Evaluation of Energy Efficiency Policy Measures for Household Air Conditioners in Australia

Prepared for

Department of Climate Change and Energy Efficiency:
Equipment Energy Efficiency Program

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Glossary

ABS	Australian Bureau of Statistics
AS/NZS	Australian Standards and New Zealand Standards
BAU	Business-as-usual
CO_2-e	Carbon dioxide equivalent units
CEC	Comparative energy consumption
COP	Co-efficient of Performance
DCCEE	Department of Climate Change and Energy Efficiency
DEWHA	Department of the Environment, Water, Heritage and the Arts
E3	Equipment Energy Efficiency Committee (formerly NAEEEC)
EER	Energy Efficiency Ratio
ERL	Energy Rating Label
GHG	Greenhouse Gas
GWh	Giga Watt hour – 1 million Watt hours
kt	Kilo Tonnes – 1 thousand Tonnes
kWh	Kilo Watt hour – 1 thousand watt hours
MEPS	Minimum Energy Performance Standards
Mt	Mega Tonnes – 1 million Tonnes
NPV	Net Present Value
PJ	Peta joules
RIS	Regulatory Impact Statement

Executive Summary

In order to increase the energy efficiency of air conditioners, mandatory Energy Rating Labels (ERLs) were introduced in 1987 followed by the introduction of Minimum Energy Performance Standards (MEPS) in October 2004, which was followed by more stringent MEPS in April 2006 and October 2007.

The main objectives of this study were to evaluate the impacts of the past regulation of air conditioners, especially on product energy efficiency and energy savings, and to determine whether the original forecasts that were made as part of the Regulatory Impact Statements (RIS) have been fulfilled following the regulation.

This study is based on the methodology used in a previous a study conducted into the effects of regulating improved energy efficiency for refrigerators and freezers in Australia (EnergyConsult 2006). The scope of this current study was on non-ducted single split systems and unitary window wall units. The methodology for this study consisted of:

- Establishing the sales-weighted efficiency trends for each product category prior to the program interventions and use these to develop the baselines which forecast the efficiency of the product categories at different times;
- Establishing the policy trends for the sales-weighted efficiency of air conditioners after the program interventions occurred, based on the actual sales and product efficiency;
- Determining the difference between the policy trends and the baseline to measure the impact of the program; and
- Comparing the forecast program impacts, predicted in the regulatory impact statements (RIS), with the actual program impacts determined using the above evaluation methods.

The results of the study show that the introduction of MEPS:

- Improved product efficiency and reduced energy consumption, compared to what would have occurred without the regulations. The annual rate of improvement before MEPS was around 0.5%, but grew to around 3% after the 2004 MEPS and to around 4% after the 2006/07 MEPS.
- Resulted in an estimated cumulative energy saving to 2008 of 515 GWh, which represents a cost savings of $88.9 million based on 2009 Australian average electric tariffs. In total from 2003 to 2020, the combined cumulative energy savings due to MEPS 2004 and MEPS 2006/07 was estimated to be 6,533 GWh, worth approximately $1,127 million.

- Did not generally affect the price of air conditioners. However, it is possible that the 2006/07 MEPS slowed the rate of decline in air conditioner prices, but other market trends may equally have been the cause of changes in price trends over 2005-2008.
- Did not affect the number of models available in the marketplace and hence did not appear to affect consumer choice.

The evaluation findings were compared to the forecast impacts made for the 2003 RIS and the 2005 RIS, with the following results:

- Based on data available to 2008 the actual annual energy savings impacts are 65% above the combined forecasts of the 2003 and 2005 RIS.
- The current estimate of the total actual impacts till 2020 is 195% above the projected impacts of the 2003 and 2005 RIS.

These large differences in the forecast impacts versus those found in this evaluation are primarily due to the 2003 RIS forecasts being based on a smaller forecast of sales volume than actually occurred. Actual sales of air conditioners were 108% higher from 2002 to 2008 than anticipated by the 2003 RIS. Other factors that caused differences between forecast and actual benefits of MEPS are the result of the RIS methodology used to determine the efficiency gains, changes in the product mix being sold, and the accepted need to be conservative when forecasting efficiency gains for RIS.

1. Introduction

Air conditioners are becoming increasingly common household appliances, with the penetration of air conditioners more than doubling from 24% to 52% in the decade between 1999 and 2008 (ABS, 2008). Space cooling represented about 3% of all residential energy consumption in 2007 and was forecast to grow from 10.5 PJ p.a. to 18.0 PJ p.a. over the period 2005 to 2020 (EES 2008). The use of air conditioners on very high temperature days and the impact on peak demand makes it a major target for government action in many countries. In the commercial sector, air conditioning represents about 21% of the energy consumption and was forecast to grow from 50 PJ p.a. to 90 PJ p.a. in 2030 (CIE 2007). This study focuses on single phase air conditioning that is mainly used in the residential sector.

In order to increase the energy efficiency of air conditioners, mandatory Energy Rating Labels (ERL) were introduced in 1987 followed by the introduction of Minimum Energy Performance Standards (MEPS) in October 2004, which were followed by more stringent MEPS in April 2006 and October 2007. Although revised ERLs and more stringent MEPS were introduced in 2010 they were not considered as part of this evaluation.

The anticipated impacts of MEPS were forecast before their introduction. Government decisions to implement energy efficiency programs are usually based on these estimates of the reduction in energy consumption that programs are expected to achieve, and the impact on product costs, including changes in product prices and implementation costs. The benefits (i.e. the value of the energy reductions) and costs of such programs are usually expressed as the difference between a baseline (or 'Business as Usual') projection and a 'with-measures' projection. Government policy is only to adopt regulations that generate a public benefit, as demonstrated by those projections.

Australian Government guidelines do not require these forecasts to be reviewed after the fact to ascertain if the modelling assumptions and projections were accurate. However, in 2005 the Productivity Commission inquiry into Energy Efficiency (PC 2005) gave considerable attention to regulatory proposals. One recommendation was to evaluate the impacts of the regulation to test if the policies had actually achieved the energy and greenhouse savings and other impacts which were forecast in the Regulatory Impact Statements (RIS).

The main objective of this study was to evaluate the impacts of past regulation of air conditioners, especially on product energy efficiency and energy savings, and to determine whether the original forecasts that were made as part of the RIS were fulfilled following the regulation. Therefore, this study was in response to the Productivity Commission recommendation for such a review.

2. Objectives

2.1 Aims

The aims of this evaluation were to:

- Examine the trends in energy consumption and energy efficiency, in terms of sales-weighted average efficiency (co-efficient of performance (COP) for Heating and Energy Efficiency Ratio [EER] for cooling), estimated energy consumption (by state if possible), and moderated by capacity (size) and type of air conditioner.
- Determined the baseline and post program intervention case over the longest period possible. This was from 1988 (using model/brand weighted data) and from 2003 to 2008 (using sales-weighted data), due to the availability of data.
- Estimated energy savings from the energy efficiency interventions of the 2004 MEPS and the 2006/07 MEPS.
- Compare the pre-program projections (sourced from Regulatory Impact Statements) with the actual impacts estimated from this study.

2.1.1 Pre-Program Estimates of Impacts

Projections and estimates of the impact of a MEPS program (typically cost/benefit and energy/greenhouse impacts) are usually undertaken before the implementation of the program as part of the RIS. These are a potential data source for comparing the pre-program impact projections with the estimated actual impacts that were found in this study. The major reports that could be used for pre-program projections were:

2003 RIS: *Minimum Energy Performance Standards for Air Conditioners Regulatory Impact Statement,* Syneca Consulting, August 2003

2005 RIS: *Proposal to increase MEPS for Room Air Conditioners and harmonise MEPS for single and three-phase units Regulatory Impact Statement,* Syneca Consulting, Feb 2005 & revised in June 2005

Both of these documents were widely circulated to stakeholders on their release and both have been available since their release through the electronic library at www.energyrating.gov.au.

Additional information and notifications are released to the industry as part of the stakeholder consultation and this may have lead industry to anticipate the impact of MEPS changes. The key dates for releasing such notifications are as follow:

- May 2002 – Presentation to the AREEMA general meeting of the proposed MEPS levels
- May 2002 - International Review of MEPS for Air Conditioners.
- June 2002 - Air Conditioner MEPS Steering Committee Meeting

- August 2002 - Product profile detailing the potential MEPS for Air Conditioners
- August 2003 – Release of Consultation RIS for MEPS on Air Conditioners:
- **October 2004 – First introduction of MEPS for single phase air conditioners**
- January 2005 - International Review of MEPS for Air Conditioners (UPDATED from 2002)
- February 2005 – Consultation RIS for Increased MEPS for Air Conditioners
- June 2005 - Proposal to increase MEPS for Room Air Conditioners and harmonise MEPS for single and three-phase units –Final Draft RIS
- September 2005 - Notice of early adoption of increased MEPS for single phase air conditioners from 1 April 2006
- **April 2006 – more stringent MEPS for most single phase products**
- May 2007 – Postponed the Proposed 2008 MEPS
- **October 2007 – More stringent MEPS introduced for remaining single phase products**
- October 2007 – More stringent MEPS introduced for all three-phase products

2.2 Scope

The study examines the attributes of new, single phase air conditioners purchased in Australia from the 1987 (when ERLs were introduced in NSW and Victoria) to 2008, the last year that comprehensive data was available.

The study follows on from a study conducted into the effects of ERLs and MEPS on refrigerators and freezers in Australia (EnergyConsult 2006) which developed a post-implementation methodology for evaluating energy efficiency regulation. The development of this methodology was further enhanced by the production of '*Evaluation framework for the ex-post evaluation of appliance and equipment energy efficiency programs*' (Ernst and Young, 2009).

The following categories of air conditioners were the focus of this study, as these were the categories where comprehensive sales data were available and they constitute about 80% of units sold annually:

- Non Ducted Single Split System Reverse Cycle
- Non Ducted Single Split System Cooling Only
- Non Ducted Unitary Window Wall Reverse Cycle
- Non Ducted Unitary Window Wall Cooling Only

3. Methodology

3.1 Overview of Methodology

This study was based on the methodology used in a previous study conducted into the effects of regulating improved energy efficiency for refrigerators and freezers in Australia (EnergyConsult 2006). The 2006 study developed and established the program impact evaluation methodology used for evaluating energy efficiency regulation in Australia.

The sales-weighted average efficiency of air conditioners in the different product categories was the prime indicator of the overall efficiency of air conditioners entering the market and the main measure of efficiency which ERLs and MEPS have attempted to improve. Consequently the methodology focused on determining whether the efficiency program has led to improvements in the sales-weighted average efficiency of air conditioners.

The fundamentals of the methodology for this study consisted of:

- Establishing the sales-weighted efficiency trends for each of the product categories prior to the program interventions and using these trends to develop the baselines which forecast the efficiency of the product categories at different times. The baselines are the forecasts of efficiency of the air conditioners if the program interventions had not occurred. The baselines were calculated on the efficiency trends two years preceding the actual introduction of MEPS regulations, as the long lead times in suppliers ordering air conditioner means the industry tends to anticipate regulatory changes well in advance of them occurring.

- Establishing the policy trends for the efficiency of air conditioners after the program interventions occurred. These trends consist of two parts:
    - The actual sales-weighted efficiency trends for each of the product categories after the program interventions occurred and before any additional program intervention occurs, such an another increase in MEPS levels
    - Forecast efficiency trends, based on projections of the actual sales-weighted efficiency trends past the point where additional program interventions occurred.

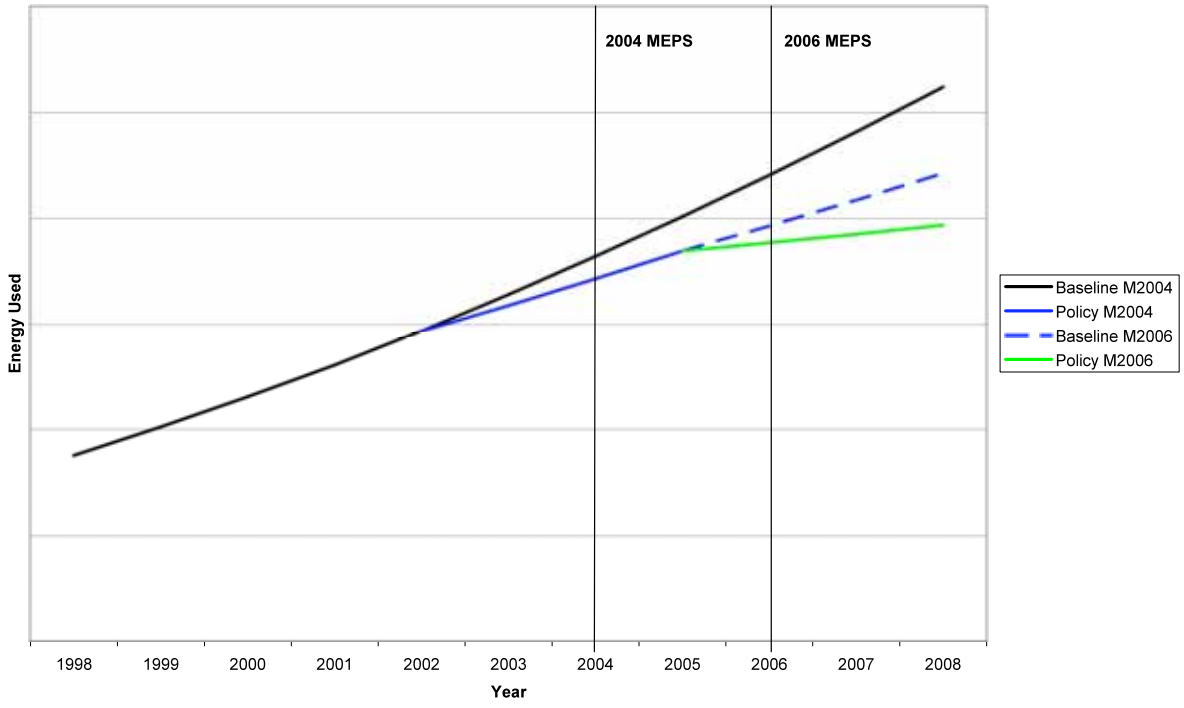
  Where multiple program interventions occur over time, the policy trend of one program intervention could become the baseline trend of a second program intervention (see Figure 1).

- Determining the difference between the policy trends and the baseline to measure the impact of the program. The impacts can be assessed in several ways:
    - The energy efficiency values of the baseline and policy trends can be compared to determine the principle impact of energy efficiency programs on product efficiency.

- Efficiency impacts can be combined with sales data to estimate energy savings from the program.
- Changes in other attributes of air conditioners, such as capacity and price, can also be used to explore other impacts of the program.

- Comparing the forecast program impacts in the RIS with the actual program impacts using the above evaluation methods. The causes of differences such as changes in annual sales or additional efficiency gains due to over compensation by suppliers can then be explored.

Figure 1: Illustrative example of energy use baselines and policy trends resulting from two policy implementations.



3.2 Data Sources

To implement the methodology described above appropriate data needs to be available before and after program interventions for air conditioners, especially the sales and energy efficiency of all air conditioner models in each product category. Ideally price and capacity data are also required.

The primary data used for this study included:

1. **Comprehensive GfK sales data from 2003 to 2008.** The data comprised of make, model, maximum capacity, number of units sold each year, and average unit price. Four categories of 1 phase air conditioners i.e. reverse and cooling only systems of split and

unitary type air conditioners were found to account for about 80% of total sales, hence only these categories were used in the analysis.

2. **Appliance Registration Database:** This database was developed and maintained to register details of all models of air conditioners sold in Australia, for the purpose of mandatory ERLs and MEPS. The key data available in the database included; registration number, brand, model, various technical and physical parameters, installation type, comparative energy consumption (CEC), cooling capacity, EER and/or COP, date of registration and star rating. The data covered the period between 1987 and 2008.

The lack of complete historic sales data was a major constraint of the study as the registration database (1987 to 2008) did not include national sales data with state level breakdown, or average price. However, the registration database could be used to develop model-weighted estimates of the average efficiency of air conditioners. An approach was developed to identify and develop the most accurate model-weighted analysis approach and this was used to estimate the annual sales-weighted averages and baseline trends (see Technical Appendix for further details).

The lack of sales data prior to 2003 also meant it was not possible to assess the impact of ERLs on air conditioner efficiency, therefore the study focuses on the impacts of the 2004 and 2006/07 MEPS.

3.3 Limitation of Results

A key limitation of the study was that only data for non-ducted residential air conditioners has been available and analysed. Non-ducted systems make up approximately 80% of the air conditioners models currently registered, and would have formed a greater proportion of the model base until recently when ducted air conditioners became more popular. Consequently, though the restriction of the data to non-ducted air conditioners does limit the conclusions apply to over 80% of the air conditioners sold since MEPS were introduced.

Generally the results of this study are based on reliable, quantitative data. Significant amounts of data were obtained from reliable sources, such as GfK sales data from 2003 and data from the registration database from 1987. GfK is an international organisation that collects, processes and disseminates comprehensive market information on household's appliances, not only in Australia but in many countries around the world. The registration database is also a comprehensive record of all models of air conditioners sold in Australia since ERLs became mandatory in 1987 for some states. Ever since the 1990's the registration database has been coordinated nationally and the data is highly reliable back to 1988. The model level data from the registration database, which includes the energy rating and capacity details, was generally more comprehensive and accurate than the data collected by GfK.

It is worth noting that the available datasets are among the most comprehensive and reliable data sources available from countries where energy efficiency regulations have been implemented. Hence the majority of the results are based on empirical evidence rather than

broad ranging assumptions. Nonetheless, there are no authentic means to verify the level of accuracy and reliability of the final data used in the analysis.

Consequently, while the authors of this report are confident of the reliability of the results, the results should always be used in consideration to the techniques used to overcome data gaps.

4. Results

The objective of MEPS was to improve the efficiency of the air conditioners, and a key outcome of this objective was to reduce the energy that air conditioners would otherwise consume. Therefore, the main focus of this study was to estimate the impact of MEPS on the average efficiency trends of air conditioners and to estimate energy savings achieved by MEPS. Another important focus was to compare the evaluation results with RIS projections.

In addition the data was analysed to determine secondary impacts, such as:

- Average market price trends;
- Changes in product offering;
- Average capacity trends; and
- Input power trends.

The most important results are those relevant to average efficiency and estimated energy savings and the comparison with past projections, which will be presented in the following sections. The impact of MEPS on price trends and their impact on product availability are also presented below. The results for the average capacity trends and input power trends are provided in the Technical Appendix.

4.1 Average Efficiency Trends

The efficiency of air conditioners was measured in terms of an EER value for its efficiency in cooling and a COP value in terms of its efficiency for heating. The trends in these attributes provide the measure of the change in the efficiency of air conditioners.

4.1.1 Average Efficiency Trends after the Introduction of MEPS

The trends of average efficiency for different groups of air conditioners were assessed using a combination of results from GfK and registration database to determine estimated sales-weighted baselines and policy trends.

Measures of the annual improvement in EER pre and post MEPS confirms that MEPS increased the rate of improvement in the efficiency of air conditioners. The rates of improvement in the EER for the period pre MEPS 2004 and post MEPS 2004 and MEPS 2006/07 are shown in Table 1. The changes in the rate of improvement clearly show that the introduction of both MEPS lead to increases in the rate of improvement in efficiency in all the four product categories examined. This strongly supports the claim that MEPS significantly increases the energy efficiency improvements in air conditioners.

Table 1: Annual Improvement in Average Energy Efficiency Ratio (EER) and Coefficient of Performance (COP) –Pre- and Post-MEPS.

Annual Change	*Pre MEPS*	*Post MEPS 2004*	*Post MEPS 2006/07*
Period of Change	1998-2002	2003-2005	2006-2008
EER Annual Change			
Split Reverse Cycle	0.5%	3.8%	5.5%
Split Cooling Only	0.8%	1.2%	6.9%
Window Reverse Cycle	0.3%	2.1%	5.1%
Window Cooling Only	0.7%	1.1%	4.0%
COP Annual Change			
Split Reverse Cycle	0.5%	3.0%	4.8%
Window Reverse Cycle	0.5%	0.5%	2.8%

In addition to the analysis of the rate of improvements in energy efficiency the increase in efficiency under MEPS was also compared to the baseline projections. Figure 2 to Figure 5 illustrates the policy trends for MEPS 2004 and for 2006/07, and projected baseline trends, based on the standardised sales-weighted average EER for air conditioners. The EER trends all show acceleration in the improvement of air conditioner efficiency compared to the baseline improvements starting from around 2003, or slightly earlier. This strongly suggests that the announcement of the impending 2004 MEPS and its implementation lead to an improvement in the cooling efficiency of the four groups of air conditioners. The trends also appear to show a second acceleration in the improvement of EER around 2005, which again was consistent with industry anticipating the introduction of the 2006/07 MEPS the following year.

Figure 2: Baseline and Policy Trends for EER: Split System Air Conditioners - Cooling Only.

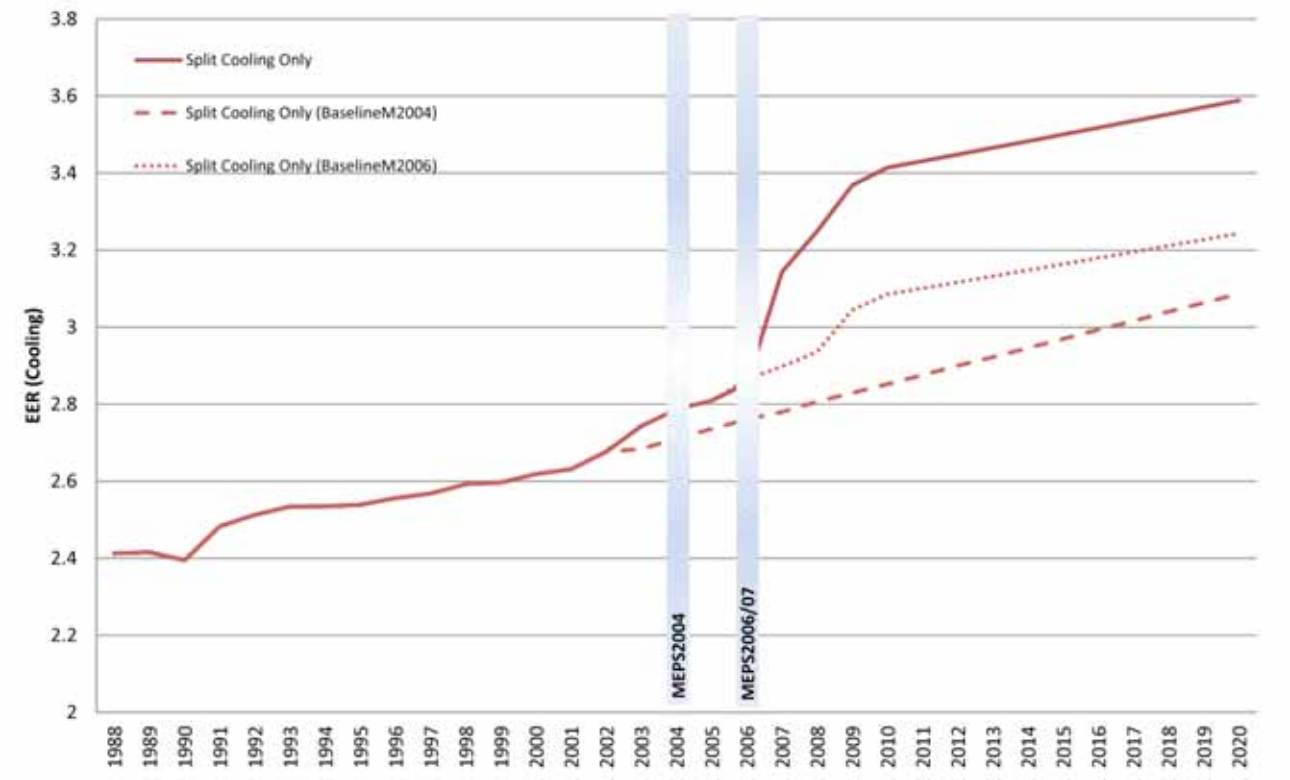


Figure 3: Baseline and Policy Trends for Energy Efficiency Ratio (EER): Split System Air Conditioners- Reverse Cycle.

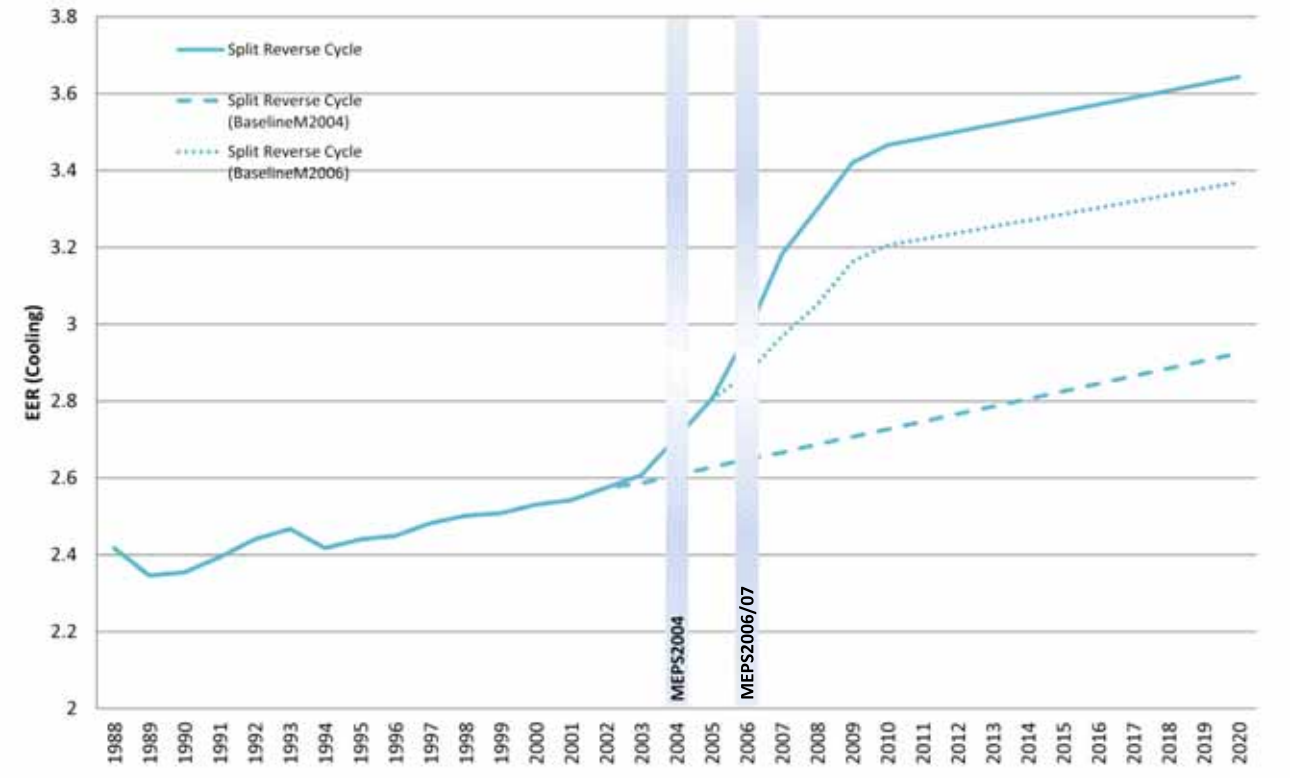


Figure 4: Baseline and Policy Trends for Energy Efficiency Ratio (EER): Window Wall (WW) Air Conditioners - Cooling Only (CO).

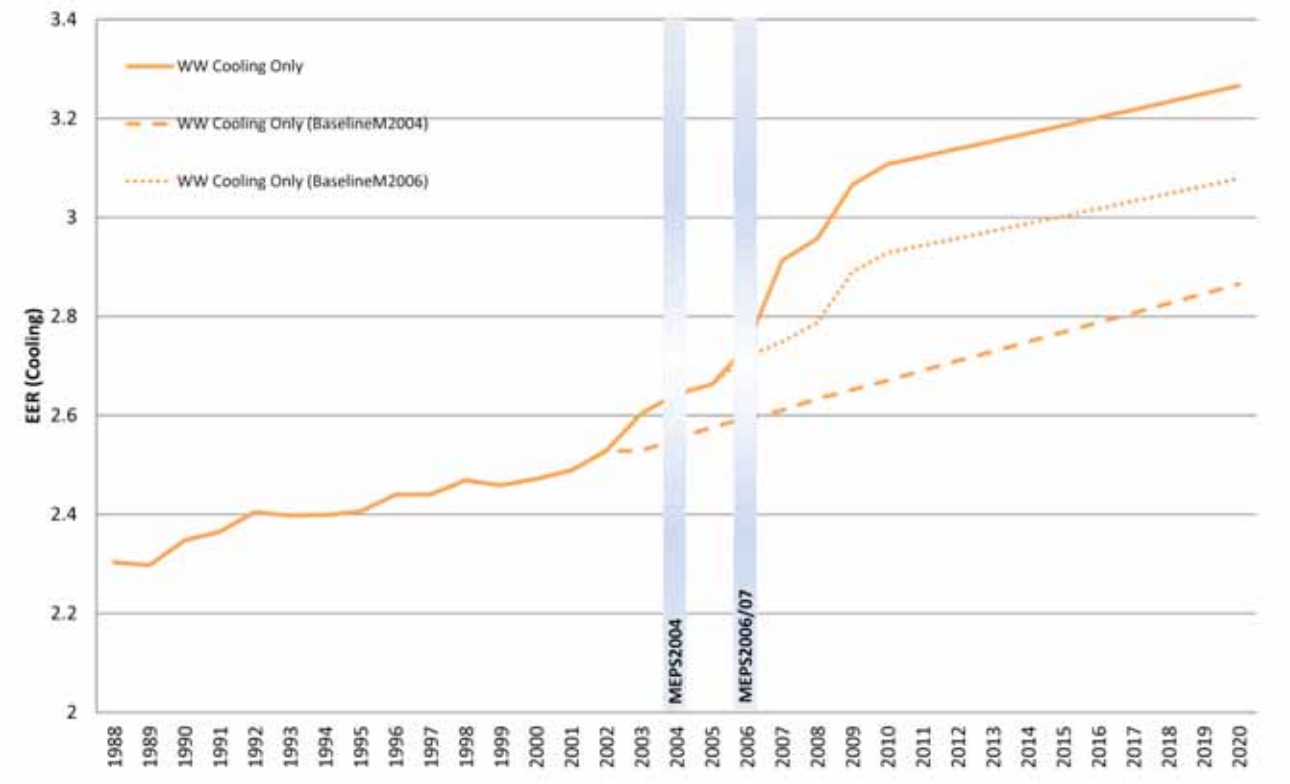
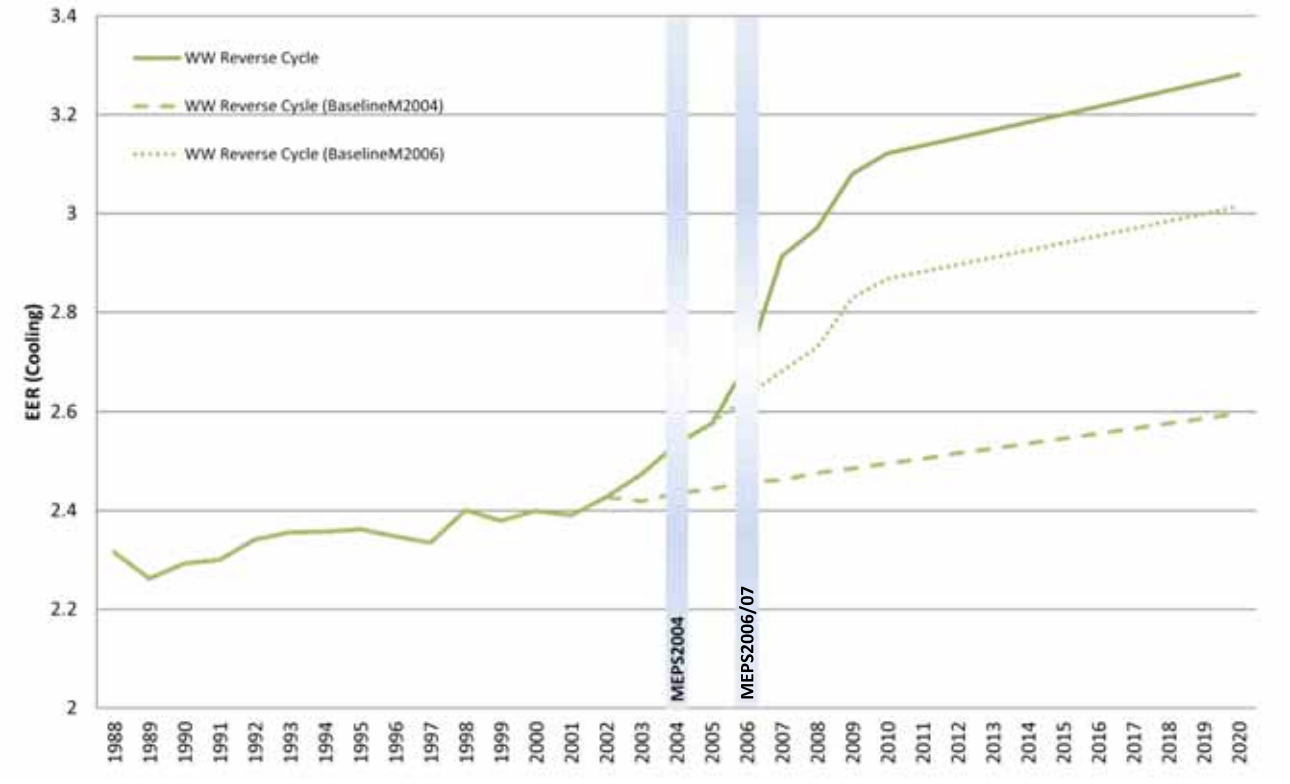
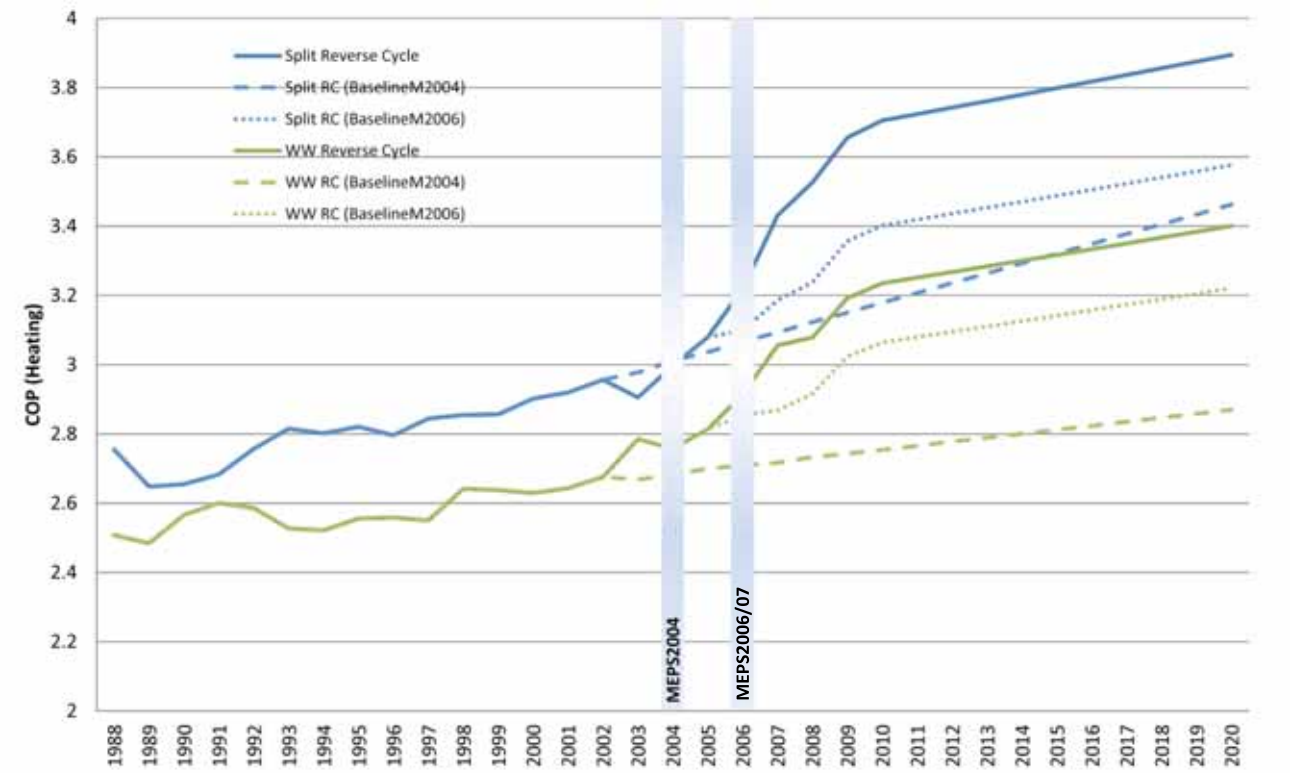


Figure 5: Baseline and Policy Trends for Energy Efficiency Ratio (EER): Window Wall (WW) Air Conditioners – Reverse Cycle (RC).



The baseline and policy trends in standardised sales-weighted average COP for reverse cycle air conditioners are shown in Figure 6. Like the EER results, the COP trends suggest that both MEPS lead to increases in the efficiency of air conditioners in response to the introduction of MEPS. The sales-weighted COP trends show acceleration in the improvement of air conditioner efficiency starting from around 2002 before the first MEPS was introduced and again in 2005, which proceeded when MEPS levels were again raised.

Figure 6: Baseline and Policy for COP: Split System and Window Wall (WW) Reverse Cycle (RC) Air Conditioners.



The COP improvements were not as noticeable for reverse cycle air conditioners as their heating capability they were not regulated by MEPS, as only a minimum EER was required in 2004 and 2006/07. The improvement in EER probably resulted in some COP improvements though, as the technology changes that increase cooling efficiency also often improve the efficiency of the heating cycle. However, as Table 1 shows, COP only improves at about half the rate for window wall units and two thirds of the rate for split units. The results strongly suggest that the announcement of the impending 2004 MEPS and 2006/07 MEPS for EER, and their implementation, lead to improvements in the heating efficiency of the two groups of air conditioners.

4.1.2 Comparison of Efficiency Trends with Past RIS Forecasts

One of the objectives of this study was to establish the difference between the projected/forecasted benefits that were expected from implementation of MEPS and the actual impacts that may have resulted from the implementation of such a policy. The anticipated impacts and benefits of implementation of MEPS 2004 and MEPS 2006/07 regulation were provided in their RIS before the regulations were implemented, and are based on comprehensive forecasts of anticipated impacts of the regulation.

The efficiency trends were forecast by Syneca Consulting in the reports *Minimum Energy Performance Standards for Air Conditioners Regulatory Impact Statement*, August 2003 and *Proposal to increase MEPS for Room Air Conditioners and harmonise MEPS for single and three-phase units Regulatory Impact Statement* Feb/June 2005. Unfortunately the forecasting models that were used by Syneca Consulting were not available, so the air conditioning efficiency forecasts they made were derived from the published reports. There are differences in their methodology to the current evaluation, and the limited amount of information on the efficiency forecasts supplied in the RIS document, made it difficult to compare the RIS forecasts with the evaluation findings.

Consequently a direct comparison of the RIS forecast efficiency of air conditioners and the evaluation findings was not possible. However, the information available suggests that the RIS only forecasts a small and static improvement in efficiency but the evaluation found an ongoing increase in efficiency. The RIS forecast was consistent with the RIS authors taking a conservative position when undertaking the benefits-cost analysis to justify the regulation.

The methodology used in the RIS forecasts and the current evaluation differed because the RIS:

- Used modelled weighted EER averages, instead of the sales-weighted approach used in this evaluation.
- Developed EER averages over all single phase air conditioners, rather than for the four product categories in this evaluation.
- Estimated energy savings based on the changes in efficiency of non-complying models becoming compliant, rather than on the average efficiency of all products sold as was done in the evaluation
- Used a post-MEPS EER trend that does not appear to include any autonomous improvement in efficiency, but their baseline trend does. In the current evaluation, an autonomous improvement in both baseline and policy trends was found to occur.

4.2 Estimated Energy Savings

The EER and COP trend information can be combined with information on air conditioner sales by product type and size, plus information on hours of use, to develop estimates of the energy consumption of air conditioners under the baseline and policy scenarios. The difference

between the estimated energy to be consumed under the baseline and policy scenarios is an estimate of the energy savings resulting from MEPS regulations.

4.2.1 Energy Saving from MEPS 2004

The energy savings from the introduction of MEPS 2004 was calculated by determining the difference between the energy expected to be used under the baseline scenario versus what occurred under the actual MEPS 2004 policy.

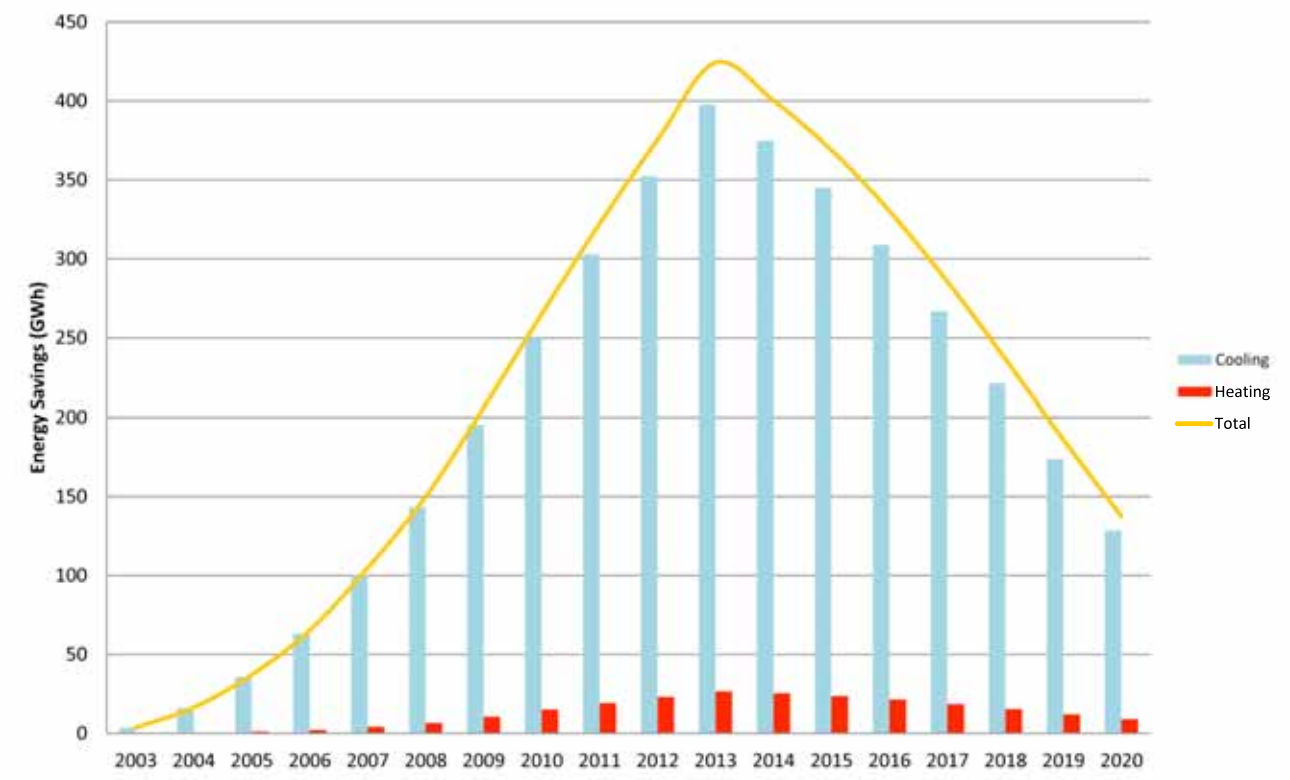
The results are shown in Figure 7 as energy savings from improved efficiency in heating and cooling and further details are provided in Table 2, page 21, and in the Technical Appendix.

Using actual data on air conditioner sales and performance, the estimated cumulative energy saving from 2003 to 2008 was 377 GWh. This was a cost savings of $65.1 million, based on 2009 Australian average electric tariffs. In total by 2020, the cumulative energy savings due to MEPS was estimated to be 3,915 GWh[1], assuming the current sales trends continue.

The annual energy savings show that the 2004 MEPS immediately produced energy savings from air conditioners when cooling, with savings starting in 2003, the annual saving peaked in 2013 and then declined. The savings declined from 2013 mainly due to the assumption that MEPS regulations would only affect appliances being sold for the next ten years. Improvements to the efficiency of reverse cycle split systems were the main component of these saving.

[1] These and all evaluation estimates of energy savings assume that product registration data is accurate but significant non-compliance would affect the estimates.

Figure 7: Annual Energy Savings from 2004 MEPS.



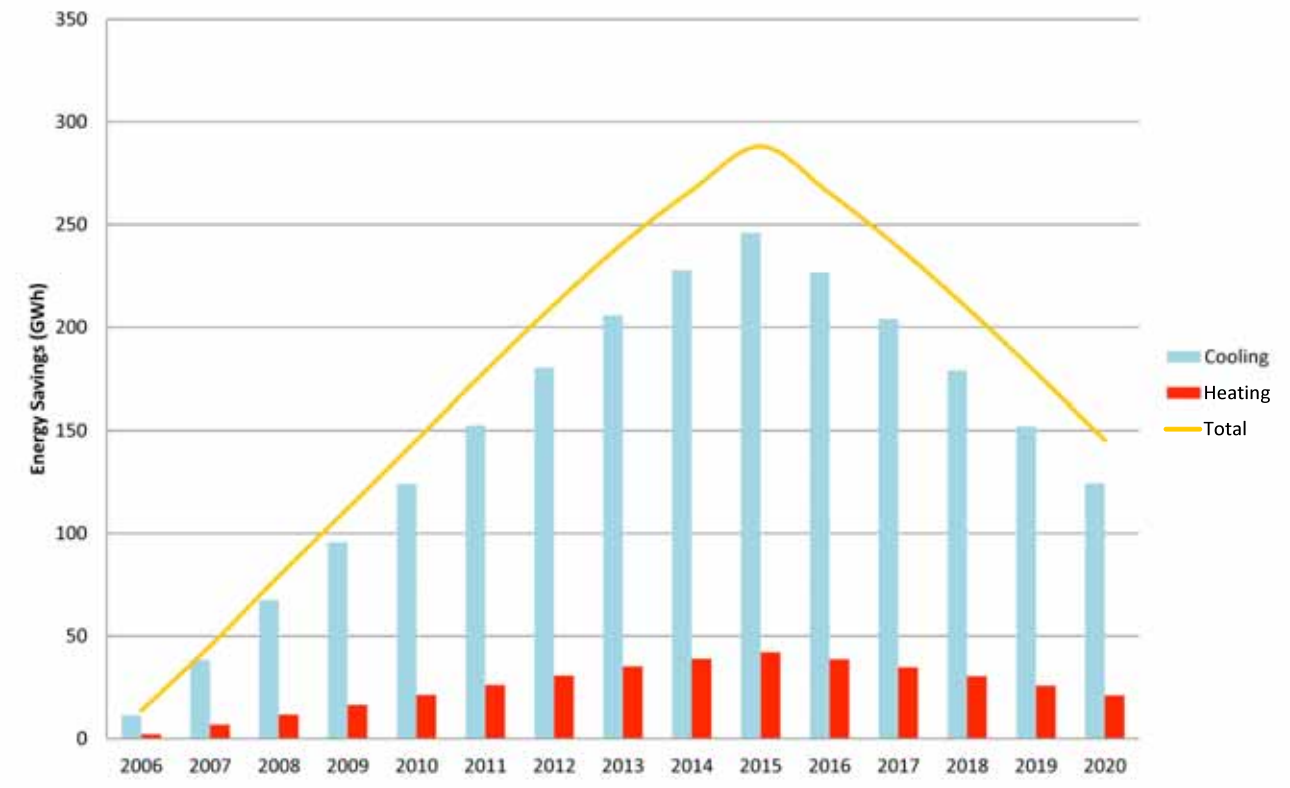
4.2.2 Energy Saving from MEPS 2006/07

The energy savings from the introduction of MEPS 2006/07 was calculated by determining the difference between the energy expected to be used under the baseline scenario versus what occurred under MEPS 2006/07 actual policy. The baseline scenario assumes MEPS 2004 was introduced and the saving estimates are shown as energy savings.

Figure 8 shows the combined energy savings, with a peak in savings in 2014, with the majority of savings coming from increased cooling efficiency. Again the main reason savings decline from 2015 was due the assumption that MEPS regulations would only affect appliances being sold for the next ten years. Energy savings from the changes to the split reverse cycle systems were the main component of this savings. Further details are provided in Table 2, page 21, and in the Technical Appendix.

Using actual data on air conditioner sales and performance, the estimated cumulative energy saving to 2008 was estimated at 138 GWh. This was a cost savings of $23.8 million, based on 2009 Australian average electric tariffs. In total by 2020, the cumulative energy savings due to MEPS 2006/07 is estimated to be 2,618 GWh, which was in addition to the savings from MEPS 2004, again assuming the current sales trends continue.

Figure 8: Annual Energy Savings from 2006/07 MEPS.



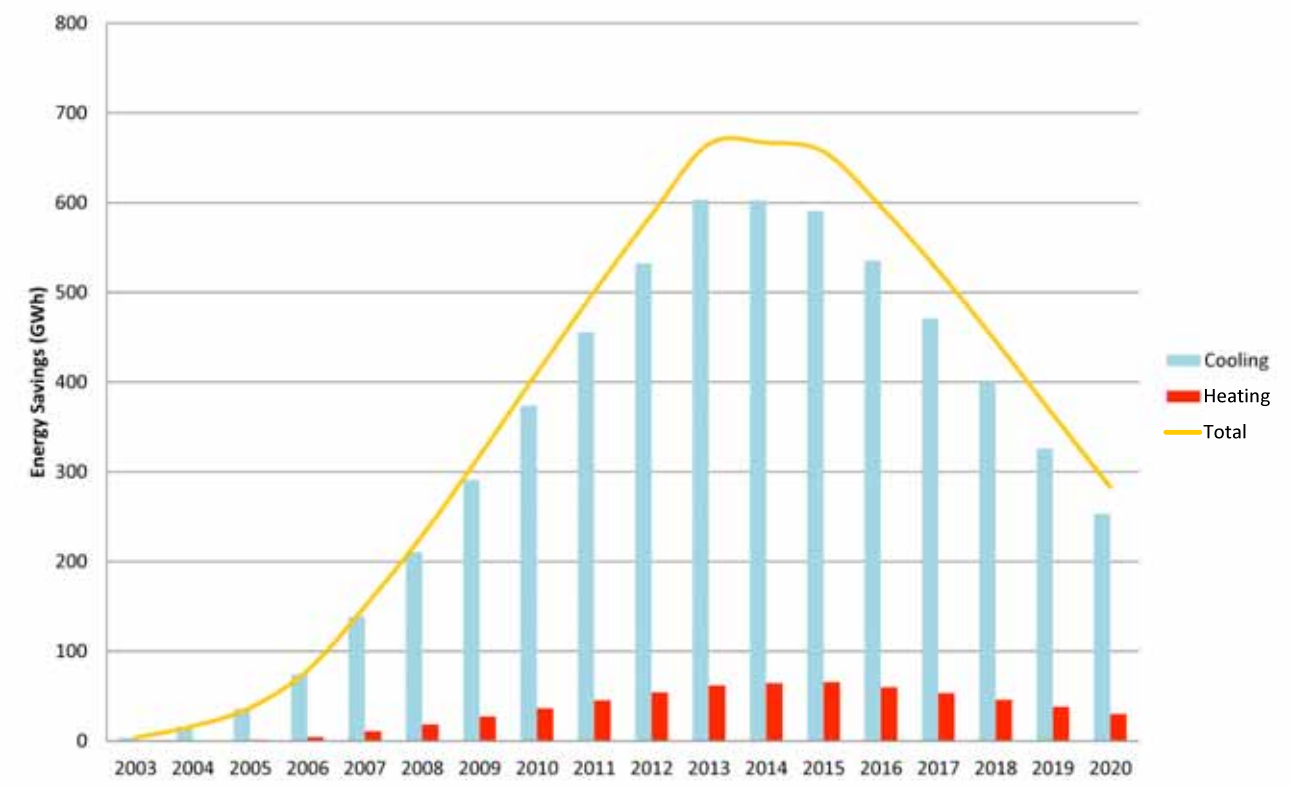
4.2.3 Combined Saving from MEPS 2004 and 2006/07

The energy savings from the introduction of MEPS 2004 were calculated by determining the difference between the energy expected to be used under MEPS 2004 baseline scenario versus what occurred under the MEPS 2004 and then MEPS 2006/07 actual policy. Effectively the total savings were the combined savings from MEPS 2004 and MEPS 2006/07 scenarios (Figure 9). Further details are provided in Table 2, page 21, and in the Technical Appendix.

Using actual data on air conditioner sales and performance, the estimated cumulative energy saving to 2008 was estimated at 515 GWh. This represents a cost savings of $61.8 million, based on 2009 Australian average prices. In total by 2020, the combined cumulative energy savings due to the MEPS 2004 and MEPS 2006/07 were estimated to be 6,533 GWh, worth approximately $1,127 million based on 2009 Australian average electric tariffs.

Figure 9 shows that the energy saving from air conditioners as a result of both MEPS, with the annual saving peaked in 2014 and then declining, due to the assumptions that MEPS would have ten year impact on appliances being sold. The majority of the energy savings was from improvements to the cooling function, and the majority of this was from improvements to reverse cycle split systems.

Figure 9: Annual Energy Savings from 2004 and 2006/07 MEPS.

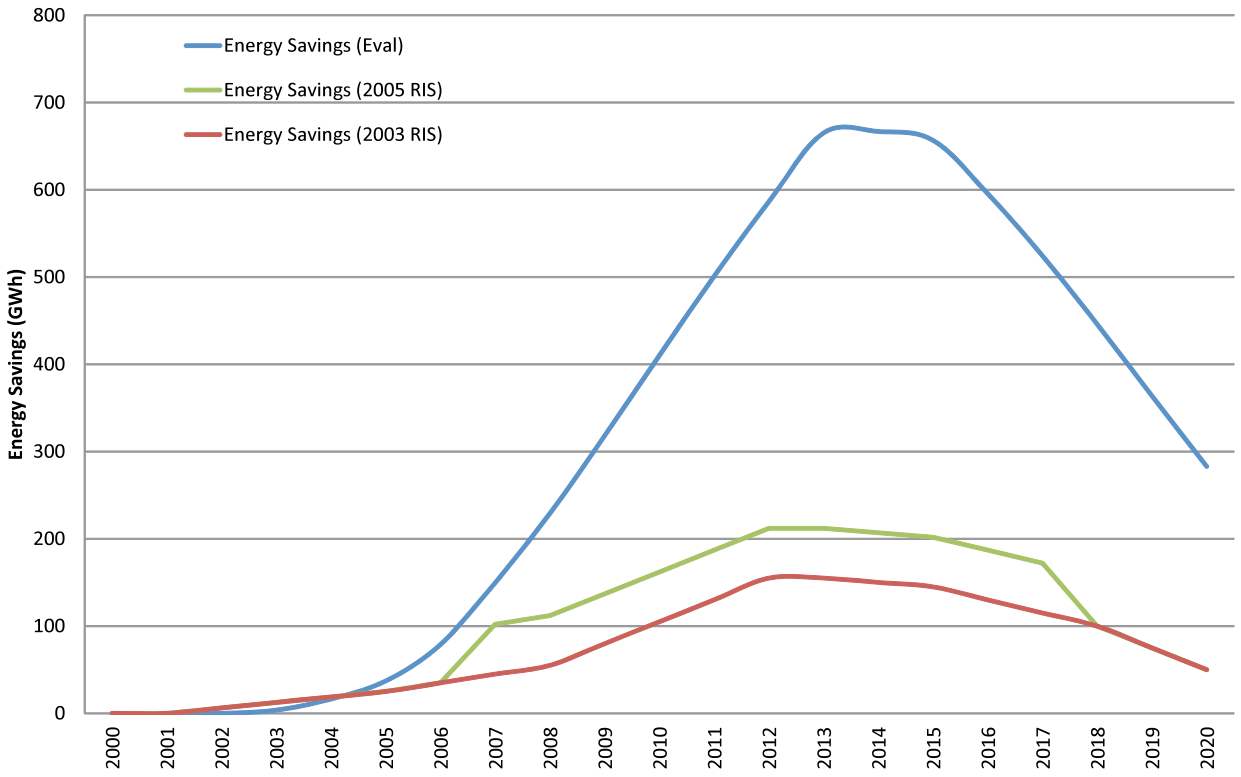


4.2.4 Comparison of Energy Savings Results with RIS Forecasts

One of the objectives of this study was to establish the difference between the projected/forecast benefits that were expected from implementation of MEPS policy options and the actual impacts that may have resulted from the implementation of such policy options. For air conditioners, there were two relevant RIS forecasts, 2003 RIS and 2005 RIS. The relevant parts of the 2005 RIS can almost be considered an extension of the first RIS, as they involved only moving forward by twelve months the 2007 MEPS, proposed in the 2003 RIS. Consequently, the combined 2003 and 2005 RIS forecasts were compared to the actual results found in the current evaluation.

Figure 10 illustrates the comparison of the cumulative energy savings resulting from the two policy options (MEPS 2004 and MEPS 2006/07), previously reported above, and the estimated impacts from the 2003 and 2005 RIS. In both cases the combined total savings rise steadily before declining as the policy effect dissipates.

Figure 10: Comparison of energy savings forecast in the RIS and this evaluation.



This evaluation shows that the impacts of the 2004 and 2006/07 MEPS were significantly larger than those estimated in the 2003 and 2005 RIS.

Table 2 provides a detailed comparison between the estimated actual and forecasted impacts of MEPS 2004 and MEPS 2006/07. The table shows the energy savings projections starting in 2002, two years before of the implementation of MEPS 2004. The table also shows:

- Estimated actual MEPS annual energy savings impacts, based on actual data available to 2008, are 65% above the combined 2003/2005 RIS forecast.
- The current estimate of the total actual impacts till 2020 is 195% above the projected MEPS impacts.

Table 2: Comparison between forecast and estimated actual energy savings (GWh) from MEPS – Summary.

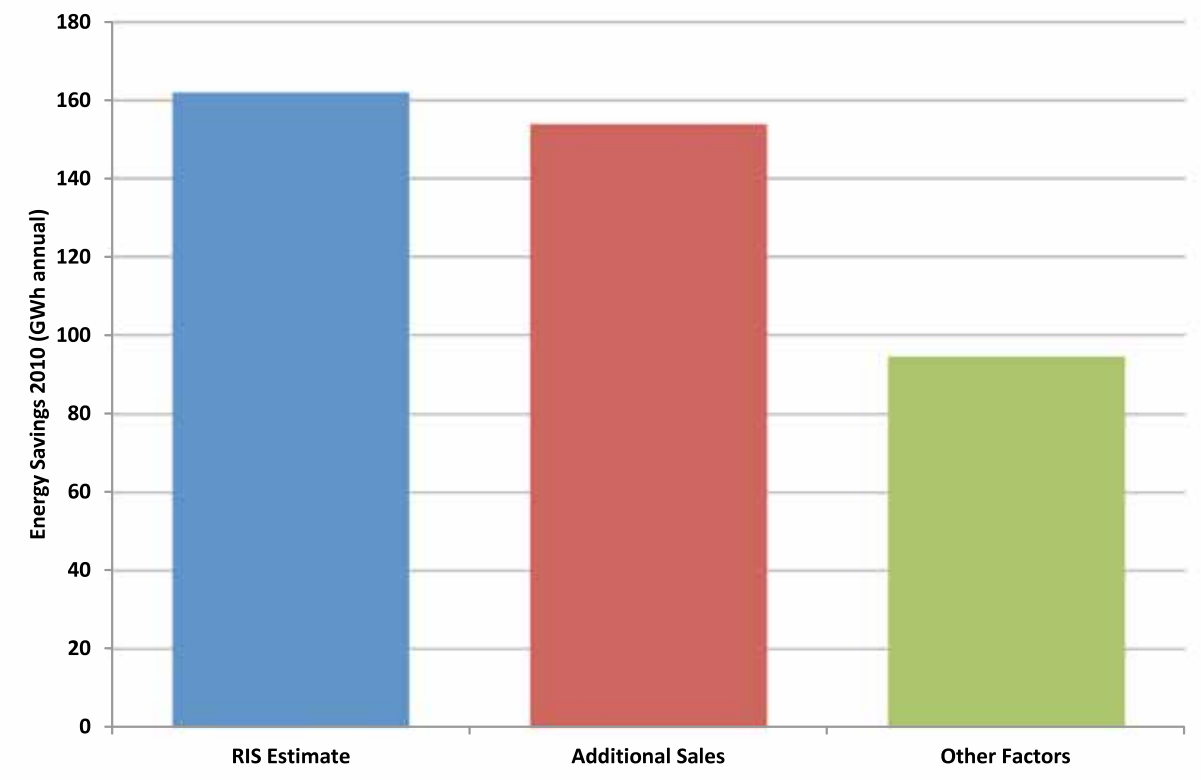
Year	Projected MEPS (RIS 2003)	Projected MEPS (RIS 2005)	Actual MEPS 2004	Actual MEPS 2006/07	Total Projected MEPS	Total Actual MEPS
2000	0		0	0	0	0
2001	0		0	0	0	0
2002	6		0	0	6	0
2003	13		4	0	13	4
2004	19		16	0	19	16
2005	25		37	0	25	37
2006	35		65	14	35	79
2007	45	57	105	45	102	150
2008	55	57	150	79	112	229
2009	80	57	206	112	137	318
2010	105	57	265	145	162	410
2011	130	57	322	179	187	501
2012	155	57	375	211	212	586
2013	155	57	424	241	212	665
2014	150	57	400	267	207	667
2015	145	57	369	288	202	657
2016	130	57	330	265	187	596
2017	115	57	286	239	172	524
2018	100		237	209	100	446
2019	75		186	178	75	364
2020	50		138	145	50	283
Total (Cumulative GWh)	1,588	627	3,915	2,618	2,215	6,533
GWh Difference from RIS Estimate						4,319
% Above						195%

An analysis was conducted to compare the assumptions underlying the RIS forecasts and the facts and assumptions used in the current estimates of the impact of MEPS, as differences may explain why the large differences in the actual and forecast energy savings occurred. This analysis was not able to fully quantify the contribution of various factors to the differences, but the main factor will be the difference in the forecast versus actual sales.

Estimated sales numbers used for the forecasts of the 2003 RIS were based on earlier market forecasts and underestimated actual sales data. Actual sales of air conditioners were 108% higher from 2002 to 2008 than anticipated in the 2003 RIS. The 2005 RIS was reasonably accurate in its sales forecast, but as this RIS only affected the energy savings from one year of product sales, it has much less impact on the combined forecast of energy savings from the two RISs.

The role of the different factors in explaining the difference between the evaluation estimation of energy savings and the RIS forecasts are presented in Figure 11.

Figure 11: Decomposition of factors contributing to estimate 2010 energy savings from 2004 and 2006/07 MEPS.



Other factors which would have explained the differences between the forecasts and the actual findings include the RIS forecasts:

- not using estimated sales-weighted efficiency gains in the forecasts, but instead focusing only on the proportion of non-complying product, and the savings that would occur when that product became compliant; and
- not anticipating the changes in the weighting of product types, with the big upsurge in split systems affecting efficiency changes and energy savings.

4.3 Average Market Price Trends

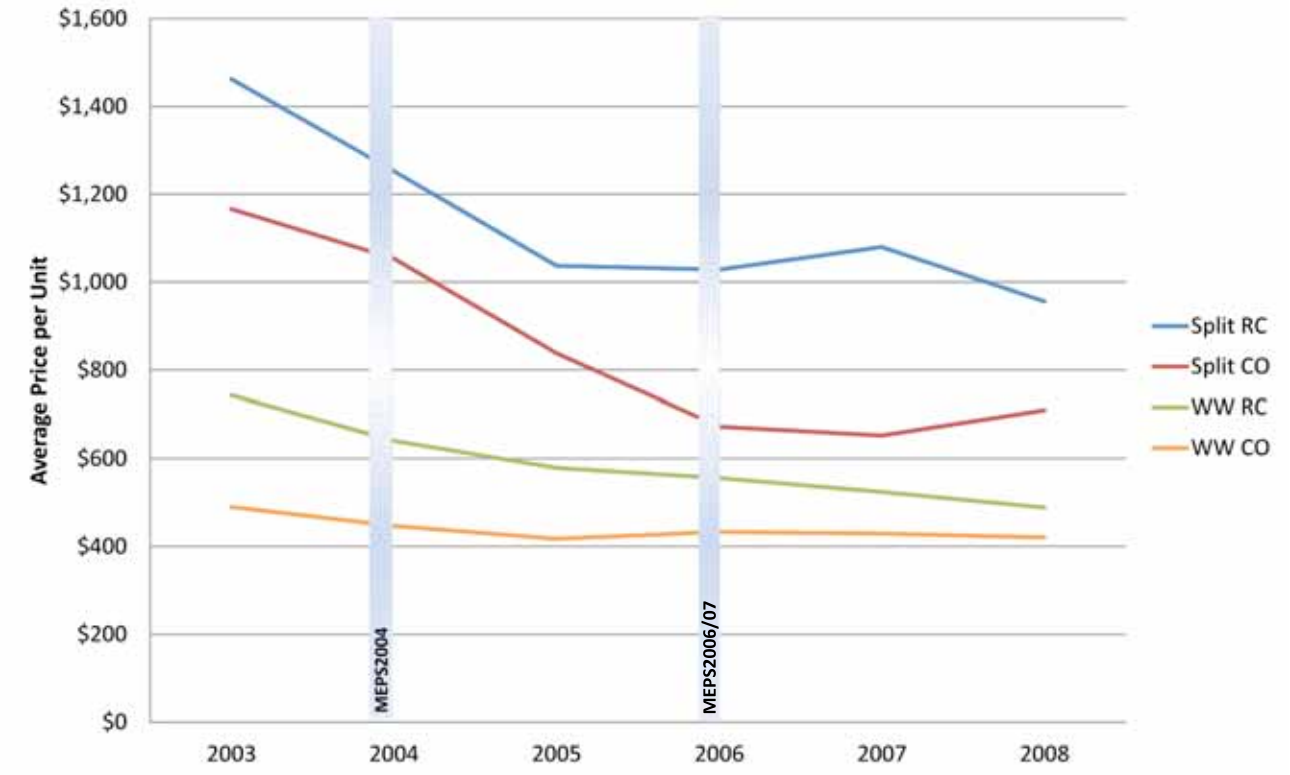
A RIS generally includes an estimated impact on price arising from the regulation as part of the overall cost benefits assessment conducted and it was often assumed that energy efficiency regulations will increase the price of products. An analysis of changes in product price was conducted in order to assess the actual impacts of MEPS regulations on price trends.

4.3.1 Average Market Price Trends after the Introduction of MEPS

GfK data was used to produce sales-weighted trends of average market prices of different groups of air conditioners. Figure 12 illustrate trends in sales-weighted average market prices

for various groups of air conditioners. The trends start from 2003 as this is when data was available.

Figure 12: Sales-weighted real average prices of air conditioners by groups.



The analysis of sales-weighted average market prices, in real prices based on 2003 dollars[2], of air conditioners show that the average market price of all the non-ducted air conditioners has declined since 2003, especially for split systems. For window-wall systems this price decline has been relatively steady for the five years, 2003 to 2008. For reverse cycle split systems there was a considerable price decline for two years till 2005, followed by both increases and decreases to 2008. For cooling-only split systems there was a considerable price decline till 2006, followed by an increase in 2008. Despite the variations in the trends, overall real prices for air conditioners are continuing to decline.

Given that MEPS were introduced in 2004 and then increased in 2006/07, there appears to be no evidence of price increases resulting from the introduction of MEPS. The only increases in real prices occurred for reverse cycle split systems in 2007 and for cooling only split systems in 2008, neither of which coincide with the introduction of new MEPS. However, the rate of price decrease did slow for reverse cycle split systems and cooling-only window wall systems in 2005 which was when the 2006/07 MEPS would start to affect the selection of air conditioners by suppliers.

[2] Nominal prices corrected for inflation using historic CPI values obtained from the ABS CPI Time Series 6401.0.

So it is possible the 2006/07 MEPS did slow the rate of price decrease for air conditioners, even if it did not produce price rises. However, an alternative explanation is that the increasing popularity of inverter systems, which tend to be more expensive systems, may have contributed to the slowing in the rate of price decline for the split systems.

4.3.2 Average Market Price per Unit of Capacity Trends

Assessment of changes in the market price of products on the basis of the average market price can sometimes be misleading if the size or capacity of products has changed. Consequently, if capacity changes have occurred then the analysis of price trends may not reflect any market impact of MEPS. Average price standardised over the adjusted capacity of the product may provide a better level of analysis of price trends.

The GfK data was used to produce sales-weighted trends of average market prices per unit of capacity for different categories of air conditioners from 2003, the first year where complete price and sales data was available. Figure 13 and Figure 14 illustrate trends of changes in sales-weighted average market prices per unit of capacity for various categories of air conditioners.

Figure 13: Sales-weighted average price per unit cooling capacity of air conditioners.

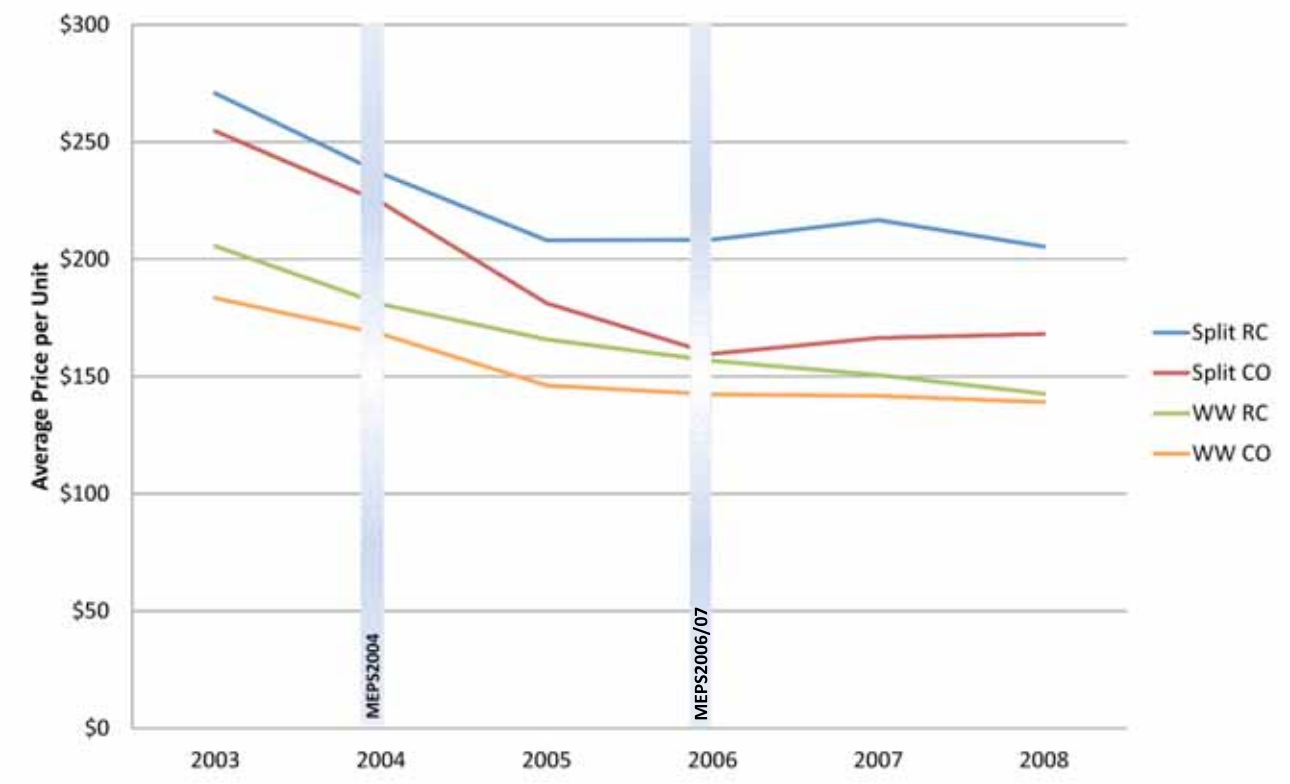
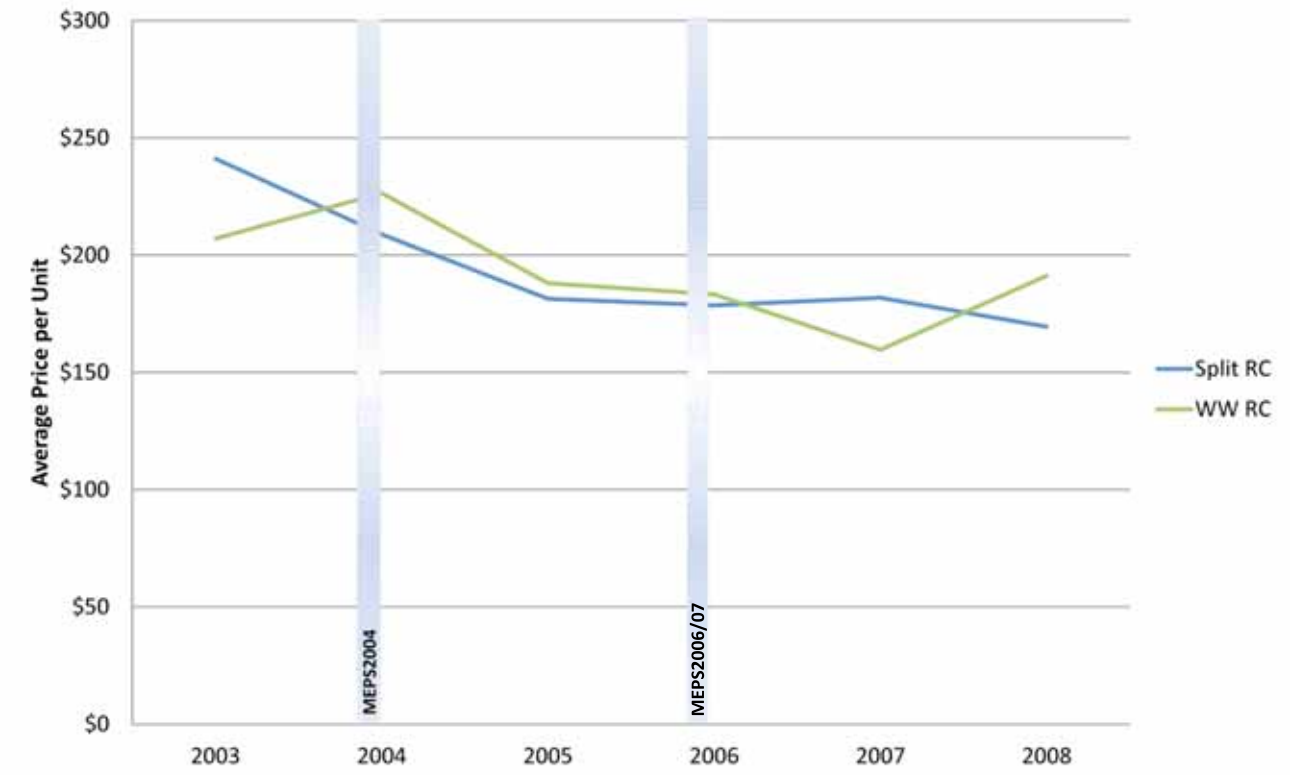


Figure 14: Sales-weighted average price per unit heating capacity of air conditioners.



The prices of split system air conditioners when adjusted for capacity clearly show a decrease in the rate of the price decline in 2005, a slight increase in price from 2006 to 2007, and another increase in 2008 for cooling only split systems, but the reverse cycle split systems decline in price after 2007. The prices of window-wall systems declined throughout the period to 2008, but the rate of decline slows in 2005. However, sales of window wall units have been in decline since 2004, so it is possible the decline in sales is affecting the ability of suppliers to reduce prices.

The results show again it is possible that the 2006/07 MEPS may have led to a decrease in the rate of price decreases in air conditioners, when the capacity of the air conditioners is considered. The MEPS started to raise the efficiency of the systems in 2005, as discussed earlier in Section 4.1.1 page 10, and this is when the rate of price decline slowed, suggesting the MEPS may have had an effect. However, an alternative explanation is that there has been an increasing trend toward the purchase of smaller split systems, whose price per capacity is higher than for larger systems, and towards inverter systems. These trends may have led to a slowing in the price decrease observed in 2005, as may have the decline in sales for window wall units. In addition, there are many other factors that may have influenced the air conditioner price trends, such as changes in exchange rates, prices of copper and steel and transport costs.

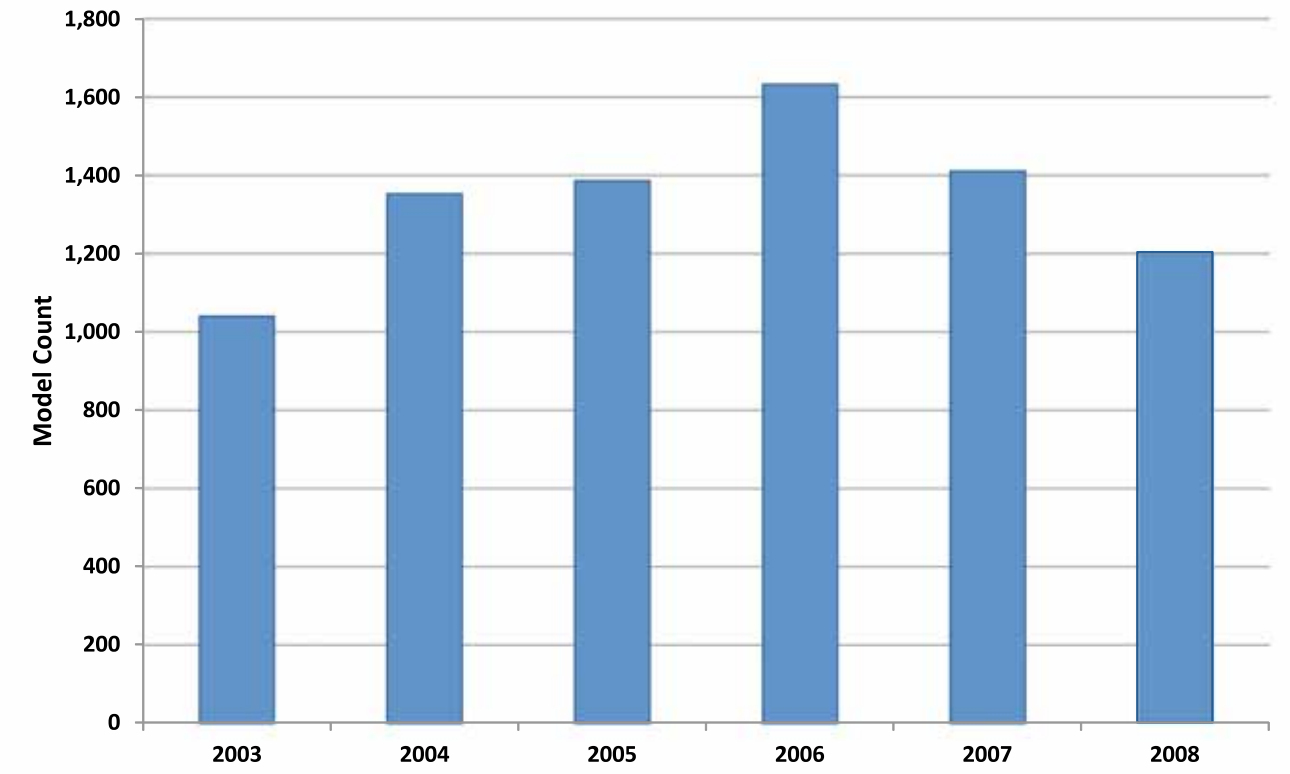
Consequently with the limited data available it was not possible to draw firm conclusions regarding the impact of MEPS on the decline in air conditioner prices. It is possible that the 2006/07 MEPS slowed the rate of decline in air conditioner prices, when system capacity was

considered, but other market trends may equally have been the cause of price trends over 2005-2008.

4.4 Changes in Product Offering

MEPS can lead to the removal from the market of more inefficient air conditioner models. Potentially this could lead to a decline in the number and type of models available in the market, if the inefficient models are not replaced with more efficient models that meet the MEPS requirements. To determine if there was evidence that MEPS led to a reduction in the number of air conditioners offered for sale, the number of different models recorded as sold in the GfK data were analysed. The results are shown in Figure 15.

Figure 15: Number of GfK Listed Air Conditioner Models from 2003 to 2008.



If MEPS had produced a decrease in the models available, we would expect a decrease in models sold in 2004 and then 2006/07. There was no evidence of MEPS affecting the number of models available in 2004, or again in 2006, as the number of models steadily increased from 2003 to 2006. There was a decline in models numbers in 2007, which might have been in response to the second phase of the 2006/07 MEPS, but the numbers kept declining in 2008 which suggests factors other than MEPS may be important. An examination of GfK sales data

showed sales declined in 2007 and again in 2008, so this would explain the decline in the number of models sold[3].

Consequently, there appears to be no evidence that the introduction of MEPS lead to a decrease in the models of air conditioners available or in consumers' choice.

[3] This decline in sales is typical of the year-to-year variation in annual sales, despite the overall trend towards increasing annual sales.

5. Findings and Conclusions

5.1 Findings

5.1.1 MEPS Impacts

The impact of MEPS on air conditioner efficiency was substantial, and savings are projected to continue to increase. In all air conditioner categories there was an upward trend in EER and COP before the implementation of MEPS and these trends appear to be rapidly changing as a result of the implementation of MEPS. The sales weighted trends for the efficiency show a clear substantial increase since the introduction of the two rounds of MEPS in 2004 and 2006/07. For example, the EER of reverse cycle split type air conditioners increased by an average annual rate of just under 3.8% due to the 2004 MEPS and by 5.5% due to the 2006/07 MEPS. This compares to a long term trend of 0.5% pa increase in EER prior to MEPS

Although the Energy Rating Label will also have some impact on the estimated savings, this is considered minimal over the period that was examined for MEPS impacts (2003 to 2020). The long term trend change in efficiency of 0.5% pa is quite small, and would include the effect of ERLs compared to the changes observed from the 2004 MEPS and the 2006/07 MEPS. These changes in sales-weighted efficiency are much larger and are considered to be attributed solely to the implementation of MEPS. In addition, the 0.5% natural efficiency improvement was also included in the baseline trends to ensure that only the MEPS impacts were calculated.

The MEPS have also achieved cumulative energy savings of 515 GWh, and energy cost savings of $88.9 million, in the period to 2008. In total from 2003 to 2020, the combined cumulative energy savings due to MEPS 2004 and MEPS 2006/07 was estimated to be 6,533 GWh, worth approximately $1,127 million. The vast majority of impacts from these MEPS are still to be achieved and it would be valuable to review the evaluation of the impacts of these and the 2010 MEPS in the future.

There appears to be no evidence of price increases resulting from the introduction of MEPS affecting window-wall systems, but the 2006/07 MEPS may have affected prices of reverse cycle systems during 2005-2008. However, other market trends may equally have influenced split system prices over this period, and the impact of MEPS on prices could not be determined from the data available.

5.1.2 Comparison to RIS Forecasts

The forecast impacts of the 2003 and 2005 RIS were compared to the efficiency gains and energy savings determined in the current evaluation. It was difficult to compare the evaluation findings to the RIS forecasts, as the RIS modelling was not available, methodologies differed and required information for the comparisons was not always documented. However, both RIS forecasts were conservative in their estimation of the impacts of MEPS and underestimated the efficiency and energy savings obtained.

The most obvious reason for the difference in the RIS forecasts and the present evaluation was the RIS forecasts greatly underestimated the sales of air conditioners that occurred. They also assumed that MEPS would only affect non-complying models rather than creating a trend towards greater efficiency in all models, so they underestimated the efficiency and energy savings gains from the introduction of MEPS. However, the RIS projections undertaken before a MEPS policy options are implemented are required to be conservative, due to the uncertainties that surround the forecasts, and so this result supports that the RIS forecasts were undertaken according to appropriate professional practice.

5.2 Conclusions

The impact of MEPS was substantial, and savings are projected to increase to a cumulative energy saving of 6,533 GWh by 2020. The MEPS has achieved cumulative energy savings of 515 GWh in the period from 2003 to 2008.

The combined forecast impacts of MEPS 2004 and MEPS 2006/07 were conservative, partly due to underestimating air conditioning sales in the 2003 RIS, but also probably due to some aspects of their methodology and their need to undertake conservative forecasts as part of appropriate professional practice.

Regarding future evaluations, the following conclusions are made:

- Evaluations should be conducted at the state level if possible, in order for analyses to include the variations in energy usage by appliances that occur at the state level.
- Baseline projections that do not consider existing trends in efficiency and energy use risk overestimating energy savings and efficiency improvements.
- In markets where multiple policy measures are used such as air conditioners caution needs to be applied to ascribing benefits to one or other policy measures because the dynamic market place is continually taking account of pre-regulatory debates and adjusting its models accordingly. A simple allocation of all benefits to labelling while MEPS are being developed in a transparent fashion would be inaccurate.
- Post evaluation studies are a valuable means to measure the effectiveness of policy interventions like MEPS and labelling. They should be conducted where data is available and on an appropriate time cycle that reflects the technology improvement for the product type.

This study provides lessons for the future evaluations of not only air conditioners but other technology types and would form a useful basis for developing a generic methodology that could be used to evaluate the effectiveness of energy efficiency policies for other regulated products.

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