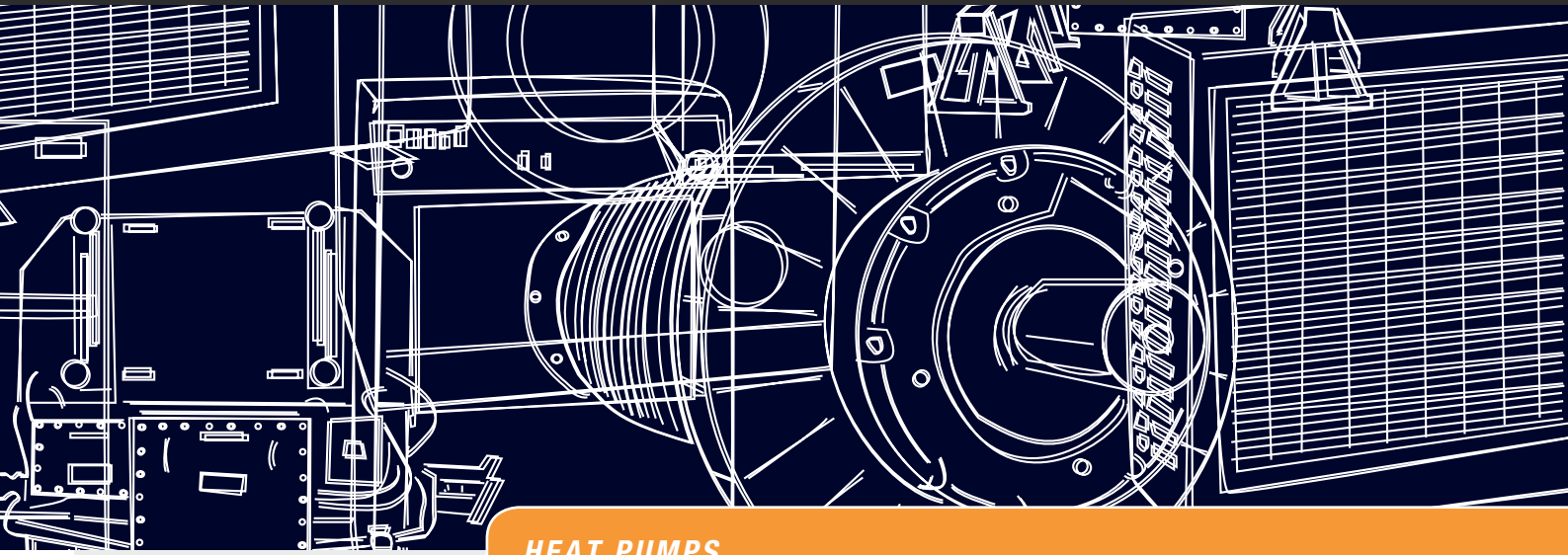


NATIONAL APPLIANCE AND EQUIPMENT ENERGY EFFICIENCY PROGRAM

Minimum Energy Performance Standards



HEAT PUMPS

PREPARED FOR

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



Minimum Energy Performance Standards - Heat Pumps

Heat Pumps or reverse cycle air conditioners are used for providing heating to households and small commercial premises in Australia and New Zealand. Some 11% of households used heat pumps as their main heater in 2002. Heat pump type air conditioners are also the most common air conditioner type being sold with a 100% increase in sales over the period 1998 to 2003. Sales of cooling only air conditioners are stagnating or slightly declining.

Energy consumption from heat pumps in 2002 is estimated to be over 600 GWh/yr and forecast to grow to 1,100 GWh in 2010. Heat pumps are typically replacing electric resistive heating and solid fuel heaters as the main heating source.

The heating cycle of reverse cycle air conditioners and heat pumps is not regulated for Minimum Energy Performance Standards (MEPS) in Australia and New Zealand; however the heating mode is required to be reported on the Energy Rating Label. Air sourced heat pumps are the most common type of heat pump. The sales of water sourced air conditioners and heat pumps are relatively minimal in Australia. Also, ground source and water sourced air conditioners and heat pumps are inherently more efficient than air sourced units.

Heat pumps use a technique called the vapour compression cycle to “move” energy in the form of heat from one space to another. This is generally a very efficient process and the amount of heat moved is typically 2 to 3 times (or more)

the energy required to run the compressor system. Typically the coefficient of performance (COP) is in the range 2.0 to 3.5, meaning that the heating output is 2 to 3.5 times as great as the power input, or an efficiency of 200% to 350%.

The performance of a heat pump ranges according to the outside ambient temperature. In low temperatures outside temperatures, the heating output and COP are generally less than when the outside temperature is high. Sizing a heat pump for the correct indoor requirements and outside temperature conditions is critical to the satisfactory heating of the space especially in colder climates. Consumer reports from New Zealand and Australia indicate that some householders are not satisfied with the heating performance of some heat pumps, particularly in extremes, eg icy cold or warm and humid conditions. Standard test conditions for rating heat pump performance are outside temperatures of 7°C dry-bulb and 6°C wet-bulb, however operation in temperatures of 2°C or lower are common in many parts of Australia and New Zealand.

Providing more information on MEPS on the performance of a heat pump at cold conditions might better meet the Australian governments' efficiency goals, and improve the satisfactory installation of heat pumps in homes. Data from the Energy rating database shows there is a range of efficiencies for available models in Australia and these suggest that a MEPS will have an impact.

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 28 February 2005. 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

The USA and Canada have Minimum Energy Performance Standards for the heating cycle of air conditioners and heat pumps, while Japan has targets (Top Runner) for the average efficiency of both heating and cooling cycles. Internationally and in Australia, the efficiency of heating mode for heat pumps is typically measured by its Coefficient of Performance (COP) at outdoor temperature of +7°C. The USA and Canada use a different measure of efficiency, called the Heating Seasonal Performance Factor (HSPF). The HSPF is equivalent to the total heating output of a heat pump in Btu divided by the total electric energy in watt-hours consumed over a year. The USA/Canadian methodology uses tests of heating capacity and performances at three outdoor conditions +8.3°C, +1.6°C and -8.3°C to determine the HSPF. As the USA and Canada measure heat pump efficiency differently, a direct comparison of MEPS levels with efficiency of Australian product is not possible.

The Japanese use the international test conditions, however the Top Runner target is expressed as an average of both heating and cooling COP. An equivalent heating COP MEPS level derived from the Japanese 2004/2007 Top Runner targets shows this target is in the middle of the range of models available in the USA and at the top of the range of models available in Australia. The Japanese 1997 efficiency targets were specified on the heating cycle COP and hence can be compared directly to Australian models. Approximately 30% of the non-ducted split models currently on the market would not meet the Japanese 1997 efficiency target. It is clear that heat pumps in the Australian market are capable of efficiency improvement when compared to international peers.

The current Australian standard AS/NZS 3823 specifies the test for determining heating output and COP at three outdoor conditions: +7°C, +2°C and -7°C. These are termed high, low and extra low in the Australian Standard and H1, H2 and H3 respectively in the ISO standard. All standard rating conditions are reported at H1 though as recognised above many heat pumps are purchased to operate in colder conditions.

There is potential for Australia and New Zealand to match the 1997 Japanese efficiency targets for heat pumps. There is also potential to make modifications to the Energy Rating Label or registry database to improve the information available for heat pump selection and sizing in cold climates.

NAEEEC PLAN

The analysis of potential MEPS and Energy Labelling options for air and water sourced heat pumps has led to the following recommendations:

AIR

- That Australia and New Zealand consult on the options to introduce a Minimum Energy Performance Standard (MEPS) and associated changes to the Energy Rating Label for the heating mode of air sourced air conditioners and heat pumps.
- That the MEPS and Energy Rating Label scheme be announced in April 2005, to allow sufficient time for changes to be introduced in October 2007 when the new MEPS levels for cooling mode are introduced for all single phase air sourced air conditioners.
- That the following options or combinations of options be considered:
 - **MEPS Option 1:** Mandatory H1 MEPS on all new models sold. Those units that are reverse cycle would be required to pass this MEPS or not be offered for sale.
 - **MEPS Option 2:** Optional H1 MEPS on those models that offer heating and cooling. Those reverse cycle units that choose not to participate will have the label modified to remove the heating cycle Star Rating and Power Input/Capacity Output. In place of the star rating, a statement would read “may not heat as effectively as competitive products” or similar.



- **MEPS Option 3:** Mandatory H2 MEPS on all reverse cycle models sold. Those units that are reverse cycle would be required to pass this MEPS or not be offered for sale.
- **MEPS Option 4:** Optional H2 MEPS on those models that claim suitability for heating in certain cold climate zones. A label change could be made that includes the Power Input/Capacity Output at H2 and/ or the words “this unit meets the minimum energy efficiency heating performance requirements” or similar. Alternatively the information may be only displayed on the registration web site.
- There may be some combination of these options that better suits all stakeholders.

WATER

- Water sourced air conditioners and heat pumps are not recommended for MEPS due to the low volume of sales and their inherent higher efficiency, compared to the dominant air sourced air conditioner market.

The potential options could result in MEPS set out in Table 1 at H1 and H2 test conditions, based on the levels set in Japan for 1997 for units over 4 kW output capacity.

TABLE 1: POTENTIAL AUSTRALIAN MEPS LEVELS HEAT PUMPS

Category (all output size)	Minimum COP @ H2	Minimum COP @ H1
Split – Non ducted	2.15	2.74
Split – ducted	2.20	2.80
Window Wall	2.00	2.55

IMPACT OF MEPS

It is estimated that a mandatory MEPS based on these levels would reduce the energy consumption of new heat pumps by 136 GWh in 2020. The potential MEPS is estimated to reduce GHG emission by 623 kt CO₂-e by 2012 and 1.2 Mt CO₂-e in 2020.

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/index.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 the Potential Policy Options:

Heat Pumps

Prepared for
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Contents

<i>Introduction</i>	1
Scope	1
Background on Air Conditioner MEPS and Energy Labelling	1
<i>Product Descriptions</i>	3
Air Sourced Heat Pumps	3
Water Sourced Heat Pumps and Air Conditioners	3
<i>Measures of Efficiency & Standard Test Conditions</i>	4
Efficiency Measures	4
Coefficient of Performance (COP)	4
HSPF	4
Test Standards & Conditions	5
ISO and Australia	5
USA & Canada	6
Heat Pump Performance – Cold Temperatures	7
<i>Market Characteristics</i>	13
Sales of Heat Pump Air Conditioners – Australia	13
Sales of Heat Pump Air Conditioners – New Zealand	16
Stock of Air Conditioners and Heat Pumps – Australia	17
Efficiency of Registered Heat Pumps – Australia and NZ	20
Energy Consumption of Heat Pumps – Australia	22
Summary Market Characteristics	24
<i>Review of International Approaches</i>	26
Canada	26
Air Sourced Heat Pumps	26
Water sourced heat pumps	26
USA	27
Air Sourced Heat Pumps	27
Water Sourced Heat Pumps	27
Energy Star	28
Air Source Heat Pumps	28
Water Source Heat Pumps	28
Japan	29
Air Source Heat Pumps	29
<i>Analysis of Potential for MEPS</i>	31
Comparison of Heat Pump Efficiency	31
Comparison of International MEPS Levels	32
Australian Potential MEPS Levels	35
Rationale for Testing to H2	35
Potential MEPS Levels	36
Energy and Greenhouse Impact of Potential MEPS	39
<i>Potential MEPS and Labelling Scheme Options</i>	42
Current Labelling Scheme	42
Potential MEPS and Labelling Schemes	43
<i>Recommendations</i>	44
Air Sourced	44
Water Sourced	44
<i>References</i>	45

List of Tables & Figures

Table 1: Test conditions: AS 3823 and ISO	5
Table 2: Test conditions: USA compared to Australia	7
Table 3: New Zealand Sales of Heat Pumps – 2002	17
Table 4: Households with Air Conditioners: Type of Air Conditioners — 2002	19
Table 5: Households Using Heat Pumps as Main Heater – 2002	19
Table 6: Estimated Average Hours of Heater Use	23
Table 7: Canadian MEPS for Air Sourced Heat Pumps	26
Table 8: Canadian MEPS for Water Sourced Heat Pumps	27
Table 9: USA MEPS for Air Sourced Heat Pumps	27
Table 10: USA MEPS for Water Sourced Heat Pumps	28
Table 11: ENERGY STAR requirements for Air Source Heat Pumps	28
Table 12: ENERGY STAR requirements for Geothermal Heat Pump	29
Table 13: Japanese Top Runner Targets for Heat Pumps 2004 -2007	30
Table 14: Japanese Efficiency Target - Heating and Cooling Air Conditioners -1997	30
Table 15: Potential Australian MEPS Levels Heat Pumps	37
Table 16: Potential MEPS - No of Models Pass	39
Figure 1: Heat Pump COP vs Outside Ambient Temperature	8
Figure 2: Mean Minimum Temperature – July Australia	9
Figure 3: Comparison of USA Heat Pump COP at 8°C & -8°C Ducted Split Systems	10
Figure 4 Comparison of USA Heat Pump COP at 8°C & -8°C Non-Ducted Split Systems	11
Figure 5: USA Heat Pump COP (H1) vs COP (H3) – Non Ducted Split	12
Figure 6: USA Heat Pump COP (H1) vs COP (H3) – Ducted Split	12
Figure 7: Annual Sales of all air conditioners by system type	13
Figure 8: Annual Sales of Heat Pump air conditioners by system type	14
Figure 9: Annual sales of cooling only air conditioners by system type	15
Figure 10: Proportion of total sales of Heat Pump air conditioners by system type	16
Figure 11 Air Conditioner Penetration by State	17
Figure 12: Heat Pump COP by Capacity – Non Ducted Split	20
Figure 13: Heat Pump COP by Capacity – Ducted Split	21
Figure 14: Heat Pump COP by Capacity – Window Wall	21
Figure 15: Electricity consumption of Heat Pumps and Electric Resistive Heating	22
Figure 16: Electricity Consumption for Heat Pumps and Resistive Heating - NSW	23
Figure 17: Heating and Cooling Mode – Electricity Consumption Australia	24
Figure 18: Comparison of USA and Australian Units: Non Ducted Split	31
Figure 19: Comparison of USA and Australian Units: Ducted Split	32
Figure 20: Heat Pump MEPS Japan Compared to USA/Australia non-ducted Split Units	33
Figure 21: Heat Pump MEPS Japan Compared to USA/Australia Ducted Split Units	34
Figure 22: Heat Pump MEPS Japan Compared to Australia Window Units	35
Figure 23: Australian Potential MEPS – Window Wall Units	37
Figure 24: Australian Potential MEPS – Non-Ducted Split Units	38
Figure 25: Australian Potential MEPS – Ducted Split Units	38
Figure 26: Energy Impact of Potential MEPS	40

Figure 27: Greenhouse Gas Emissions Impact of Potential MEPS	41
Figure 28: Energy Rating Labels for Cooling and Heating Air conditioners	42

Introduction

The purpose of this report is to provide an analysis of the policy options, primarily the suitability for Minimum Energy Performance Standards (MEPS) and Energy Rating Labelling, for the following new product types identified in the 2003 Forward Work Program of the National Appliance & Equipment Energy Efficiency Program (NAEEEP):

- selected heating and cooling equipment including heat pumps and chillers
- selected space conditioning equipment such as non-air sourced heat pumps and dehumidifiers

Dehumidifiers were part of this group of equipment, however they are now being separately considered in the 2005 work program, while Chillers are addressed in a separate report. Hence this report focuses on the heating side of air conditioners and non-air sourced heat pumps.

Scope

This report covers air sourced and water sourced heat pumps (or reverse cycle air conditioners). In most cases, this report uses the term heat pump to describe a reverse cycle air conditioner, although these units may not be marketed or sold as a “heat pump” in marketing literature. The term “heat pump” can apply to all reverse cycle air conditioners but the performance of reverse cycle air conditioner as a heat pump varies depending on the design of the air conditioner and the outside ambient temperature. When temperatures outside are low, generally the heating output is also less.

Reverse cycle air conditioners are used to provide heating for households and some commercial sector buildings, such as motels, small offices and retail. The cooling cycle of air conditioners and heat pumps is already regulated for MEPS. Both the cooling energy efficiency and heating energy efficiency is also displayed on the mandatory energy label for air conditioners and heat pumps. The primary purpose of this analysis is to investigate the suitability of applying a MEPS on the heating cycle. A secondary purpose is to consider what changes could be made to the energy rating label that would compliment a MEPS for heating.

Background on Air Conditioner MEPS and Energy Labelling

Single phase room air conditioners (except ducted models) for household use are regulated for energy labelling in Australia. The cooling mode of three phase air conditioners up to 65kW cooling capacity is regulated for MEPS. Manufacturers can choose to label three phase air conditioners, but this is not mandatory. MEPS requirements for the cooling mode of three phase air conditioners will be revised in 2007 while MEPS for the cooling mode of all single phase units will be introduced in 2004 and revised in 2007. The 2007 revised MEPS for certain types of single phase units – including non-ducted split units of less than 7.5kW capacity – is currently being proposed

to be introduced in April 2006. MEPS details are set out in Australian and New Zealand Standard 3823.2-2003.

The heating mode of air conditioners is not currently subject to MEPS however the heating mode is required to be reported for the energy labelling requirements.

Product Descriptions

The two main heating product types were further defined as follows

- Air sourced heat pumps
- Water sourced heat pumps and air conditioners

Air Sourced Heat Pumps

Heat pumps have both heating and cooling capabilities. Air sourced heat pumps are the most common type of heat pump and use the difference between outdoor air temperatures and indoor air temperatures to cool and heat a building. The process involves using a liquid refrigerant and a reversing valve to extract heat from the air and transfer it to either inside the building for heating or outside the building for cooling.

In Australia air sourced heat pumps are more commonly used for air cooling purposes; however an increasing number of units are being installed as the main source of heating. Air sourced heat pumps are commonly used in both residential dwellings and commercial properties.

Water Sourced Heat Pumps and Air Conditioners

Water source heat pumps – as with air sourced heat pumps – transfer heat between the inside and outside of a building, the difference being the medium used. To facilitate the transfer of heat, the heat pump accesses water, usually ground water via a series of pipes laid under the water. The pipes then carry the heat into the building. There are three main systems used to access the heat. They are:

- Closed Loop System, which consists of a ground heat exchanger that permanently contains the heat transfer fluid in a closed system.
- Open Loop System, which consists of a ground heat exchanger where the heat transfer fluid (usually ground water or surface water) is part of a larger environment.
- Direct Expansion (DX) system in which the refrigerant is circulated in pipes buried in the ground, rather than using a heat transfer fluid.

Measures of Efficiency & Standard Test Conditions

Efficiency Measures

The efficiency of heating mode for heat pumps is typically measured by its Coefficient of Performance (COP). The USA and Canada use a different measure of efficiency, called the Heating Seasonal Performance Factor (HSPF). The basic differences are explained below.

Coefficient of Performance (COP)

The Coefficient of Performance (COP) is a measure of the efficiency of heating. It is the ratio of the heating capacity to the effective power input of the device, at any given set of rating conditions. The COP is used by Australia Standards and ISO as the measure of efficiency for the heating cycle. It is also used for a measure of efficiency for units greater than 19kW in the USA and Canada. All COP ratings in the USA/Canada are based on the high temperature (+8.3°C) condition.

In most cases, the COP is also used to describe the efficiency of the water sourced heat pump.

HSPF

The USA and Canada use the Heating Seasonal Performance Factor (HSPF) as the main measure of efficiency for units less than 19kW. The HSPF is the total heating output of a heat pump in Btu – including supplementary electric heat – necessary to meet the building heating requirements during its normal annual usage period for heating, divided by the total electric energy in watt-hours consumed during the same period.

The current USA DOE (Department of Energy) procedures determine air-source heat pump heating capacity and performances at three outdoor conditions (db): High Temperature Heating (+8.3°C), Frost Accumulation (+1.6°C) and Low Temperature Heating (-8.3°C), with indoor conditions set at 21.1°Cdb and 15.6°Cwb. These points are sufficient to permit interpolation or extrapolation to determine air-source heat pump performance over the full-range of conditions in different climatic regions by using a bin method procedure.

The rule for air-source heat pumps takes into account that HSPF for a given heat pump and climate region varies depending on the match of building load to heat pump capacity. For the purposes of “standard” rating, the rule defines minimum design heating requirements (building loads) for each region. In the United States, Region IV is the climatic region which is the basis for the published HSPF ratings. Region V is the climatic region for standard HSPF ratings in Canada. In both regions, it is assumed, for the published rating, that the air-source heat pump is installed in a house with a design heating requirement equal to the air-source heat pump’s capacity obtained in the high temperature heating test at 8.3°C (47°F).

Test Standards & Conditions

ISO and Australia

The applicable test standard for heat pumps in Australia and New Zealand are AS/NZS 3823 Performance of electrical appliances— Air conditioners and heat pumps

- Part 1.1: Non-ducted air conditioners and heat pumps—Testing and rating for performance.
- Part 1.2: Test Methods—Ducted air conditioners and air-to-air heat pumps—Testing and rating for performance.

Both these standards are equivalent to the ISO standards and have proven methods of testing for heating performance and rating.

Table 1: Test conditions: AS 3823 and ISO

Parameter	Standard test conditions
Temperature of air entering indoor side (°C)	
dry-bulb	20±1(0.3)
wet-bulb (maximum)	15±0.5(0.2)
Temperature of air entering outdoor side (high) (°C)	
dry-bulb	7±1(0.3)
wet-bulb	6±0.5(0.2)
Temperature of air entering outdoor side (low) (°C)	
dry-bulb	2±1(0.3)
wet-bulb	1±0.5(0.2)
Temperature of air entering outdoor side (extra low) (°C)	
dry-bulb	-7±1(0.3)
wet-bulb	-8±0.5(0.2)

Note: The Japanese also utilise the ISO test conditions for measuring the efficiency of heat pumps

The standard is applicable to non-ducted and ducted room air conditioners of the vapour compression type with a single or multiple refrigeration circuits. The cooling and heating capacity and energy is determined under AS/NZS 3823.1.1 or AS/NZS 3823.1.2. These standards have been cloned from ISO5151 and ISO13253 respectively and are technically equivalent. A number of minor amendments have been included (mostly regarding tolerances and minor editorial changes), but many of these changes are scheduled to appear in the forthcoming revised edition of the ISO standards.

If a unit is to be tested for both energy labelling and MEPS applications, the following procedure applies:

- one unit has to be tested (physical test) and results supplied with the labelling application (registrations to AS/NZS 3823.2-2001 still require 3 test reports but are not required to meet MEPS)

- the model must be capable of meeting the maximum cooling test requirement
- all tests must be carried out in a calorimeter (enthalpy method is not acceptable)
- cooling capacity and energy consumption is determined to condition T1
- heating capacity and energy consumption is determined to condition H1 (ISO condition "high")
- for each unit tested, the measured capacity shall be > 0.95 of the rated value
- for each unit tested, the measured energy consumption shall be < 1.05 of the rated value

If a unit is to be tested for MEPS applications, the following procedure applies:

- one unit has to be tested (or simulated) and results supplied with the MEPS application
- a physical test in a calorimeter or the enthalpy method is acceptable
- a simulation to AS/NZS 3823.3 is an acceptable alternative to a physical test
- cooling capacity and energy consumption is determined to condition T1
- heating capacity and energy consumption is determined to condition H1 (ISO condition "high")
- for each unit tested, the measured capacity shall be > 0.95 of the rated value
- for each unit tested, the measured energy consumption shall be < 1.05 of the rated value

The preface of AS/NZS 3823 describes the relationship between the Australian Standard and the International Standards Organisation standards for air conditioners. It should be noted that ISO has undertaken a revision of both the ducted (ISO5151) and non ducted air conditioner standard (ISO13253) over the past few years and many of the changes proposed by International Standards Organisation TC86 SC6 working group 1 have been included in AS/NZS 3823.1.1-1998 and AS/NZS 3823.1.2-2001.

USA & Canada

The USA and Canada use a different set of test conditions to measure the efficiency of heat pumps. These conditions are shown and compared in Table 2, and are used for the calculation of the HSPF.

Table 2: Test conditions: USA compared to Australia

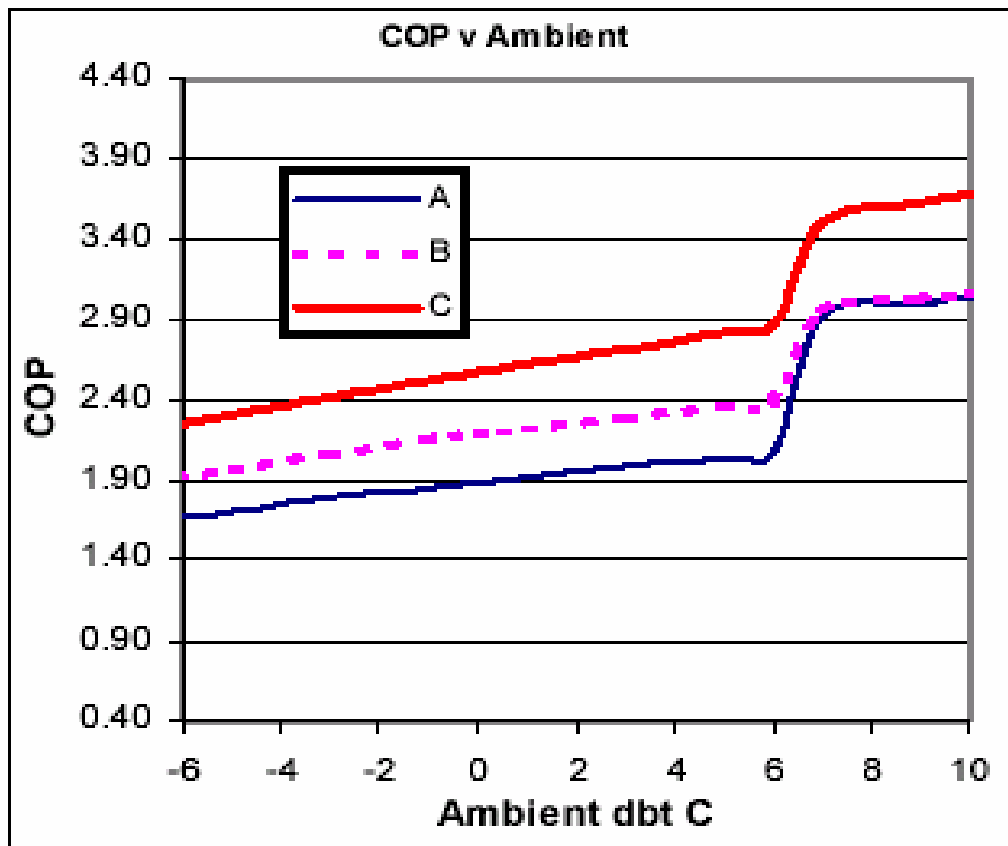
Parameter	Standard test conditions	
	ARI 210/240, C744-93	ISO (AS3823)
Temperature of air entering indoor side (°C)		
dry-bulb	21.1±0.56	20±1
wet-bulb	15.6±0.34	15±0.5
Temperature of air entering outdoor side (°C)		
high temperature rating test		<i>H1 (high)</i>
dry-bulb	8.3±0.56	7±1
wet-bulb	6.1±0.34	6±0.5
Frost Accumulation test		<i>H2 (Low)</i>
dry-bulb	1.7±0.56	2±1
wet-bulb	0.6±0.34	1±0.5
Low (extra-low in ISO) temperature rating test		<i>H3 (Extra Low)</i>
dry-bulb	-8.3±0.56	-7±1
wet-bulb	-9.4±0.34	-8±0.5

Heat Pump Performance – Cold Temperatures

Heat pumps use a technique called the vapour compression cycle to "move" energy in the form of heat from one space to another. This is generally a very efficient process and the amount of heat moved is typically 2 to 3 times (or more) the energy required to run the compressor system. Typically the COP is in the range 2.0 to 3.5 (meaning that the heating output is 2 to 3.5 times as great as the power input, or an efficiency of 200% to 350%). This is achieved by the use of a refrigeration heat pump which collects ambient heat from outside and moves it inside when in heating mode. The apparent efficiency of heat pumps is high as they can move much more low grade energy in the form of heat than they require as electrical power input.

However, the performance of a heat pump ranges according to the outside ambient temperature. In low outside temperatures, the heating output and COP are generally less than when the outside temperature is high. This is illustrated in Figure 1, where the COP of three models of heat pumps is shown at a range of outside temperatures. This figure clearly shows the lower temperatures mean a lower COP and hence lower heating output when at the same time, the heating requirements of the space are greatest. It is also interesting that the COP decreases steeply after the standard rating conditions for H1 (at 6 to 7 °C), and the relationship between COP and ambient is relatively linear after this point.

Figure 1: Heat Pump COP vs Outside Ambient Temperature

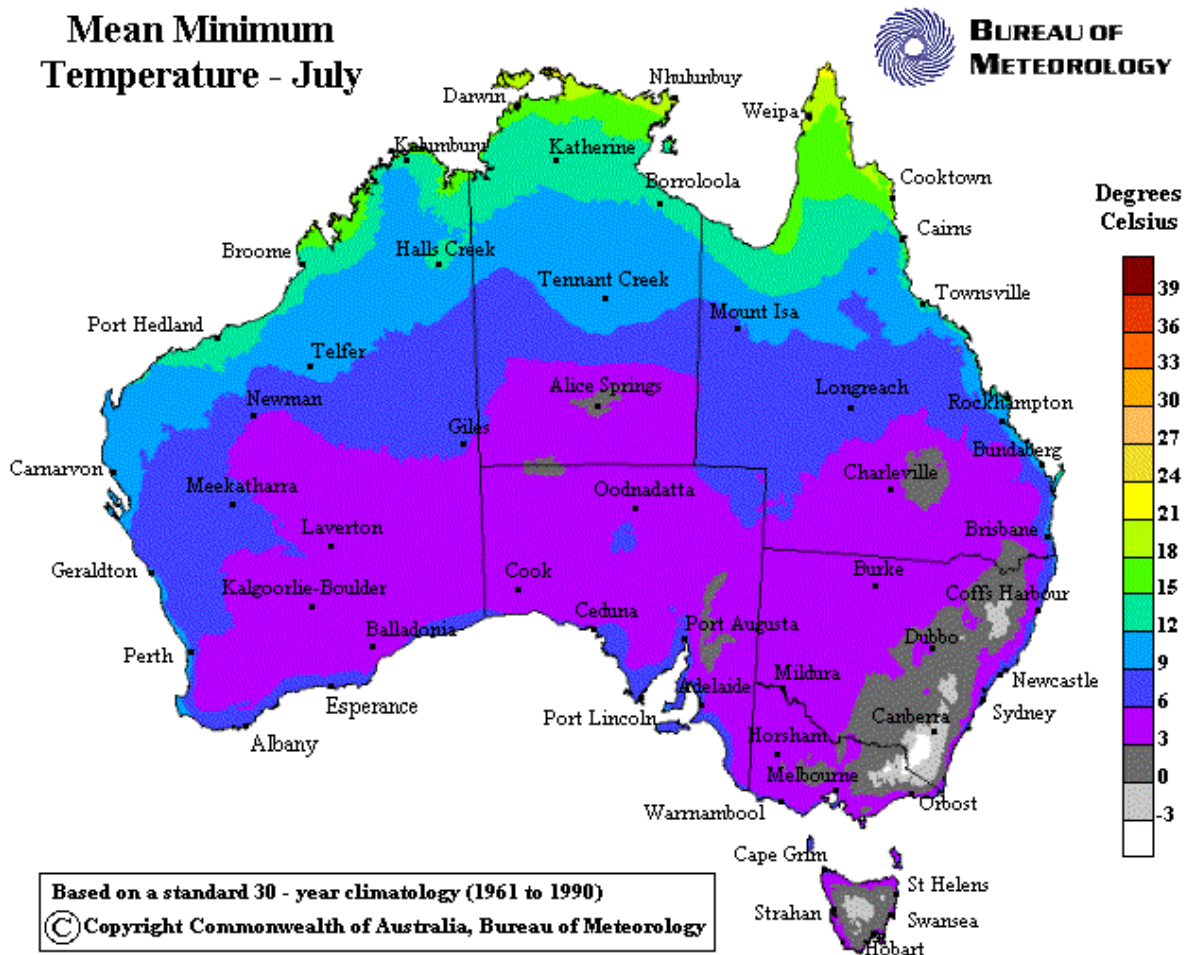


Source: Adrian Hall, Presentation to MEPS Steering Committee 18 September , 2003

This performance issue is critical if the heat pump is to be used in cold climates where the ambient is regularly below 6°C. Therefore, the current performance of heat pumps measured at H1 conditions does not represent the performance of a heat pump where outside conditions are cold and households want to utilise the heat pump the most.

It would be more appropriate to measure and display the performance of a heat pump at temperature conditions where the unit is more likely to be used. As large areas of New Zealand and Australia regularly experience these temperatures, as shown in Figure 2, the H2 test conditions may be more representative. A MEPS and/or labelling program that utilised the performance information of heat pumps at the H2 test conditions would enhance the information available to consumers when selecting a heat pump to provide heating for their household.

Figure 2: Mean Minimum Temperature – July Australia



Manufacturers have generally not provided data of heat pump performance at the H2 conditions for an analysis of heat pump performance. Hence the following sections provide an analysis of the relationship of the COP at various temperature conditions, and how this can lead to the development of a factor for the estimation of COP of H2, based on the measured data recorded at H1. Interestingly, the USA have recorded the steady state COP of many types of air conditioners at the +8°C and -8°C test condition, but not at the Frost Accumulation test conditions, which are closest to the H2 test conditions

The analysis following takes the approach:

- Determine the relationship between USA empirical data of +8°C and -8°C test conditions
- Estimate a ratio for COP at the H2 test conditions which can be applied to COP at the H1 test condition.

Figure 3: Comparison of USA Heat Pump COP at 8°C & -8°C Ducted Split Systems

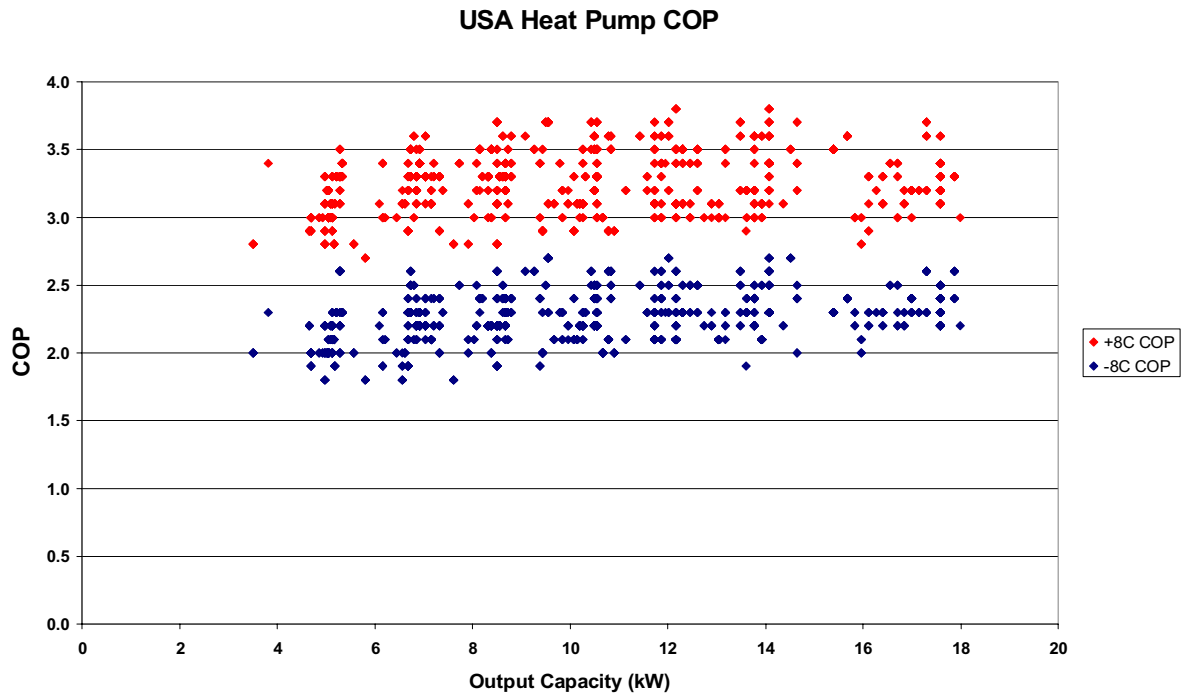


Figure 3 shows the COP at +8°C and COP at -8°C for USA models of ducted split units.

Figure 4 Comparison of USA Heat Pump COP at 8°C & -8°C Non-Ducted Split Systems

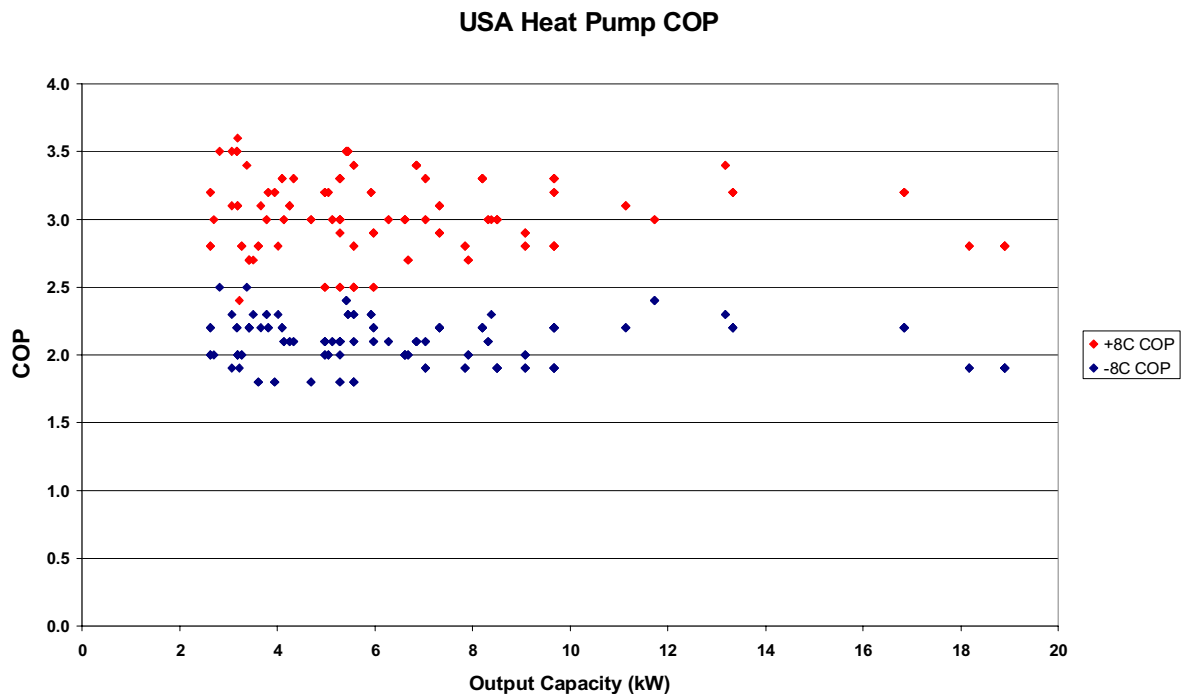


Figure 3 and Figure 4 show that generally the COP measured at +8°C is approximately 45 – 50% higher than the COP measured at -8°C.

Figure 5 shows that no direct relationship is apparent between COP at +8°C and COP at -8°C for non-ducted split heat pumps as shown. Figure 6, however shows that there does appear to be a general increase in COP at -8°C for those ducted split units with higher COP at +8°C.

Further analysis of the COP ratio for non-ducted splits shows the median $COP_{+8^{\circ}C}/COP_{-8^{\circ}C}$ ratio is 1.55, with a relatively normal distribution from a sample of 89 unique units. The maximum ratio is 1.85 and the minimum is 1.17. For ducted splits, the median $COP_{+8^{\circ}C}/COP_{-8^{\circ}C}$ ratio is 1.50, with a relatively normal distribution and sample of 1056 unique units. The maximum ratio is 1.79 and the minimum is 1.20.

This aim of determining a ratio of $COP_{+8^{\circ}C}/COP_{-8^{\circ}C}$ is to estimate the COP at the H2 test condition, so further analysis of a MEPS and labelling program can be made for Australia, as described later on page 35

Figure 5: USA Heat Pump COP (H1) vs COP (H3) – Non Ducted Split

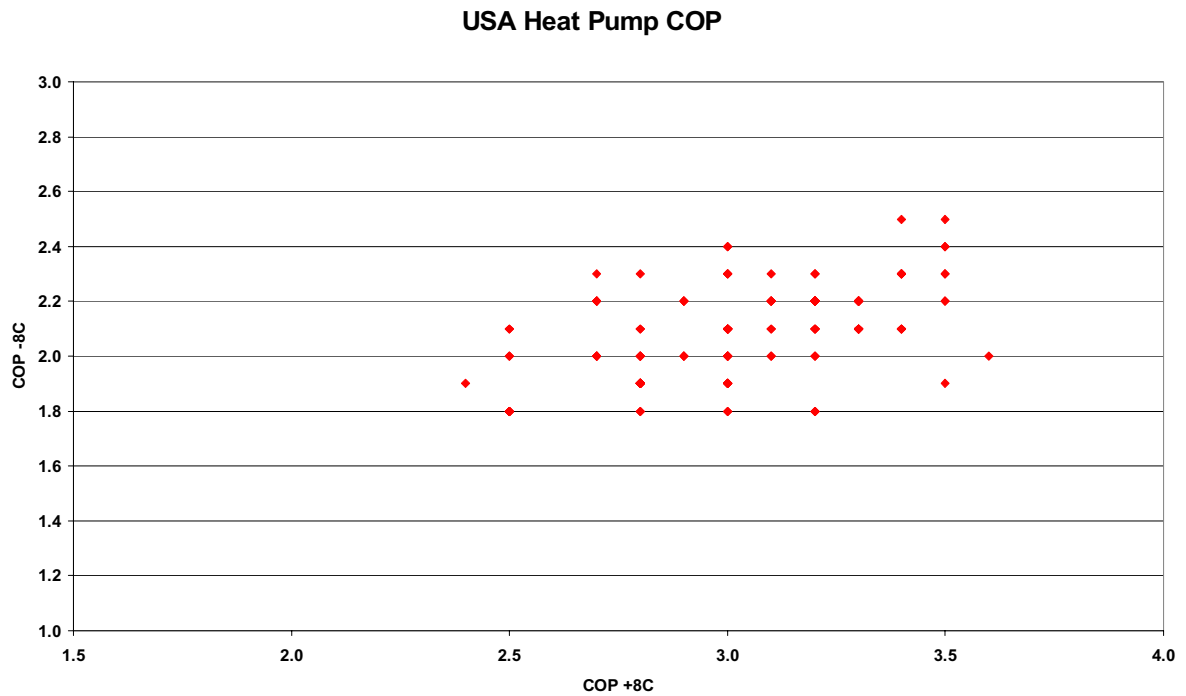
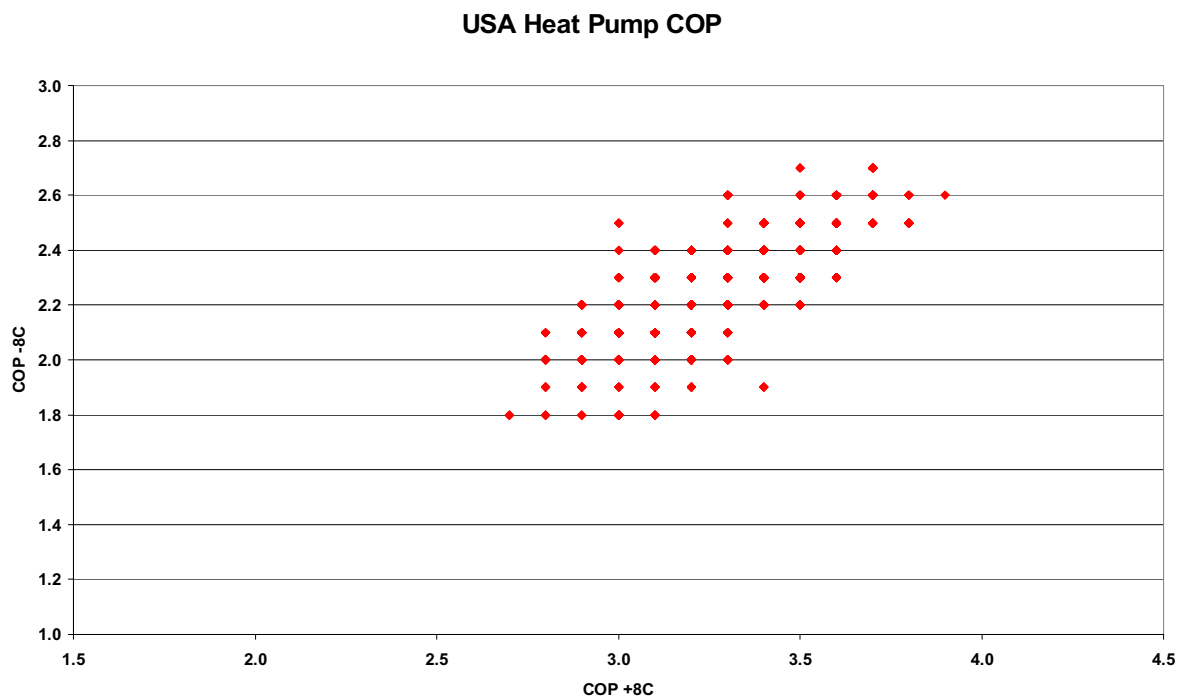


Figure 6: USA Heat Pump COP (H1) vs COP (H3) – Ducted Split



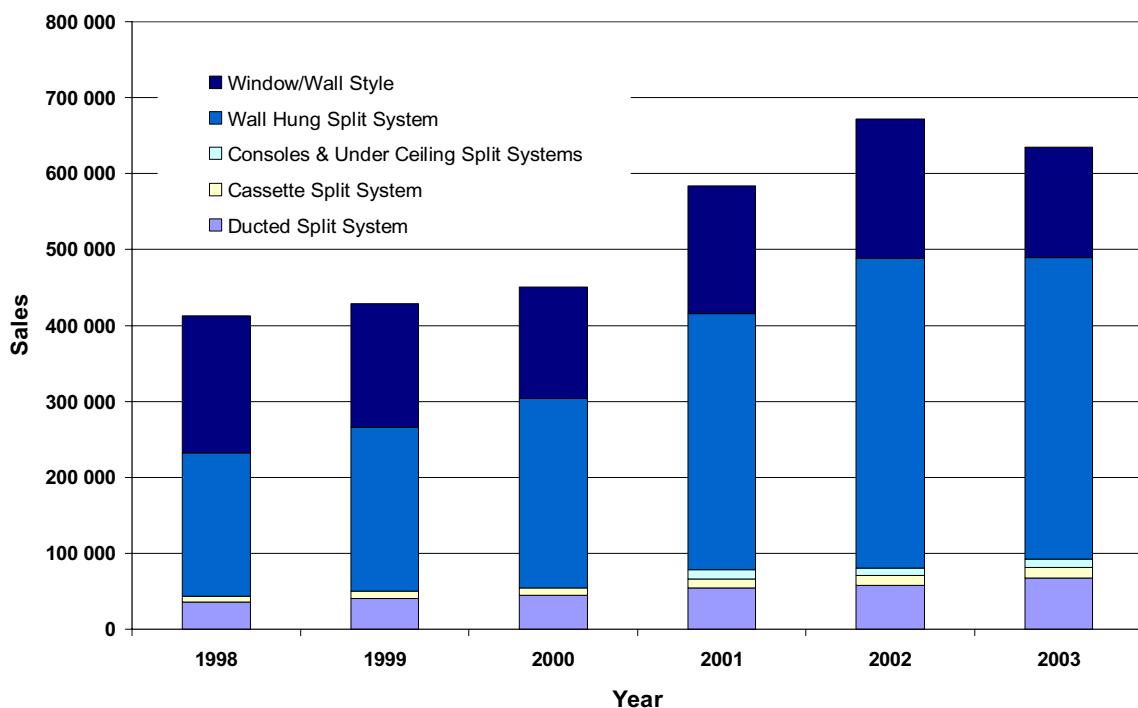
Market Characteristics

The installed stock and sales of heat pump type air conditioners are increasing in Australia and New Zealand. Detailed sales and stock estimates are available for Australia, however only information on the aggregate output capacity of sales of new air conditioners is available for the New Zealand market.

Sales of Heat Pump Air Conditioners – Australia

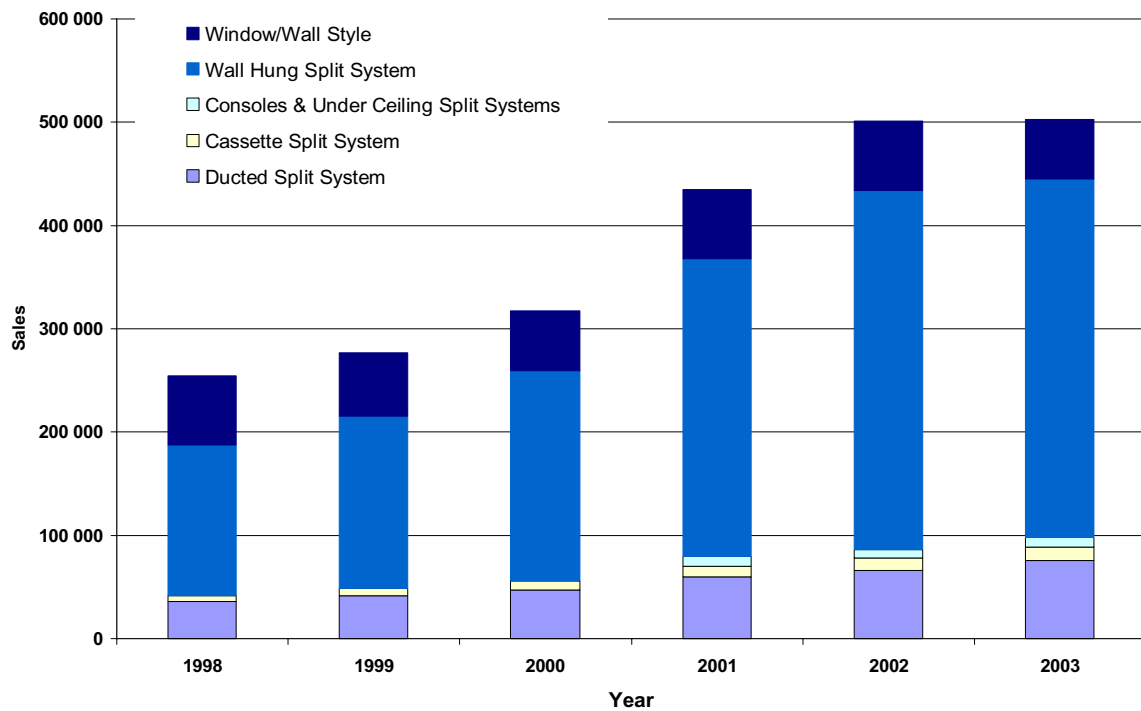
Figure 7 shows the annual sales of air conditioners by system type. Sales have increased each year since 1998 except for 2003. In 2003, suppliers report that the relatively cooler early summer period lead to slower sales in the pre-end of year period, pushing sales into the first quarter of 2004. If the sales from early 2004 were included in the 2003 data, suppliers report that again an increase in total sales would be observed. Wall hung and console/ceiling split systems have dominated the sales increase in Australia in recent years.

Figure 7: Annual Sales of all air conditioners by system type



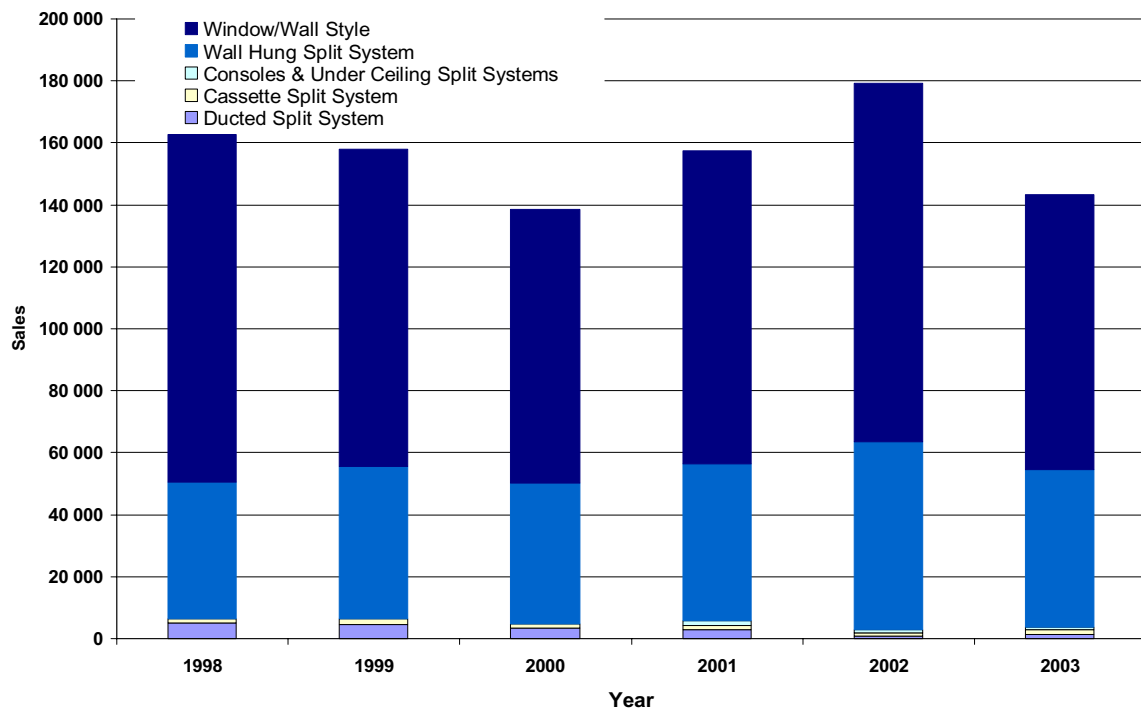
Source: Informark 2004

Heat pump type air conditioners are also the most common air conditioner type being sold, as shown in Figure 8. A 100% increase in sales has occurred over the last 5 years, from 1998 to 2003.

Figure 8: Annual Sales of Heat Pump air conditioners by system type

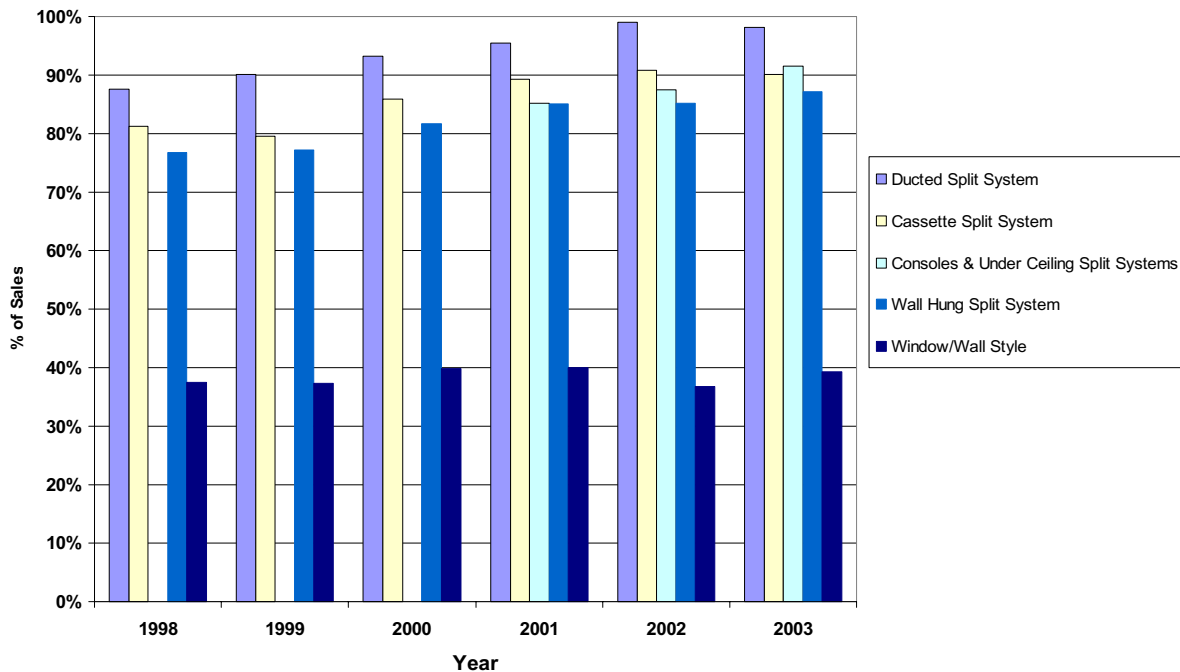
Source: Informark 2004

As heat pump systems become more prevalent in the market place, sales of cooling only air conditioners are stagnant or slightly declining, as shown in Figure 9. Sales of heat pump type air conditioners are about 4 times of those cooling only systems.

Figure 9: Annual sales of cooling only air conditioners by system type

Source: Informark 2004

Figure 10 shows the proportion of sales of different system types attributed to heat pump type air conditioners. The figure shows that over 80% of all split type air conditioners sold are heat pumps (reverse cycle), while the majority of window wall units are cooling only systems.

Figure 10: Proportion of total sales of Heat Pump air conditioners by system type

Source: Informark 2004

It is obvious that the predominant air conditioner being sold in Australia can be used for both heating and cooling, with the vast majority of units being split type air conditioners. The need to address the energy use implications of the heating cycle is more important now due to the increasing sales of heat pump air conditioners and it is likely that this trend will continue with increasing sales of split type air conditioners.

Statistics on sales of water source heat pumps are not collected, however suppliers have reported that sales are less than 10,000 per annum and these are mainly used in new apartments with a water chiller as the cooling source. Suppliers report that very few sales are being used in the heating market.

Sales of Heat Pump Air Conditioners – New Zealand

The information for New Zealand is sourced from the Regulatory Impact Assessment for MEPS for air conditioners. It provides the aggregate output capacity of sales of heat pump type air conditioners in New Zealand as shown in Table 3, with the number of sales estimated by dividing the output capacity by the estimated average capacity. The total number of heat pumps type air conditioner sold in 2002 is estimated at 290,000 units, with the majority of these split non ducted of less than 8 kW output capacity.

Table 3: New Zealand Sales of Heat Pumps – 2002

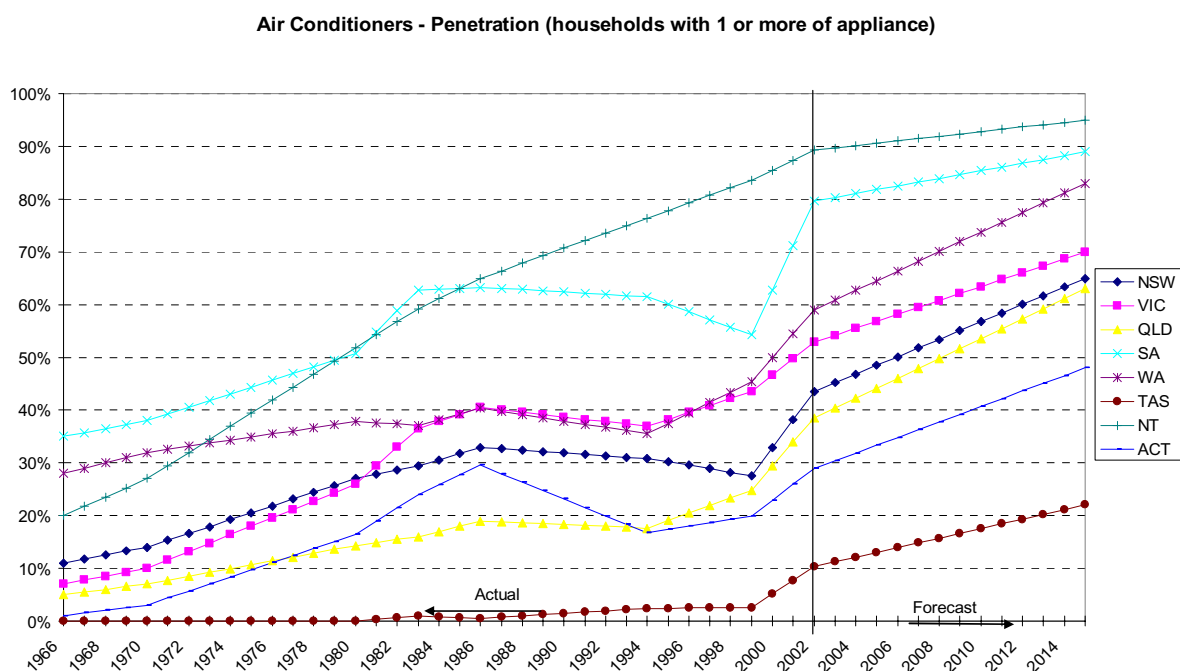
Type and size range (kW)	Cooling capacity (kW)	Heating capacity (kW)	Estimated Number
Ducted , 0-4	3 114	3 155	1 246
4-8	79 335	82 264	13 223
8-12	56 161	62 004	5 616
12+	12 011	12 669	858
Split, non-ducted , 0-4	311 540	369 522	124 616
4-8	641 954	725 385	106 992
8-12	53 149	56 560	5 315
12+	18 633	20 458	1 331
Wall/window, 0-4	57 184	58 357	22 874
4-8	50 312	49 783	8 385
Total	1 283 393	1 440 157	290 455

Source: Minimum energy performance standards for air conditioners – Impact Assessment, EECA April 2004

Stock of Air Conditioners and Heat Pumps – Australia

In Australia, it is estimated that the penetration of all types of air conditioners is increasing, with the largest penetrations in the NT, SA and WA, as shown in Figure 11. In Victoria the current penetration of air conditioners is estimated at over 50% and this will soon be the case in NSW and Queensland.

Figure 11 Air Conditioner Penetration by State



Source: EES 2004

The total number of households using air conditioners by type of air conditioner is shown in Table 4. In Australia, over 1.7M households in 2002 used reverse cycle air conditioners with the majority of these being window wall units. NSW had the largest installed stock of air conditioners in 2002.

Some 11% of households used heat pumps as their main heater in 2002, as shown in Table 5, with over 400,000 being used in NSW. As a proportion of main heating, 23% of South Australians use heat pumps as their main heater, while only 2% in Victoria use heat pumps. The availability of gas for heating in Victoria probably contributes to the lower percentage using heat pumps. However, in Tasmania only 7% use heat pumps as the main heater, where wood combustion heating is more common (42% in 2002).

Table 4: Households with Air Conditioners: Type of Air Conditioners — 2002

	<i>NSW</i>	<i>Vic</i>	<i>Qld</i>	<i>SA</i>	<i>WA</i>	<i>Tas</i>	<i>NT</i>	<i>ACT</i>	<i>Aust.</i>
Split system									
Reverse cycle/heat pump	212.0	80.4	92.5	47.6	52.6	8.9	2.5	8.2	504.6
Cooling only	15.0	33.7	36.9	6.3	17.5	0.0	12.1	0.2	121.7
Evaporative	1.4	10.4	1.2	1.1	0.8	0.0	0.0	0.4	15.2
Not known	5.2	3.6	1.8	0.0	0.8	0.0	0.2	0.2	11.9
<i>Total</i>	<i>233.6</i>	<i>128.1</i>	<i>132.4</i>	<i>54.9</i>	<i>71.7</i>	<i>8.9</i>	<i>14.8</i>	<i>9.0</i>	<i>653.4</i>
Window/Wall									
Reverse cycle/heat pump	336.0	183.3	131.2	136.7	60.2	6.6	2.0	4.7	860.8
Cooling only	102.9	277.0	160.0	82.7	68.6	0.0	20.4	4.7	716.2
Evaporative	19.8	33.7	12.3	6.7	9.3	0.0	2.7	1.4	85.8
Not known	27.8	29.2	13.1	1.8	3.6	0.0	0.5	0.2	76.2
<i>Total</i>	<i>486.5</i>	<i>523.1</i>	<i>316.6</i>	<i>227.9</i>	<i>141.6</i>	<i>6.6</i>	<i>25.6</i>	<i>10.9</i>	<i>1738.9</i>
Ducted									
Reverse cycle/heat pump	214.3	29.5	35.7	62.0	44.9	2.2	0.0	6.5	395.0
Cooling only	5.8	25.2	8.0	6.2	14.9	0.0	2.1	0.2	62.2
Evaporative	89.5	219.3	26.5	124.6	155.6	0.0	6.3	3.2	625.0
Not known	2.2	4.7	0.5	0.4	2.4	0.0	0.0	0.0	10.2
<i>Total</i>	<i>311.7</i>	<i>278.7</i>	<i>70.8</i>	<i>193.1</i>	<i>217.7</i>	<i>2.2</i>	<i>8.4</i>	<i>9.9</i>	<i>1092.5</i>
Portable									
Reverse cycle/heat pump	5.0	2.0	3.2	0.3	0.4	0.6	0.0	0.0	11.5
Cooling only	10.8	10.9	2.6	1.4	4.3	0.0	0.0	0.6	30.6
Evaporative	24.8	25.8	25.0	10.2	8.2	1.3	0.0	4.9	100.2
Not known	2.4	3.8	0.6	0.0	0.4	0.0	0.0	0.3	7.5
<i>Total</i>	<i>42.9</i>	<i>42.5</i>	<i>31.4</i>	<i>11.9</i>	<i>13.4</i>	<i>1.8</i>	<i>0.0</i>	<i>5.8</i>	<i>149.8</i>
Total									
Reverse cycle/heat pump	767.4	295.1	262.6	246.6	158.1	18.3	4.5	19.4	1771.9
Cooling only	134.4	346.8	207.5	96.5	105.3	0.0	34.6	5.7	930.8
Evaporative	135.4	289.2	64.9	142.6	173.9	1.3	9.0	9.9	826.1
Not known	37.6	41.3	16.0	2.2	7.2	0.0	0.8	0.8	105.8
<i>Total</i>	<i>1074.7</i>	<i>972.4</i>	<i>551.1</i>	<i>487.9</i>	<i>444.4</i>	<i>19.5</i>	<i>48.8</i>	<i>35.7</i>	<i>3634.6</i>

Source: ABS 4602 – additional cross tabs

Table 5: Households Using Heat Pumps as Main Heater – 2002

	<i>NSW</i>	<i>Vic.</i>	<i>Qld</i>	<i>SA</i>	<i>WA</i>	<i>Tas.</i>	<i>NT(a)</i>	<i>ACT</i>	<i>Aust.</i>
Total dwellings using reverse cycle air conditioner as main heater	406.6	42.7	157.7	141.5	73.3	13.1	0.6	8.7	844.4
% dwellings using reverse cycle air conditioner as main heater	16.4	2.3	11	23.1	9.7	6.9	1.2	7.1	11.3

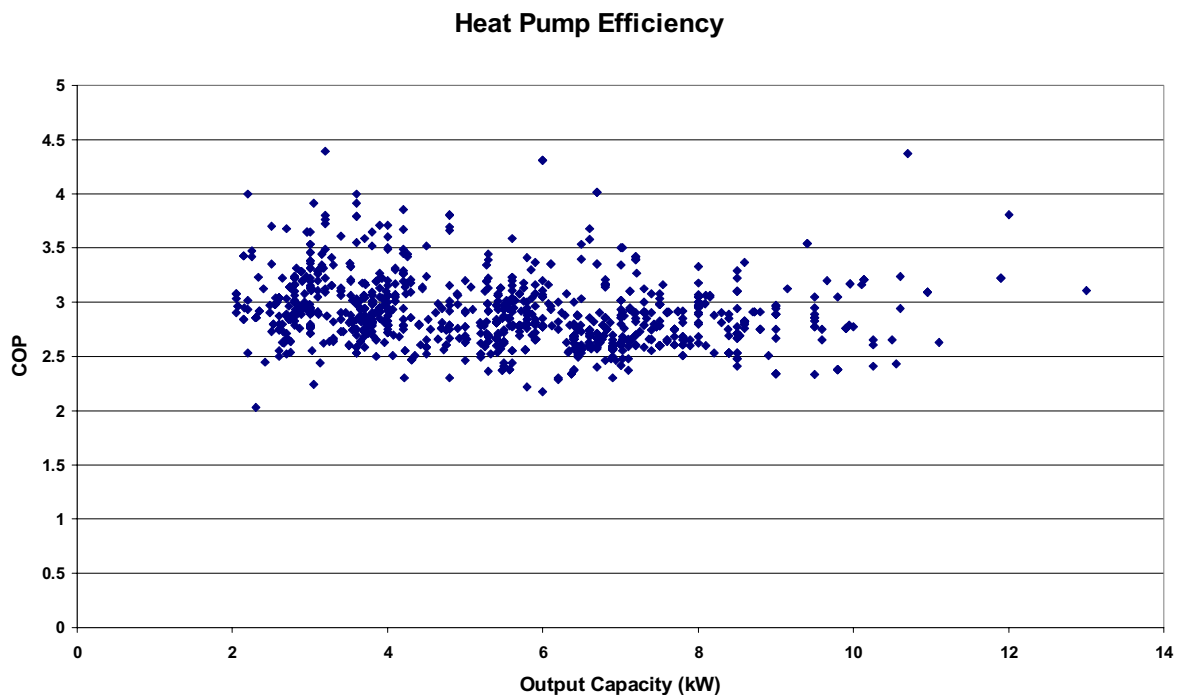
Source: ABS 4602. Note (a) Northern Territory data refers to mainly urban areas only

From the above tables and figures, it is clear that air conditioners and heat pumps will continue to be commonly installed in Australian households and that they will increasingly be used for heating. The tables show that just under 50% of all heat pumps are used as the main heater in the household.

Efficiency of Registered Heat Pumps – Australia and NZ

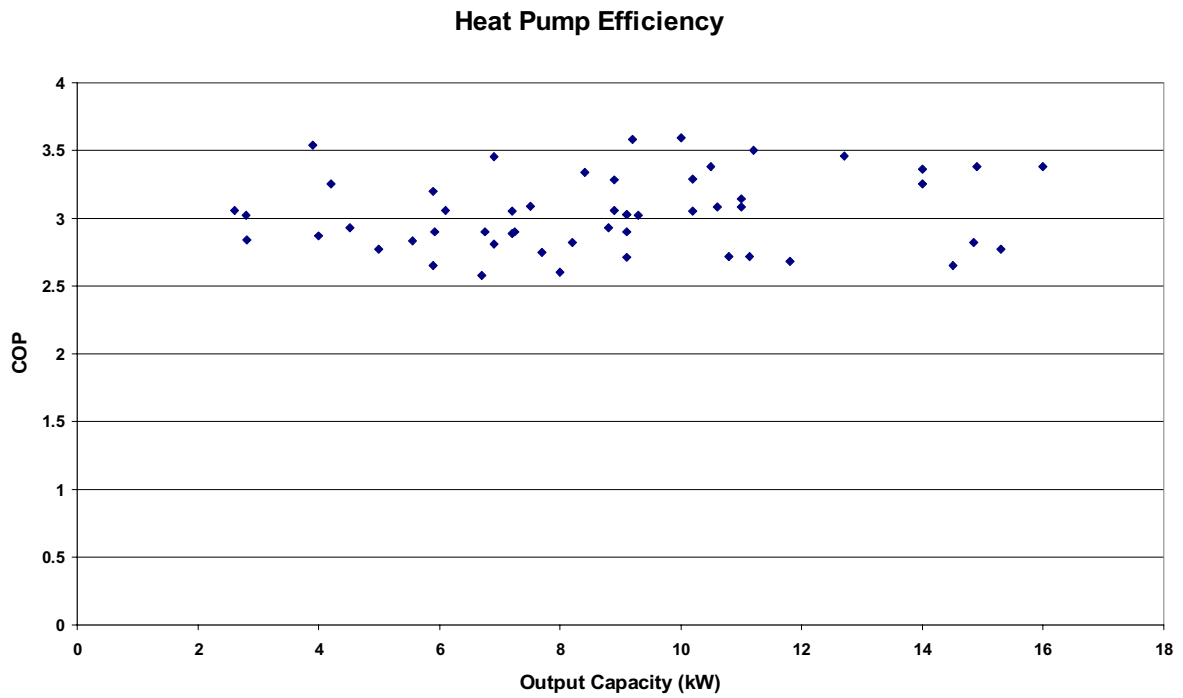
The range of efficiency of non-ducted split type heat pumps being sold in Australian and New Zealand is relatively large, from COP of 2 to over 4, as shown in Figure 12. The majority of models registered for energy labelling are in the 2.5 to 3.5 COP range. These COP measurements are taken at the H1 conditions.

Figure 12: Heat Pump COP by Capacity – Non Ducted Split



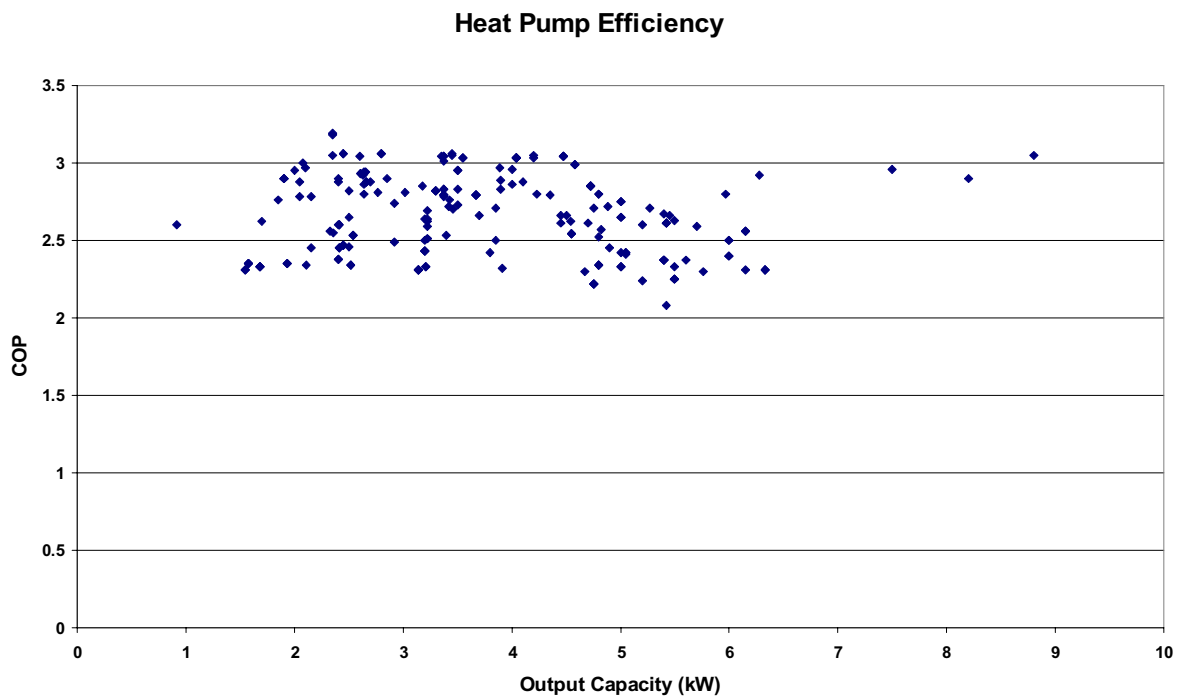
Fewer models are available for ducted split heat pumps and the range of COP is from 2.5 to 3.5 as shown in Figure 13.

Figure 13: Heat Pump COP by Capacity – Ducted Split



The efficiency of heat pump type window/wall systems are shown in Figure 14.

Figure 14: Heat Pump COP by Capacity – Window Wall

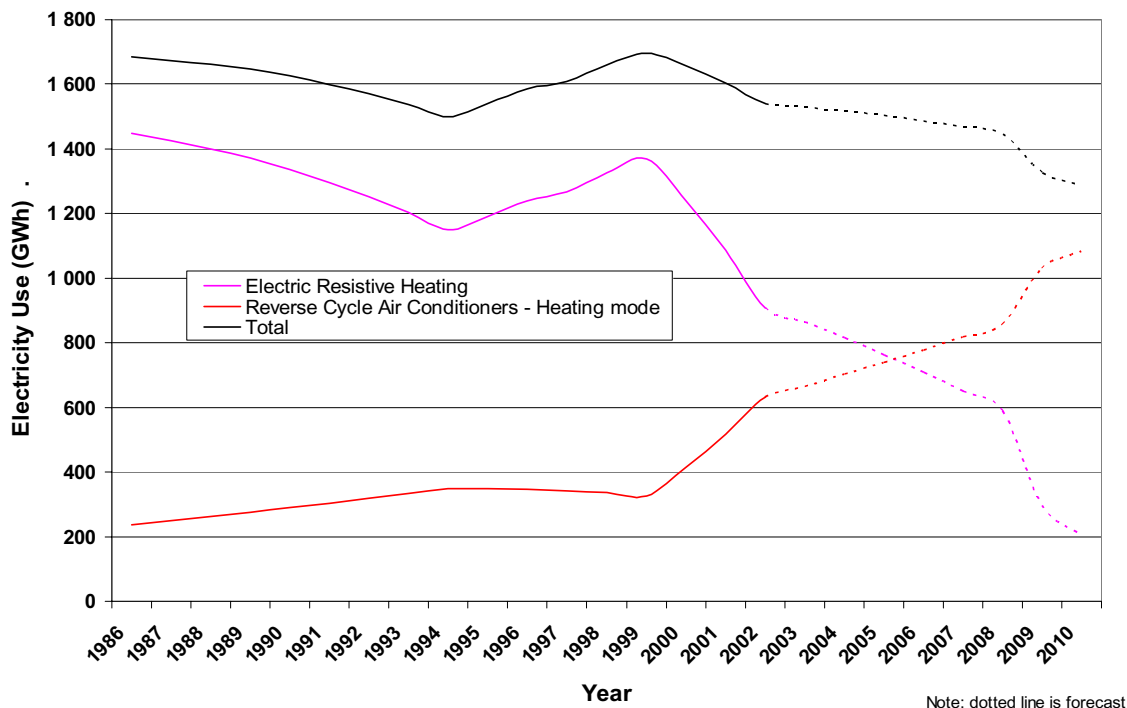


No data is available on the efficiency of water sourced heat pumps sold in Australia, however they are inherently more efficient than air sourced heat pumps due to the higher temperature of water compared to ambient air.

Energy Consumption of Heat Pumps – Australia

Figure 15 shows the estimated electricity consumption of heat pump and electric resistive heating for Australia. It is estimated that the energy use of heat pumps will increase from just over 600 GWh in 2002 to 1,100 GWh in 2010. This is typically replacing electric resistive heating as the main heating source, as shown below, probably as the efficiency of heat pump heaters allows for more cost effective heating compared to electric resistive.

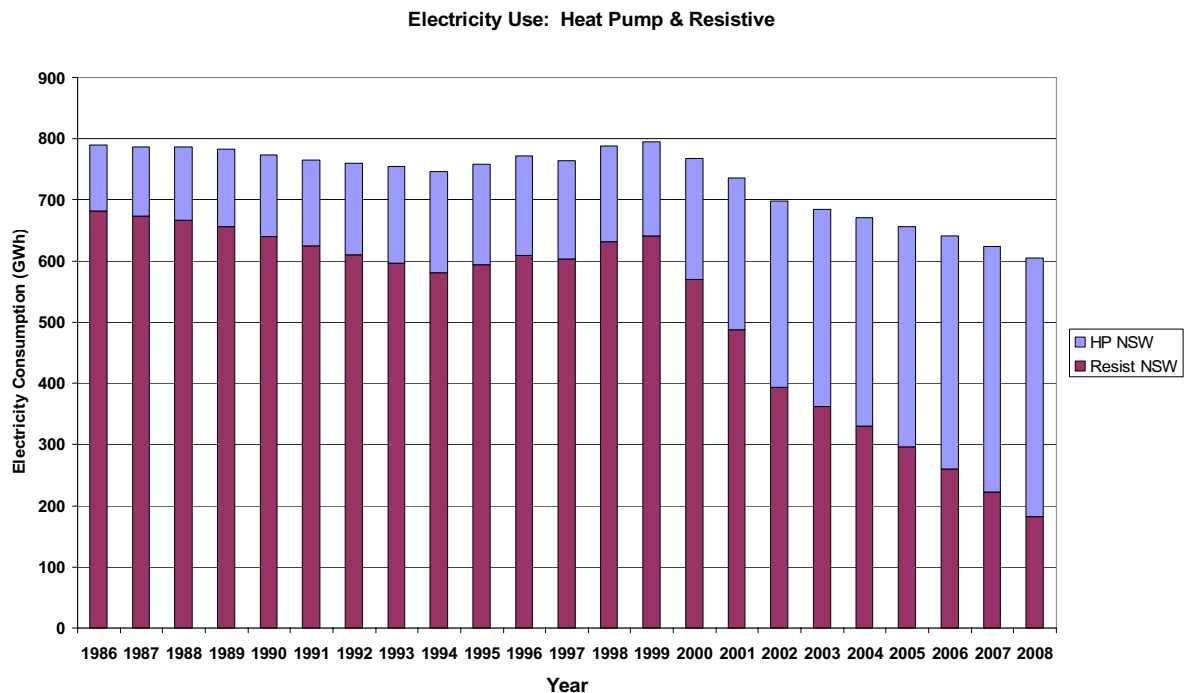
Figure 15: Electricity consumption of Heat Pumps and Electric Resistive Heating



Source: EES 2004

Figure 16 provides an example of the relative energy consumption of heat pumps and electric resistive heating in NSW. Again, it shows the rapidly increasing electricity consumption of heat pumps and the decline of electricity use for electric resistive space heating.

Figure 16: Electricity Consumption for Heat Pumps and Resistive Heating - NSW



Source: EES 2004

These estimated energy consumption figures for heat pumps have utilised the ABS data providing the annual average hours of use of heating, as shown in Table 6. These figures are derived from ABS survey data.

Table 6: Estimated Average Hours of Heater Use

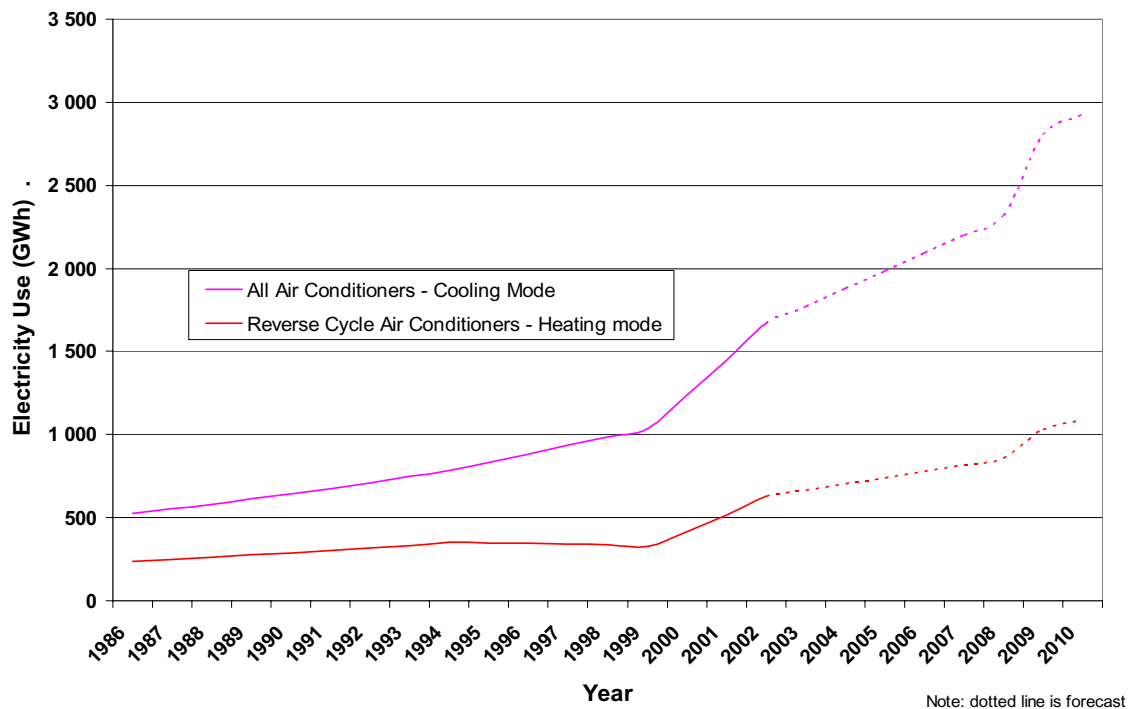
Annual Average Use (Hours)	
Sydney	669
Melbourne	1586
Brisbane	215
Adelaide	822
Perth	556
Hobart	1518
Darwin	0
Canberra	2029
Australia	943

Source: ABS 8218.0

To provide a comparison with the energy consumption of all single phase air conditioners, Figure 17 shows the total heating and cooling electricity consumption and forecasts. The figure demonstrates that heating mode electricity consumption by heat

pumps is approximately 34% of the electricity consumption of cooling mode in 2000, increasing to 38% by 2010

Figure 17: Heating and Cooling Mode – Electricity Consumption Australia



Source: EES 2004

Summary Market Characteristics

It is apparent that air sourced heat pumps are increasing in stock and sales in Australia and probably New Zealand.

- Energy consumption of heat pumps is rising rapidly; likely to increase by 600 GWh pa for electricity by 2012 which in greenhouse gas terms is approximately 600 kt CO₂-e pa
- The trend is likely to continue as heat pumps replace electric resistance and solid fuel heating. Also the use of the heating cycle of air conditioners sold for cooling purposes as secondary heating in households is likely to increase.
- There is a range of efficiencies for available models in Australia and these suggest that a MEPS will have an impact
- There will be a difference in stock installed in different Australian states and New Zealand due to primary heating fuel source availability and climate.

The sales of water sourced air conditioners and heat pumps are relatively minimal in Australia. Also, ground source and water sourced air conditioners and heat pumps are inherently more efficient than air sourced units.

Review of International Approaches

Canada

Canada has a MEPS program that covers air and water sourced heat pumps. A voluntary comparative labelling program for heat pumps also exists.

Air Sourced Heat Pumps

Canada introduced MEPS for single phase heat pumps in 1995 with standards for other types of heat pumps following in 1998. The test standards used for these MEPS are CAN/CSA-C746-98, CAN/CSA-C744-93, CAN/CSA-C656-M92, and CAN/CSA-C273.3-M91. Canada has a voluntary label for air sourced heat pumps however only cooling efficiency is compared. The MEPS levels for Canada are shown in Table 7

Table 7: Canadian MEPS for Air Sourced Heat Pumps

Heat Pump Type	Cooling Capacity kW	Minimum COP at +8.3°C	Minimum COP at -8.3°C
Single Packaged	>19 ≤ 40	3.0	2.0
	>40 <73	2.9	2.0
Remote outdoor unit	>19 ≤ 40	3.0	2.0
Split System	>19 ≤ 40	3.0	2.0
	>40 <73	2.9	2.0
<i>Minimum COP</i>			
Packaged terminal		2.75	
<i>Minimum HSPF</i>			
Single Phase and three Phase single packaged central	< 19	5.7	
Single Phase and three Phase Split System Central	<19	5.9	

Water sourced heat pumps

MEPS have been in place since 1995 for water sourced heat pumps with a rated capacity less than 35kW using either open or closed loop systems. The Canadian standard CAN/CSA-C446-M90 sets out the test procedure. Additionally split system and single packaged units that are less than 40kW and have an internal water loop system are required to meet the MEPS level set out in CAN/CSA-C655-M91. Units are required to meet the MEPS levels shown in Table 8.

Table 8: Canadian MEPS for Water Sourced Heat Pumps

Open/Closed Loop Heat Pumps	Minimum EER	Minimum COP
Cooling		
All Units (10 ⁰ C)	11.0	3.2
Closed loop (25 ⁰ C)	10.5	3.1
Heating		
All Units (10 ⁰ C)		3.0
Closed loop (25 ⁰ C)		2.5
Internal Water Loop Heat Pumps	10	3.8

USA

The USA has MEPS and mandatory labels that compare heating (HSPF), for air sourced heat pumps and water sourced heat pumps. Some rebate programs and information schemes also exist.

Air Sourced Heat Pumps

The USA has had MEPS for air sourced heat pumps since 1995 and these will be upgraded in 2006. These MEPS levels are determined in accordance with ARI standards and are shown in Table 9.

Table 9: USA MEPS for Air Sourced Heat Pumps

Heat Pump Type	Cooling Capacity Btu/h	Efficiency
single packaged	≤ 65,000 Btu/h	6.6 HSPF
split system	≤ 65,000 Btu/h	6.8 HSPF
3 phase packaged single and Split System	65,000 Btu/h and ≤ 135,000 Btu/h	3.0 COP
Split System and single packaged	135,000 Btu/h and ≤ 240,000 Btu/h	2.9 COP
Packaged terminal	All	COP 1.3 + (0.16* prescribed minimum EER)
Changes beginning 2006		
single packaged	≤ 65,000 Btu/h	7.4 HSPF
split system	≤ 65,000 Btu/h	7.4 HSPF
Through the wall split	≤ 30,000 Btu/h	7.1 HSPF
Through the wall single	≤ 30,000 Btu/h	7.0 HSPF
Small Duct High Velocity	All	6.8 HSPF

Water Sourced Heat Pumps

MEPS for water sourced heat pumps are tested according to ARI standard 320-98, and shown in Table 10.

Table 10: USA MEPS for Water Sourced Heat Pumps

Heat Pump Type	Cooling Capacity Btu/h	Efficiency
Packaged	≤ 135,000 Btu/h	3.8 COP

Energy Star

The Energy Star program is a voluntary labelling scheme that identifies energy efficient products for consumers. Canada and the USA both use this program to label efficient air sourced heat pumps, water source heat pumps, cold water dispensers and dehumidifiers.

Air Source Heat Pumps

Energy Star labels are available for air sourced Heat Pumps with a rating less than 65,000 Btu/h. The test standards are in accordance with ARI Standard 210/240-94 and have been applicable since October 2002. ENERGY STAR anticipates that future changes to this program will include increasing levels for single package units to 13 SEER and 11 EER and increasing the specification level for heat pumps to 8.0 HSPF. Table 11 sets out the current levels.

Table 11: ENERGY STAR requirements for Air Source Heat Pumps

Air-Source Heat Pumps	HSPF	SEER	EER
Split systems	>8.0	>13	>11
Single package equipment including gas/electric package units	>7.6	>12	>10.5

Water Source Heat Pumps

Since April 2001 the ENERGY STAR program has had criteria for geothermal heat pumps including water sourced heat pumps, as shown in Table 12. The units are classified by the type of system used and are tested according to ISO 13256-1 and ARI 870 standards.

Table 12: ENERGY STAR requirements for Geothermal Heat Pump

Heat Pump system	COP	EER
Open Loop	>3.6	>16.2
Closed Loop	>3.3	>14.1
Direct Expansion	>3.5	>15

Japan

Air Source Heat Pumps

The Energy Conservation Law was revised in June 1998 and put into force in April 1999. In the Law target efficiency standards and requirements for energy-consuming products were established. The revised Law introduced the Top Runner Program, which sets very high efficiency target standards for refrigerators, air conditioners, televisions, video cassette recorders (VCRs), fluorescent lamps, photocopiers, computers, and magnetic disk drives. This new program aims to dramatically improve energy efficiency of these products by setting target values based on the current highest efficiency level of each type of product instead of the current average efficiency level. For Air conditioners and heat pumps, the target value is the weighted mean value of non-ducted, wall-mounted cooling/heating items of less than 4 kW shipped October 2003 to September 2004. For all other units, the target date is October 2007 to September 2008. It is important to note that the target is an average of the cooling and heating COP, the formulae is:

- $(COP_c + COP_h)/2$ (W/W) (The COP_c in Japan is the same as an EER_c)

The heating capacity test (Japanese Industrial Standards (JIS), B8615-1 or B8615-2) conditions are also identical to ISO 5151-94 except for the overload and defrosting tests.

The target values for heating are shown in Table 13.

Table 13: Japanese Top Runner Targets for Heat Pumps 2004 -2007

Type of Air Conditioner	Cooling Capacity Category (kW)	Target Level Cooling Only (EER)	Target Level Heat Pump (COP+EER)/2
Window Wall	All	2.67	2.85
Split systems – non ducted	≤ 2.5	3.64	5.27
	2.5 < CC ≤ 3.2	3.64	4.90
	3.2 < CC ≤ 4.0	3.08	3.65
	4.0 < CC ≤ 7.1	2.91	3.17
	7.1 < CC ≤ 28	2.81	3.10
Split Systems - Ducted	≤ 4.0	3.02	2.72
	4.0 < CC ≤ 7.1	3.02	2.71
	7.1 < CC ≤ 28	3.02	2.71
Others – non ducted (excluding Multi type)	≤ 2.5	2.88	3.96
	2.5 < CC ≤ 3.2	2.88	3.96
	3.2 < CC ≤ 4.0	2.88	3.20
	4.0 < CC ≤ 7.1	2.85	3.12
	7.1 < CC ≤ 28	2.85	3.06
Multi Type Split Systems	≤ 4.0	3.23	4.12
	4.0 < CC ≤ 7.1	3.23	3.23
	7.1 < CC ≤ 28	3.07	3.07

CC = cooling capacity

The Japanese Law Concerning the Rational Use of Energy – Effectively Mandatory Minimum Energy Efficiency Standards (1979), previously specified a target for the 1997 year for both the COP and EER of air conditioners and heat pumps, as shown in Table 14

Table 14: Japanese Efficiency Target - Heating and Cooling Air Conditioners - 1997

Product Class	Minimum Cooling EER	Minimum Heating COP
(Window Wall) Utilised cooling capacity < 4kW	2.19	2.38
(Split type) Separate cooling capacity < 4kW	2.67	3.20
Cooling capacity 4kW – 7.1kW	2.34	2.56
Cooling capacity > 7.1kW	2.45	2.62

The target for COP in 1997 is not an average of EER and COP as in the Top Runner Target, but the heating only COP, measured at ISO H1 conditions, and hence directly comparable to H1 conditions in Australia.

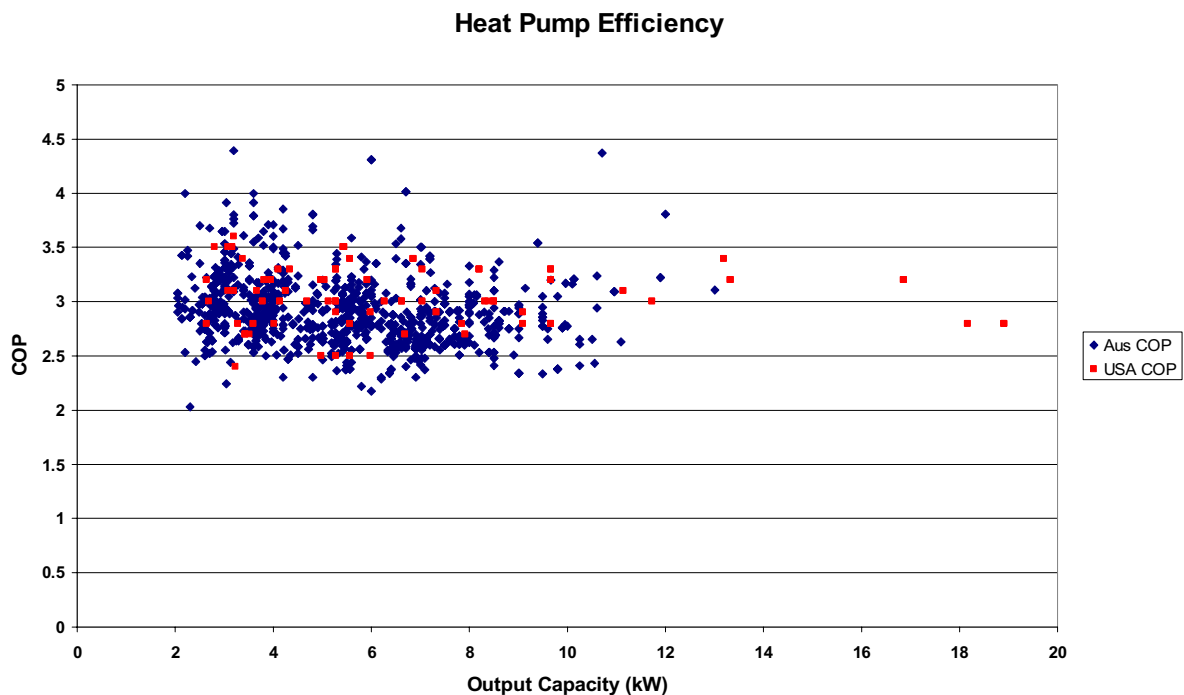
Analysis of Potential for MEPS

Comparison of Heat Pump Efficiency

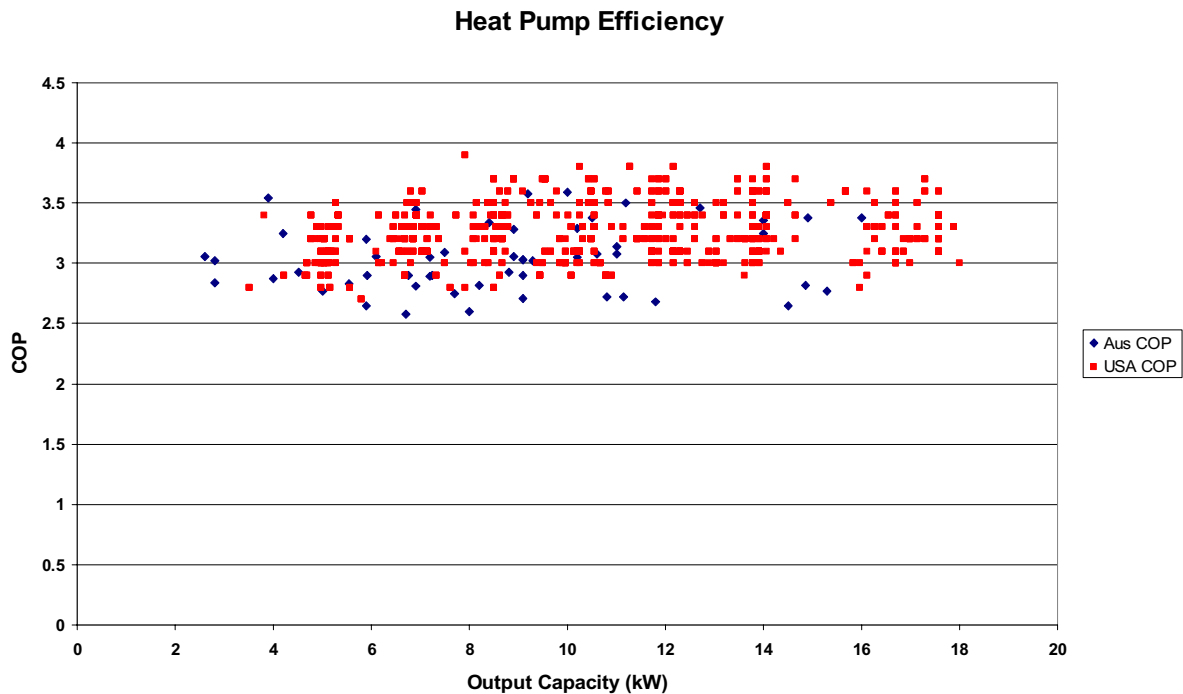
The Australian heat pumps are measured at 7°C (H1) and very little data is published in Australia for the performance of heat pumps at 2°C (H2) or -7°C (H3). Therefore the comparisons of Australian data with overseas data can only be made at the H1 test conditions.

The following section compares the efficiency of the available models from Australia and the USA. Units are tested at the rated conditions for the country; hence the USA units are tested at 8.3°C while the units in Australia are tested at 7°C. While this difference in test conditions means the comparison is not direct, this small difference would be likely to increase COP by less than 5% (~0.15 COP) compared to the test being conducted at an indoor temperature of 7°C

Figure 18: Comparison of USA and Australian Units: Non Ducted Split



Efficiency of USA non ducted split units is generally similar to the Australian units. Several Australian models have a significantly higher COP, compared to models available in the USA.

Figure 19: Comparison of USA and Australian Units: Ducted Split

The efficiency performance of Australian models is generally lower than the units available in the USA, even if the difference in test conditions is taken into account.

Comparison of International MEPS Levels

Countries with MEPS for the heating cycle of air conditioners or heat pumps include:

- USA
- Canada
- Japan

The USA/Canada specify the MEPS on the basis of minimum HSPF for all units of less than 19kW, and as noted earlier, the HSPF is not directly related to the COP of heat pumps. This means a direct comparison of USA/Canada MEPS levels is not possible with the data from Australia, as the Australian units have measurements of COP only (at H1 test conditions). The Japanese Top Runner/MEPS target is specified in terms of the average COP of both the heating and cooling cycle. This makes a direct comparison with Australian units also difficult, however the COP on the heating cycle can be estimated by calculating an equivalent heating COP using the cooling COP values specified in the Top Runner program for cooling only air conditioners. The estimated minimum COP derived by this approach is likely to be conservative (lower) as the cooling only minimum COP is more likely to be lower in a heat pump air conditioner compared to a cooling only air conditioner. Based on the formula to calculate the average COP, for units with lower

cooling COP/EER, the heating COP would need to be higher to reach the minimum average COP Top Runner target.

Figure 20 shows the heat pump COP Top Runner target/MEPS compared to the non-ducted split models available in Australia and the USA. The Top runner target is significantly higher than most of the models available in either Australia or the USA.

Figure 20: Heat Pump MEPS Japan Compared to USA/Australia non-ducted Split Units

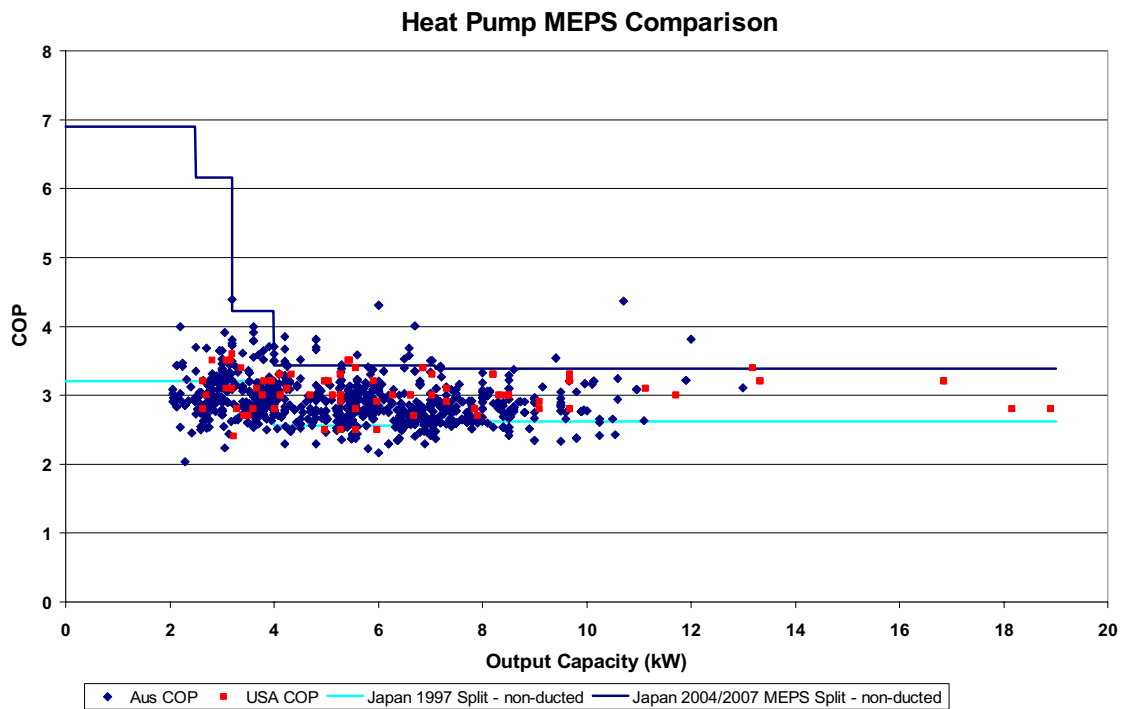


Figure 21 shows the heat pump COP Top Runner target/MEPS compared to the ducted split models available in Australia and the USA. The Top runner target is approximately in the middle of the range of models available in the USA and at the top of the range of models available in Australia.

Figure 21: Heat Pump MEPS Japan Compared to USA/Australia Ducted Split Units

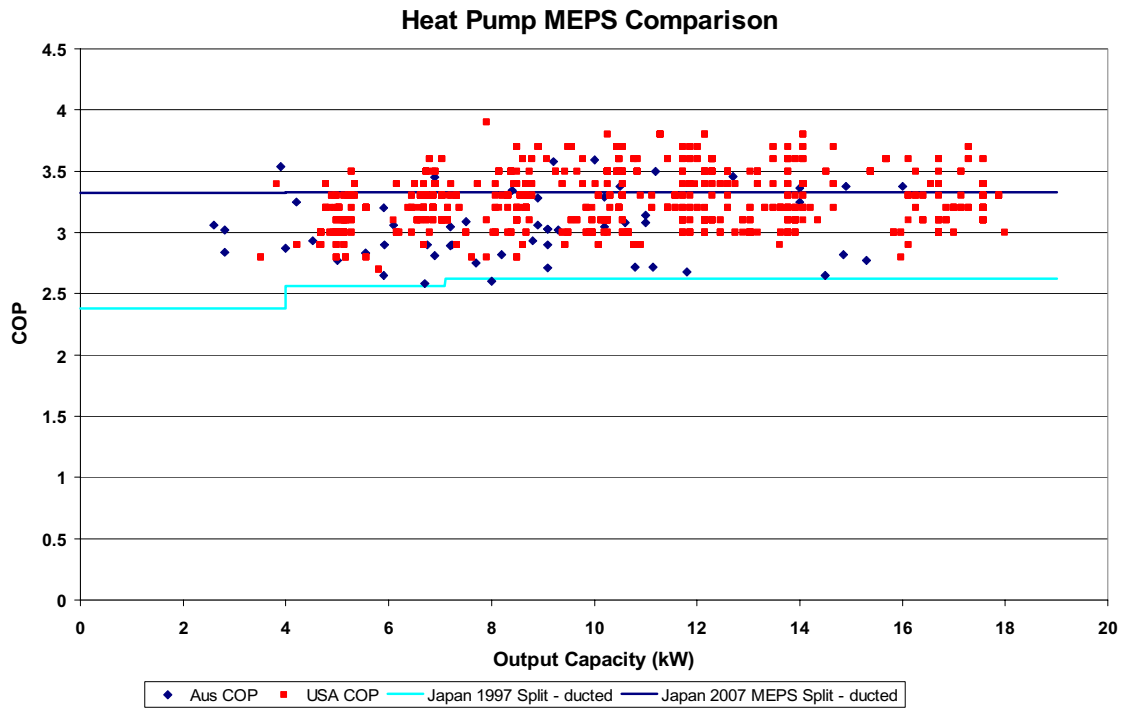
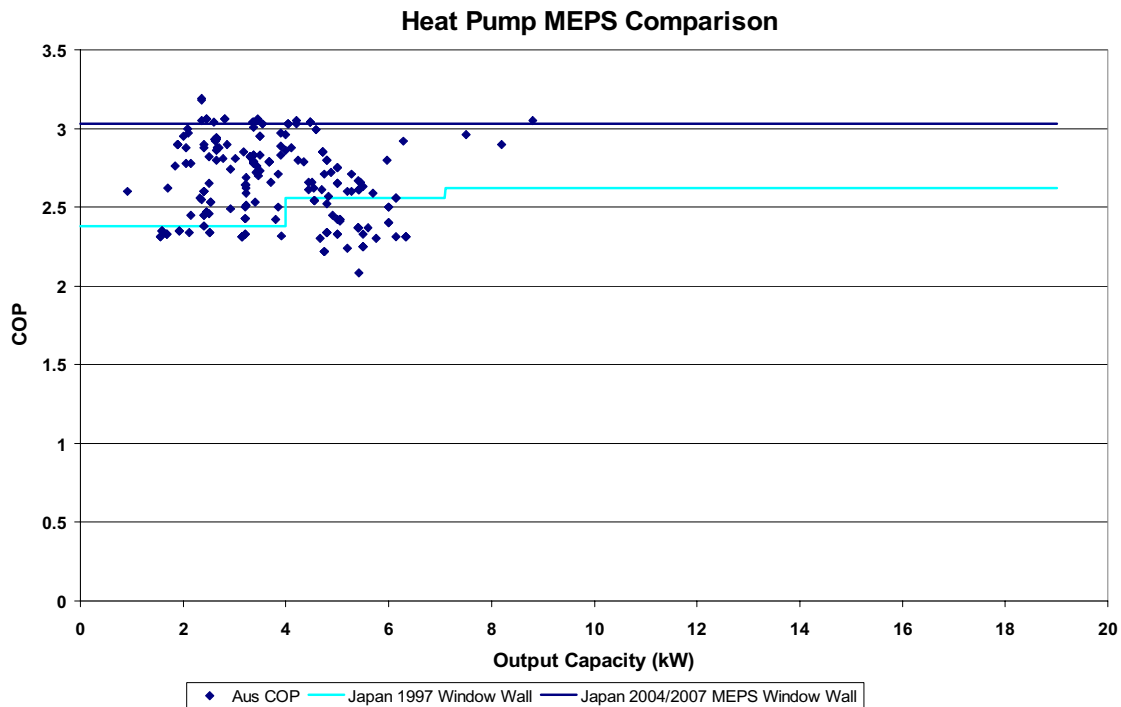


Figure 22 shows the heat pump COP Top Runner target/MEPS compared to the window/wall models available in Australia. No data is currently accessible for the USA models. The Top runner target is approximately at the top of the range of models available in Australia.

Figure 22: Heat Pump MEPS Japan Compared to Australia Window Units



Australian Potential MEPS Levels

The Australian MEPS levels are usually based on matching international best regulatory practice. In the case of heat pumps, the Japanese Top Runner program is the best practice internationally, with the USA/Canada setting their MEPS target on the basis of minimum HSPF. The H1 test conditions are used to measure units against the Japanese MEPS target and in the USA/Canada, the equivalent to H1, H2 and H3 are used to derive the HSPF.

No MEPS is proposed for water sourced heat pumps and air conditioners, due to their relatively minimal stock and sales in Australia and New Zealand.

Rationale for Testing to H2

In Australia and New Zealand, significant numbers of heat pumps are used for heating in climates that regularly experience outside temperatures below the H1 test conditions (7°C). In the USA and Canada, similar or more extreme outdoor winter temperatures are also experienced and the HSPF takes into account the amount of time heating is required at various climate conditions by using tested results at +8°C, 1°C and -8°C and proportion of time operating at these conditions.

The establishment of a seasonal rating (similar to the HSPF) for Australia is not recommended, as there is a lack of experience with this type of efficiency measure in Australia/NZ and a lack of data to establish this measure (i.e., multiple testing conditions, proportion of time at various conditions by climate).

Some product suppliers do test their units at the H2 conditions, however they are not easily obtainable, compared or verified as the current labelling requirements do not specify the collection of data at H2. The stipulation of H2 as the test condition for MEPS could allow for the collection and publication of COP and output capacity at the H2 conditions. In addition, the minimum performance requirements of a heat pump at the lower temperature (H2), would provide consumers with sufficient information to size a unit to actually heat the required area at these temperatures.

To determine a MEPS and compare Australian units at a H2 test condition requires an estimate of the COP at the H2 conditions. Output will also decrease at H2 conditions, however, the most critical element for MEPS is the COP.

H2 conditions have been simulated for the Australian models by adjusting the COP at H1 conditions by a constant ratio. This ratio is determined on the basis of the ratio of over 1000 models with data measured close to the H1 and H3 tests conditions from the CEC appliance database. Although a linear relationship is not the most appropriate relationship between COP and Temperature, it is the best approximation available for extrapolating the COP between H1 and H3 conditions, to obtain the COP at the H2 condition. The ratio determined for the COP (H1)/COP(H2) is 1.275, based on the COP+8°C/COP-8°C ratio of 1.55. This ratio is applied to all the COP (H1) registrations to simulate the COP (H2) test condition.

Potential MEPS Levels

The Japanese Top Runner Program can provide guidance on the MEPS levels that may be applicable; however these are sales weighted average values and hence are not directly comparable. In addition, most of these efficiency targets are not in place until 2007/08. Only non-ducted split air conditioners of 4kW or lower output capacity will have to meet the target in 2004/05. The 1997 Efficiency Target set in Japan for heating COP is however more directly comparable to the Australian market, as it represents a target some 6 years in the past and is not an average of the EER and COP.

Another design principle for determining MEPS levels when international levels are available but not directly comparable is to set the MEPS level sufficiently stringent to remove approximately 30% of the least efficient models currently available.

The potential MEPS levels for heat pumps are based on the Japanese 1997 levels and the principle of removing approximately 30% of the models currently available.

Table 15 presents the potential MEPS levels for heat pump air conditioners. These levels are based on the levels set in Japan for 1997 for units over 4 kW output capacity. No

differentiation in MEPS levels for output capacity is proposed at this stage as vast majority of units sold are over 4 kW.

Table 15 presents the estimated equivalent MEPS level at H1 and H2 test conditions.

Table 15: Potential Australian MEPS Levels Heat Pumps

Category (all output size)	Minimum COP @ H2	Minimum COP @ H1
Split – Non ducted	2.15	2.74
Split – ducted	2.20	2.80
Window Wall	2.00	2.55

The effect on the current models of these potential MEPS is shown in the following figures when compared to the COP measured at H2 test conditions. The display of estimated H2 MEPS for these figures is for illustrative purposes. A H1 MEPS will have similar effect. The effect of the potential MEPS on current models is shown in Figure 23 for window wall units, Figure 24 for non-ducted split units and Figure 25 for ducted split units.

Figure 23: Australian Potential MEPS – Window Wall Units

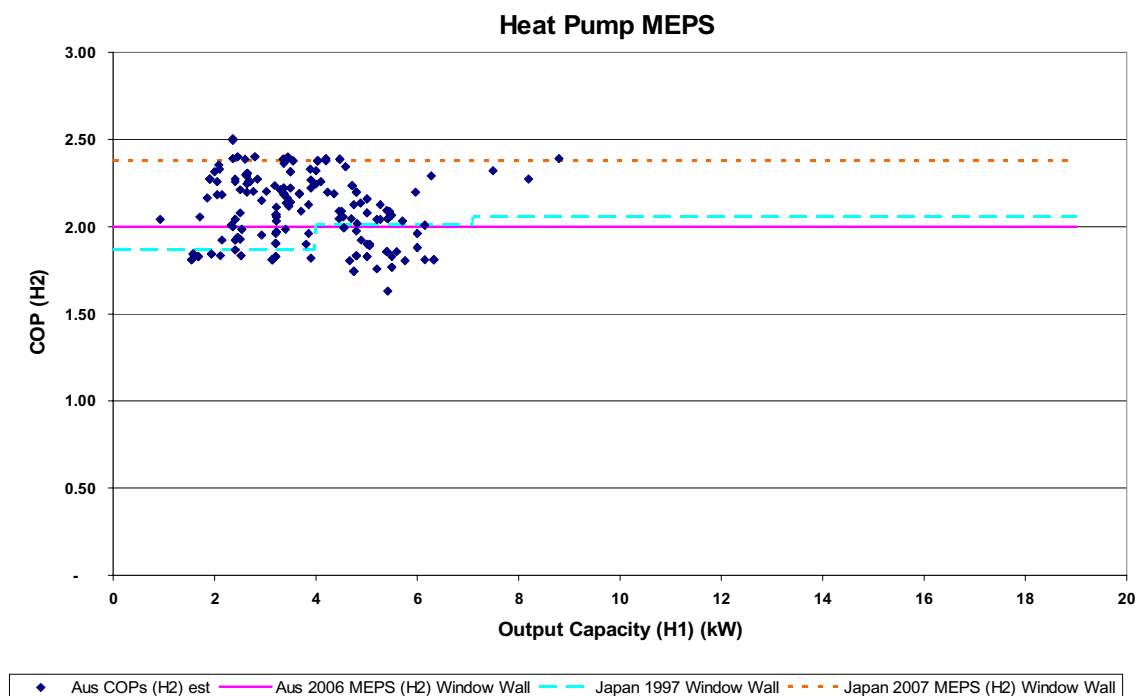


Figure 24: Australian Potential MEPS – Non-Ducted Split Units

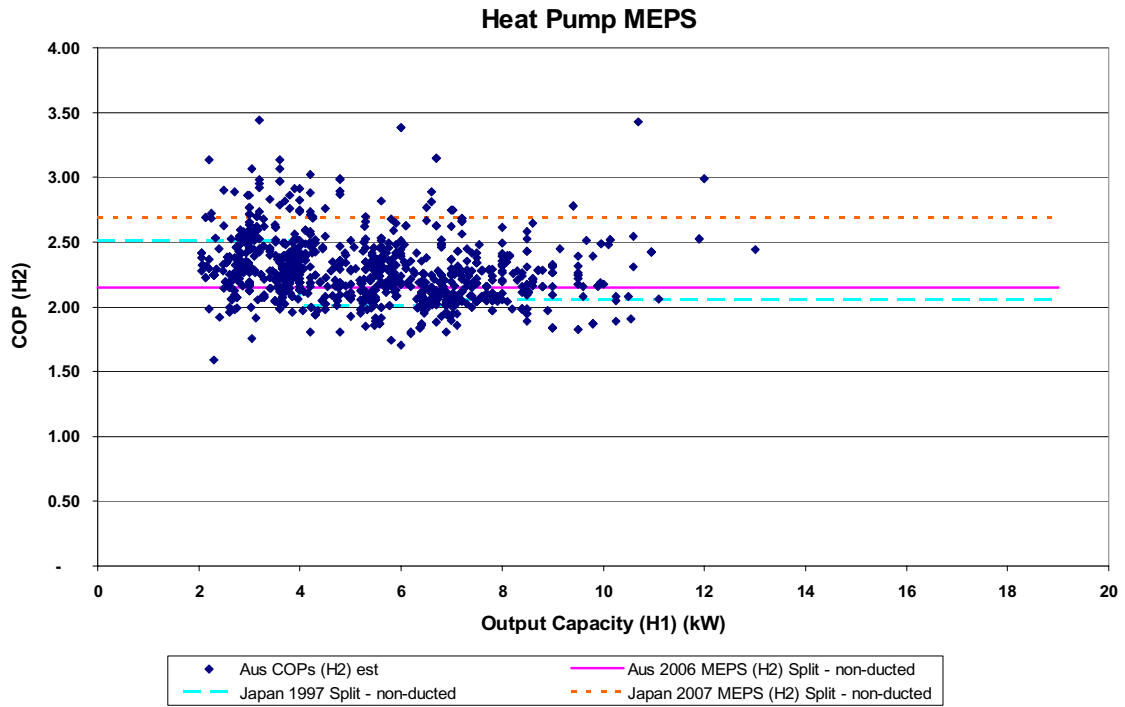
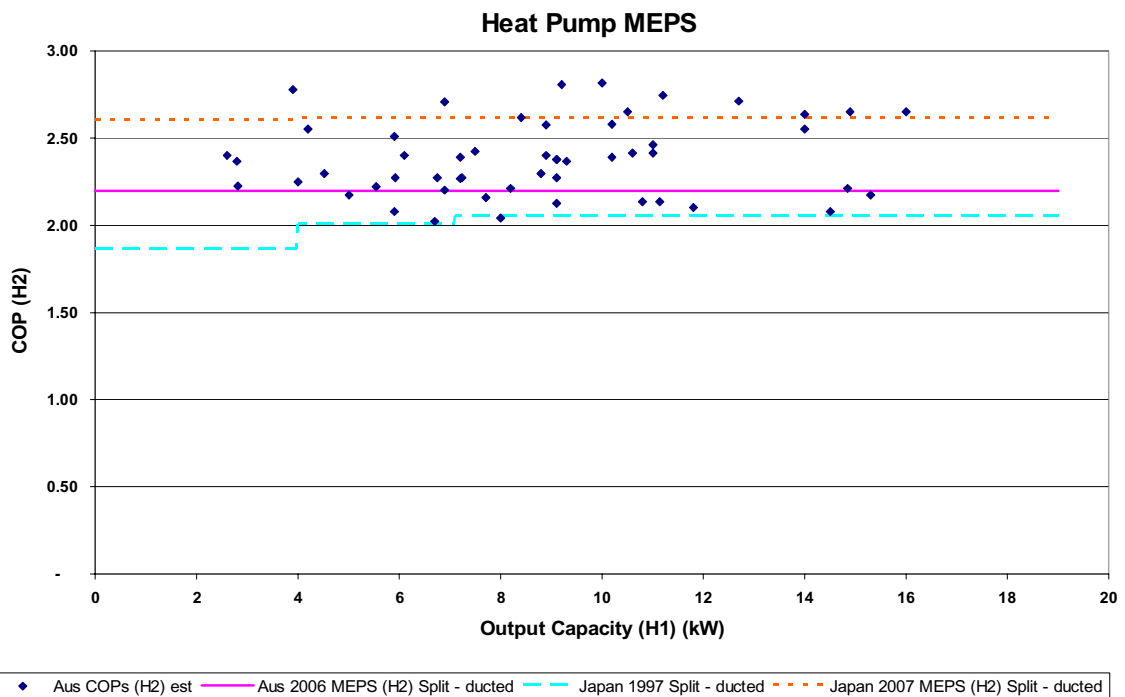


Figure 25: Australian Potential MEPS – Ducted Split Units



The Japanese 2007 MEPS target (Top Runner) can be used as the high efficiency level for heat pumps that claim to have higher efficiency and suppliers wish to identify these units.

The total number of models that currently comply with the potential MEPS is shown in Table 16.

Table 16: Potential MEPS - No of Models Pass

Category	Configuration	MEPS Units	MEPS - Fail	MEPS - Pass
Single Split System	Ducted	% MEPS	20.8%	79.2%
		No of Models	11	42
	Non Ducted	% MEPS	30.9%	69.1%
		No of Models	355	795
Window Wall	Non Ducted	% MEPS	36.9%	63.1%
		No of Models	80	137
Total % MEPS			31.4%	68.6%
Total No of Models			446	974

The effect of the potential MEPS if made mandatory for all units registered as of August 2004 is to remove approximately 30% of the total heat pump air conditioners.

The MEPS could be applied at the H1 or H2 standard rating conditions, as mandatory or optional, with associated changes to the Energy Rating Label, as discussed on page 43

Energy and Greenhouse Impact of Potential MEPS

For the purposes of modelling the impact of a potential MEPS, the following calculations assume that the MEPS is mandatory. The impact of this mandatory MEPS on the estimated energy consumption of new heat pumps installed is shown in Figure 26. The estimated impact of the MEPS compared to business as usual (BAU) is 136 GWh in 2020.

Figure 26: Energy Impact of Potential MEPS

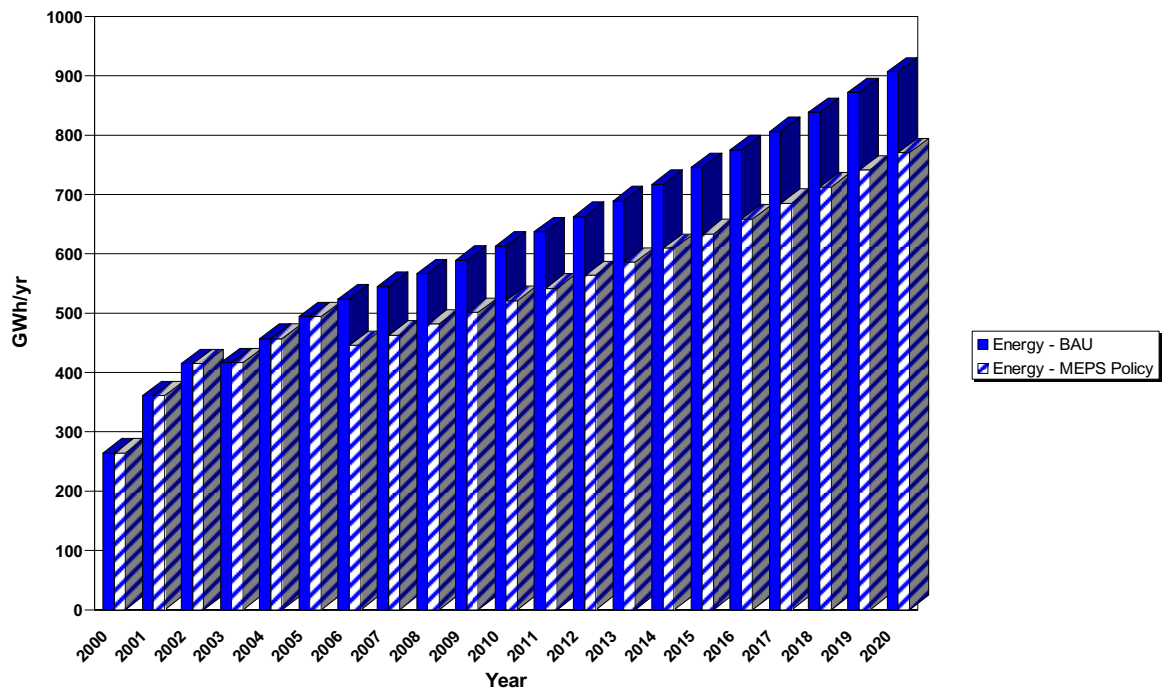
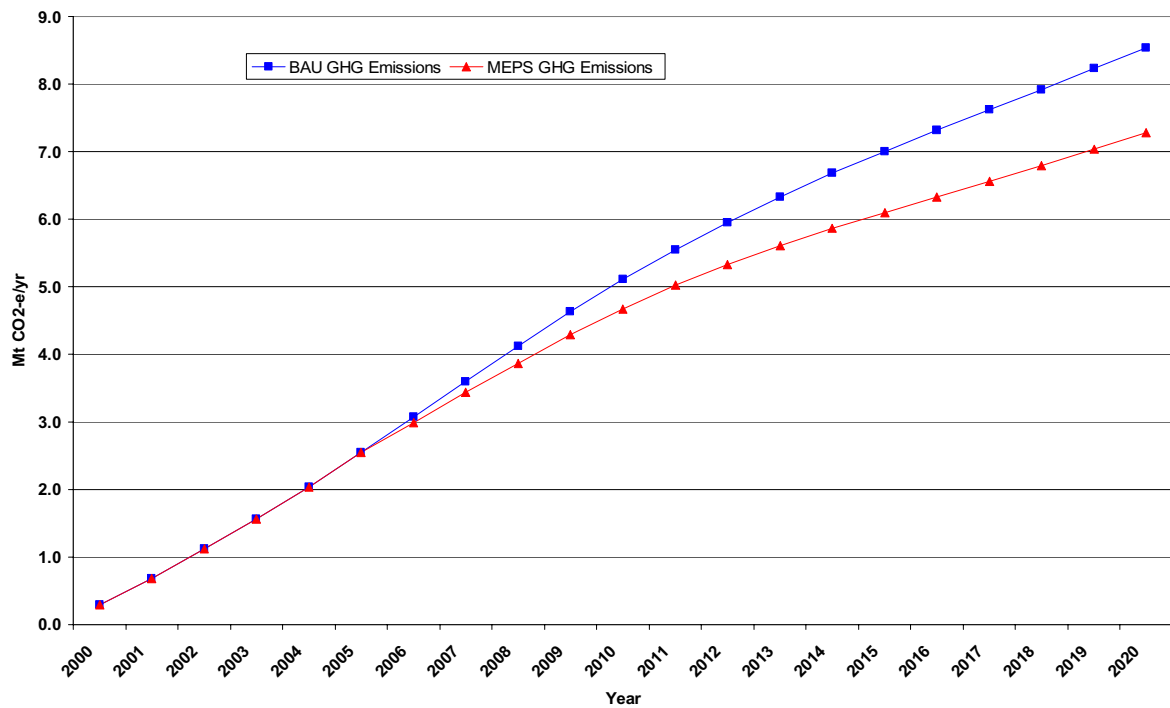


Figure 27 shows the estimated impact on GHG emissions for new heat pumps installed. The potential MEPS is estimated to reduce GHG emission by 623 kt CO₂-e by 2012 and 1.2 Mt CO₂-e in 2020.

Figure 27: Greenhouse Gas Emissions Impact of Potential MEPS

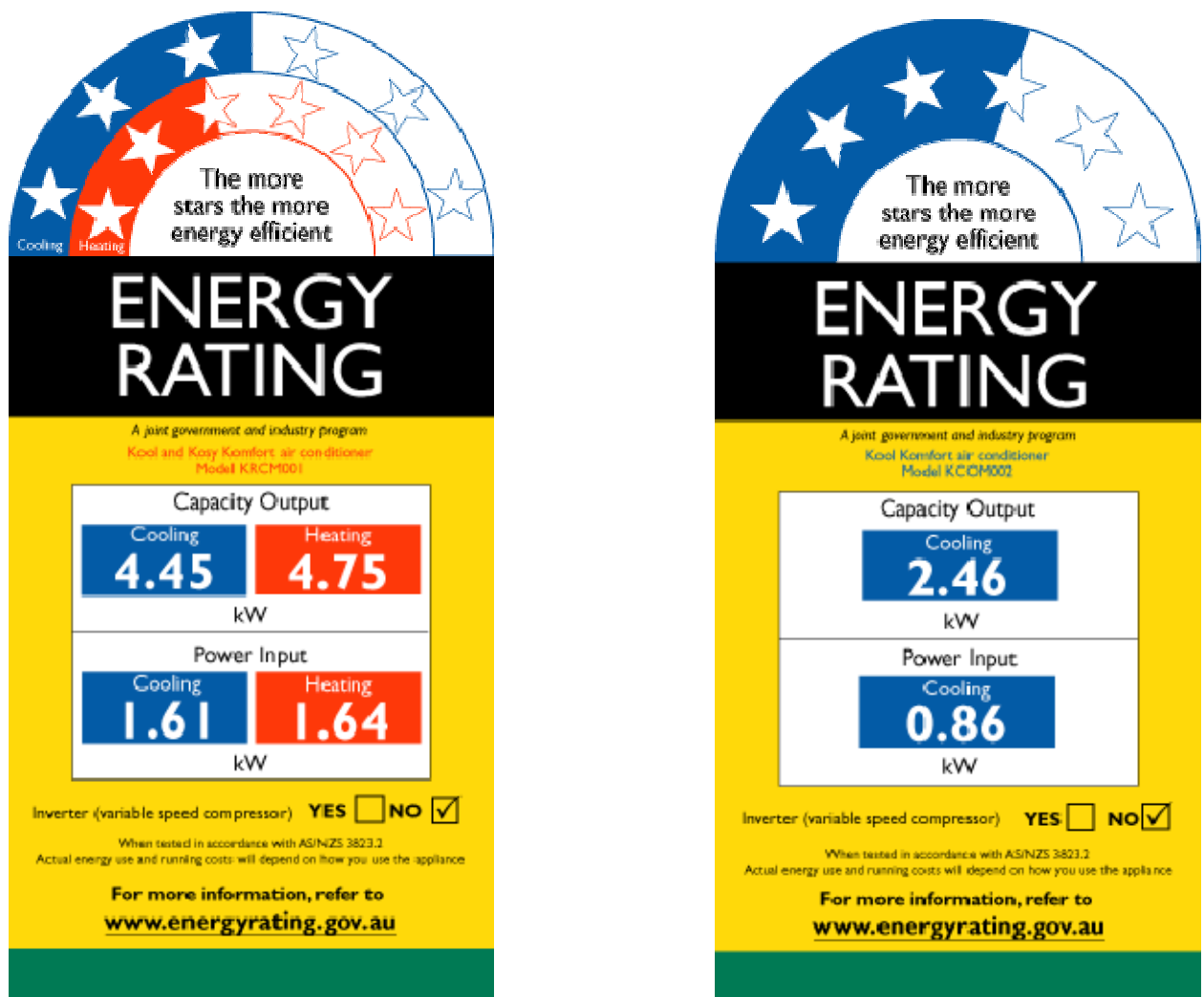
The calculations of estimated impact assumes that the MEPS will be implemented in 2006 and reduce the average sales weighted electricity consumption of new heat pumps by 15%.

Potential MEPS and Labelling Scheme Options

Current Labelling Scheme

Currently, the cooling and heating efficiency of heat pumps is shown on the energy rating label, as shown in Figure 28.

Figure 28: Energy Rating Labels for Cooling and Heating Air conditioners



The star rating for air conditioners is determined differently to other appliances. For air conditioners, the measure of energy efficiency is the Energy Efficiency Ratio (EER) for cooling and the Coefficient of Performance (COP) for heating. The EER and COP are defined as the capacity output divided by the power input. The Star Rating Index is calculated on the tested values for energy and capacity, rather than the nameplate or rated values.

Typically, the EER and COP are in the range 2.0 to 3.5 (meaning that the cooling or heating output is 2 to 3.5 times as great as the power input, or an efficiency of 200% to 350%). The star rating for air conditioners is determined from the tested EER and COP. For cooling, 1 star is equal to an EER of 2.0 with an extra star for an increase in EER of 0.3. For heating, 1 star is equal to a COP of 2.3 with an extra star for an increase in COP of 0.3.

Potential MEPS and Labelling Schemes

The potential MEPS and labelling scheme should build on the existing framework. A number of options are available for consideration. Due to relationship between the testing conditions chosen for a MEPS and the information displayed on the energy rating label, a number of potential options exist. The aim of these labelling options is to improve the available information to consumers who use a heat pump as their main form of heating. The potential MEPS options are:

- **MEPS Option 1:** Mandatory H1 MEPS on all new models sold. Those units that are reverse cycle would be required to pass this MEPS or not be offered for sale.
- **MEPS Option 2:** Optional H1 MEPS on those models that claim to offer heating and cooling. Those reverse cycle units that choose not to participate will have the label modified to remove the heating cycle Star Rating and Power Input/Capacity Output. In place of the star rating, a statement would read “does not meet minimum heating performance” or similar
- **MEPS Option 3:** Mandatory H2 MEPS on all new models sold. Those units that are reverse cycle would be required to pass this MEPS or not be offered for sale.
- **MEPS Option 4:** Optional H2 MEPS on those models that claim suitability for heating in certain cold climate zones. A label change could be made that includes the Power Input/Capacity Output at H2 and/or the words “this unit meets the minimum energy efficiency heating performance requirements” or similar. Alternatively the information may be only displayed on the registration web site.

A combination of these potential options is also possible, such as Option 1 and Option 4. It is proposed that consultation on these options be undertaken and a favoured option or alternative be considered in April 2005 for action.

Recommendations

The analysis of potential MEPS and Energy Labelling options for air and water sourced heat pumps has led to the following recommendations:

Air Sourced

- That Australia and New Zealand consult on the options to introduce a Minimum Energy Performance Standard (MEPS) and associated changes to the Energy Rating Label for the heating mode of air sourced air conditioners and heat pumps
- That the MEPS and Energy Rating Label scheme be announced in April 2005, to allow sufficient time for changes to be introduced in October 2007 when the new MEPS levels for cooling mode are introduced for all single phase air sourced air conditioners
- That the following options or combinations of options be considered:
 - **MEPS Option 1:** Mandatory H1 MEPS on all new models sold. Those units that are reverse cycle would be required to pass this MEPS or not be offered for sale.
 - **MEPS Option 2:** Optional H1 MEPS on those models that offer heating and cooling. Those reverse cycle units that choose not to participate will have the label modified to remove the heating cycle Star Rating and Power Input/Capacity Output. In place of the star rating, a statement would read “may not heat as effectively as competitive products” or similar
 - **MEPS Option 3:** Mandatory H2 MEPS on all reverse cycle models sold. Those units that are reverse cycle would be required to pass this MEPS or not be offered for sale.
 - **MEPS Option 4:** Optional H2 MEPS on those models that claim suitability for heating in certain cold climate zones. A label change could be made that includes the Power Input/Capacity Output at H2 and/or the words “this unit meets the minimum energy efficiency heating performance requirements” or similar. Alternatively the information may be only displayed on the registration web site.
 - There may be some combination of these options that better suits all stakeholders.

Water Sourced

- Water sourced air conditioners and heat pumps are not recommended for MEPS due to the low volume of sales and their inherent higher efficiency, compared to the dominant air sourced air conditioner market

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