IN FROM THE COLD

Strategies to increase the energy efficiency of non-domestic refrigeration in Australia & New Zealand

DRAFT STRATEGIC PLAN

30 October 2009

This paper has been prepared for the Equipment Energy Efficiency Committee under the auspices of the Australian and New Zealand Ministerial Council for Energy.

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Disclaimer

This Strategy has been developed with the involvement and cooperation of a range of stakeholders, but individual stakeholders have not necessarily committed to undertaking specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the Strategy due to changes in knowledge and the need to address other priorities.

The authors have made their best endeavours to ensure the accuracy and reliability of the data used herein, however make no warranties as to the accuracy of data herein nor accept any liability for any action taken or decision made based on the contents of this report.

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GLOSSARY

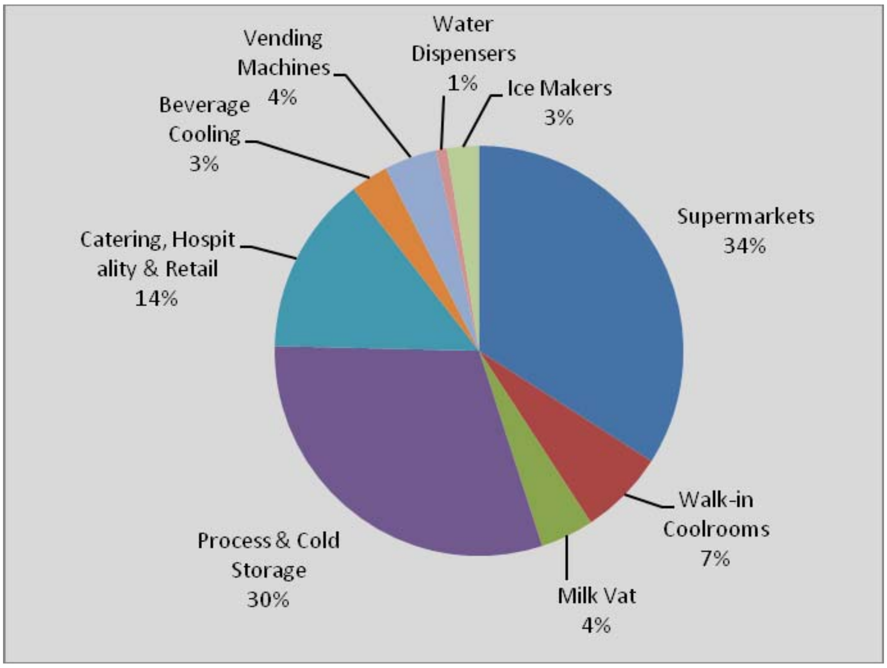
Alternative refrigerants:	Alternative to those commonly used in the Commercial Refrigeration Industry e.g. (R744-CO2 and R717-ammonia).
Ammonia refrigerant:	Refrigerant - R717 (NH_3). Ammonia's thermodynamic properties, make it very effective as a refrigerant, and is widely used in industrial refrigeration applications because of its high energy efficiency and relatively low cost. Ammonia is used less frequently in commercial applications, such as in grocery store freezer cases and refrigerated displays due to its toxicity.
ARCTICK:	Australian Refrigeration Council's authorised business symbol.
Carbon Pollution Reduction Scheme:	The CPRS is a proposed Australian Government initiative which places a limit, or cap, on the amount of carbon pollution industry in Australia can emit. It will require the largest businesses (approximately the top 1,000) to buy a 'pollution permit' for each tonne of carbon they emit.
Cascade refrigeration system:	A cascade system is made up of two separate but connected refrigeration systems, each of which have a primary refrigerant where refrigerants work in concert to reach the desired temperature. Cascade system in operation today in Australia are R404A/R744(CO2); R134a/R744 and R717(ammonia)/R744.
CFCs (R12 and R502):	Refrigerants that are in the chlorofluorocarbons group and known as CFCs, are now in a process of complete elimination from use, as it is both illegal to release into the atmosphere, and removal from existing systems must be undertaken in an approved manner for disposal in the event of system decommissioning. Alternative approved products are available as substitutes.
CO_2 refrigerant R 744:	An Industrial and Process refrigerant with high thermodynamic properties suitable for refrigeration use, but due to its high pressure operating levels in typical commercial refrigeration ranges, applications are not in common use. More systems are being designed as components e.g. compressors and other equipment, are available.
Cold food chain:	The cold food chain is part of the food value chain, which involves transport, storage, distribution and retailing of chilled and frozen foods.
Compressor:	A device in the refrigeration circuit which compresses refrigerant vapour, and circulates that refrigerant through to its phases of condensation and evaporation, in order to produce refrigeration effect. The compressor is available in many forms such as piston, scroll, or screw.
Compressor rack:	The machine assembly which accommodates the main high pressure components of a refrigeration circuit in a single structure, allowing off site connection to associated pipe work and vessels.
EN:	European Standard denotation.
EN ISO:	European Standard based on International Standard.
HCFCs refrigerant (R22):	A refrigerant which has predominant use in the air conditioning industry, and is being phased out. As components become available, its general replacement may be R410A.
Heat Transfer Fluids:	Any fluid which is used to transport its heat content to another location within a process, for either removal or adding to, or storage for subsequent use.

HFC refrigerant:	HFCs (R404A/R507 and R134a) refrigerants used as replacements for those in the now illegal CFC range.
Integral RDCs:	Refrigerated display cabinet with its refrigerating machinery contained integrally within the structure.
K-value:	The k-value, or heat transfer coefficient, is the measured value of the heat flow which is transferred through an area of 1 m^2 at a temperature difference of 1 K. The units of measure are watts per square meter per temperature difference (W/m^2K). K-value = energy / (area x temperature difference x time).
R-value:	Is a measure of thermal resistance, commonly used in the building and construction industry. Under uniform conditions it is the ratio of the temperature difference across an insulator and the heat flux (heat flow per unit area) where the bigger the number, the better the building insulation's effectiveness. R-value is the reciprocal of U-value. The R-value can be expressed in SI units, typically m^2K/W (or equivalently to $m^2{}^\circ C/W$) or in the United States, R-values are given in units of $ft^2{}^\circ F/Btu$. The conversion between SI and US units of R-value is 1 $h{\cdot}ft^2{}^\circ F/Btu$ = 0.176110 $K{\cdot}m^2/W$, or 1 $K{\cdot}m^2/W$ = 5.678263 $h{\cdot}ft^2{\cdot}{}^\circ F/Btu$.
Low Temperature:	Typically temperatures lower than -18^oC.
Medium Temperature:	Typically temperatures higher than -5^oC.
PIR:	Polyiscyanurate (PIR), an insulating foam product, has a higher thermal rating than Expanded Polystyrene (EPS).
Remote RDC:	Refrigerated display cabinet with its refrigerating machinery sited remote from the cabinet structure.
Screw compressor:	A rotary screw compressor is a type of gas compressor which uses a rotary type positive displacement mechanism; either a single screw or two counter rotating Helical Screws.
Scroll compressor:	A Scroll compressor uses two interleaved scrolls to pump, compress, or pressurize fluids such as liquids and gases.
Secondary loop refrigeration system:	A system which is so designed with two basic loops of refrigerating fluid flow, the primary one may be a conventional direct expansion of a phase change refrigerant, cooling a liquid flow that is pumped to the secondary loop. The primary loop utilises considerably less refrigerant in the closed short circuit, generally restricted to the plant room location. The secondary loop may consist of a Heat Transfer fluid being circulated to all of the heat exchange sites.
Self-contained RDCs:	Refrigerated display cabinet with its refrigerating machinery contained integrally within the structure.
Semi-Hermetic compressor:	A compressor which is connected to its driving motor within an accessible enclosure. The enclosure is hermetically sealed to retain the refrigerant and oil contents, along with the electrical stator windings of the motor.
Test Packs:	ISO type M packages for temperature testing as detailed in AS1731-4.2003 Clause 5.2
Walk-in coolroom (WIC):	A walk-in coolroom is a structure formed by an insulated enclosure of walls and ceiling, having a door through which personnel can pass through and close behind them. The floor space occupied by this structure, may or may not be insulated, depending on the operating temperature level.

EXECUTIVE SUMMARY

In 2008 non-domestic refrigeration consumed over 16,000 GWh of electricity in Australia and New Zealand, and was responsible for 15.4 Mt CO_2-e greenhouse gas emissions. Electricity is consumed throughout the cold food chain, as indicated in Figure 1.

Figure 1: Distribution of electricity consumption in non-domestic refrigeration, Australia and NZ, 2008



Source: MEA modelling estimates (see section 7 for further details)

This quantity of electricity consumption is approximately equivalent to the combined total of all residential lighting and refrigeration in both countries, which have already been targeted by energy efficiency policy measures over recent years.

The aim of this strategy, ***In from the Cold***, is to improve the energy performance and uptake of energy efficient non-domestic refrigeration products and services within Australia and New Zealand, and stimulate the development of an internationally competitive industry serving local and overseas markets.

In from the Cold Identifies the priority refrigeration technologies and market sectors to be targeted over the next ten years that will make a significant improvement to the energy performance of products and services throughout the non-domestic refrigeration sector. This will be achieved through measures which encourage the improved design and installation of new refrigeration equipment and systems, together with better maintenance practices to ensure that savings endure.

The strategy includes a range of policy measures, including the provision of information, voluntary and regulatory initiatives, designed to break down the barriers which currently prevent optimal energy efficiency. Fully implemented, these measures are expected to reduce electricity consumption from non-domestic refrigeration by 3,300 GWh in 2020, and by 8,000 GWh in 2030.

The estimated savings in greenhouse gas emissions between 2010 and 2030 total nearly 50 Mt CO_2-e, and 5 Mt CO_2-e in 2030.

Despite forecasted improvements to technology and services, electricity consumption in the sector is likely to continue rising, driven by demand for more refrigerated food and beverages, which will increase the total volume of refrigerated space. Against this 'business as usual' (BAU) scenario, ***In from the Cold*** will come close to stabilising electricity consumption from this sector. This helps secure energy supply for the future and reduce the need to rely on greenhouse intensive fossil fuels or further investment in electricity generation and infrastructure. Combining this with the lowering greenhouse gas intensity of electricity supplies in Australia and New Zealand means that implementation of ***In from the Cold*** will cause an absolute reduction in greenhouse emissions from the sector.

In from the Cold provides the broad strategic framework for stimulating energy efficiency in the non-domestic refrigeration sector across Australian and New Zealand. Co-ordination by the E3 Committee will ensure broad alignment to the aims of the strategy while allowing for different policy priorities and measures in these countries. Co-ordination of implementation will also take account of any differences between the national policy-making processes in each country. ***In from the Cold*** also provides an opportunity to align requirements with those of our major trading partners, many of whom are implementing similar policies.

1 INTRODUCTION

This document is presented by the Equipment Energy Efficiency (E3) Committee as a draft strategic plan for the non-domestic refrigeration sector with the objective of publishing a final strategic plan that has broad industry support early in 2010.

In from the Cold aims to improve the energy performance and uptake of energy efficient non-domestic refrigeration products and services within Australia and New Zealand, and stimulate the development of an internationally competitive industry serving local and overseas markets. The strategy:

- Provides a coordinated, strategic framework for reducing energy used by non-domestic refrigeration in Australia and New Zealand over the next ten years, 2010-2020.
- Describes the context and rationale for the strategy, including the policy framework in Australia and New Zealand, international policy developments and energy use in the non-domestic refrigeration sector.
- Explains the extent to which existing policy measures impact on the non-domestic refrigeration sector.
- Identifies priority projects for implementation over the next ten years that will make a significant improvement to the energy efficiency of products and services throughout the non-domestic refrigeration sector.
- Recommends a number of coordinated mandatory and voluntary measures that Government and industry will adopt to reduce greenhouse gas emissions due to refrigeration energy consumption.
- Outlines the specific projects for introduction in the first three years and commits all parties to continue to develop detailed three year work plans over the course of the strategy with a review in the final year.

Within this strategy reference is made to two background technical reports: Volume 1 deals with refrigerated cabinets, including display cabinets, while Volume 2 covers other sectors and technologies in the non-domestic refrigeration sector (MEA, 2009a; 2009b).

All stakeholders are encouraged to provide written comments on this draft so that the final document can take into account the priorities and views of industry, consumers and other interested parties.

Written comments may be provided before 8 January 2010 by post or email to:

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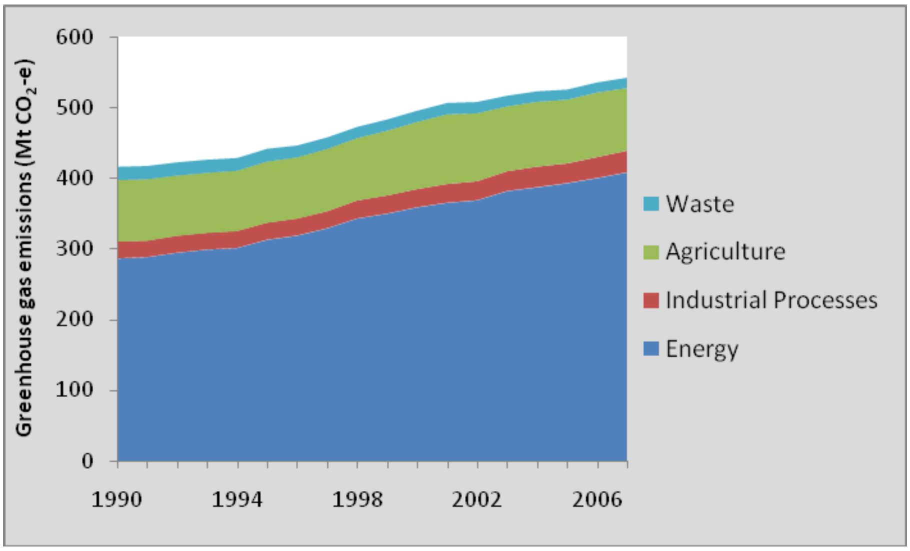
2 Context for this Strategic Plan

2.1 Energy Use

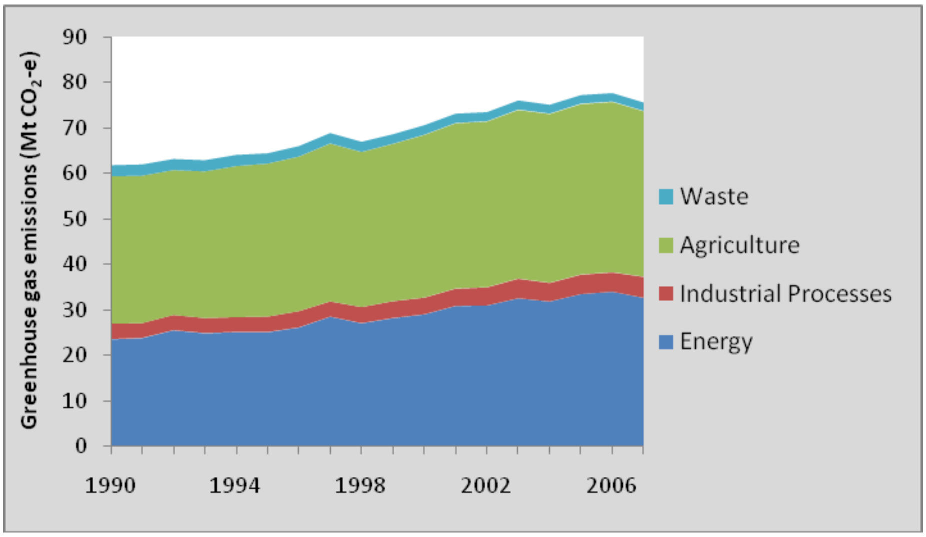
In both Australia and New Zealand, the energy sector is the largest and fastest growing contributor to greenhouse gas emissions, growing at an average of 2% per annum between 1990 and 2007 (Commonwealth of Australia, 2009b; Ministry for the Environment, NZ, 2009).

Figure 2: GHG Emissions trend, Australia, 1990-2007 (not including land use, land use change and forestry)



Source: Commonwealth of Australia, 2009b, 2009

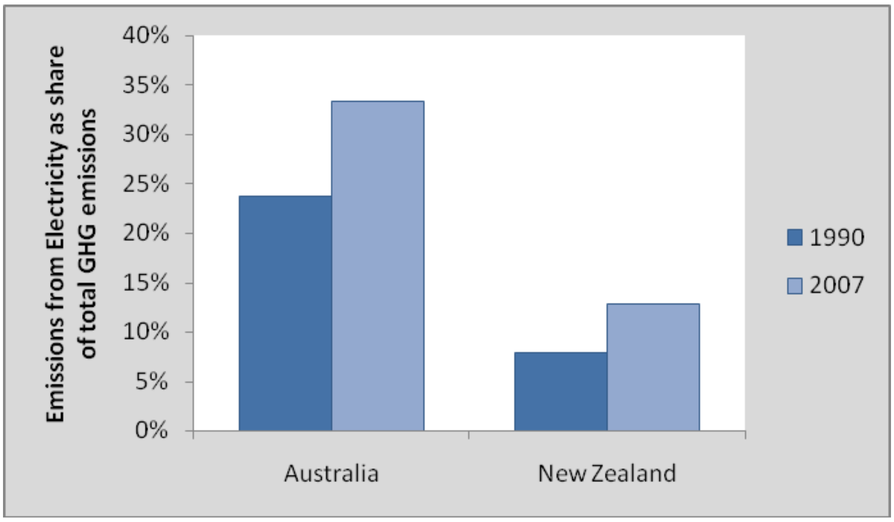
Figure 3: GHG Emissions trend, NZ, 1990-2007(not including land use, land use change and forestry)



Source: Ministry for the Environment, NZ, 2009

Between 1990 and 2007, greenhouse gas emissions from electricity generation rose by 50% in Australia and by 90% in New Zealand so that in 2007 electricity contributed one-third of all greenhouse gas emissions in Australia and around 12% in New Zealand[1], as shown in Figure 4.

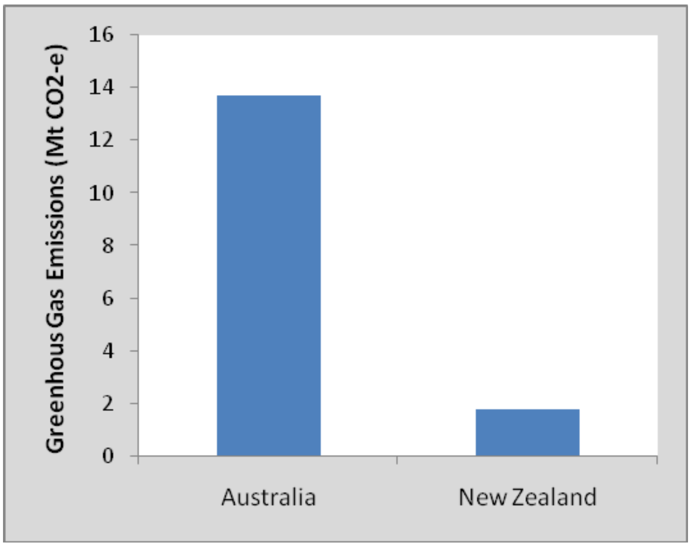
Figure 4: Electricity consumption share of total emissions, 1990-2007



Source: Commonwealth of Australia, 2009b; Ministry for the Environment, 2009

Against this backdrop, non-domestic refrigeration consumed approximately 13,400 GWh in 2008[2] and was responsible for greenhouse gas emissions of 13.7 Mt CO_2-e; equivalent to 4% of emissions from all fuel combustion in Australia's energy sector. In New Zealand, non-domestic refrigeration consumed an estimated 2,900 GWh in 2008, equivalent to 1.7 Mt CO_2-e or 6% of emissions from all fuel combustion in the energy sector.

Figure 5: Greenhouse gas emissions from non-domestic refrigeration, Australia and New Zealand, 2008



Source: MEA modelling estimates (see section 7 for further details)

Non-domestic refrigeration is therefore responsible for a quantity of electricity consumption approximately equivalent to the combined total of all residential lighting and refrigeration in both

[1] The lower contribution in NZ results from the significant use of hydro electricity generation.
[2] Excluding mobile refrigeration sources.

countries (Commonwealth of Australia, 2008b; EECA, 2009). These sectors have been sufficiently large to warrant targeting with energy efficiency policy measures over recent years.

2.2 Government support for Energy Efficiency

Improving the efficient use of energy is consistent with the important public policy objectives of stimulating economic development, maintaining energy security and achieving environmental benefits. For this reason, all Australian and the New Zealand Governments are committed to measures which promote greater energy efficiency.

In April 2009, the Council of Australian Governments (CoAG) adopted a comprehensive National Strategy for Energy Efficiency (NSEE), building on measures contained in the National Framework on Energy Efficiency (COAG, 2009; Commonwealth of Australia, 2009a).

The NSEE is designed to substantially improve minimum standards for energy efficiency and accelerate the introduction of new technologies through improving regulatory processes and addressing the barriers to uptake of new energy-efficient products and technologies. Two key measures contained in the National Strategy are:

- Accelerate and expand the current Minimum Energy Performance Standards (MEPS) and labelling program.
- Establish national legislation for MEPS and labelling, and over time move to add Greenhouse and Energy Minimum Standards (GEMS) (Commonwealth of Australia, 2009a).

The New Zealand Energy Efficiency and Conservation Strategy, 2007 (NZEECS) is a detailed action plan for increasing the uptake of energy efficiency, conservation and renewable energy programs across the economy and to make doing so part of the normal behaviour of New Zealanders (EECA, 2007). Amongst the key energy efficiency projects identified are the adoption of MEPS for 17 new residential product classes and update stringency levels for seven existing product classes by the end of 2012. NZEECS is in the process of being updated.

While these national strategies span a wide range of initiatives, the prominent role of an expanded appliance MEPS and labelling program is common to both, and follows the proven success of these initiatives over the past 15 years. Across the two economies, existing programs are forecast to reduce electricity consumption by over 32,000 GWh by 2020, saving approximately AUD$5 billion at the same time. From the current time to 2020, the MEPS and labelling programs will reduce greenhouse gas emissions by an estimated 200 Mt CO_2-e at a cost of minus AUD$ 23/tonne of CO_2-e reduced (Commonwealth of Australia, 2008a).

The effectiveness of these programs has been greatly enhanced by the co-ordinated approach across the New Zealand Government and the Australian Commonwealth, State and Territory Government agencies, provided by the Equipment Energy Efficiency (E3) Committee under the Ministerial Council on Energy (MCE). Signalling a further commitment to policy implementation, the E3 Committee has expanded its enforcement capacity through a major increase in the budget for verification testing and market surveillance (E3, 2009).

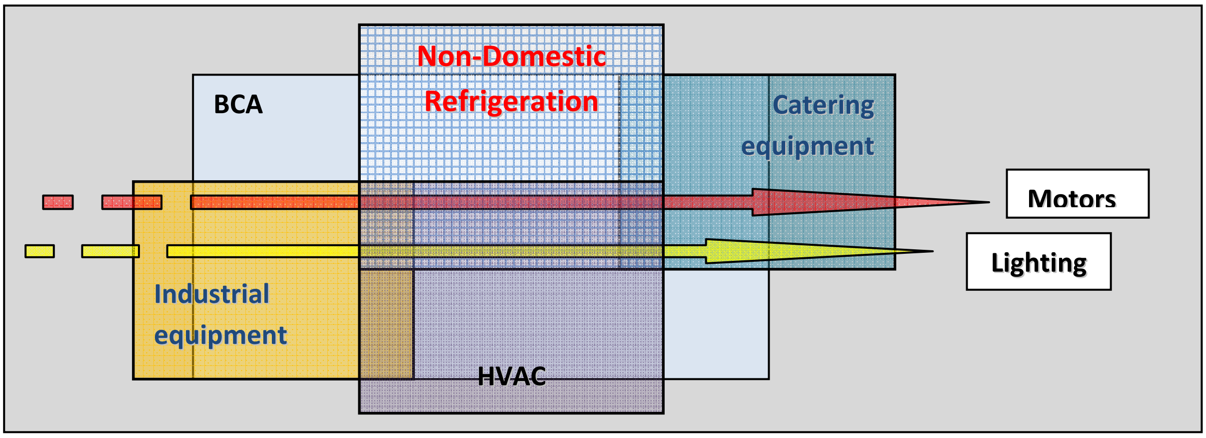
2.3 Related policy initiatives in Australia and New Zealand

In addition to the regulatory program for commercial refrigerated display cabinets, in place since 2004 (AS1731), and for beverage vending machines and ice makers (not yet in force), a number of other energy efficiency initiatives in Australia and New Zealand have a potential impact on non-domestic refrigeration. The most relevant of these include:

- The **HVAC High Efficiency Systems Strategy (HESS),** with its implementation program called the **Cool Efficiency Program,** and MEPS on **Chillers** (E3, 2007; AS/NZS 4776).
- **Greenlight Australia:** a 10 year energy efficiency strategy for improving the efficiency of lighting in Australia 2005–2015 (Commonwealth of Australia, 2004a).
- **Industrial equipment**: a 10 year energy efficiency strategy spanning all industrial equipment, currently in development under NFEE (E3, 2009a).
- **Catering equipment:** a 10 year energy efficiency strategy spanning gas and electric catering equipment, currently in development under NFEE (E3, 2009b).
- **Motors:** regulations for three-phase electric motors (AS/NZS 1359).
- **Building Code of Australia (BCA):** regulations for the design and construction of buildings, including some energy using equipment categories (ABCB, 2009).

The overlap between these policy initiatives, illustrated in Figure 6, relate to building and energy technologies, and also to operators, service providers and customers. It is therefore important that the intersections between these policy initiatives are co-ordinated so that the boundaries are transparent and the requirements consistent, thereby minimising potential confusion. These boundary issues are identified in detail in the two background technical reports (MEA, 2009a; 2009b) associated with this strategy.

Figure 6: Intersections between E3 policy measures



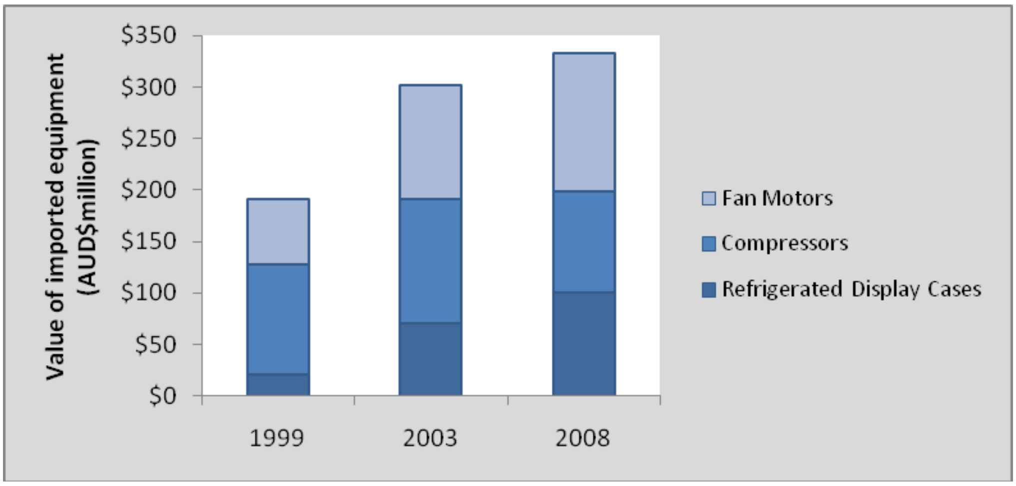
2.4 Related international energy efficiency policies

The growing importance of Climate Change on the political agenda of economies all around the world has highlighted the potential for energy efficiency to delivery substantial reductions in greenhouse gas emissions at a lower cost than most other options (IEA, 2007a).

Governments have responded by developing a range of policies including both new measures and enhancements to existing programs, particularly highlighting the scope to expand the 'Standards and Labelling' (S&L) programs which are now in place in most economies. Domestic refrigerators were the first technology to be included in national S&L programs, which have typically grown to cover between 10-25 different categories of appliances and equipment at the present time. Canada and the United States (in addition to Australia and New Zealand) have included non-domestic refrigeration equipment within their S&L portfolio for a number of years. These continue to be strengthened, for example in the United States by legislation in 2005 and 2007, and in Canada in 2009 (USC, 2005, 2007; OOE, 2009). Similarly, new mandatory measures are being considered under the European EcoDesign Directive that build on the previous industry certification scheme and that directly and indirectly impact on non-domestic refrigeration (EC, 2009).

This Strategic Plan should therefore be viewed in the context of an international trend to extend the reach of national energy efficiency programs into the non-domestic refrigeration sector, as well as other commercial and industrial equipment.

Figure 7: Value of non-domestic refrigeration equipment imported into Australia, 1999-2008



Source: Australian Bureau of Statistics, 2009

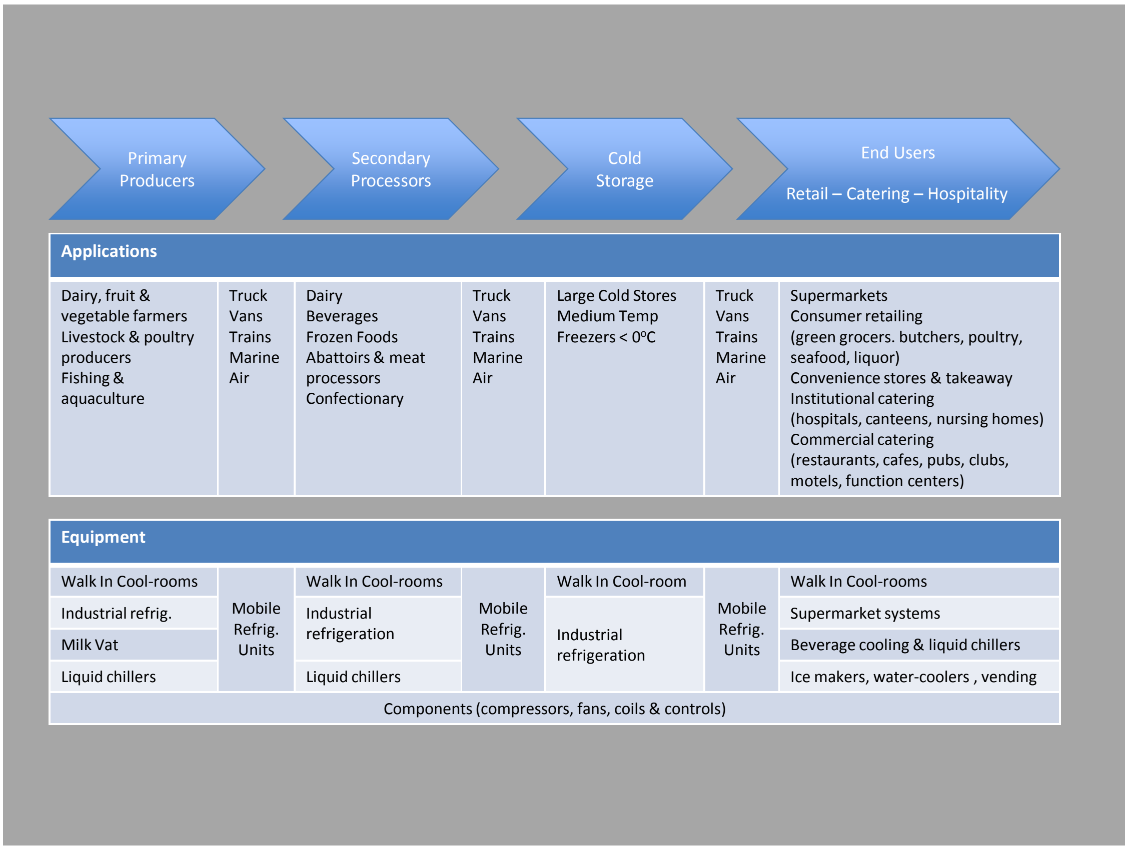
Since 1999 the value of refrigeration equipment and components imported into Australia has nearly doubled (see Figure 7), strengthening the need to keep abreast of international developments and explore opportunities for policy convergence. Many of these opportunities are highlighted in the technical support documents, and will be further explored during the implementation phases of this strategic plan.

3 THE NON-DOMESTIC REFRIGERATION SECTOR

The non-domestic refrigeration sector spans a wide range of technologies, and suppliers of products and services from small specialised operations to large companies that provide multiple products across Australia and New Zealand. End-users are similarly diverse, including national supermarket and fast-food chains, large processors and distributors of foodstuff, fishing fleets, schools, cafes and restaurants.

All of these are participants in the cold food chain, sometimes called the commercial refrigeration sector, which is illustrated in Figure 8. However since this strategy also spans industrial applications, the sector is referred to as 'non-domestic' in this document.

Figure 8: The cold food chain



Source: Expert Group, 2009

It should be noted that diesel-fuelled mobile refrigeration, which accounts for approximately 2% of sectoral greenhouse gas emissions, is currently beyond the jurisdiction of the E3 Committee. Nevertheless, this has been included in this analysis for completeness and because of the potentially wider scope of legislation foreshadowed by the National Strategy on Energy Efficiency.

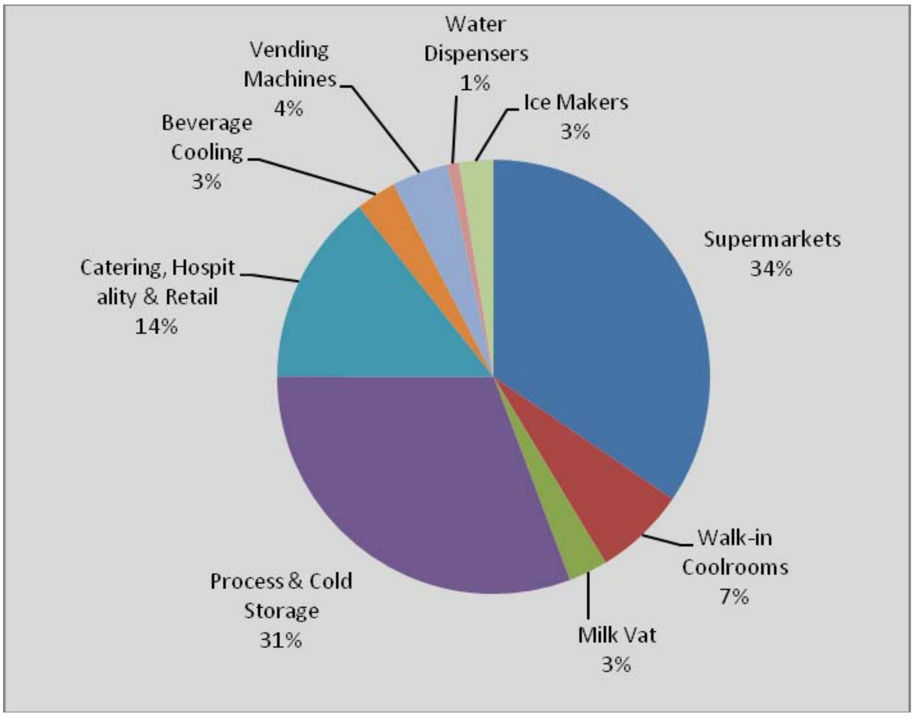
Figure 9 and Source: MEA modelling estimates (see section 7 for further details)

Figure 10 provide one view of the distribution of electricity consumption in non-domestic refrigeration, although the sector can be subdivided in many ways: by application, by technology, by equipment category or even by groupings with similar service providers.

Understanding these relationships and how they overlap is a key facture in designing effective policies and determining their potential impact. As in all sectors, no single policy measure will be successful in optimising energy efficiency across non-domestic refrigeration (IEA 2009).

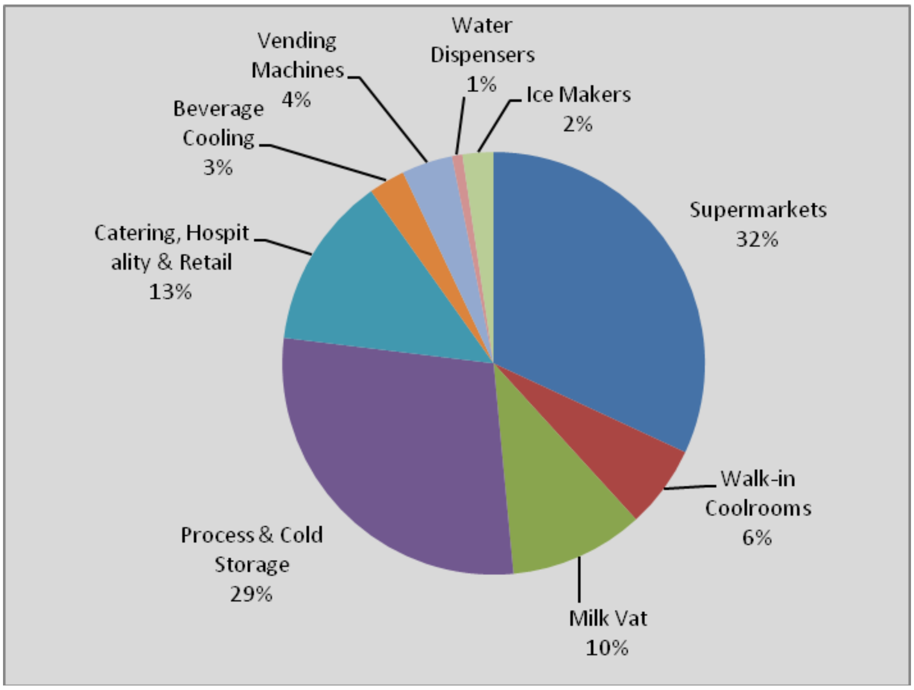
This strategy identifies a cohesive package of policies acting on the different stakeholders to increase energy efficiency.

Figure 9: Distribution of electricity consumption in non-domestic refrigeration, Australia, 2008



Source: MEA modelling estimates (see section 7 for further details)

Figure 10: Distribution of electricity consumption in non-domestic refrigeration, New Zealand, 2008



Source: MEA modelling estimates (see section 7 for further details)

4 TAKING A STRATEGIC VIEW

The need for a strategic approach to the development and implementation of energy efficiency policies for non-domestic refrigeration is evident from the following issues:

- Changes to the existing regulation for refrigerated display cabinets are required in order to make them more effective, and the proposed requirements for beverage vending machines and ice makers need to be reviewed and implemented. This provides an ideal opportunity to examine further opportunities for energy savings across the sector.
- There is compelling evidence of substantial opportunities to reduce energy consumption in the sector, providing large financial returns and savings in greenhouse gas emissions.
- The long life-time of equipment, and the lead-times for specification, design and production, requires a sustained approach; and altering practices may take even longer.
- Reaching the potential for energy efficiency within the sector requires the alignment of interests and improved co-ordination between suppliers and customers within Australia and New Zealand.
- The regulation for display cabinets has provided industry with experience of energy efficiency policy measures, and governments with a better understanding of this industry and how it operates.
- Non-domestic refrigeration is increasingly being included within energy efficiency policy measures by countries outside Australia and New Zealand, including regions which supply products to the Australasian market.
- With the adoption of the National Strategy on Energy Efficiency, Australian governments are committed to extending policy measures beyond the previous scope of activities, notwithstanding the introduction of the Carbon Pollution Reduction Scheme (CPRS).

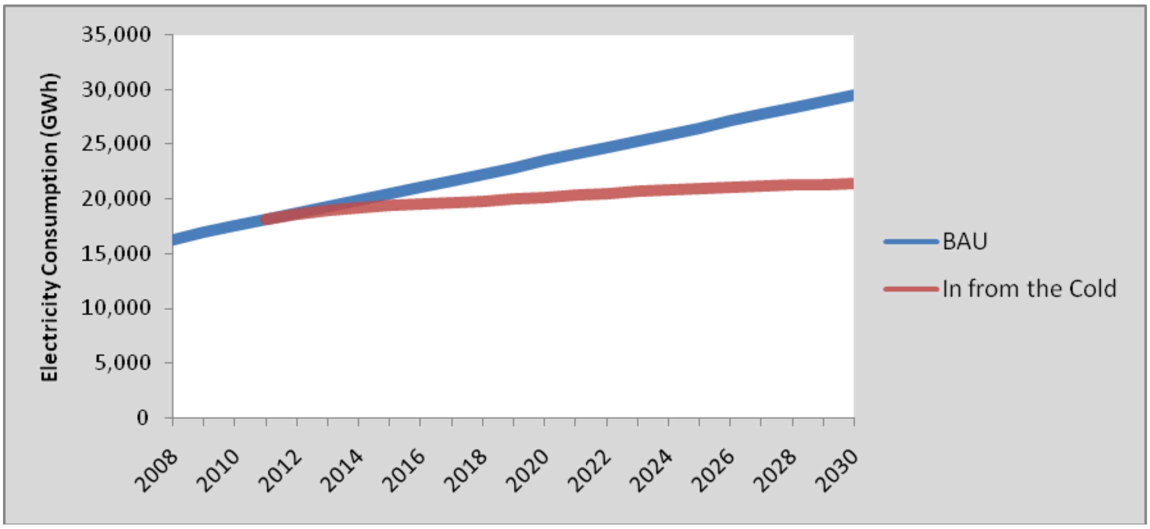
In from the Cold provides the broad strategic framework for stimulating energy efficiency in the non-domestic refrigeration sector across Australian and New Zealand. Co-ordination by the E3 Committee will ensure broad alignment to the aims of the strategy while allowing for different policy priorities and measures in these countries. Co-ordination of implementation will also take account of any differences between the national policy-making processes in each country.

In from the Cold provides a solid framework which will allow the Australasian non-domestic refrigeration industry and the broader community to realise the economic and environmental benefits of energy efficient refrigeration. It also provides an opportunity to align requirements with those of our major trading partners, many of whom are implementing similar policies.

4.1 Expected energy and greenhouse gas savings

Fully implemented, ***In from the Cold*** is expected to reduce annual electricity consumption from non-domestic refrigeration by 14% (3,300 GWh) in 2020, and cut annual greenhouse gas emissions by 2.5 Mt CO_2-e. Due to the lead time for policy measures which improve the efficiency of new equipment, the projected impacts continue to grow long after 2020 so that by 2030 the strategy will reduce electricity consumption from non-domestic refrigeration by 27% (8,000 GWh), equivalent to 5 Mt CO_2-e. Between 2010 and 2030, greenhouse gas savings will total nearly 50 Mt CO_2-e.

Figure 11: Estimated impact on electricity consumption in non-domestic refrigeration, Australia and NZ

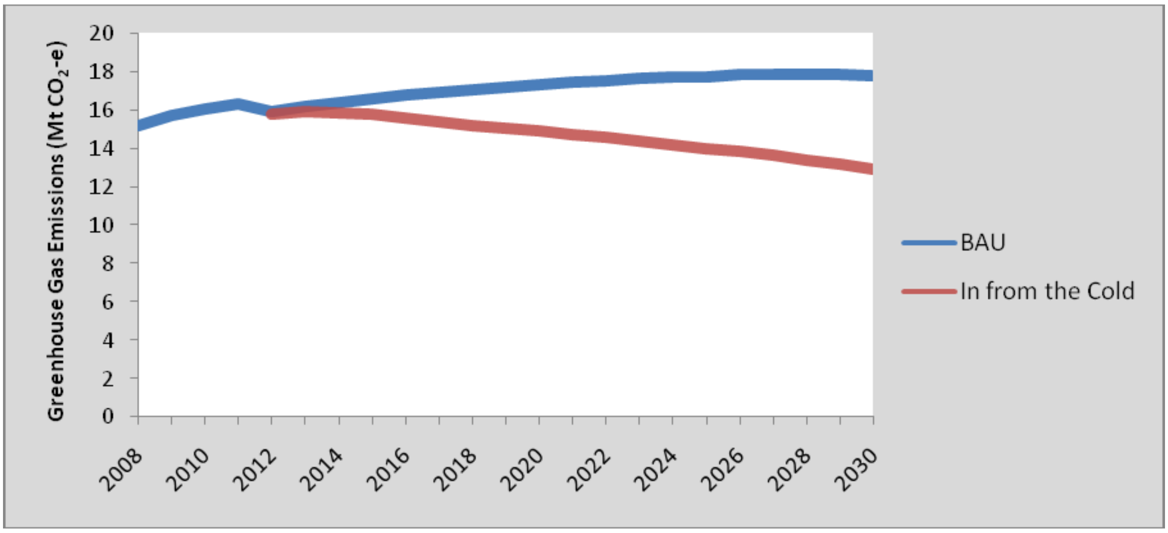


Source: MEA modelling estimates (see section 7 for further details)

Despite forecasted improvements to technology and services, electricity consumption in the sector is likely to continue rising, driven by demand for more refrigerated food and beverages, which will increase the total volume of refrigerated space. Against this 'business as usual' (BAU) scenario, ***In from the Cold*** will come close to stabilising electricity consumption from this sector.

The lowering greenhouse gas intensity of electricity supplies in Australia and New Zealand mean that implementation of ***In from the Cold*** will cause an absolute reduction in greenhouse emissions from the sector, as shown in Figure 12.

Figure 12: Estimated impact on greenhouse gas emissions in non-domestic refrigeration, Australia and NZ



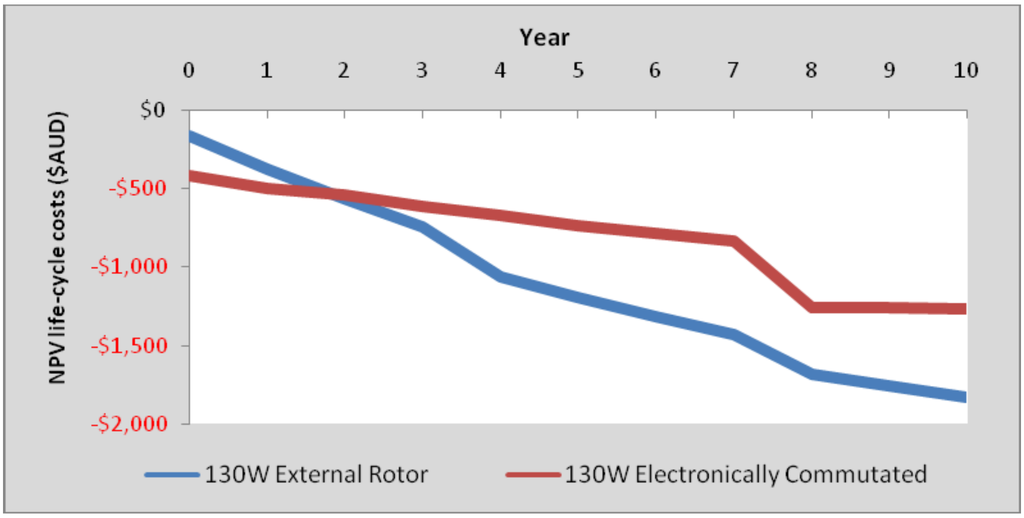
Source: MEA modelling estimates (see section 7 for further details)

4.2 Financial impacts

In from the Cold is estimated to deliver over AUD$ 11 billion in savings on the electricity bills of end users from the date of implementation to 2030; comprising AUD$9.7 billion to Australian consumers and NZD$1.8 billion to consumers in New Zealand. These savings will repay many times over any additional investment required in products and services.

As illustrated in Figure 13, the financial payback from switching to more energy efficient components is often less than two years. However, the full benefits of energy efficiency are sometimes only apparent when purchasers consider the full life-cycle cost of equipment. Encouraging end-users to take this approach is one of the key challenges for ***In from the Cold***.

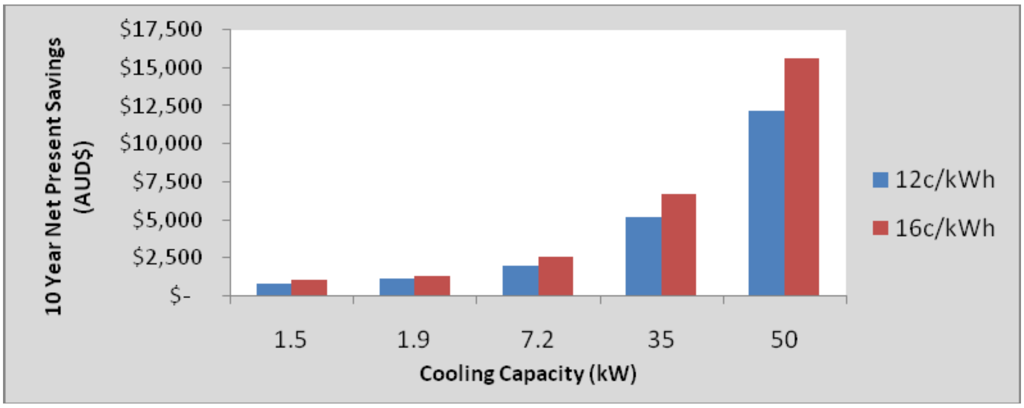
Figure 13: Life-cycle costs of two motor options, 10% discount rate, AUD$0.16/kWh electricity price



Source: MEA modelling estimates (see section 7 for further details)

Investment in energy efficiency will become an increasingly attractive means to reduce overheads as electricity prices rise in the commercial sector. Figure 14 shows the considerable impact changes in electricity prices make on the returns over the life of a product.

Figure 14: Life-cycle costs of compressor options, 10% discount rate, AUD$0.12 and $0.16/kWh electricity price



Source: MEA modelling estimates (see section 7 for further details)

In from the Cold policy measures will stimulate the market for low energy technologies, thereby gaining economies of scale and improving the financial returns from investment in energy efficiency.

4.3 Energy efficiency policies for non-domestic refrigeration

A range of barriers prevent the optimal uptake of energy efficiency technology and practices. These barriers, including a lack of adequate information, split incentive issues and low energy prices amongst others, apply in different market segments suggesting that no single policy measure will be sufficient to overcome all barriers. The most efficient outcome will require a range of targeted policies designed to achieve specific aims (IEA 2008).

In formulating this strategy, a number of generic policies that apply across the market sectors have been considered, and these are described in Table 1.

Table 1: Description of policy types

Policy type	Description
Minimum Energy Performance Standards (MEPS)	Mandatory requirements designed to remove the worst performing products from the market
High Efficiency Performance standards (HEPS)	Identified performance levels used as a reference threshold for procurement, specification, labelling or incentives
Energy Performance Labels	Includes labelling to aid comparison across products (star rating) or to identify the best products (endorsement), in order to provide point of sale information to consumers
Benchmarks	A set of performance metrics designed to enable comparison across a range of similar facilities or activities
Voluntary Agreements	Contractual relationship between industry and governments to achieve specified goals within a given timeframe
Information programs	Encompassing a variety of methods for the provision of information to different stakeholder groups, including on-line facilities
Industry training	Specific energy efficiency training or education modules for service providers, typically within existing training processes
Market based incentives	Including measures designed to encourage new investment and draw attention to energy efficiency opportunities

The following notes summarise the key policy measures contained within the strategy.

4.3.1 Identifying high efficiency technologies

Where feasible, thresholds relating to the most efficient refrigeration technologies should be identified under the strategy, so that high efficient models can be promoted. This may have many different policy applications, for example: used by customers for specification purposes, linked to financial measures, or for procurement processes. Some of these potential applications are outlined in this strategy.

Typical high efficiency thresholds should seek to include the top 15% to 25% performing models on the market, depending on the distribution of performance within a product category, and updated every 2-3 years to keep pace with technological advancement.

4.3.2 Good system design, installation and maintenance

The correct design and installation of refrigeration systems has a major impact on the quantity of energy consumed throughout the life of that system. Equally important, a system that is not regularly maintained can lose 10-15% of its efficiency.

The High Efficiency Systems Strategy (HESS) has identified 20 measures that address these issues within the HVAC sector, which is already closely allied to the non-domestic refrigeration industry.

Acknowledging the importance of improving existing practices, it is recommended that a working group be established to identify the priority projects for stimulating good design, installation and maintenance in non-domestic refrigeration. This group, provisionally called the *Best Practice in Refrigeration working group (BPR)*, will draw on members from industry, universities and government. The BPR will explore synergies with HVAC HESS and the Cool Efficiency Program, and existing professional and training/professional development organisations; producing recommendations within 12-18 months that include opportunities for funding implementation.

Some specific recommendations on the provision of information have been identified and are discussed below. The BPR may identify further specific information needs.

4.3.3 Information, benchmarks and labels

A lack of appropriate information acts as a barrier to the uptake of energy efficiency in several market segments. There is demand for a range of content including, lists of high efficiency products or benchmarks, examples of best practice system design and maintenance, financial benefits of investment in energy efficiency and specification guidelines.

To meet this demand, the E3 Committee will work with relevant stakeholders to identify the most appropriate and effective means to communicate this information to industry and end-users, including the option of on-line tools.

Benchmarks enable operators of facilities to easily assess whether there are opportunities for improvement by comparison with the energy performance of equivalent facilities. This strategy includes the application of benchmarks for supermarkets and cold storage facilities, and recommends their investigation for the dairy industry.

Labelling of equipment in the non-domestic refrigeration sector is not considered the most effective means of providing information on energy performance. Labels have little impact where purchasing decisions are made by contractors rather than the final equipment operators and generally when end users have no say in the equipment provided to them. A further consideration is the additional costs imposed as a result of the additional testing required to support the introduction of a labelling program, particularly if mandatory. As a result, product labelling is not supported under this strategy.

4.3.4 Refrigerated cabinets

Improvements need to be made to the current regulations for refrigerated display cabinets in order to bring them in-line with similar international schemes and increase energy savings. The requirements also need to be more transparent to suppliers and regulators in order to facilitate compliance. The key elements of this include:

a) Replace AS 1731 Part 1 to Part 13 with EN ISO 23953(2005) and adopt the ISO classification system for refrigerated display cabinets.

b) Extend the current scope of MEPS to cover all types of non-domestic refrigerated cabinets used to display and store foodstuffs and beverages. The energy performance of refrigerated service cabinets (RSCs) should be specified according to electricity consumption per unit refrigerated volume, with energy performance tested to EN ISO 23953(2005).

c) For cabinets built on site, introduce an alternative ‘deemed to comply’ allowance comprising minimum efficiency specifications for key technology components.

d) Increase the stringency of MEPS and HEPS levels for RDCs to reflect the performance of products in the current market and, where appropriate, in line with overseas programs. Performance levels for RSCs should be harmonized with US MEPS levels to be introduced in 2010.

4.3.5 Compressors

Compressors are used all forms of refrigeration technologies, accounting for more than 40% of the total energy used in the non-domestic sector. Improving the performance of all compressors will therefore be an effective way to maximise savings across the whole sector, covering some applications which might not otherwise warrant individual policy measures. Proposed recommendations for implementation are:

a) MEPS and HEPS should be introduced for all compressors with a displacement between 1.4 m^3/hr to 836m^3/hr.

b) MEPS and HEPS levels should be based on the calculated coefficient of performance (COP) based on input power and the refrigerating capacity of the compressor tested according to widely accepted international test standards.

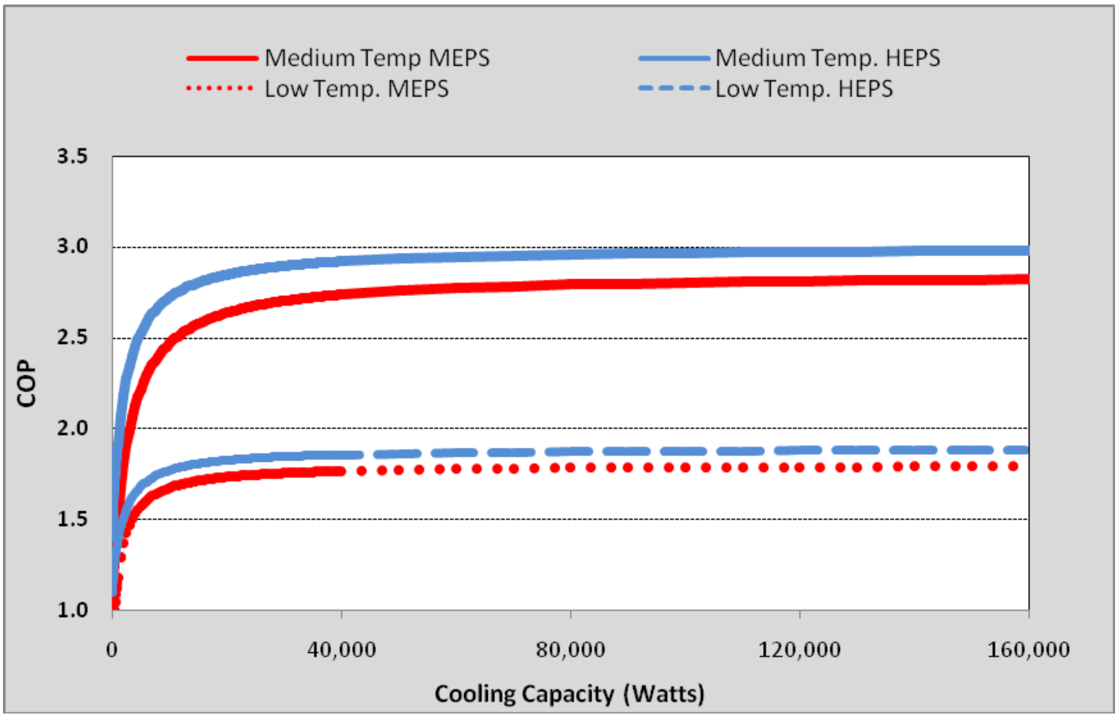
- Indicative levels for implementation are shown in Table 2 and Figure 15:

Table 2: Indicative MEPS and HEPS levels for compressor COP

	MEPS COP	HEPS COP
Medium Temperature (+5°C Evaporator Temp)	$1 + (1.85 * \Phi_0 / (\Phi_0 + 2600))$	$1.4 + (1.60 * \Phi_0 / (\Phi_0 + 2100))$
Low Temperature (-25°C Evaporator Temp)	$0.7 + (1.10 * \Phi_0 / (\Phi_0 + 1300))$	$1.1 + (0.79 * \Phi_0 / (\Phi_0 + 1800))$

Where: Φ_0 = Cooling Capacity (Watts)

Figure 15: Indicative MEPS and HEPS levels for compressor COP



4.3.6 Fan motors

Fan motors are used throughout most refrigeration applications, consuming an estimated 30% of electricity used in non-domestic refrigeration. There is considerable potential to reduce energy consumption and life-cycle costs through increasing the uptake of more efficient fan motors, with good prospects that policy measures which grow the market for these products will bring about further cost reductions. It is therefore recommended that:

a) Minimum energy performance standards (MEPS) are introduced for fan motors used in non-domestic refrigeration with an output power rating of between 5 Watts and 2000 Watts. Suggested MEPS levels are;

- Single-phase fan motors with an output power rating of between 5 Watts and 70 Watts shall have an energy efficiency of 60% or greater;
- All single-phase or three-phase fan motors with an output power rating of between 71 Watts and 2000 Watts shall have an energy efficiency of 90% or greater. This requires further consideration in order to maintain consistency with other MEPS regulations;

b) MEPS to apply to fan motors used in non-domestic refrigeration in Australia and New Zealand at the earliest opportunity that allows for reasonable adjustment by suppliers and customers. It is considered likely that this might be towards the end of 2012.

c) Consideration needs to be given to the appropriate measurement method(s) and to the extension of MEPS to fan assemblies once the international efficiency standard for these products (ISO 12759) has been finalised.

4.3.7 Supermarkets

The supermarket industry is the largest single end-user of electricity for non-domestic refrigeration in Australia and New Zealand and is forecast to remain at this level for the next decade. The development of 'green' stores demonstrates that the industry is keen to display its environmental credentials to customers, and that many significant improvements can be made in addition to the individual measures already identified in this strategy.

The key measures proposed for supermarkets are as follows:

a) The development and use of store-wide benchmarks based on total electricity consumption per unit area to drive forward a range of energy efficiency investments.

- Table 3 provides the proposed initial benchmarks to be met by 2013 for categories of large, medium and small sized stores.

Table 3: Proposed benchmarks by store size

Category	Size of trading floor size (m^2)	MEPS Energy intensity (kWh/m^2 p.a.)
Large	≥ 2,750	820
Medium	≥1,500 to < 2,750	850
Small	< 1,500	980

b) Further benchmarks are to be set for intervals of not more than five years to at least 2020, based on analysis of data provided by the retailers directly or via the *National Greenhouse and Energy Reporting Act 2007* (NGERS) in Australia, or other sources.

c) 'Open' display cabinets for refrigerated and frozen foods should be phased-out by 2015 through switching to cabinets with doors and 'coffin' style freezers with lids.

d) Implementation of these measures could be driven by a voluntary agreement between the supermarket industry and government. It is recommended that this approach be explored. Should this prove difficult to negotiate or at the behest of the industry, these benchmarks could be adopted as regulations. Requirements for regular reporting and verification will need to be included in any agreement or regulation.

4.3.8 Walk-in coolrooms (WICs)

More than 60,000 walk-in coolrooms are currently used throughout the cold food chain in Australia. The majority are small and built on-site. Current designs provide poor energy performance even though modest investment in thermal improvements and efficient components yield good rates of return. The key measures proposed for the WICs are:

a) The introduction of MEPS harmonised with the regulatory requirement for WICs in force in the United States. These include:

- Minimum thermal insulation ratings for walls, ceilings, doors and floors. Walls, ceilings, doors to have R-value of R4.5 m^2K/W for in medium temperature WICs; and R6.0 m^2K/W on low temperature WICs. The R-value of all floors in WICs to be R4.9 m^2K/W. All WICs to be properly sealed to ensure air-tightness.
- Double glazing for all transparent areas in medium temperature WICs and triple glazing in freezers
- Use of HEPS rated compressors and motors meeting proposed MEPS levels.

4.3.9 Process refrigeration and cold storage

Responsible for 31% of the total electricity used in Australia for non-domestic refrigeration and 29% in New Zealand, process refrigeration and cold storage is essential for the production, handling and storage of many food products consumed today. Several countries now use benchmarking as a means to stimulate understanding and investment in energy efficiency opportunities, and with over 10 million m^3 of cold storage facilities in Australia, there is considerable potential to introduce similar tools and practices. The key measures proposed for this sector are:

a) That Government and industry organisations combine to establish an online benchmarking facility to provide best practice information to the cold storage industry.

b) Government and industry should set appropriate benchmark targets and key performance indicators (KPIs) by a date not later than 2011, based on the data on individual sites collected through this tool, and other sources.

c) Governments should further investigate how such benchmarks and key performance indicators should be applied in order to be most effective, including through voluntary agreements with industry or through regulation.

4.3.10 Milk Vats

Up to 30% of the electricity consumed in a dairy is used for milk cooling, with some dairies using four times the energy used by others to process the same amount of milk. The combination of pre-chillers, heat recovery systems, energy reduction education, benchmarking and improved maintenance practices has been shown to save 20% of all electricity consumed by a typical farm. Designing and operating an efficient milk cooling system can reduce energy demand and costs considerably.

Contributing to the energy efficiency of milk vats are the proposed measures for compressors and fan motors in this strategy. However other activities that make a significant contribution and require further investigation include:

a) Mechanisms to develop and distribute well targeted information, including industry best practice and benchmarks.

b) Work with government and industry stakeholders to consider incentives for the adoption of best practice and investment in equipment that is focused on energy efficiency opportunities.

The New Zealand Government may consider this an area for special attention, given that milk vats are estimated to account for 10% of NZ non-domestic refrigeration electricity consumption.

4.3.11 Beverage cooling

Since most of the potential savings will be achieved through horizontal measures for compressors and fan motors in this strategy, and consideration of measures for pumps in the Industrial Equipment Strategy (E3, 2009a), no additional measures are proposed.

4.3.12 Mobile refrigeration

Energy reductions of more than 35% are available from improved thermal insulation of the refrigerated rolling stock, together with more efficient refrigeration equipment. The key measures proposed for the mobile refrigeration sector are to further investigate with relevant government agencies and the industry the following:

a) The design and use of materials to increase insulation capacity of refrigerated rolling stock to enhance benefits such as reduced fuel use, greater quality control of products and reduce risk of product spoilage.

b) The feasibility of increasing the maximum permitted width of trucks to 2.6m to allow space for adequate insulation materials when standard pallets are used.

c) Ensuring that new refrigerated transport products are insulated to a minimum of R3.9 m^2K/W. Investigate mechanisms such as regulation to achieve this.

d) Specific incentives to encourage the uptake of practices that increase the energy efficiency of rolling stock and develop and promote targeted information on 'best practice' for this sector.

e) The feasibility of putting in place emission standards for refrigeration transport systems similar to the US EPA Tier 4 non-road engine standards and the CARB in-use program.

4.3.13 Data collection

The collection and analysis of data will be required throughout the implementation of measures contained within this strategy; to finalise specific policy measures as well to monitor and verify implementation and compliance. Both industry and governments undertake to provide information to support this strategy. Recommendations for data collection activities include:

a) Detailed information on non-domestic refrigeration markets and use in New Zealand.

b) Electricity consumption in supermarkets and cold storage facilities to establish and monitor benchmarks by type of facility.

c) Other data as necessary to support the development, implementation and monitoring of specific policy measures with the strategy.

5 TIMING & WORK PLAN

The following points are relevant to timeframes for particular policies or industry segments.

5.1 Overall timeframe

5.1.1 Regulatory processes

Regulatory policy measures require a period of between 2-3 years at a minimum from the commencement of development tasks to the time when they come into force. Since these measures form a major part of the Strategy, commencement of development processes is a priority.

The lead time allows for a regulatory impact statement (RIS) to be drafted, subjected to consultation and approved by the Office of Best Practice Regulation (OBPR) and the Ministerial Council on Energy (MCE). The preparation of relevant technical or regulatory standards can be accommodated alongside these processes. Consultation with industry, through the RIS and standards development procedures, will identify the final date of enactment of regulation, with the allowance for adequate preparation typically being at least two years from the start date. These processes are complex and time-consuming for all stakeholders, and therefore it is advisable for all regulations be included within the one single RIS, although dates of enactment may vary between individual measures.

Regulations will be reviewed every three years to assess whether they need updating in line with technological improvements and changes in similar international policies.

5.1.2 Voluntary Agreements and Benchmarking

Initial negotiations on voluntary agreements with the supermarket industry should be commenced in early 2010 in order to determine within 6-9 months whether they are feasible. Negotiations with the cold storage industry will commence in the 2010-11 financial year. If decisions are then made that regulations are the preferred option, these will be included within the RIS process.

Progress towards targets established in voluntary agreement will need to be monitored, and benchmarks set or refined for the duration of the agreement.

5.1.3 Best Practice in Refrigeration (BPR) working group

E3 Committee should proceed with the formation of the BPR working group early in 2010 (so that it can report back with recommendations within 12-18 months), starting with the issuing of terms of reference and invitations to key sectoral industry associations.

5.1.4 Information

Notwithstanding the wider considerations of the BPR working group, government and industry need to proceed with consideration of appropriate communication tools for market segments identified within this strategy.

5.1.5 Mobile refrigeration

Currently the use of diesel fuel is beyond the scope of the E3 committee. The committee should proceed with identifying relevant branches of government with responsibility for vehicle size and emissions, before raising the recommendations contained within this strategy.

5.1.6 Data collection

The collection of data on non-domestic refrigeration in New Zealand sufficient to determine strategic priorities is a priority. Other informational demands will be met as required by the development of each policy measure.

5.2 Work plan for the 1st triennium

		Financial Year		
		2009-2010	2010-2011	2011-2012
Regulations	Completion of Strategic Plan	✓		
	Drafting of regulatory standards under ME-008	✓	✓	
	Preparation of Regulatory Impact Statement (RIS)	✓	✓	
	RIS consultation process		✓	
	Regulations approved by MCE		✓	
	Regulations come into force			✓
Voluntary Agreements and benchmarking	Engagement with supermarket chains	✓		
	Engagement with cold Storage operators		✓	
	Agreements finalised		✓	✓
Best Practice in Refrigeration	Working group meetings, liaison and final report		✓	
	Funding sought for implementation of BPR			✓
Information	Communication tools: development and implementation		✓	✓
Data collection	On-going collection for monitoring and verification	✓	✓	✓

6 ABBREVIATIONS

AUD	Australian dollar
BaU	Business as usual
BCA	Building Code of Australia
CO2-e	Carbon dioxide equivalent units
COP	coefficient of performance
CPRS	Carbon Pollution Reduction Scheme (Australia)
E3	Equipment Energy Efficiency Committee (Australia)
EC	European Commission
EPS	expanded polystyrene
GHG	greenhouse gas
GW	gigawatt (1 watt x 10^9)
GWh	gigawatt-hour (1 watt x 10^9)
HEPS	high efficiency performance standards
IEA	International Energy Agency
IEC	International Electrotechnical Commission
ISO	International Standards Organisation
kW	kilowatt (1 watt x 10^3)
kWh	kilowatt-hour
kWr	kilowatts of refrigeration
MCE	Ministerial Council on Energy
MEPS	minimum energy performance standards
Mt	megatonne (ie million tonnes)
NPV	net present value
NZD	New Zealand dollar
OBPR	Office of Best Practice Regulation (Australia)
PIR	polyiscyanurate insulation
RDC	refrigerated display cabinet
RSC	refrigerated service cabinet
RIS	regulatory Impact statement
t	tonnes
TEC/TDA	total energy consumption (kW/day)/Total Display Area (m^2)
TWh	terawatt-hours (1 watt-hour x 10^{12})
Wh	watt-hour
WIC	walk-in coolroom
VA	voluntary agreement

7 DATA SOURCES USED IN MODELLING

MEA modelling estimates

Modelling undertaken to estimate total energy consumption and greenhouse gas emissions, and the savings due to implementation of policy measures, is based on a variety of sources, many of which are discussed in the Background Technical Reports, Volumes 1 and 2 and referenced. These include data on the market penetration of technologies, average efficiency or performance levels and typical usage patterns.

The modelling also uses data from ***Cold Hard Facts***, published in 2007. In some cases this data has been corrected using more up-to-date or accurate information where available. ***Cold Hard Facts*** together with the source data is available from:
http://www.environment.gov.au/atmosphere/ozone/publications/cold-hard-facts.html

The initial background research for these reports was focused on the Australian market and therefore no bottom-up data has been collected at this stage for New Zealand. The energy consumption and greenhouse gas emissions for segments of the non-domestic refrigeration sector in New Zealand have been calculated on a pro-rata basis from the Australian estimates according to the relative populations of the two countries. The exception is milk vats, where the total energy consumption for this segment has been estimated based the quantity of milk produced in New Zealand and industry information on the energy intensity of milk production.

Greenhouse gas intensity

The following greenhouse gas coefficients have been used in order to calculate greenhouse gas emissions from electricity consumption in accordance with advice from E3.

Table 4: Electricity fuel cycle emission factors (t CO2-e/MWh delivered)

Year	Australia (1)	New Zealand (2)	Year	Australia	New Zealand
2005	-	0.6			
2006	1.036	0.6	2016	0.883	0.4
2007	1.021	0.6	2017	0.865	0.4
2008	1.007	0.6	2018	0.847	0.4
2009	0.993	0.6	2019	0.829	0.4
2010	0.980	0.6	2020	0.811	0.4
2011	0.964	0.6	2021	0.794	0.4
2012	0.948	0.4	2022	0.777	0.4
2013	0.932	0.4	2023	0.761	0.4
2014	0.916	0.4	2024	0.744	0.4
2015	0.901	0.4	2025	0.727	0.4

Source: http://naeeec.energyrating.com.au/reports/household-greenhouse.xls

(1) Average fuel cycle emission factors (2) Marginal fuel cycle emission factors (updated 23/07/2009)

Electricity tariffs

Unless stated, the consumer price of electricity is assumed to be AUD$0.16/kWh in Australia and NZD$0.1519/kWh in New Zealand, in accordance with advice from E3.

8 REFERENCES

ABCB (2009) *The Building Code of Australia*, produced by the Australian Building Codes Board, 2009.

AGO (2005) *Towards a National Hot Water Strategy: Introduction and Scope*, Version 1.1, 12 September 2005.

AS 1731 (2003) *Refrigerated display cabinets*, Parts 1 to 14. Amended 2005.

AS/NZS 1359 (2004) *Rotating electrical machines.*

AS/NZS 4776 (2008) *Liquid-chilling packages using the vapour compression cycle.*

COAG (2009) *Communiqué of Council of Australian Governments' Meeting 2 July 2009*, available from http://www.coag.gov.au/coag_meeting_outcomes/2009-07-02/index.cfm

Commonwealth of Australia (2004a) *Greenlight Australia - a strategy for improving the efficiency of lighting in Australia 2005–2015*, prepared for the National Appliance & Equipment Energy Efficiency Program.

Commonwealth of Australia (2004b) *Switch on Gas - Australia's strategy to improve the energy efficiency of gas appliances and equipment 2005–2015*, an initiative of the Ministerial Council of Energy forming part of the National Framework for Energy Efficiency.

Commonwealth of Australia (2008a) *Achievements 2007/08 Equipment Energy Efficiency Program*, an initiative forming part of the National Framework for Energy Efficiency and the New Zealand National Energy Efficiency and Conservation Strategy, Report No. 2008/03, September 2008.

Commonwealth of Australia (2008b) *Energy Use in the Australian Residential Sector 1986 – 2020*, published by the Department of the Environment, Water, Heritage and the Arts.

Commonwealth of Australia (2009a) *National Strategy on Energy Efficiency*, Council of Australian Governments (COAG), July 2009.

Commonwealth of Australia (2009b) *National Greenhouse Gas Inventory accounting for the KYOTO target*, Department of Climate Change, May 2009.

E3 (2007) *The Measures: HVAC High Efficiency Systems Strategy,* prepared by Energy Strategies, for the Equipment Energy Efficiency Committee, March 2007.

E3 (2009a) *Improving Energy Efficiency of Industrial Equipment:* (Draft) Discussion Paper, not published.

E3 (2009b) *Commercial Catering Equipment Energy Efficiency Study*, not published.

E3 (2009c) Circuit Breaker, Edition 1, September 2009, available from: http://www.energyrating.gov.au/pubs/circuit-breaker-2009-09.pdf

EC (2009) Eco-design of Energy-Using Products, outline available from: http://ec.europa.eu/energy/efficiency/ecodesign/eco_design_en.htm. Details of non-domestic refrigeration studies available from: http://www.ecofreezercom.org

EECA (2007) *New Zealand Energy Efficiency and Conservation Strategy: Making it Happen*, Energy Efficiency and Conservation Authority, 2007.

EECA (2009) *Energy end use database,* accessed 4 September 2009 at http://www.eeca.govt.nz/energy-end-use-database

IEA (2007a) *World Energy Outlook 2007*, International Energy Agency, Paris, 2007.

IEA (2007b) *Experience with Energy Efficiency Regulations for Electrical Equipment*, Information Paper, International Energy Agency, Paris, 2007.

IEA (2008) *Energy Technology Perspectives – Scenarios and Strategies to 2050*, International Energy Agency, Paris, 2008.

IEA (2009) *Gadgets and Gigawatts - Policies for Energy Efficient Electronics*, International Energy Agency, Paris, 2007.

MEA (2009a) *In from the Cold – Strategies to increase the energy efficiency of non-domestic refrigeration in Australia and New Zealand, Background Technical Report Volume 1*, prepared for the E3 Committee by Mark Ellis and Associates, September 2009.

MEA (2009b) *In from the Cold – Strategies to increase the energy efficiency of non-domestic refrigeration in Australia and New Zealand, Background Technical Report Volume 2*, prepared for the E3 Committee by Mark Ellis and Associates, September 2009.

Ministry for the Environment (2009) *New Zealand's Greenhouse Gas Inventory 1990–2007*, fulfilling reporting requirements under the United Nations Framework Convention on Climate Change and New Zealand's voluntary submission under Article 7.1 of the Kyoto Protocol.

OOE (2009) *Proposed Amendment to Standard, Bulletin 2009: Energy Efficiency Regulations, Self-contained Commercial Refrigerators, Freezers and Refrigerator-freezers*, published in Ecoaction, 2009.

USC (2005) *Energy Policy Act of 2005*, Public Law 109–58 109th Congress, 8 August 2005, available from: http://www.epa.gov/oust/fedlaws/publ_109-058.pdf

USC (2007) *Energy Independence and Security Act of 2007*, 110th Congress, 4 January 2007.