5.9 kWh
		301 - 500	≤ 5.5 kWh	4.7 kWh
		501 - 1000	≤ 4.6 kWh	3.8 kWh
		1001 - 1500	≤ 4.3 kWh	4.0 kWh
		> 1500	≤ 4.0 kWh	3.5 kWh
Self-contained[4]	Air-cooled	101 - 200	≤ 10.7 kWh	9.7 kWh
	Water-cooled	101 - 200	≤ 9.5 kWh	6.8 kWh
		201 - 300	≤ 7.6 kWh	7.3 kWh
Remote condensing[5]	Air-cooled	301 - 400	≤ 8.1 kWh	< 7.9 kWh
		401 - 500	≤ 7.0 kWh	6.1 kWh
		501 - 1000	≤ 6.2 kWh	5.4 kWh
		1001 - 1500	≤ 5.1 kWh	4.5 kWh
		> 1500	≤ 5.3 kWh	4.4 kWh

[1] 1 lb = 0.45 kg; ice harvest rate = capacity; [2] Based on ARI Standard 810;
[3] 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.
[4] Self-contained units contain built-in storage bins.
[5] Remote condensing units transfer the heat generated by the ice-making process outside (comparable to split system air conditioners).

The FEMP website also provides other information to help buyers purchase efficient ice makers. For example it gives: a sample cost effectiveness model of an air-cooled, ice-making head (800 lbs/24 hrs) at varying efficiencies; an energy cost calculator for commercial ice cube machines; and also general tips for ice maker buyers.

6.2.3 United States: Energy Star

At this stage, the Energy Star program (which provides a voluntary labeling system for products that meet key energy efficiency criteria) does not cover ice makers and ice storage bins. However the US Environment Protection Agency and the US Department of Energy are conducting preliminary research on ice machines over the next year to determine whether to include them in the program.

6.2.4 United States: Consortium for Energy Efficiency

The Consortium for Energy Efficiency (CEE), a nonprofit public benefits corporation, launched an initiative for commercial ice makers in 2002. This aims to maximize energy savings by increasing the market share of efficient commercial ice-making equipment. The CEE sets minimum efficiency criteria which are approximately equal to FEMP's, as well as 'high efficiency levels' which are 20% lower than the baseline levels. The CEE website provides a list of commercial ice maker models which meet these specifications.

6.3 Test Methods for Ice Makers and Ice Storage Bins

Table 8 shows which test methods are used for the efficiency standards and programs described in Section 6. It should be noted that the listed test methods are technically equivalent.

Table 8: International test methods adopted by efficiency programs for ice makers and ice storage bins

Efficiency program	Test method used
Canadian standards	References ANSI/ASHRAE Standard 29; ARI 810 and ARI 820
US FEMP recommendations	Based on ARI 810
Californian standard	Based on ARI 810
CEE	Based on ARI 810

Table 9: International energy performance test methods applying to ice makers and ice storage bins

Standard	Test method description
ARI 810-2003	*2003 Standard for Performance Rating of Automatic Commercial Ice-makers*, Air-conditioning and Refrigeration Institute. Energy consumption test method for factory made automatic commercial ice-makers. Applicable to self-contained and modular ice making units. Energy consumption rate calculated in kWh/100 lb (kWh/45.0 kg) ice produced, according to ANSI/ASHRAE 29 (see below).
ARI 820-2000	*2000 Standard for Ice Storage Bins*, Air-conditioning and Refrigeration Institute. Applies to factory made ice storage bins, excluding automatic dispensing machines and cold plate drink dispensers. Test method for determining theoretical storage capacity and theoretical storage effectiveness (% of ice remaining in the ice storage bin after 24 hrs under specific conditions).
ANSI/ASHRAE 29-1988 (RA 99)	*Methods of Testing Automatic Ice Makers,* American Society of Heating, Refrigerating and Air-conditioning Engineers. Updated in 1999. Provides methods of testing automatic ice makers (self-contained and modular), excluding automatic ice makers installed in household refrigerators and/or freezers. Energy consumption rate calculated in kWh/100 lb or kWh/kg ice produced.
ISO/IEC 1992 Draft	*Performance testing and rating of factory-made refrigeration systems – Automatic commercial ice makers and storage bins*, 1992 Draft, International Organization for Standardization. Provides test methods for factory-made automatic ice makers (self-contained and modular), excluding those intended for use in household appliances. Energy consumption rate calculated in kWh/10 kg ice produced. Also test method for determining the theoretical storage effectiveness of ice storage bins (weight of water melt after 2 hrs and 6 hrs, under specific conditions).

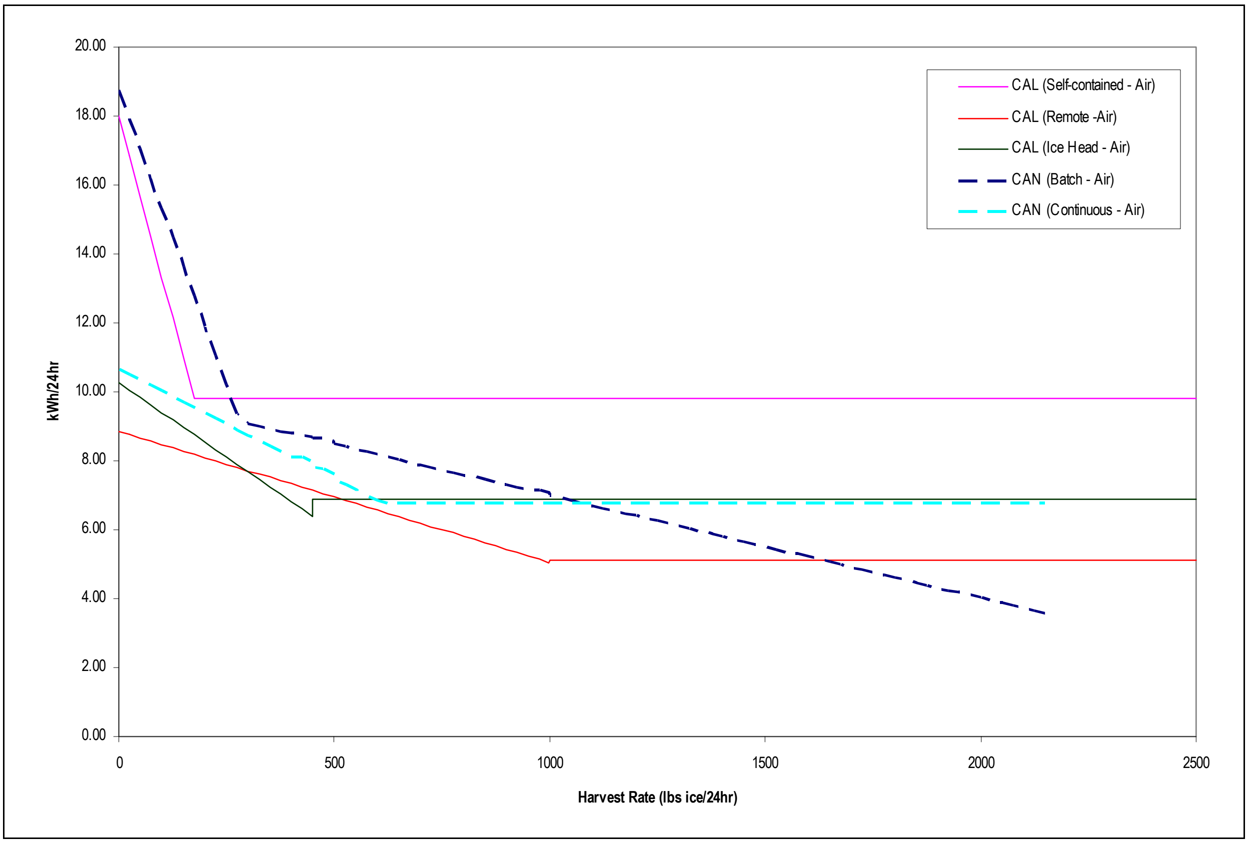
6.4 Comparison of Ice Maker Standards / Efficiency Recommendations

6.4.1 Comparison of efficiency levels in Canada and California

Although both Californian and Canadian efficiency levels are based on a similar test method, California ascribes efficiency levels by type of ice maker (self-contained, remote, ice making head), while Canada has one level for all batch ice makers and another for continuous ice makers.

This different approach makes direct comparison difficult. As can be seen in Figure 14, the levels between the two standards for air-cooled ice makers are similar, however for all but small capacity machines, the California levels assume a constant rate of energy consumption. However, for batch ice makers, the Canadians assume that the rate of energy consumption decreases as the machine capacity increases.

Figure 14: Comparison of efficiency levels for air-cooled ice makers in Canada and California



6.4.2 COMPARISON OF CALIFORNIA & FEMP STANDARDS

The following charts show California's proposed MEPS levels, and FEMP's recommended and best available efficiency levels for ice makers. Each chart also plots US ice maker performance data from ARI's 2004 directory [ARI 2004]. These efficiency standards are directly comparable since both are based on the same test standard and ascribed to the same categories of machines.

The points to note include:

- For all but ice making heads, the levels are similar;
- The FEMP levels for ice making heads are considerably more stringent than the Californian levels;
- The Californian requirements cover a wider range of product sizes than the FEMP requirements.

Figure 15: Ice making heads – air-cooled: comparison of Californian MEPS, FEMP efficiency levels and ARI data [ARI 2004]

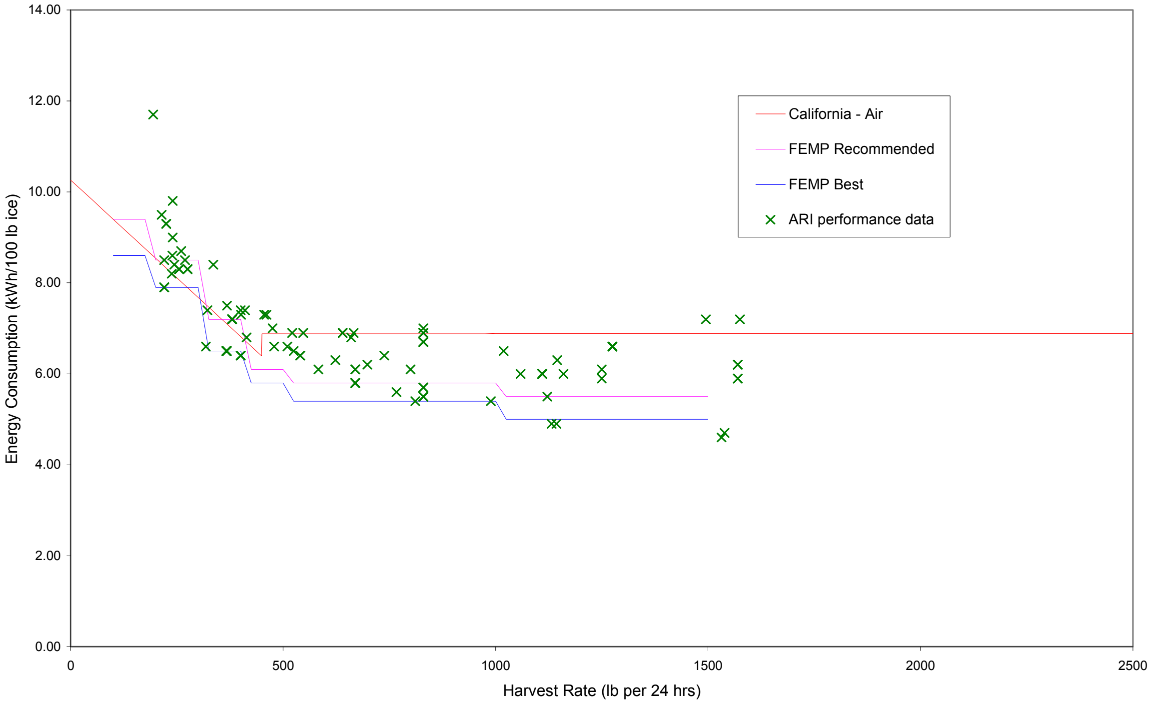


Figure 16: Ice making heads – water-cooled: comparison of Californian MEPS, FEMP efficiency levels and ARI data [ARI 2004]

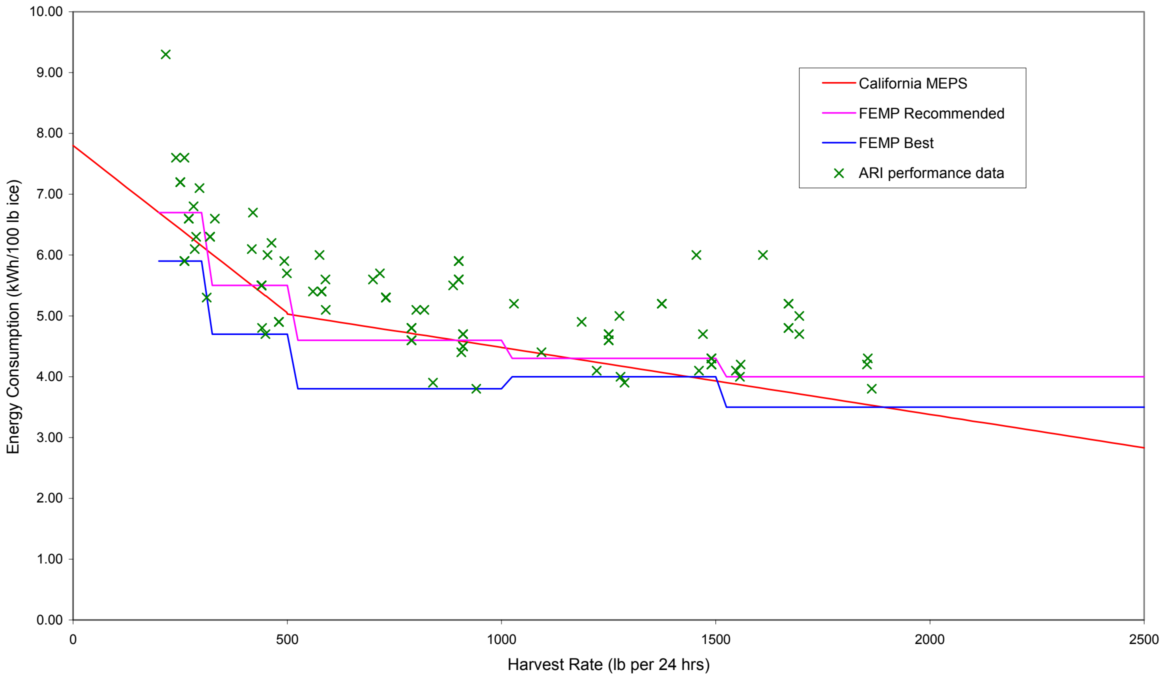


Figure 17: Remote condensing units – air-cooled: comparison of Californian MEPS, FEMP levels and ARI data [ARI 2004]

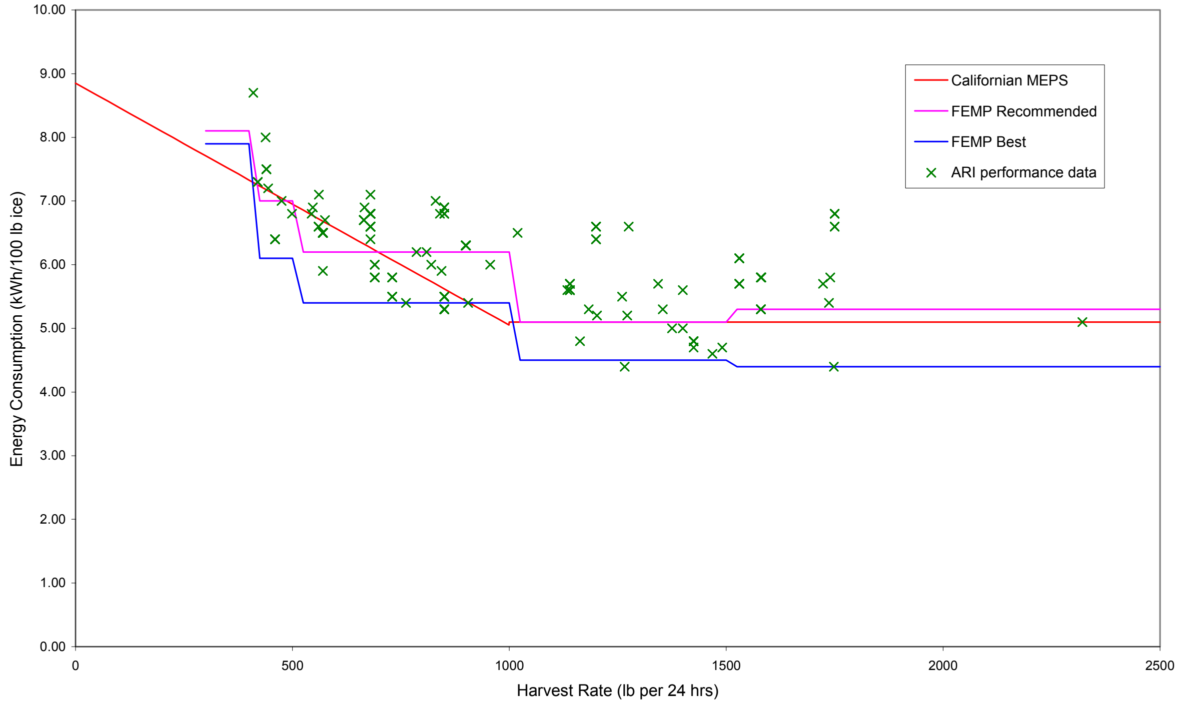


Figure 18: Self-contained units – air-cooled: comparison of Californian MEPS, FEMP levels and ARI data [ARI 2004]

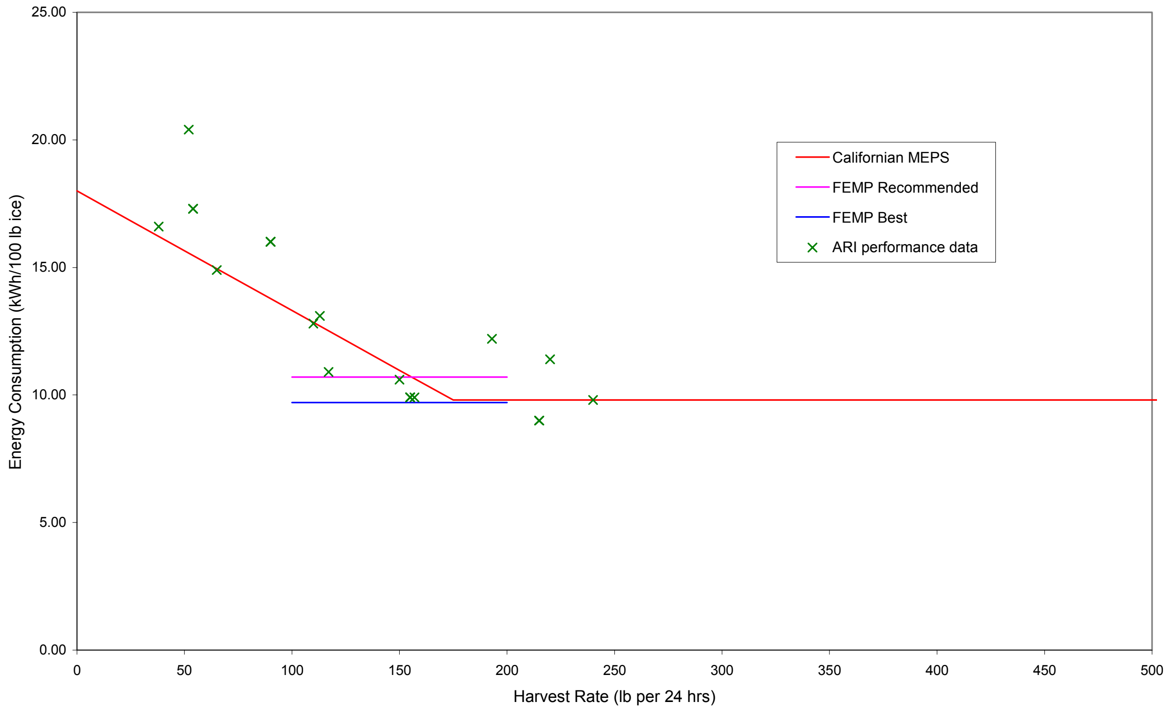
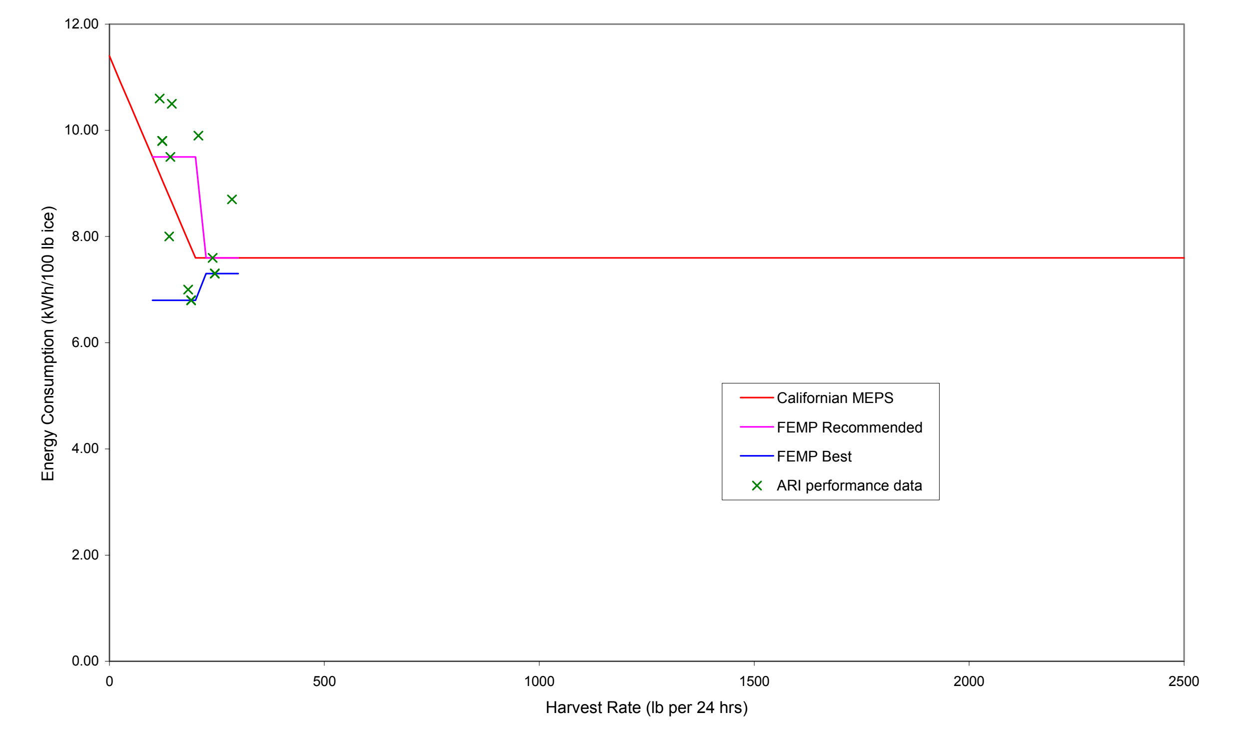


Figure 19: Self-contained units – water-cooled: comparison of Californian MEPS, FEMP levels and ARI data [ARI 2004]



7. Conclusions

7.1 General conclusions

On the basis of this analysis, we conclude that:

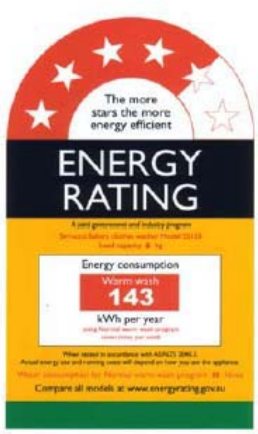
- There is significant variation in the energy consumed by ice makers currently on the Australian market;
- This, together with information on potential technical improvements to general refrigeration systems, indicates that energy savings in the order of 15-20% are feasible, with a payback within 2-3 years;
- However, there is evidence that the market does not fully value these financial savings, or is ignorant of them;
- As a result, not only are economic benefits being foregone, but opportunities for environmental benefits in terms of greenhouse gas and water savings are also being overlooked;
- These potential savings are considerable and likely to grow in forthcoming years due to the increasing market penetration of ice makers;
- There is an additional threat of poor performing, lower cost ice makers coming on to the market and further reducing the efficiency of the stock;
- While ice storage bins do not directly consume electricity for refrigeration, their effectiveness has a significant impact on the demand for ice production and therefore on energy consumption.
- Although there is little data on the performance of ice storage bins in Australia, measures should be introduced to ensure that insulation levels are maintained at a high standard.

Government intervention is usually justified when there is evidence of market failure, such as the low uptake of energy efficient products even when their purchase is economically advantageous. It is therefore a conclusion of this report that the energy performance of ice makers and ice storage bins should be targeted for action by Australian Governments. The following section discusses the options to achieve this.

7.2 PROGRAM OPTIONS

The major program choices open to Australian Governments are minimum energy performance standards (MEPS) or product labeling. Other programs, such as government procurement or voluntary agreements with major end-users, may also assist but are unlikely to impact on the majority of the market.

7.2.1 ENERGY PERFORMANCE LABELS



The **comparative** energy label which has been used in Australia on many whitegoods has been highly effective. It provides an easily understood and credible means for consumers to compare the energy performance of competing products. However, even though the display of the label is generally mandatory, any benefit in terms of reduced energy consumption relies upon the selection of more efficient appliances by the purchaser.

Australia has also used an **endorsement** label for some consumer products, most notably the ENERGY STAR logo on computer monitors and other electronic equipment. The impact of this program is not well known in Australia but is probably not as effective as in the United States due to the relatively low profile of the ENERGY STAR brand here, and the lower penetration of conforming appliances.

Both types of labels have the aim of promoting the better or best performing products, but this requires that the label is well-known by consumers, is visible and is carried by a reasonable range of products.

7.2.2 MINIMUM ENERGY PERFORMANCE STANDARDS (MEPS)

MEPS aim to remove the worst performing products from the marketplace altogether, rather than promoting the best. In Australia this is usually achieved by including the criteria within an Australian Standard which is implemented through State and Territory legislation. These requirements apply to all products covered by the standard which are sold in Australia (and usually New Zealand as well).

Australia has introduced MEPS for a range of products and has a very successful track record in this area. Further information is available from: www.energyrating.gov.au/meps1.html.

For some commercial products, including distribution transformers and commercial refrigerated cabinets, Australia has introduced a 'high efficiency' level within the appropriate standard. The purpose of this is to provide a marketing advantage to manufacturers who supply products meeting these requirements. Under the standards, products which fail to meet this level are prevented from being promoted as 'high efficiency'. The high efficiency levels can also be used to indicate the likely future levels for MEPS, which are usually implemented 3-4 years after the current MEPS levels.

It is considered unlikely that comparative energy labeling alone will have much effect on the market, as products are rarely purchased 'off the shelf', and purchasers are primarily driven by capital cost, rather than the financial payback achievable on higher efficiency models. By removing the worst performing products from the market, MEPS would deliver immediate results, creating a mandatory benchmark which all manufacturers and importers must meet. The introduction of MEPS is therefore the preferred option, together with the establishment of a 'high efficiency' category to encourage the manufacture and promotion of high efficiency ice makers and ice storage bins.

7.2.3 INTERNATIONAL HARMONISATION

In terms of setting appropriate MEPS levels, the Australian Government has a policy of matching world's best regulatory practice, where feasible. The Canadian and Californian levels have similar levels of stringency, however there are some benefits in adopting the Californian approach, namely:

- there is some doubt about how thoroughly the Canadian levels are implemented and enforced;
- the categories used in the Californian standard are more appropriate;
- the Californian levels are more recent, and therefore probably better reflect actual performance levels;
- California has a history of implementing energy efficiency measures which are later adopted throughout the United States.

We therefore suggest that Australia should adopt equivalent MEPS levels to those proposed for California.

It should be noted that the Californian MEPS levels are based on the ARI 810 test method, whereas Australia prefers to use international test methods wherever possible. However, although ISO produced a draft test method in 1992, it has never been published. Inquiries made during the course of this investigation suggest that the committee is likely to reconvene to complete this work in the near future. Since ARI 810 and the draft ISO standard are similar, one option is for Australia to recommend to the ISO committee that the ISO standard should be technically equivalent to the ARI standard.

7.2.4 WATER CONSUMPTION

Water conservation is an increasingly important issue in Australia, and the Commonwealth Government has recently announced mandatory water efficiency labeling for a number of household products (showerheads, toilets, washing machines, etc). Further details can be obtained from www.ea.gov.au/water/urban/scheme.html.

The introduction of energy performance regulations for ice makers provides an opportunity to also promote water conservation, and therefore the options have been considered in this report.

The approach taken by California is to include maximum water consumption rates for condenser cooling in addition to maximum energy consumption rates, so that a product has to meet both requirements in order to comply.

In considering this approach, it should be noted that the quantity of water used in a water cooled-condenser is generally higher than that used directly in the ice making process. The average water consumption for condenser-cooling in the 2004 ARI list is 159 gal/100lb ice, compared to 23 gal/100lb ice for ice production. Therefore the water used for condenser cooling is a more significant factor, in terms of total water consumption. However, since an estimated 90% of ice makers are air-cooled, condenser cooling is only an issue for around 10% of products on the market.

Ice-makers which are water cooled are generally more energy efficient than air cooled equivalents. In the ARI list, the average energy consumption rate of water-cooled ice makers is 20% better than that for air cooled models. However, as shown in Figure 12, many water-cooled products do not meet the Californian water consumption requirements and it is therefore of concern that measures to promote water conservation may disadvantage products with potential for energy savings.

Figure 11 and Figure 13 show that there is a wide variation in potable water use, and indicate that products with a low water use typically consume less energy. This suggests that measures could be targeted at potable water use, rather than cooling water. It should be noted that although the quantity of potable water used is less than the amount of condenser water consumed, because all ice makers use potable water, the total amount of potable water consumed (and potentially saved) in ice-making will outweigh the quantity of condenser water consumed.

The possible measures adopted by Government could include the inclusion of a maximum water consumption limit in the standard, the use of a comparative water efficiency information label, or both.

Based on Figure 11 a maximum potable water consumption of between 25 and 35 gal/100lb ice would remove the worst performing products across all sizes. This would therefore serve as an appropriate maximum level to be included as a requirement alongside the energy performance requirements contained in the Standard. Table 10 shows the proportion of products meeting potential potable water limits from the ARI 2004 list.

Table 10: Number and proportion of ice makers meeting limits of potable water consumption

Water consumption rate (gal/100lb ice)	25	26	27	28	29	30	31	32	33	34	35
Number of conforming products	242	254	281	290	296	301	308	313	321	327	332
% of conforming products	69%	73%	81%	83%	85%	86%	88%	90%	92%	94%	95%

If the water labeling option was adopted in addition to the maximum consumption level, the lowest label rating would start at the maximum consumption levels and reduce in steps from there, such that 10 gals/100lb ice represented the highest rating level (5 or 6 stars).

Alternatively, if water labeling were to be the only measure used, it would probably need to span the complete range of consumption rates, from 50 to 10 gals/100lb ice.

Based on these arguments, it is concluded that any measures to include requirements for water conservation should be targeted at potable water use, not condenser water consumption. There is a case for using only a comparative water efficiency label for ice-makers, however it must be recognized that this may not influence purchasers to any great extent and therefore savings cannot be guaranteed. It will nevertheless incur considerable costs and the resultant cost-benefit analysis of this measure is likely to be unfavorable.

The use of a comparative water efficiency label in addition to a maximum water consumption limit would suffer from the same problems as the use of label on its own, and is therefore not recommended.

Undoubtedly the simplest approach will be to include limits for maximum water consumption within the same standard used to set MEPS, with the requirement that the performance of products must be less than both thresholds. It would be also feasible to include a high efficiency category in the standard which stipulated both energy and water requirements. This would be a voluntary level since products do not have to conform to this level except when a manufacturer claims that a product is 'high efficiency'. This produces a useful benchmark for customers who wish to select the most efficient products while being substantially less expensive to implement by Government and industry.

Detailed recommendations are included in the following section.

8. Recommendations

It is recommended that:

1. Australia implements minimum energy performance standards (MEPS) for commercial ice makers with an ice harvest rate up to 2,500 kg/24hrs, not later than October 2006.
2. These MEPS levels should be equivalent to the levels due for implementation in California from 1/1/2006, as shown in Table 11:

Table 11: Proposed Australian MEPS levels for ice makers

Product class	Type	Ice harvest rate (kg/24 hrs)	Maximum energy consumption (kWh/45kg ice)
Ice making head	Air-cooled	< 200	$10.26 - 0.0086H^2$
		≥ 200	6.89 - 0.0011H
	Water-cooled	< 230	7.80 - 0.0055H
		≥ 230	5.58 - 0.0011H
Self-contained	Air-cooled	< 80	18.0 - 0.0469H
		≥ 80	9.80
	Water-cooled	< 90	11.40 - 0.0190H
		≥ 90	7.60
Remote condensing	Air-cooled	< 450	8.85 - 0.0038H
		≥ 450	5.10

Table 12: Proportion of sample passing proposed Australian MEPS levels

Product class	Type	Pass MEPS
Ice maker head	Air-cooled	72%
	Water	81%
Self-contained	Air-cooled	53%
	Water	57%
Remote condensing	Air-cooled	65%
Total		**70%**

3. An additional requirement should be that potable water consumption will not exceed 22.5 litres/10 kg ice (27 gals/100 lbs) for all ice makers.
4. It is recommended that no limits should be set for condenser water consumption.
5. A category of 'high efficiency' products should be established, such that only products which meet these specified performance standards can be promoted as 'high efficiency' products. Indicative levels for this category are shown in the following table. Further examination of these high efficiency levels should be undertaken once the US EPA has announced Energy Star criteria for ice makers, in the event that there is scope to harmonise with these levels.

Table 13: Proposed Australian 'high efficiency' levels for ice makers

Product class	Type	Ice harvest rate (kg/24 hrs)	Maximum energy consumption (kWh/45kg ice)
Ice making head	Air-cooled	< 200	8.64 - 0.0086H
		≥ 200	4.96 - 0.0011H
	Water-cooled	< 220	7.04 - 0.0055H
		≥ 220	4.96 - 0.0011H
Self-contained	Air-cooled	< 75	16.00 - 0.0469H
		≥ 75	8.00
	Water-cooled	< 90	9.92 - 0.0190H
		≥ 90	6.56
Remote condensing	Air-cooled	< 450	8.22 - 0.0038H
		≥ 450	4.50

6. An additional requirement for high efficiency products should be that potable water consumption will not exceed 12 litres/10 kg ice (15 gals/100 lbs) for all ice makers.
7. 'High efficiency' levels should be used as the basis for stage 2 MEPS levels, proposed for introduction no later than October 2010.
8. Factory-made ice storage bins should also be subject to MEPS regulation governing their heat loss, as shown in the table below:

Table 14: Proposed Australian storage effectiveness ratings applying to ice storage bins

Product class	Capacity (kg)	Minimum storage effectiveness (%)*
Ice storage bins	less than 70	60
	70 to 99	70
	100 to 200	75
	greater than 200	80

** percentage of ice remaining in the bin 24 hours after production (under specified conditions)*

9. Consideration should be given to establishing a category of 'high efficiency' storage bins, however there is insufficient publicly-available information on which to propose levels at this stage.
10. Both MEPS and 'high efficiency' levels should be published in a new Australian Standard, to be based on the ARI 810 and ARI 820 test method. This test method, once published should be proposed as a new ISO/IEC international test method.

8.1 COMPLEMENTARY PROGRAMS

There are a number of activities which should be undertaken to ensure the effective transition to the introduction of MEPS. These include:

- Clearly communicating Government's intentions with manufacturers and importers of commercial ice makers and storage bins, at each stage of the process;
- Working with relevant trade associations, and using trade publications and food service events to reach smaller companies which are likely to be affected.

To maximize the environmental benefits of the regulations, efforts should be targeted at major customers, particularly to encourage the specification of 'high efficiency' products, or where these do not exist, the best performing products.

8.2 TIMETABLE

The recommended timetable for the implementation of MEPS for ice-makers and storage bins, as outlined above, is shown in Table 15. It is important that sufficient time is allowed for manufacturers, importers and customers to adjust to these proposals, and hence a period of two years has been allowed from the first public announcement of government intentions to the date that these measures are implemented.

This allows for a period a consultation in relation to the proposals, and for Government to consider representations from industry and other stakeholders. Following this, a working group under the Standards Australia committee ME-008 (Commercial Refrigeration) should be formed to consider a new draft Standard. Since this would be based on existing standards, it is envisaged that this drafting exercise could be completed relatively quickly.

From the time that a draft standard is published, a further period of one year is allowed to enable a regulatory impact statement to be completed, together with the mandatory consultation associated with this task. It should be noted that it is a requirement before any new legislation is passed, that the regulatory impact assessment is undertaken and the national cost-benefit of the proposal is proved to be positive.

This period also allows for the AGO to advertise the impending requirements to industry and customers.

Table 15: Proposed timetable for implementation of MEPS for ice makers

Item	Date
Consultation with Industry	Oct 2004 – April 2005
Publication of Draft Standard	Sept 2005
Regulatory Impact Statement	Sept 2005 – April 2006
Implementation of MEPS	Oct 2006

9. Energy & Greenhouse Reduction Potential

The estimated impact of MEPS on greenhouse emissions resulting from the use of ice makers and ice storage bins in Australia is shown in Figure 20.

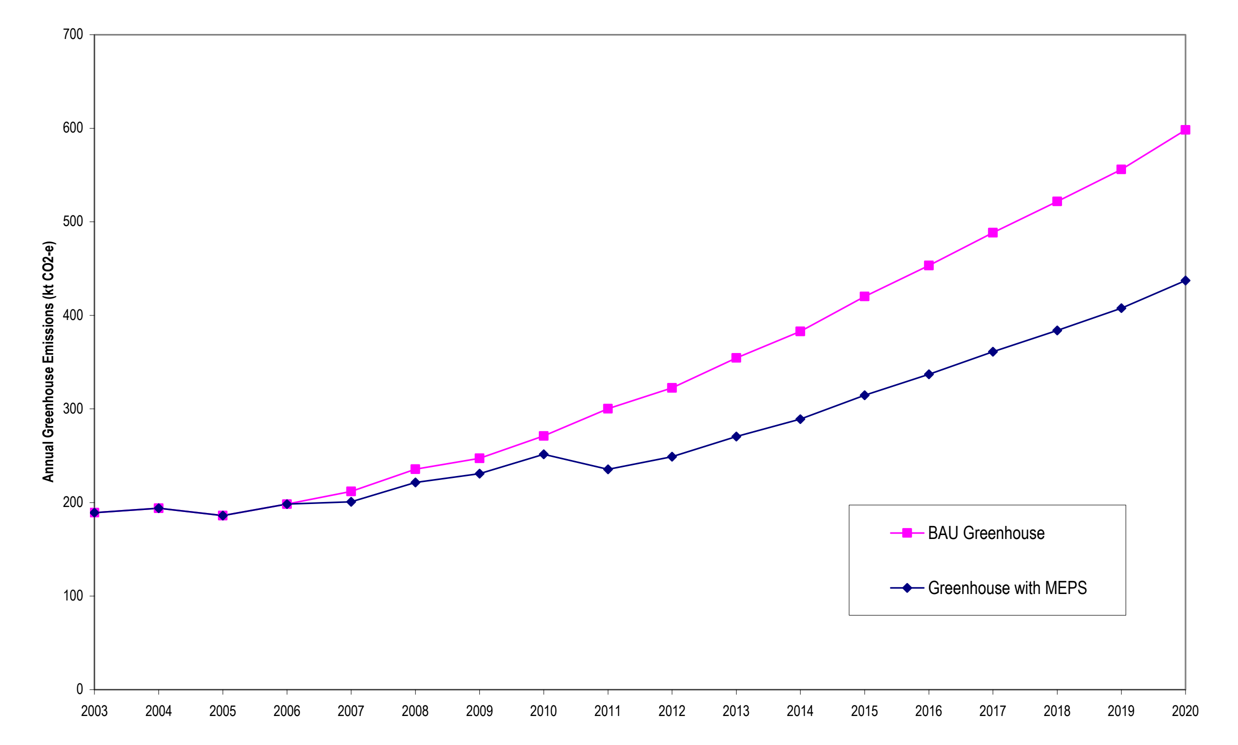
This assumes that:

- MEPS apply only to new products and therefore it takes time before MEPS levels have a significant impact on the performance of the stock of products;
- Initial MEPS levels improve the average energy consumption of new products by 10% from 2007;

- The second MEPS levels improve the average energy consumption of new products by a further 20% from 2011;
- The average national commercial greenhouse gas coefficient for electricity consumption improves steadily throughout this period.

By 2020, the estimated impact of these measures is to reduce annual energy consumption by 200GWh and annual greenhouse emissions by 160 ktCO_2-e. The total cumulative savings in greenhouse gas emissions from 2006 – 2020 is estimated to be 1.2 MtCO_2-e.

Figure 20: Estimated Impact of MEPS on greenhouse emissions from ice makers in Australia



10. Financial and Trade Implications

The Council of Australian Governments (COAG) requires that all proposed Australian regulations undergo a Regulatory Impact Statement (RIS) process. This includes detailed examination of the costs and benefits of the proposal, together with any associated economic and trade implications. The resultant report must be published for comment, and any adverse reaction must be addressed. Therefore, detailed consideration of the financial and trade implications of MEPS for ice makers should properly be undertaken as part of the RIS, commissioned once the Australian Standard has been published.

However, some points are worth making at this stage.

- There is a range of efficiencies of available products. It is expected that there is a correlation between increased efficiency and purchase price.
- With respect to the impact on trade, the vast majority of ice makers are imported. Therefore any impact on Australia's manufacturing industry should be small. The requirements on ice storage bins can be met relatively easily, and therefore it is considered unlikely that these will pose problems for industry. Importers and product specifiers will need to ensure that ice makers and ice storage bins comply with the new MEPS requirements, and there is a wide range of products currently available which meet these requirements.
- By allowing at least 12 months between the publication of the new Australian Standard and implementation of MEPS in 2006, there should be adequate time for the Australian industry to make any necessary adjustments to purchasing policies.

REFERENCES

ABS 2004	Australian Bureau of Statistics - International Trade Statistics: Imports – ice-making machines, calendar years 1996 – 2003.
ARI 2004	Directory of Certified Automatic Commercial Ice-cube Machines and Ice Storage Bins 810/820, Air-conditioning and Refrigeration Institute, 2004.
Bansal 2001	Intrinsic Effects of Voltage and Frequency Variation on Compressor Efficiency. P.K. Bansal, Associate Professor, Dept. of Mechanical Engineering, The University of Auckland, New Zealand. Report for the Energy Efficiency Team, Australian Greenhouse Office, Canberra, Australia.
MEA 2001	*Minimum Energy Performance Standards for Ice Makers and Ice Storage Bins – Self-contained,* Mark Ellis and Professor Eddie Leonardi, for the Australian Greenhouse Office, December 2001.
NAEEEC 2001	*Minimum Energy Performance Standards: Self-contained Commercial Refrigeration*, National Appliance Equipment Energy Efficiency Committee, March 2001.
NGS 1998	National Greenhouse Office. Commonwealth of Australia.
US Dept of Energy 1996	Energy Savings Potential for Commercial Refrigeration Equipment. Report by Arthur D Little for the Building Equipment Division, Office of Building Technologies, US Dept of Energy. June 1996.

APPENDIX 1: DIRECTORY OF CERTIFIED AUTOMATIC COMMERCIAL ICE-CUBE MACHINES, ARI 2004

Model Designation		Ice Harvest Rate (lb per 24 hr)	Potable Water Use Rate (gal / 100lb ice)	Condenser Water Use Rate (gal / 100lb ice)	Energy Consumption Rate (kWh / 100lb ice)	Refrigerant Type
Hoshizaki						
Type IMH-A						
	KM-280MAH	194	24.3	----	11.7	HFC/HFC/HFC-404A
	KML-250MAH	238	35.2	----	8.2	HFC/HFC/HFC-404A
	KML-350MAH	322	24.6	----	7.4	HFC/HFC/HFC-404A
	KML-450MAH	336	27.1	----	8.4	HFC/HFC/HFC-404A
	KM-500MAH	401	27.9	----	7.3	HFC/HFC/HFC-404A
	KM-630MAH	479	31.9	----	6.6	HFC/HFC/HFC-404A
	KML-600MAH	521	28.9	----	6.9	HFC/HFC/HFC-404A
	KM-900MAH	738	32.1	----	6.4	HFC/HFC/HFC-404A
	KM-1300MAH	1059	32.3	----	6	HFC/HFC/HFC-404A
	KM-1300SAH3	1132	23.6	----	4.9	HFC/HFC/HFC-404A
	KM-1300SAH	1143	28.6	----	4.9	HFC/HFC/HFC-404A
	KM-1800SAH3	1532	21.1	----	4.6	HFC/HFC/HFC-404A
	KM-1800SAH	1539	22	----	4.7	HFC/HFC/HFC-404A
Type IMH-W						
	KM-280MWH	216	35.8	158	9.3	HFC/HFC/HFC-404A
	KML-250MWH	287	34.9	120	6.3	HFC/HFC/HFC-404A
	KML-350MWH	331	25.9	112	6.6	HFC/HFC/HFC-404A
	KML-450MWH	417	26.7	130	6.1	HFC/HFC/HFC-404A
	KM-500MWH	463	28	129	6.2	HFC/HFC/HFC-404A
	KML-600MWH	560	27.6	96	5.4	HFC/HFC/HFC-404A
	900MWH	801	32.3	100	5.1	HFC/HFC/HFC-404A
	KM-1300MWH	1222	30.6	76	4.1	HFC/HFC/HFC-404A
	KM-1300SWH	1278	22.1	72	4	HFC/HFC/HFC-404A
	KM-100SWH3	1287	22.7	72	3.9	HFC/HFC/HFC-404A
	KM-1600SWH3	1547	30.2	106	4.1	HFC/HFC/HFC-404A
	KM-1600SWH	1558	25.3	80	4.2	HFC/HFC/HFC-404A
	KM-2000SWH3	1864	20.7	77	3.8	HFC/HFC/HFC-404A
Type RCU-A						
Icemaking head	*Condenser*					
KM-500MRH	URC-6F	444	29.8	-----	7.2	HFC/HFC/HFC-404A
KM-630MRH	URC-6F	499	33.3	----	6.8	HFC/HFC/HFC-404A
KML-600MRH	URC-7F	561	37.1	----	7.1	HFC/HFC/HFC-404A
KM-900MRH	URC-12F	786	31.7	----	6.2	HFC/HFC/HFC-404A
KM-900MRH3	URC-12F	809	32.1	----	6.2	HFC/HFC/HFC-404A
KM-1300SRH	URC-12F	1163	30.5	----	4.8	HFC/HFC/HFC-404A
KM-1300	URC-12F	1183	32	----	5.3	HFC/HFC/HFC-404A
KM-1300SRH3	URC-12F	1266	19.8	----	4.4	HFC/HFC/HFC-404A
KM-1600MRH	URC-20F	1343	30	----	5.7	HFC/HFC/HFC-404A
KM-1600MRH3	URC-20F	1354	30.7	----	5.3	HFC/HFC/HFC-404A
KM-1600SRH3	URC-20F	1375	31.7	----	5	HFC/HFC/HFC-404A
KM-1600SRH	URC-20F	1400	33.8	----	5.6	HFC/HFC/HFC-404A
KM-2000SRH3	URC-20F	1748	20	----	4.4	HFC/HFC/HFC-404A
KM-2400SRH3	URC-24F	2321	21.9	----	5.1	HFC/HFC/HFC-404A

Type SC-A

	KM-150BAF	113	30	----	13.1	HFC/HFC/HFC-404A
	KM-250BAF	193	28.7	----	12.2	HFC/HFC/HFC-404A

Type SC-W

	KM-150BWF	117	25.8	169	10.6	HFC/HFC/HFC-404A
	KM-250BWF	207	39.5	136	9.9	HFC/HFC/HFC-404A

Cornelius

Type IMH-A

	AC322	240	27	----	9.8	HCF/HFC/HFC-404A
	XAC322,330	269	16.7	----	8.5	HFC/HFC/HFC-404A
	XAC522,530	475	16.6	----	7	HFC/HFC/HFC-404A
	XAC630	547	16.3	----	6.9	HFC/HFC/HFC-404A
	XAC830	666	16.3	----	6.9	HFC/HFC/HFC-404A
	XAC1030	830	13.2	----	7	HFC/HFC/HFC-404A
	XAC1230	1019	14.6	----	6.5	HFC/HFC/HFC-404A
	XAC1444-3PH	1275	14.3	----	6.6	HFC/HFC/HFC-404A
	XAC1444	1275	14.3	----	6.6	HFC/HFC/HFC-404A
	XAC1844-3PH	1495	14.5	----	7.2	HFC/HFC/HFC-404A
	XAC1844	1575	14.5	----	7.2	HFC/HFC/HFC-404A

Type IMH-W

	WC322	240	27	160	7.6	HFC/HFC/HFC-404A
	XWC322,330	281	16.7	149	6.8	HFC/HFC/HFC-404A
	XWC522,530	493	16.6	133	5.9	HFC/HFC/HFC-404A
	XWC630	589	16.3	116	5.6	HFC/HFC/HFC-404A
	XWC830	700	16.3	116	5.6	HFC/HFC/HFC-404A
	XWC1030	887	13.2	112.7	5.5	HFC/HFC/HFC-404A
	XWC1230	1029	14.6	105	5.2	HFC/HFC/HFC-404A
	XWC1444	1374	14.3	149	5.2	HFC/HFC/HFC-404A
	XWC1444-3PH	1374	14.3	149	5.2	HFC/HFC/HFC-404A
	XWC1844-3PH	1455	14.5	155	6	HFC/HFC/HFC-404A
	XWC1844	1610	14.5	155	6	HFC/HFC/HFC-404A

Type RCU-A

Icemaking head	*Condenser*					
XRC522,530	CR500	475	16.6	----	7	HFC/HFC/HFC-404A
XRC630	CR800	547	16.3	----	6.9	HFC/HFC/HFC-404A
XRC830	CR800	666	16.3	----	6.9	HFC/HFC/HFC-404A
XRC1030	CR1200	830	13.2	----	7	HFC/HFC/HFC-404A
XRC1230,	CR1200	1019	14.6	----	6.5	HFC/HFC/HFC-404A
XRC1444,	CR1400	1275	14.3	----	6.6	HFC/HFC/HFC-404A
XRC1844,	CR2400	1581	14.6	----	5.8	HFC/HFC/HFC-404A

Type SC-A

	ACS50	38	16	----	16.6	HFC-134a
	IACS224	150	25	----	10.6	HFC/HFC/HFC-404A
	IACS227	240	27	----	9.8	HFC/HFC/HFC-404A

Type SC-W

	IWCS224	145	22	195	10.5	HFC/HFC/HFC-404A
	IWCS227	240	27	160	7.6	HFC/HFC/HFC-404A

Manitowoc

Type IMH-A

QD-0322A	220	27.5	----	7.9	HFC/HFC/HFC-404A
QY-0324A	220	27.5	----	7.9	HFC/HFC/HFC-404A
QD-0282A	225	34.8	----	9.3	HFC/HFC/HFC-404A
QY-0284A	225	34.8	----	9.3	HFC/HFC/HFC-404A
SY-0304A	255	26	----	8.3	HFC/HFC/HFC-404A
SD-0302A	255	26	----	8.3	HFC/HFC/HFC-404A
QY-0374A	275	26	----	8.3	HFC/HFC/HFC-404A
QD-0372A	275	26	----	8.3	HFC/HFC/HFC-404A
QD-0422A	380	26.4	----	7.2	HFC/HFC/HFC-404A
QD-0452A	380	26.4	----	7.2	HFC/HFC/HFC-404A
QY-0424A	380	26.4	----	7.2	HFC/HFC/HFC-404A
QY-0454A	380	26.4	----	7.2	HFC/HFC/HFC-404A
SY-0504A	400	18	----	6.4	HFC/HFC/HFC-404A
SD-0502A	400	18	----	6.4	HFC/HFC/HFC-404A
QD-0602A	540	24	----	6.4	HFC/HFC/HFC-404A
QY-0604A	540	24	----	6.4	HFC/HFC/HFC-404A
QD-0802A	640	21.6	----	6.9	HFC/HFC/HFC-404A
QD-0802A3	640	21.6	----	6.9	HFC/HFC/HFC-404A
QY-0804A	640	21.6	----	6.9	HFC/HFC/HFC-404A
QY-0804A3	640	21.6	----	6.9	HFC/HFC/HFC-404A
SY-0854A	670	18	----	6.1	HFC/HFC/HFC-404A
SY-0854A3	670	18	----	5.8	HFC/HFC/HFC-404A
SD-0852A	670	18	----	6.1	HFC/HFC/HFC-404A
SD-0852A3	670	18	----	5.8	HFC/HFC/HFC-404A
QD-1002A	830	20.4	----	6.9	HFC/HFC/HFC-404A
QD-1002A3	830	20.4	----	6.7	HFC/HFC/HFC-404A
QY-1004A	830	20.4	----	6.9	HFC/HFC/HFC-404A
QY-1004A3	830	20.4	----	6.7	HFC/HFC/HFC-404A
SY-1004A	830	18	----	5.7	HFC/HFC/HFC-404A
SY-1004A3	830	18	----	5.5	HFC/HFC/HFC-404A
SD-1002A	830	18	----	5.7	HFC/HFC/HFC-404A
SD-1002A3	830	18	----	5.5	HFC/HFC/HFC-404A
QD-1302A	1110	19.2	----	6	HFC/HFC/HFC-404A
QD-1302A3	1110	19.2	----	6	HFC/HFC/HFC-404A
QY-1304A	1110	19.2	----	6	HFC/HFC/HFC-404A
QY-1304A3	1110	19.2	----	6	HFC/HFC/HFC-404A
QD-1802A	1570	18	----	6.2	HFC/HFC/HFC-404A
QD-1802A3	1570	18	----	5.9	HFC/HFC/HFC-404A
QY-1804A	1570	18	----	6.2	HFC/HFC/HFC-404A
QY-1804A3	1570	18	----	5.9	HFC/HFC/HFC-404A

Type IMH-W

QD-0283W	250	34.8	196	7.2	HFC/HFC/HFC-404A
QY-0285W	250	34.8	196	7.2	HFC/HFC/HFC-404A
QD-0323W	260	27.5	215	5.9	HFC/HFC/HFC-404A
QY-0325W	260	27.5	215	5.9	HFC/HFC/HFC-404A
SY-0305W	270	26	180	6.6	HFC/HFC/HFC-404A
SD-0303W	270	26	180	6.6	HFC/HFC/HFC-404A
QY-0375W	320	26	160	6.3	HFC/HFC/HFC-404A
QD-0373W	320	26	160	6.3	HFC/HFC/HFC-404A
QD-0423W	440	26.4	177	5.5	HFC/HFC/HFC-404A
QY-0425W	440	26.4	177	5.5	HFC/HFC/HFC-404A

	QD-0453W	440	26.4	177	5.5	HFC/HFC/HFC-404A
	QY-0455W	440	26.4	177	5.5	HFC/HFC/HFC-404A
	SY-0505W	480	18	138	4.9	HFC/HFC/HFC-404A
	SD-0503W	480	18	138	4.9	HFC/HFC/HFC-404A
	QD-0603W	580	24	215	5.4	HFC/HFC/HFC-404A
	QY-0605W	580	24	215	5.4	HFC/HFC/HFC-404A
	QD-0803W	730	21.6	195	5.3	HFC/HFC/HFC-404A
	QD-0803W3	730	21.6	195	5.3	HFC/HFC/HFC-404A
	QY-0805W	730	21.6	195	5.3	HFC/HFC/HFC-404A
	QY-0805W3	730	21.6	195	5.3	HFC/HFC/HFC-404A
	SD-0853W	790	18	180	4.8	HFC/HFC/HFC-404A
	SD-0853W3	790	18	180	4.6	HFC/HFC/HFC-404A
	SY-0855W	790	18	180	4.8	HFC/HFC/HFC-404A
	SY-0855W3	790	18	180	4.6	HFC/HFC/HFC-404A
	QD-1003W	900	20.4	167	5.9	HFC/HFC/HFC-404A
	QD-1003W3	900	20.4	167	5.6	HFC/HFC/HFC-404A
	QY-1005W	900	20.4	167	5.9	HFC/HFC/HFC-404A
	QY-1005W3	900	20.4	167	5.6	HFC/HFC/HFC-404A
	SY-1005W	910	18	165	4.7	HFC/HFC/HFC-404A
	SY-1005W3	910	18	165	4.5	HFC/HFC/HFC-404A
	SD-1003W	910	18	165	4.7	HFC/HFC/HFC-404A
	SD-1003W3	910	18	165	4.5	HFC/HFC/HFC-404A
	QD-1303W	1250	19.2	178	4.7	HFC/HFC/HFC-404A
	QD-1303W3	1250	19.2	178	4.6	HFC/HFC/HFC-404A
	QY-1305W	1250	19.2	178	4.7	HFC/HFC/HFC-404A
	QY-1305W3	1250	19.2	178	4.6	HFC/HFC/HFC-404A
	QD-1603W	1490	19	150	4.3	HFC/HFC/HFC-404A
	QD-1603W3	1490	19	150	4.2	HFC/HFC/HFC-404A
	QY-1605W	1490	19	150	4.3	HFC/HFC/HFC-404A
	QY-1604W3	1490	19	150	4.2	HFC/HFC/HFC-404A
	QD-1803W	1670	18	160	5.2	HFC/HFC/HFC-404A
	QD-1803W3	1670	18	160	4.8	HFC/HFC/HFC-404A
	QY-1805W	1670	18	160	5.2	HFC/HFC/HFC-404A
	QY-1805W3	1670	18	160	4.8	HFC/HFC/HFC-404A

Type RCU-A

Icemaking head	*Condenser*					
QD-0492N	JC-0495	420	26.4	----	7.3	HFC/HFC/HFC-404A
QY-0494N	JC-0495	420	26.4	----	7.3	HFC/HFC/HFC-404A
SY-0594N	JC-0495	460	18	----	6.4	HFC/HFC/HFC-404A
SD-0592N	JC-0495	460	18	----	6.4	HFC/HFC/HFC-404A
QD-0692N	JC-0895	560	24	----	6.6	HFC/HFC/HFC-404A
QY-0694N	JC-0895	560	24	----	6.6	HFC/HFC/HFC-404A
IB-0622DC	CVD-0675	570	26.4	----	6.5	HFC/HFC/HFC-404A
IB-0622DC	CVD-06753	570	26.4	----	6.5	HFC/HFC/HFC-404A
IB-0624YC	CVD-0675	570	26.4	----	6.5	HFC/HFC/HFC-404A
IB-0624YC	CVD-06753	570	26.4	----	6.5	HFC/HFC/HFC-404A
QD-0672C	CVD-0675	570	24	----	6.5	HFC/HFC/HFC-404A
QD-0672C	CVD-06753	570	24	----	6.5	HFC/HFC/HFC-404A
QY-0674C	CVD-0675	570	24	----	6.5	HFC/HFC/HFC-404A
QY-0674C	CVD-06753	570	24	----	6.5	HFC/HFC/HFC-404A
QD-0872C	CVD-0875	680	21.6	----	6.6	HFC/HFC/HFC-404A
QD-0872C	CVD-08753	680	21.6	----	6.8	HFC/HFC/HFC-404A
QY-0874C	CVD-0875	680	21.6	----	6.6	HFC/HFC/HFC-404A
QY-0874C	CVD-08753	680	21.6	----	6.8	HFC/HFC/HFC-404A

IB-0822DC	CVD-0875	680	26.4	----	6.6	HFC/HFC/HFC-404A
IB-0822DC	CVD-08753	680	26.4	----	6.8	HFC/HFC/HFC-404A
IB-0824YC	CVD-0875	680	26.4	----	6.6	HFC/HFC/HFC-404A
IB-0824YC	CVD-08753	680	26.4	----	6.8	HFC/HFC/HFC-404A
QD-0892N	JC-0895	665	21.6	----	6.7	HFC/HFC/HFC-404A
QD-0892N3	JC-0895	665	21.6	----	6.7	HFC/HFC/HFC-404A
QY-0894N	JC-0895	665	21.6	----	6.7	HFC/HFC/HFC-404A
QY-0894N3	JC-0895	665	21.6	----	6.7	HFC/HFC/HFC-404A
SD-0872C	CVD-0885	690	18	----	6	HFC/HFC/HFC-404A
SD-0872C	CVD-08853	690	18	----	5.8	HFC/HFC/HFC-404A
SY-0874C	CVD-0885	690	18	----	6	HFC/HFC/HFC-404A
SY-0874C	CVD-08853	690	18	----	5.8	HFC/HFC/HFC-404A
SD-0892N	JC-0895	730	26.6	----	5.8	HFC/HFC/HFC-404A
SD-0892N3	JC-0895	730	18	----	5.5	HFC/HFC/HFC-404A
SY-0894N	JC-0895	730	18	----	5.8	HFC/HFC/HFC-404A
SY-0894N3	JC-0895	730	18	----	5.5	HFC/HFC/HFC-404A
SD-1092N	JC-0895	850	18	----	5.5	HFC/HFC/HFC-404A
SD-1092N3	JC-0895	850	18	----	5.3	HFC/HFC/HFC-404A
SY-1094N	JC-0895	850	18	----	5.5	HFC/HFC/HFC-404A
SY-1094N3	JC-0895	850	18	----	5.3	HFC/HFC/HFC-404A
SD-1072C	CVD-1085	850	18	----	5.5	HFC/HFC/HFC-404A
SD-1072C	CVD-10853	850	18	----	5.3	HFC/HFC/HFC-404A
SY-1074C	CVD-1085	850	18	----	5.5	HFC/HFC/HFC-404A
SY-1074C	CVD-10853	850	18	----	5.3	HFC/HFC/HFC-404A
QD-1072C	CVD-1075	900	20.4	----	6.3	HFC/HFC/HFC-404A
QD-1072C	CVD-10753	900	20.4	----	6.3	HFC/HFC/HFC-404A
QY-1074C	CVD-1075	900	20.4	----	6.3	HFC/HFC/HFC-404A
QY-1074C	CVD-10753	900	20.4	----	6.3	HFC/HFC/HFC-404A
IB-1024YC	CVD-1075	900	20.4	----	6.3	HFC/HFC/HFC-404A
IB-1024YC	CVD-10753	900	20.4	----	6.3	HFC/HFC/HFC-404A
IB-1022DC	CVD-1075	900	20.4	----	6.3	HFC/HFC/HFC-404A
IB-1022DC	CVD-10753	900	20.4	----	6.3	HFC/HFC/HFC-404A
QD-1092N	JC-1095	850	20.4	----	6.9	HFC/HFC/HFC-404A
QD-1092N3	JC-1095	850	20.4	----	6.8	HFC/HFC/HFC-404A
QY-1094N	JC-1095	850	20.4	----	6.9	HFC/HFC/HFC-404A
QY-1094N3	JC-1095	850	20.4	----	6.8	HFC/HFC/HFC-404A
QD-1392N	JC-1395	1140	19.2	----	5.7	HFC/HFC/HFC-404A
QD-1392N3	JC-1395	1140	19.2	----	5.6	HFC/HFC/HFC-404A
QY-1394N	JC-1395	1140	19.2	----	5.7	HFC/HFC/HFC-404A
QY-1394N3	JC-1395	1140	19.2	----	5.6	HFC/HFC/HFC-404A
QD-1472C	CVD1475	1200	21.6	----	6.6	HFC/HFC/HFC-404A
QD-1472C	CVD14753	1200	21.6	----	6.4	HFC/HFC/HFC-404A
QY-1474C	CVD1475	1200	21.6	----	6.6	HFC/HFC/HFC-404A
QY-1474C	CVD14753	1200	21.6	----	6.4	HFC/HFC/HFC-404A
QD-1692N	JC-1895	1425	19	----	4.8	HFC/HFC/HFC-404A
QD-1692N3	JC-1895	1425	19	----	4.7	HFC/HFC/HFC-404A
QY-1694N	JC-1895	1425	19	----	4.8	HFC/HFC/HFC-404A
QY-1694N3	JC-1895	1425	19	----	4.8	HFC/HFC/HFC-404A
QD-DUAL2C	CVD-1875	1530	18	----	6.1	HFC/HFC/HFC-404A
QD-DUAL2C	CVD-18753	1530	18	----	5.7	HFC/HFC/HFC-404A
QY-DUAL4C	CVD-1875	1530	18	----	6.1	HFC/HFC/HFC-404A
QY-DUAL4C	CVD-18753	1530	18	----	5.7	HFC/HFC/HFC-404A
QD-1892N	JC-1895	1580	18	----	5.8	HFC/HFC/HFC-404A
QD-1892N3	JC-1895	1580	18	----	5.3	HFC/HFC/HFC-404A
QY-1894N	JC-1895	1580	18	----	5.8	HFC/HFC/HFC-404A

QY-1894N3	JC-1895	1580	18	----	5.3	HFC/HFC/HFC-404A
QD-DUAL2C	CVD-2075	1750	22.8	----	6.8	HFC/HFC/HFC-404A
QD-DUAL2C	CVD-20753	1750	22.8	----	6.6	HFC/HFC/HFC-404A
QY-DUAL4C	CVD-2075	1750	22.8	----	6.8	HFC/HFC/HFC-404A
QY-DUAL4C	CVD-20753	1750	22.8	----	6.6	HFC/HFC/HFC-404A
Type RCU-W						
Icemaking head	*Condenser*					
QD-1472C	CVD-1476	1230	21.6	161	4.9	HFC/HFC/HFC-404A
QD-1472C	CVD14763	1230	21.6	161	4.6	HFC/HFC/HFC-404A
QY-1474C	CVD-1476	1230	21.6	161	4.9	HFC/HFC/HFC-404A
QY-1474C	CVD-14763	1230	21.6	161	4.6	HFC/HFC/HFC-404A
Type SC-A						
	QM-30A	52	38.4	----	20.4	HFC-134a
	QM-45A	65	38.6	----	14.9	HFC-134a
	QD-0132A	90	38.4	----	16	HFC/HFC/HFC-404A
	QY-0134A	90	38.4	----	16	HFC/HFC/HFC-404A
	QD-0212A	155	33.5	----	9.9	HFC/HFC/HFC-404A
	QY-0214A	155	33.5	----	9.9	HFC/HFC/HFC-404A
	QD-0272A	215	32.4	----	9	HFC/HFC/HFC-404A
	QY-0274A	215	32.4	----	9	HFC/HFC/HFC-404A
Type SC-W						
	QD-0133W	123	38.4	187	9.8	HFC/HFC/HFC-404A
	QY-0135W	123	38.4	187	9.8	HFC/HFC/HFC-404A
	QD-0213W	190	33.5	142	6.8	HFC/HFC/HFC-404A
	QY-0215W	190	33.5	142	6.8	HFC/HFC/HFC-404A
	QD-0273W	245	32.4	167	7.3	HFC/HFC/HFC-404A
	QY-0275W	245	32.4	167	7.3	HFC/HFC/HFC-404A

ICE-O-Matic

Type IMH-A						
	ICE0320FA,HA	214	28.5	----	9.5	HFC/HFC/HFC-404A
	ICE0250FA1,HA1	220	31	----	8.5	HFC/HFC/HFC-404A
	ICE0250FA,HA	239	31	----	8.6	HFC/HFC/HFC-404A
	ICE0250FT,HT	244	30.1	----	8.4	HFC/HFC/HFC-404A
	ICE0400JA	318	24.1	----	6.6	HFC/HFC/HFC-404A
	ICE0400FA,HA	366	24.5	----	6.5	HFC/HFC/HFC-404A
	ICE0400FT,HT	368	24.8	----	6.5	HFC/HFC/HFC-404A
	ICE0520FA,HA	368	24.3	----	7.5	HFC/HFC/HFC-404A
	ECP556FA,HA	414	26.3	----	6.8	HFC/HFC/HFC-404A
	ICE0500FT,HT	455	23	----	7.3	HFC/HFC/HFC-404A
	ICE0500FA,HA	461	23.4	----	7.3	HFC/HFC/HFC-404A
	ICE0606FT,HT	510	24.5	----	6.6	HFC/HFC/HFC-404A
	ICE0606FA,HA	525	23.5	----	6.5	HFC/HFC/HFC-404A
	ICE0806JA	623	21.6	----	6.3	HFC/HFC/HFC-404A
	ICE0806FA,HA	698	21.8	----	6.2	HFC/HFC/HFC-404A
	ICE1007FA,HA	767	19.8	----	5.6	HFC/HFC/HFC-404A
	ICE1006FA,HA	811	20.6	----	5.4	HFC/HFC/HFC-404A
	ICE1407FA,HA	989	19.6	----	5.4	HFC/HFC/HFC-404A
	ICE1406FA,HA	1122	21.3	----	5.5	HFC/HFC/HFC-404A

Type IMH-W						
	ICE0250FW,HW	284	35.6	149	6.1	HFC/HFC/HFC-404A
	ICE0320FW,HW	312	29.6	144	5.3	HFC/HFC/HFC-404A
	ICE0520FW,HW	441	26.8	118	4.8	HFC/HFC/HFC-404A
	ICE0400FW,HW	449	27	225	4.7	HFC/HFC/HFC-404A
	ICE0500FW,HW	499	21.1	189	5.7	HFC/HFC/HFC-404A
	ICE0606FW,HW	590	27.4	197	5.1	HFC/HFC/HFC-404A
	ICE0806FW,HW	840	22.8	126	3.9	HFC/HFC/HFC-404A
	ICE1007FW,HW	906	23.5	183	4.4	HFC/HFC/HFC-404A
	ICE1006FW,HW	941	23.7	170	3.8	HFC/HFC/HFC-404A
	ICE1407FW,HW	1093	20.8	139	4.4	HFC/HFC/HFC-404A
	ICE1406FW,HW	1187	22.2	153	4.9	HFC/HFC/HFC-404A
	ICE1806FW,HW	1461	20.3	178	4.1	HFC/HFC/HFC-404A
	ICE1807FW,HW	1556	20.2	190	4	HFC/HFC/HFC-404A
	ICE2107FW,HW	1853	20.2	150	4.2	HFC/HFC/HFC-404A
	ICE2106FW,HW	1855	20.9	166	4.3	HFC/HFC/HFC-404A
Type RCU-A						
Icemaking head	*Condenser*					
ICE0500FR,	ERC1002	438	25.1	----	8	HFC/HFC/HFC-404A
ICE0606FR,	ERC1062	544	21.6	----	6.8	HFC/HFC/HFC-404A
ICE0806FR,	ERC2062	762	22.5	----	5.4	HFC/HFC/HFC-404A
ICE1007FR,	ERC2062	844	21.6	----	5.9	HFC/HFC/HFC-404A
ICE1006FR,	ERC2062	905	19.1	----	5.4	HFC/HFC/HFC-404A
ICE1407FR,	ERC2661	956	19.2	----	6	HFC/HFC/HFC-404A
ICE1406FR,	ERC2661	1134	20	----	5.6	HFC/HFC/HFC-404A
ICE1506FR,	LRC2661	1202	20.3	----	5.2	HFC/HFC/HFC-404A
ICE1606FR,	ERC2661	1272	20.2	----	5.2	HFC/HFC/HFC-404A
ICE1806FR,	ERC4061	1468	18.2	----	4.6	HFC/HFC/HFC-404A
ICE1807FR,	ERC4061	1491	19.3	----	4.7	HFC/HFC/HFC-404A
ICE2106FR,	ERC5061	1723	19.2	----	5.7	HFC/HFC/HFC-404A
ICE2107FR,	ERC5061	1737	19.2	----	5.4	HFC/HFC/HFC-404A
Type SC-A						
	ICEU060A	54	49	----	17.3	HFC-134a
	ICEU150FA,HA	117	31.6	----	10.9	HFC/HFC/HFC-404A
	ICEU200FA,HA	157	29.2	----	9.9	HFC/HFC/HFC-404A
Type SC-W						
	ICEU150FW,HW	139	39.2	186	8	HFC/HFC/HFC-404A
	ICEU200FW,HW	183	37.1	170	7	HFC/HFC/HFC-404A

Scotsman

Type IMH-A						
	CME256A+-1#,32#	240	16	----	9	HFC/HFC/HFC-404A
	CME306A+-1#,32#	260	20	----	8.7	HFC/HFC/HFC-404A
	CME506A+-1#,32#	410	23	----	7.4	HFC/HFC/HFC-404A
	CME456A+-1#,32#	400	17.5	----	7.4	HFC/HFC/HFC-404A
	CME656A+-32#,3#	583	15	----	6.1	HFC/HFC/HFC-404A
	CME806A+-32#,3#	660	12.9	----	6.8	HFC/HFC/HFC-404A
	CME1056A+-32#,3#	800	15.5	----	6.1	HFC/HFC/HFC-404A
	CME1356A+-32#	1145	19.5	----	6.3	HFC/HFC/HFC-404A
	CME1356A+-3#	1160	16	----	6	HFC/HFC/HFC-404A
	CME1656A+-32#	1250	16	----	6.1	HFC/HFC/HFC-404A

	CME1656A+-3#	1250	17.7	----	5.9	HFC/HFC/HFC-404A
Type IMH-W						
	CME256W+-1#	260	16	180	7.6	HFC/HFC/HFC-404A
	CME306W+-1#	295	20.4	174	7.1	HFC/HFC/HFC-404A
	CME506W+-1#	420	15	170	6.7	HFC/HFC/HFC-404A
	CME456W+-1#	454	17.9	144	6	HFC/HFC/HFC-404A
	CME656W+-32#,3#	575	15	130	6	HFC/HFC/HFC-404A
	CME806W+-32#,3#	716	17.6	153	5.7	HFC/HFC/HFC-404A
	CME1056W+-32#,3#	820	16.8	140	5.1	HFC/HFC/HFC-404A
	CME1356W+-32#,3#	1275	19.1	147	5	HFC/HFC/HFC-404A
	CME1656W+-32#,3#	1470	16	143	4.7	HFC/HFC/HFC-404A
	CME1856W+-3#	1695	16.1	159	4.7	HFC/HFC/HFC-404A
	CME1856W+-32#	1695	16.1	159	5	HFC/HFC/HFC-404A
Type RCU-A						
Icemaking head	*Condenser*					
CME506R+-1#	ERC101-1#	410	15	----	8.7	HFC/HFC/HFC-404A
CME456R+-1#	ERC111-1#	440	18	----	7.5	HFC/HFC/HFC-404A
CME456R+-1#	ERC211-1#	440	18	----	7.5	HFC/HFC/HFC-404A
	ERC680-32#	570	15	----	5.9	HFC/HFC/HFC-404A
CME656R+-32#,	ERC201-32#	575	15	----	6.7	HFC/HFC/HFC-404A
CME806R+-32#,	ERC201-32#	680	16.9	----	7.1	HFC/HFC/HFC-404A
CME810RL+-1#	ERC680-32#	680	17	----	6.4	HFC/HFC/HFC-404A
CME1056R+-32#,	ERC311-32A	820	17.9	----	6	HFC/HFC/HFC-404A
	ERC1086-32#	840	17.5	----	6.8	HFC/HFC/HFC-404A
CME1356R+-32#,	ERC411-32#	1260	16	----	5.5	HFC/HFC/HFC-404A
CME1656R+-32#,	ERC411-32#	1400	16	----	5	HFC/HFC/HFC-404A
CME2006R+-32#,	ERC611-32#	1740	17.5	----	5.8	HFC/HFC/HFC-404A
Type SC-A						
	CSE60A+-1#	54	49	----	17.3	HFC-134a
	SCE170A-1#	110	50	----	12.8	HFC/HFC/HFC-404A
	SCE275A-1#,32#	220	29	----	11.4	HFC/HFC/HFC-404A
Type SC-W						
	SCE170W-1#	142	55.5	210	9.5	HFC/HFC/HFC-404A
	SCE275W-1#	285	29	230	8.7	HFC/HFC/HFC-404A