Report 2004/03

Minimum Energy Performance Standards for Miscellaneous Electric Water Heaters

Regulatory Impact Statement

Draft Report – 29 June 2004

Prepared for

Australian Greenhouse Office

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Abbreviations

AGO	Australian Greenhouse Office
ANZMEC	Australian and New Zealand Minerals and Energy Council (forerunner to MCE)
AS	Australian Standard
AS/NZS	Joint Australian Standard/New Zealand Standard
BAU	business as usual
E2WG	Energy Efficiency Working Group
EP	Energy Partners
GWA	George Wilkenfeld and Associates
GWh	Giga watt hours
kt	kilo tonnes, usually of carbon dioxide equivalent (CO_2-e)
LBNL	Lawrence Berkeley National Laboratories
MCE	Ministerial Council on Energy
MEA	Mark Ellis and Associates
MEPS	minimum energy performance standards
NATA	National Association of Testing Authorities, Australia
MEPS	Minimum Energy Performance Standards
NAEEEC	National Appliance and Equipment Energy Efficiency Committee
NAEEEP	National Appliance and Equipment Energy Efficiency Program
NGS	National Greenhouse Strategy
NPV	net present value
RIS	regulatory impact statement
TESAW	Top Energy Saver Award Winner
TNS	Taylor Nelson Soffres
USDoE	US Department of Energy

Executive summary

This is a regulatory impact statement for a proposal to introduce mandatory minimum energy efficiency requirements for certain types of electric water heaters supplied in Australia. These are the low pressure and heat exchanger types of water heater, jointly referred to here as 'miscellaneous electric heaters'. They account for a small (6%) and declining share of total sales of electric water heaters.

The problem
The proposal is an element of the National Appliance and Equipment Energy Efficiency Program (NAEEEP), which is jointly managed and funded by the Commonwealth, State and Territory governments. NAEEEP is part of the National Greenhouse Strategy and targets the energy efficiency of consumer appliances, industrial and commercial equipment.

The energy used by miscellaneous water heaters accounted for only a small fraction of Australia's greenhouse emissions in 2000 – less than 0.3%. Moreover, the proposed efficiency measures can only reduce the 'standing losses' from the water heater's storage tank, having no effect on losses from pipes or the energy content of hot water delivered to the user. These standing losses would account for less than 0.1% of total emissions.

Market failure
For there to be scope for regulations to achieve cost-effective reductions in standing losses, markets must be regarded as having failed to minimise the lifecycle costs of using water heaters. (The energy lost directly to the atmosphere from a storage tank is called the standing loss, and can be reduced by better insulation of the tank.)

An important consideration in this context is that the lifetime value of standing losses is typically greater than the installed cost of the heater, and may be up to 20% larger. Ideally, therefore, the rate of heat loss should be at least as significant a consideration as the purchase price. However manufacturers agree that this is not the case, and that users undervalue the long term impact of additional insulation on their electricity consumption. One obvious reason is that there is usually some urgency about replacing water heaters that have failed, leaving little time for a market search. And new home buyers generally leave heater selection to the builder, whose main concern is to minimise the installed cost.

The objective
The proposal would bring the MEPS arrangements for miscellaneous water heaters into line with the arrangements currently applying to the rest of the market for electric water heaters, comprising mains pressure units. The various types of electric heater would be treated uniformly thereafter, there being no significant technical differences in respect of heat losses and measures to reduce them.

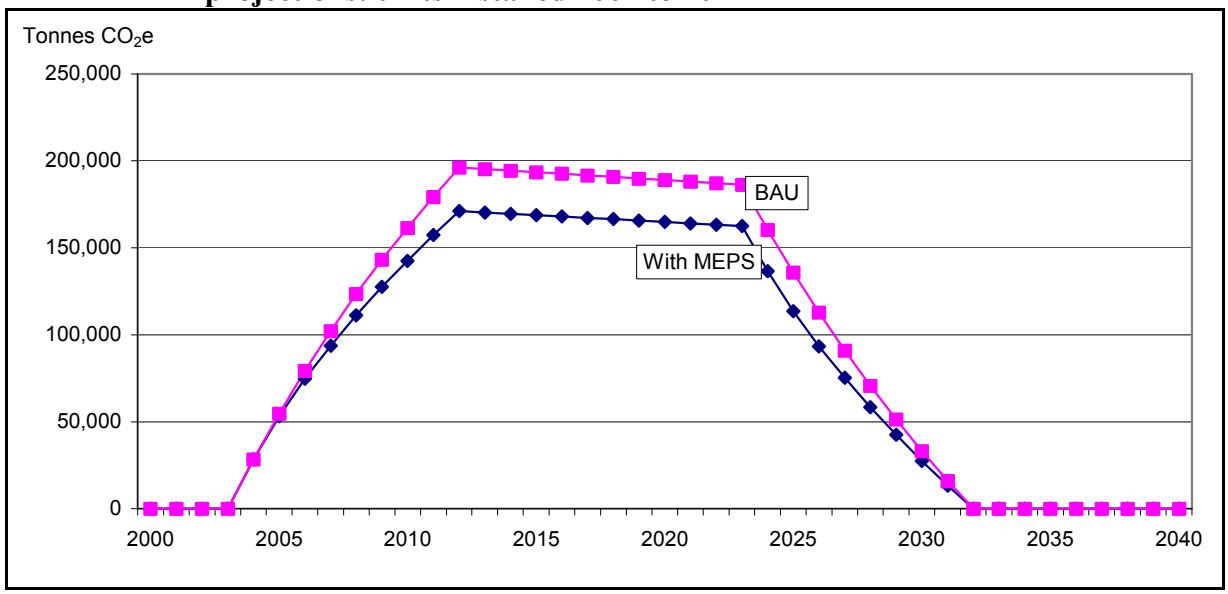
NAEEEP will apply its policy of 'world's best regulatory practice' to water heaters over the longer term. This involves setting MEPS at levels broadly comparable with the most demanding MEPS adopted by Australia's trading partners, but following that lead with a lag of several years, and after taking into account domestic market circumstances and policy settings.

The proposal
The proposed measures will replace the current recommended or voluntary MEPS with mandatory MEPS, and reduce the maximum permitted heat loss by 30%. This will require the replacement of models that account for at least 90% of existing sales. Some manufactures have already introduced more efficient models that comply with the proposed standard or will do so after further relatively minor adjustment.

Figure 1 reports estimates of greenhouse emissions from miscellaneous electric water heaters that are supplied to the market in the period to 2012, which is the final year of the first commitment period under international arrangements to reduce greenhouse emissions. Over the life of units supplied in this period, total reductions in greenhouse emissions are estimated at 487 kt of CO_2 equivalent. Coincidentally, total energy use is reduced by 487 GWh over the period.

At their peak in 2012, energy use and greenhouse emissions would be reduced by 15% relative to the BAU projections for the standing losses from miscellaneous heaters *supplied in the period 2004-2012*. However, the transition to more efficient water heaters would be incomplete at this stage, since currently supplied water heaters may not be fully retired until 2030 or later. The savings would continue to increase to about 25% of the projected levels if the regulation is maintained indefinitely.

Figure 1: Greenhouse emissions: business-as-usual (BAU) and 'With MEPS' projections: units installed 2004 to 2012



Assessment

From a regulatory perspective, the proposal will restore that level playing field that applied to electric water heaters before the 30% reduction in heat loss requirements was implemented for larger mains pressure units in 1999. Those changes have since been extended to smaller mains pressure units, with effect from October 2005. This proposal will complete the transition, also taking effect from October 2005.

Given that the remaining market segment is quite small, at 6%, the only practical options are to maintain the *status quo* or to implement the proposal. There is no significant technological or market distinction to justify an intermediate solution.

From a user perspective, the proposal will deliver net benefits of $10.1 million and a benefit/cost ratio of 2.1. The initial investment by users has a present value of $9.3 million. The assessment remains positive for reasonable variations in the underlying assumptions.

The proposal is somewhat less attractive from a national perspective. The main difference between the user and national perspective is that, allowing for the large fixed costs of electricity networks and the impact of peak demands, the tariffs paid by consumers exceed the avoidable costs of supplying electricity. Based on a conservative assessment of the avoidable costs of electricity, the net present value of the proposal is reduced to $3.2 million, and the benefit /cost ratio to 1.3.

The additional cost to government is virtually zero, since the administrative and program structures are already in place.

About 90% of the market for miscellaneous water heaters is supplied by manufacturers who are already quite comfortable with the proposed MEPS. They have developed energy efficient product and believe that it substantially complies. The remaining 10% of the market is supplied by smaller manufacturers, some of whom were not aware of the proposals. Generally, they considered that they would be able to make the appropriate adjustments, but questioned whether the effort was justified for a market that is already very small and is projected to decline further. Collectively, the upfront costs to suppliers – for redesign, testing, registration and retooling – would not be greater than $150,000.

Recommendations (draft)
It is recommended that:

1 States and Territories implement the proposed mandatory minimum energy performance standards.

2 Existing State and Territory regulations governing appliance energy labelling and MEPS be amended to implement the proposed standards.

1 The context for regulation

This regulatory impact statement (RIS) addresses a proposal to introduce mandatory minimum energy efficiency requirements of certain types of electric water heaters supplied in Australia. These are vented storage heaters (also called 'low pressure' or 'gravity fed' heaters) and the heat exchanger types of water heater. They account for a small (6%) and declining share of total sales of electric heater. They are more significant in stock terms, reflecting much higher sales in the past.

The proposal is to bring the MEPS arrangements for this minority into line with the MEPS arrangements that already apply to the mains pressure type of electric water heater, levelling the regulatory playing field for electric storage water heaters. The proposal is part of the National Appliance and Equipment Energy Efficiency Program (NAEEEP), which is an element of the National Greenhouse Strategy (NGS). This section explains the policy context.

The water heaters under consideration will sometime be referred to simply as 'miscellaneous electric water heaters'. See appendix 1 for the technical background and a description of the heaters under consideration and the proposed MEPS levels.

1.1 National Greenhouse Strategy

The Australian Government's response to concerns about the environmental, economic and social impacts of global warming was enunciated in the Prime Minister's statement of November 20, 1997, *Safeguarding the Future: Australia's Response to Climate Change.* In the statement the Prime Minister announced a package of measures to reduce Australia's greenhouse gas emissions designed to ensure Australia plays its part in the global effort to reduce greenhouse gas emissions while protecting the Australian economy.

The Prime Minister noted that the Government was seeking . . . *realistic, cost-effective reductions in key sectors where emissions are high or growing strongly, while also fairly spreading the burden of action across the economy.* He also stated that the Government is . . . *prepared to ask industry to do more than they would otherwise be prepared to do, that is, go beyond a "no regrets", minimum cost approach where this is sensible in order to achieve effective and meaningful outcomes.*

The NGS was subsequently endorsed by the Commonwealth, States and Territories as a commitment by governments to an effective national greenhouse response.

> *The Strategy maintains a comprehensive approach to tackling greenhouse issues. The range of actions it encompasses reflects the wide-ranging causes of the enhanced greenhouse effect and the pervasive nature of its potential impacts on all aspects of Australian life and the economy. (NGS 1998)*

The NGS is also the mechanism through which Australia will meet its international commitments as a party to the *United Nations Framework Convention on Climate Change*. The Australian government has announced its intention to meet an overall target by 2008-2012 of 108% of its 1990 emissions which is, in effect, a 30% reduction on the projected business-as-usual scenario that would occur in the absence of interventions.

1.2 Nationally Consistent Energy Efficiency Program

The proposed regulation is an element of the National Appliance and Equipment Energy Efficiency Program (NAEEEP). NAEEEP is part of the National Greenhouse Strategy and

targets the energy efficiency of consumer appliances, industrial and commercial equipment. The main tools of the Program are mandatory energy efficiency labelling, minimum energy performance standards, and voluntary measures including endorsement labelling, training and support to promote the best available products.

NAEEEP's governance structure is as follows:

- The Program is the direct responsibility of the National Appliance and Equipment Energy Efficiency Committee (NAEEEC), which comprises officials from the Commonwealth, State and Territory government agencies, together with representatives from New Zealand, responsible for implementing product energy efficiency initiatives in those jurisdictions.
- NAEEEC reports through the Working Group for Energy Efficiency and Greenhouse Gas (E2WG) to the Ministerial Council on Energy (MCE), which is made up of the Ministers with portfolio responsibility for implementation of the National Greenhouse Strategy in this field.
- MCE has charged E2WG to manage the overall policy and budget of the national program.

NAEEEP relies on State and Territory legislation to give legal effect. In turn, this legislation invokes the relevant Australian Standards for the specific product type. In the present case, State and Territory legislation will invoke the forthcoming AS/NZS 1056 series for water heaters[1]. These arrangements are further explained in chapter 7, dealing with implementation of the proposals.

1.3 NAEEEP's policy framework

The broad policy directions of NAEEEP were reviewed in 1998-99 and again in 2000-01, with recommendations brought together in two 'Future Directions' documents (NAEEEC 1999 & 2001). The MCE subsequently endorsed certain changes, with the result that NAEEEP operates with the authority of the MCE with respect to broad policy objectives. These relate to product coverage, communication, and procedures and timetable.

Product coverage
Any type of consumer appliance, industrial or commercial equipment is eligible for inclusion in NAEEEP, provided it is identified as a likely contributor to growth in energy demand or greenhouse gas emissions. The selection criteria include potential for greenhouse or energy savings, environmental impact of the fuel type, opportunity to influence purchase, market barriers, access to testing facilities, and administrative complexity. The measures adopted by NAEEEP are subject to a community cost benefit analysis and consideration of whether the measures are generally acceptable to the community.

Communication
NAEEEP develops its product strategies through a transparent planning process, including by providing stakeholders with formal opportunities for providing comment and feedback.

Procedures and timetable
In respect of any proposal to implement MEPS, a significant initiative in recent years has been the decision by MCE to match the best MEPS level of Australia's trading partners, after taking account of differences in test methods and other relevant differences such as climate or consumer preferences. The explicit adoption of 'world's best regulatory practice' focuses attention on specific options, provides stakeholders with confidence that proposed MEPS are

[1] Part 5 of this standard, dealing with MEPS for water heaters, is currently in draft form. It is intended that the new standard will define the MEPS for all water heaters addressed in the RIS. The standard series covering electric water heaters has been substantially revised and is being published as a joint standard for the first time and may be published as a different standard number after the public consultation process.

technically feasible, and thereby avoids the long and many-sided debates that have characterised the development process in the past.

Related to that, NAEEEP uses the standards machinery that is familiar to industry. Labelling and standards requirements are implemented in Australian and New Zealand Standards, and developed in consultation with, and using the consultative machinery of, Standards Australia.

NAEEEP has also adopted a legislative timetable, designed to implement any proposed MEPS within 3 to 5 years, giving industry adequate notice of new MEPS and some certainty about the process.

1.4 Contribution of water heaters to energy use and greenhouse emissions

Water heaters account for about 30% of the energy used in the residential sector and greenhouse emissions due to water heaters at estimated at about 19 Mt CO_2-e. Electric water heaters account for about 81% of the total. However, the water heaters under consideration here contribute a small and declining share of this total.

Table 1.1 presents a very rough accounting for the energy consumption and greenhouse emissions that may be attributed to miscellaneous water heaters. Basically, it has been assumed that the existing stock of heaters is about 20 times larger than current sales and that the total number in service is contracting by a third in each decade. On these assumptions, energy use in 2010 will stand at 43.6% of its 1990 level, and the corresponding ratio for greenhouse emissions is 36.5%.

The energy used by water heaters has three components. In addition to the energy content of the hot water delivered to consumers, heat energy is lost from the pipes and from the storage tank of the heater itself. The latter 'standby' or 'standing' losses account for about 30% of total energy consumption.

TABLE 1.1 ENERGY CONSUMPTION AND GREENHOUSE EMISSIONS: 1990-2010

	Energy use		*Greenhouse emissions*		
	GWh	*% of 1990 level*	*Mt CO_2-e*	*% of total emissions*	*% of 1990 level*
	Total - standing losses, pipe losses plus delivered hot water				
1990	2,055	100.0%	2.5	0.49%	100.0%
2000	1,356	66.0%	1.5	0.28%	60.7%
2010	895	43.6%	0.9	0.16%	36.5%
	Standing losses only				
1990	617	100.0%	0.8	0.15%	100.0%
2000	407	66.0%	0.5	0.08%	60.7%
2010	269	43.6%	0.3	0.05%	36.5%

1.5 Market failure

For there to be scope for regulations to achieve cost-effective reductions in standing losses, markets must be regarded as having failed to minimise the lifecycle costs of using water heaters.

An important consideration in this context is that the lifetime value of standing losses from miscellaneous water heaters is typically greater than the installed cost of the heater, and may

be up to 20% larger. Ideally, therefore, the rate of heat loss should be at least as significant a consideration as the purchase price. However, it is apparent that is not the case. There is little enquiry after lower loss water heaters, and less demand. An obvious reason is the circumstances under water heaters are replaced. There is usually some urgency about the transaction since a replacement is needed for a unit that has suddenly failed. The plumber who breaks the bad news is often the only source of advice about a suitable replacement.

Similarly, builders usually choose the water heaters that are installed in new dwellings, and they have no on-going interest in the heat losses of the unit.

Manufacturers agree that heat losses are often not a primary or even a significant consideration in the purchase of a water heater. Moreover, the cost effectiveness of regulatory measures to promote energy efficiency has been demonstrated across a range of appliances and equipment in many countries.

2 The objective

This section explains the objectives of the regulations, firstly in terms of NAEEEC's strategy for water heaters, and secondly in terms of the formal objectives against which the proposal is assessed in this RIS.

2.1 NAEEEP's strategy for water heaters

Existing measures
Mandatory MEPS currently apply to mains pressure types of water heater, for sizes up to 630 litres of 'rated delivery'. The Australian and New Zealand Minerals and Energy Council (ANZMEC) decided on these measures in 1996, and they took effect in October 1999. The MEPS levels are expressed as maximum standing heat losses in Australian Standard AS1056.1 *Storage Water Heaters: General Requirements* - Amendment 3 (5 August 1996). MEPS are given effect in each State and Territory by the same regulations that govern appliance energy labelling. The prospect of revising the MEPS levels for electric storage water heaters was first formally discussed between government and the industry in 1996, when the 1999 MEPS levels were adopted. It was agreed that the 1999 MEPS levels would not be revised before October 2004 at the earliest.

The possible inclusion of various type of miscellaneous water heaters within the MEPS program in Australia was flagged in the MEPS profile which was released for public discussion in October 2001.

It has since been decided that a further changes will take effect from 1 October 2005, but only for the smaller mains pressure units (<80 litres). This will bring the smaller units into line with the stringency that has applied to the larger units since 1999. This change is the subject of a separate RIS (GWA 2003)

Australia and New Zealand currently operate different MEPS regimes for water heaters. (New Zealand has the more stringent requirements and has obtained a temporary exemption under the Trans-Tasman Mutual Recognition Act preventing non-complying imports from Australia.) However a common water heater standing heat loss test method has been developed which, if adopted by both Standards Australia and Standards New Zealand, would enable the one test to be used to determine a model's compliance with MEPS in both Australia and New Zealand.

Proposed measures
As noted already, the measures addressed by this RIS would bring the MEPS arrangements for miscellaneous heaters into line with the measures already applying to mains pressure units. Mains pressure and miscellaneous units present much the same issues of standing heat loss, and the same solutions will be adopted. At a technical level, therefore, there is nothing to justify different requirements. The proposed change will also align more closely the type of products covered for MEPS in Australia and New Zealand (noting that New Zealand have covered low pressure units from their introduction).

Looking further into the future, the MEPS for mains pressure types of electric water heaters are currently the subject of further discussions with industry, with a view to further tightening and alignment with world best practice. Currently there are significant gaps between Australian MEPS and corresponding MEPS in New Zealand and North America. Most likely, this will further raise the bar for the miscellaneous types.

In view of the substantial and increasing greenhouse emissions due to electric boiling water heaters, NAEEEC is also working with the industry to develop a package of measures to address this issue. This includes monitoring overseas developments of MEPS levels and testing methodologies. At this stage, however, NAEEEC does not intend to introduce MEPS for electric instantaneous water heaters, heat pump water heaters and solar water heaters (noting that the latter two are mostly covered by the national scheme on renewable energy credits or RECS).

Another development has been the reconsideration of the role of energy labelling for water heaters. Mandatory energy labelling was originally rejected in favour of a MEPS-only strategy because there was little variation in energy efficiency that the labels could describe. This situation is now changing and NAEEEC considers that there is a role for industry to provide more systematic information to customers on running costs and greenhouse emissions.

NAEEEC is also looking to work with stakeholders to develop best practice information programs aimed at the plumbers who install hot water heaters, and the development of modules in existing training courses for the building trades.

2.2 Specific objectives of the proposal

The objective of the proposed regulation is to reduce Australia's greenhouse gas emissions from the use of water heaters, subject to the following constraints:

- The measures need to be cost-effective for the broad community of users.
- The measures need to be efficiently designed, minimising adverse impacts on manufacturers and suppliers, and minimising adverse impacts on product quality and function.
- The measures need to be clear and comprehensive, minimising potential for confusion or ambiguity for users and suppliers.

3 Options

NAEEEC's options for promoting the efficiency of miscellaneous water heaters are explained here, generating a shortlist of options for more detailed consideration in chapter 4.

3.1 The proposed regulation

Scope of the regulation
The proposed regulation applies to vented storage water heaters and heat exchanger water heaters *that are heated solely by electricity*, and currently falling within the scope of the following standards (as amended):

- AS1056.1-1991: *Storage water heaters - General requirements*
- AS1361-1995: *Electric heat-exchange water heaters - For domestic applications*

The relevant standards committee is developing a new regulatory standard covering both types of electric water heater. It is proposed that the new MEPS will be contained in Part 5 of the new standard – AS/NZS 1056.5: *Water Heaters – Minimum Energy Performance Standards Requirements*.[2]

The existing standards apply to unvented storage water heaters with a rated delivery in the range 25-630 litres, and to heat exchanger types with storage capacity in the range 45-710 litres. (See appendix 1 for an explanation of these measures of capacity.) The proposal is to reduce the lower bound to zero in both cases, which means that smaller heaters will not escape regulation.

The effect of restricting the proposal to units heated solely by electricity is to exclude units that are partially or wholly energised by solar panels or by combustion stoves.

Taken together, the vented and heat exchanger types account for about 6% of total sales of electric heaters. That small share is expected to decline even further. The common characteristic of the two basic types is that the stored water is not kept under pressure. This allows the storage tank to be made of copper rather than steel, and using a simpler design, making them somewhat cheaper and much more durable than mains pressure units.

The heat exchanger type nevertheless deliver hot water at mains pressure, since the cold water passes through the storage tank in a copper coil, exchanging heat with the stored water as it does so. On the other hand the heat exchange arrangement effectively reduces the amount of usable heat, which means that to deliver a certain amount of usable hot water these units need to be somewhat larger. For the same reason, heat exchanger types require more frequent reheating and cannot take full advantage of off-peak tariffs.

The heat exchanger types are more suited to warmer climates where the heat exchange requirement is reduced by the higher temperature of the cold water supply. Accordingly, Queensland is the main market for heat exchanger types. But there are also some sales into Victoria and Tasmania.

The market for the vented or low pressure type is very small, put here are 2,000 units per year, compared with annuals sales of 18,000 for heat exchanger types. Suppliers describe the market as one being for replacement units only, sold mainly into Victoria and South Australia but with some sales into Tasmania and NSW. The low cost of manufacture is more than negated by the following considerations:

[2] As noted previously, this revised series of joint standards may have a new standard number.

- More households have a pressurised water supply, either from a reticulated supply or by pump attached to the domestic water storage. Increasingly, there is less reason to make do with the low pressures obtained by gravity from storage tanks installed in the ceiling.
- Water quality is also improving in regional areas, reducing the non-corrosive advantage of copper over steel.
- The cost advantages are offset by the additional cost of installing units in the ceiling. Some roofing may have to be removed; battens and rafters may have to be cut.
- Industry contacts also blamed plumbers' advice and government policy. Plumbers are now much more familiar with the mains pressure units and are reluctant to work in the ceiling when the alternative is to install a mains pressure unit on the floor level or outdoors. Regarding policy direction, gas-fired and solar water heaters are strongly favoured by building codes and other elements of greenhouse and energy efficiency policy.

Timing of the regulation
The proposal is to implement the proposal from October 2005, coinciding with the introduction of more demanding MEPS for mains pressure units with rated delivery of less than less 80 litres. The effect will be to restore the level playing field that was initially disturbed when more stringent standards for mains pressure units took effect in 1999.

Stringency of the regulation
The proposed MEPS are tabulated in appendix 1, differentiated according to the type and size of the water heater. Relevant technical explanations are also provided there. These requirements are also summarised in figures 3.1 and 3.2. Note that, whereas the MEPS for vented storage types are defined for discrete sizes, the MEPS for heater exchange types are defined by continuous functions. (AS1361 actually defines MEPS levels for discrete sizes but the use of these discrete sizes is not required in the standard, so an equivalent continuous function was developed.)

FIGURE 3.1 MEPS FOR VENTED STORAGE (LOW PRESSURE) UNITS

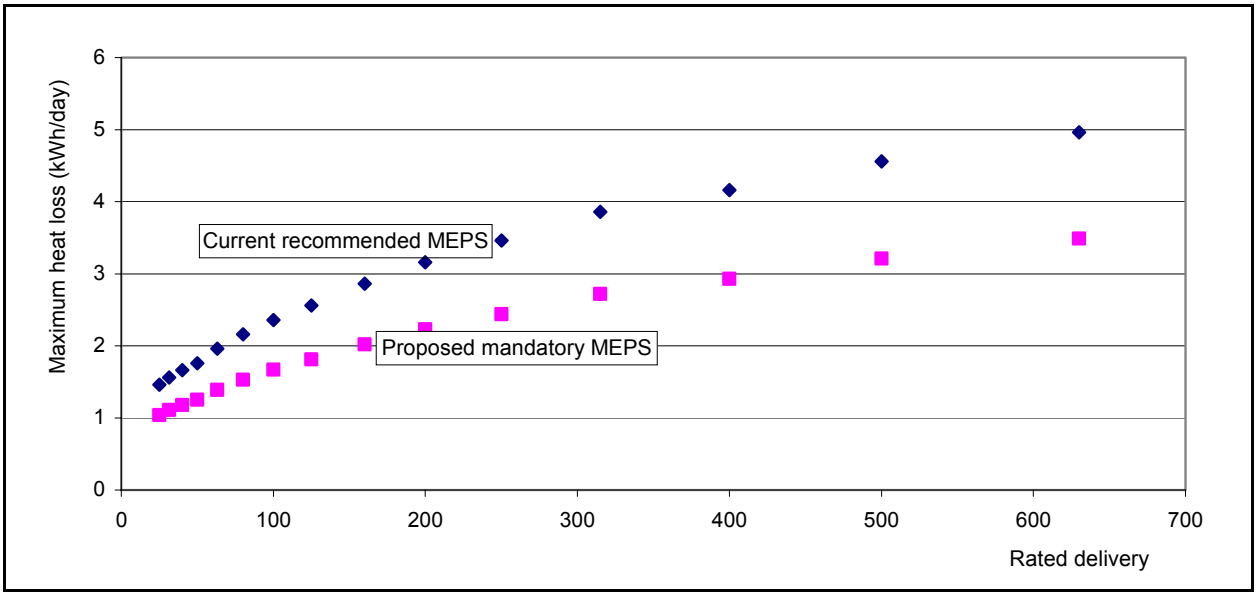
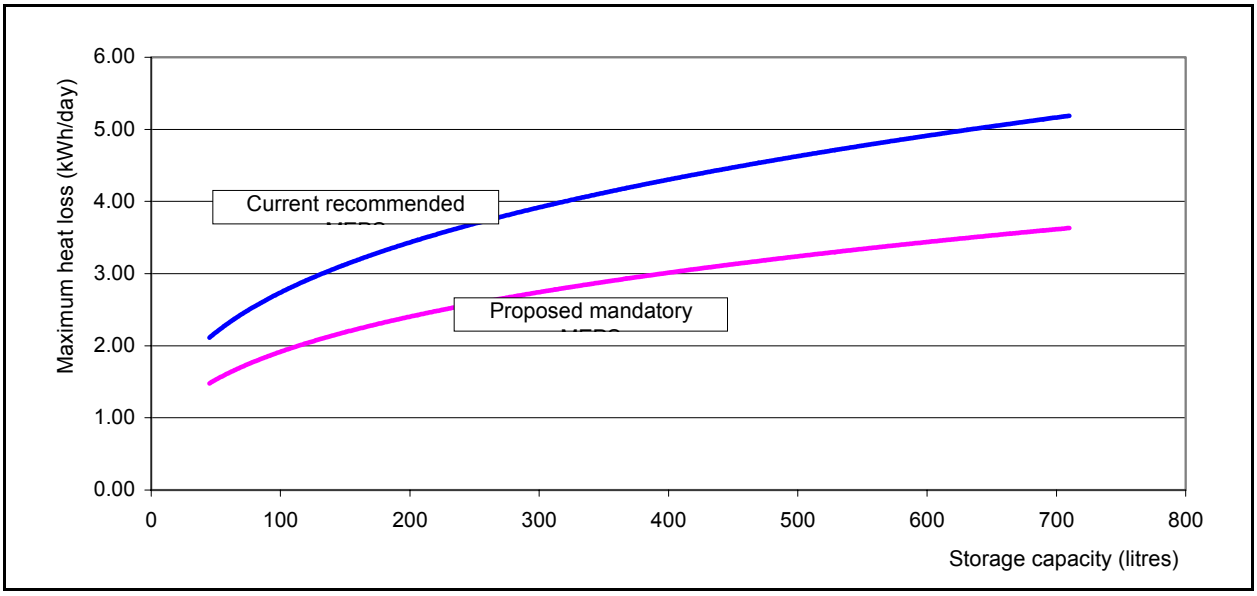


FIGURE 3.2 MEPS FOR HEAT EXCHANGER UNITS



The MEPS allow larger heat losses for larger units, but with maximum heat losses increasing less than proportionally with size. This is because the exposed external area of a heater increases less than proportionately with its volume, and it is the exposed external area that largely determines the rate of heat loss.

In both cases, the proposed mandatory requirement is to reduce the maximum standing heat loss to 30% less than the current recommended maximum.

Based on discussions with suppliers, there already exist a number of products that either comply with the proposed mandatory MEPS, or come close to doing so. However, the proportion of sales would be certainly less than 10%.

3.2 Other options

Scope of the regulation

Inclusion of partially electric heaters?

The proposal could be extended to include miscellaneous units that are only partially heated by electricity. However such a move may be counter-productive from the perspective of greenhouse policy. Solar water heaters provide the clearest example. Consider that electric boosted solar heaters typically use less than 25%[3] of the electricity used by fully electric heaters, and therefore deliver at least a 75% reduction in greenhouse emissions relative to the conventional units. However solar heaters are also quite expensive, with a market share of no more than 5%. Conceivably, the increased cost of yet more efficient solar heaters would inhibit their market penetration and put at risk the benefits already delivered.

A related argument is that solar water heaters (and some heat pump water heaters) are eligible for Renewable Energy Credits (RECS) from the Office of the Renewable Energy Regulator. RECS are assessed on the basis of the solar water heater's total performance profile and the existence of this scheme is driving manufacturers to optimise the total system performance, which include heat losses from the system, in the most cost effective fashion. Under such a regime there is only a weak argument to regulate one part of such a system (eg heat loss)

[3] The figure of 25% is implicit in a study commissioned by Environment ACT (EP 2002); actual solar contributions will vary by state and region.

separately and in addition to the total system performance under RECS. Some tanks that perform well within a solar system have higher heat losses in lower parts of the tank and appear poor under a standard heat loss test.

The financial returns to decreased heat losses are also unattractive in a solar system, a point that becomes apparent when the value of energy savings from fully electric heaters is put against the increased cost of those heaters. As reported in chapter 4, improvements in the heat loss of fully electric heaters are expected to return a benefit/cost ratio of 2.1. This ratio is reduced to 0.5 if the energy savings are reduced by 75% in the case of solar water heaters.

Similar concerns would arise if the regulation applied to storage units linked to combustion stoves and only partially heated by electricity. Based on estimates in a recent report commissioned by the AGO (Paul 2003), the burning of firewood can actually be positive for greenhouse emissions and, even at its worst, may generate emissions at 10% of the rate of equivalent electric units. To the extent that the arrangement captures waste heat that would otherwise have escaped up the flue, the energy is also free.

It may be argued that the exclusion of partially electric heaters means that the playing field is not completely level. However it needs to be understood that the regulatory objective is to deal cost-effectively with the policy issue, which is greenhouse emissions in this case. Lighter regulation is appropriate for products that present fewer opportunities to cost-effectively reduce emissions. As it happens, the case for requiring lower heat losses from partially electric heaters is weak at best. It may actually be counterproductive[4]. Accordingly, no further consideration is given to this option.

Exemptions on account of relatively few or declining sales
Suppliers have also argued the case for excluding certain products that are produced in relatively small numbers. One option is to exclude vented storage heaters, total sales of which have been put at 2,000 units/year, or about 0.3% of the total market, leaving the regulation to apply only to the heat exchanger types (18,000 units/year). Another proposition is to exclude the smallest and largest heaters, for both vented storage and heat exchanger types, leaving the regulation to apply to the mid range of heaters that dominate sales. Sales of the smallest and largest heaters might tally to several hundreds, but no more, and are spread across a number of suppliers.

Again, the key issue is cost effectiveness. On the one hand, it would generally be more difficult to recover the upfront costs of design, testing and tooling for products with small production runs and declining sales. On the other hand, there has already been a significant investment in the efficiency of 94% of the electric heaters on the market, in response to earlier regulations, and it is only the marginal cost of adapting those solutions to the remaining 6% that needs to be considered. Given that these smaller markets have the benefit of a 6 year lag behind the initial implementation of MEPS for mains pressure systems in 1999, it is reasonable to suppose there is a ready supply of exemplars and widespread industry knowledge about how best to proceed. If follows that cost effectiveness does not necessarily suffer as the remaining small markets are brought within the scope of the regulation.

A further consideration is that the ‘few sales’ criterion cannot be directly implemented. Rather, it must be approximated by excluding certain types of water heaters or certain size ranges. It is unavoidable that some small producers will find themselves on the wrong side of that dividing line, and will be treated inequitably relative to other small producers with the favoured products.

Accordingly, we consider that exclusions cannot be justified by appeals to the small size of particular markets or product lines. No further consideration is given to this option.

[4] That said, it is likely that there will be some spillover from energy standards for fully electric heaters to other heaters. Suppliers often use the same basic designs for a range of different heaters and it may prove economic to standardise the design of storage units around the new heat loss requirements

Timing of the regulation
There may be a lag of only one year between implementation of the regulation and its taking effect in October 2005. Arguably, industry should be given more time to adapt. However, it is apparent that suppliers accounting for more than 90% of the market have anticipated the proposal and are well-placed to make the adjustment. The levels for future MEPS of these products were originally flagged in a MEPS profile published in October 2001, so clearly much of industry has reacted to these initial proposals. For the most part, the industry will be catching up with MEPS that were imposed on mains pressure units in 1999, having been originally announced in 1996. No further consideration is given to this option.

Type and stringency of the regulation
A number of other options were canvassed in the earlier RIS for the smaller mains pressure types of water heater (GAW 2003). These included non-regulatory approaches – specifically, voluntary MEPS of the kind already in place, labelling, and levies on inefficient equipment and/or the consumption of electricity. Different levels of stringency were considered, ranging from a 20% reduction to a 50% reduction relative to the (then) recommended MEPS. Staged MEPS were also considered, with heat losses being reduced in a number of steps.

However, regardless of the merits or otherwise of the options considered for mains pressure types, the only practical alternative to the *status quo* for miscellaneous heaters is to align with the MEPS that have been implemented for mains pressure types. There is no significant technological or market distinction that could justify an intermediate solution.

The inclusion of low pressure units into the MEPS regime also aligns more closely – at least in terms of product type, if not MEPS level – the regulations of Australia and New Zealand, which is important under TTMRA.

Having created a level playing field in regulatory terms, it will be preserved in future by uniformly applying regulatory changes to the entire sector.

Labelling of 'high efficiency' units and the option of sales weighted compliance
Suppliers of miscellaneous water heaters have rejected AGO's offer to be included in a sales-weighted compliance scheme that is being made available to suppliers of mains pressure units. To explain, the proposed scheme for mains pressure units has the following elements:

- The Standard will contain a provision allowing suppliers to designate certain models as 'low loss' water heaters. The proposed 'low loss' level is about 20% lower than the heat loss specified under 2005 MEPS. This level is broadly equivalent to New Zealand MEPS requirements for tanks up to about 200 litres.
- Manufacturers of the 'low loss' heaters will be acknowledged as part of the Top Energy Saver Award Winner (TESAW) program. TESAW is a new award system that created by NAEEEC to recognise the most efficient products on the market and to help consumers to identify those products. It complements rather than replaces the star rating scheme, an important difference being that the minimum efficiency criteria for the awards are reviewed each year. In the case of electric water heaters, however, the criteria are likely to remain unchanged for some time as there is no comparative energy label for these products and large changes in heat loss are not expected from year to year after the implementation of MEPS.
- The emergence of a range of lower heat loss water heaters provides the context for the regulatory option of sales-weighted compliance that is being implemented only for mains pressure units with a rated delivery of 50 litres. The effect of this provision is to allow manufacturers to continue providing some non-complying (higher heat loss products that comply with 1999 MEPS levels) product for a period of 5 years after the introduction of the 2005 MEPS, provided those sales are offset by equivalent sales of 'low loss' product. The proposed requirement is that such a 'low loss' product will have to meet or exceed the TESAW criteria to be part of the sales weighted arrangement.

This provision recognises that a minority of customers would otherwise face substantial additional costs when replacing small heaters in confined spaces that were not designed to accommodate the thicker insulation and increased bulk of low loss units. It is restricted to units with rated delivery of 50 litres because that is particular size most affected by space restrictions.

That said, suppliers of miscellaneous water heaters have indicated to AGO that they are not interested in having access to this option. Based on industry advice, none of the vented storage products fall in the relevant size range (50 litres of rated hot water delivery), and only a small proportion of the heat exchanger product would do so. In the latter case, the continuous nature of the volume specifications also creates the opportunity of overcoming dimensional constraints by slightly reducing the storage volume. Given the small number of units involved, this option is more attractive than the option of engaging the TESAW program.

Given the lack of supplier interest in this option, no further consideration is given to the option of sales-weighted compliance.

3.3 Shortlist of alternative options

Accordingly, the shortlist of options contains only two items. One is to preserve the *status quo*. The other is to adopt the proposal. None of the other options is given further consideration.

4 Impacts analysis

This chapter is organised in 5 sections. The first four examine the difference between the proposed regulation and the BAU scenarios from a number of perspectives, as follows:

- Impact on energy use and greenhouse emissions – section 4.1
- Impact on users – section 4.2
- Impact on government – section 4.3
- Impact on suppliers – section 4.4

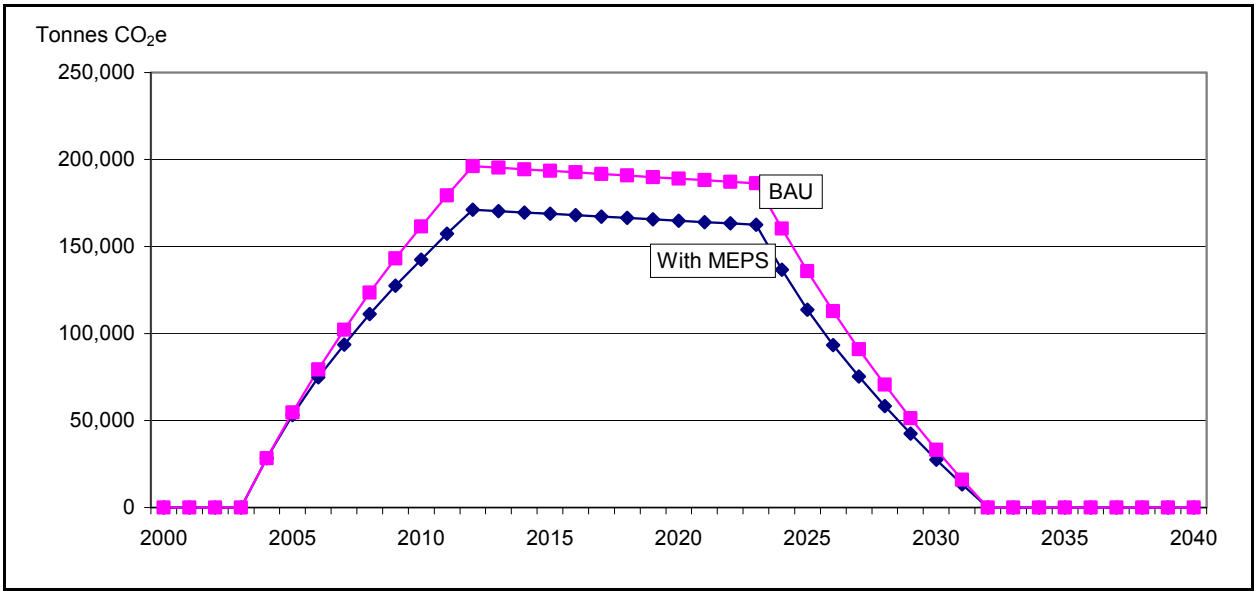
A national perspective is adopted in the final section, incorporating the results of the first four sections in a single statement.

4.1 Impact on energy use and greenhouse emissions

Figure 4.1 reports estimates of greenhouse emissions from miscellaneous water heaters that will be supplied to the domestic market in the period to 2012. The greenhouse reductions are represented by the gap between the BAU (business as usual) projection and the 'With MEPS' projection. The profile reflects the following considerations:

- 2012 is a convenient end point for examining the impact of the regulation. It is not only the final year of the first commitment period under the Kyoto Protocol, it is also reasonable to expect that MEPS for water heaters will be given fresh consideration by 2012. It is unreasonable to assume that decisions taken know would have impacts on water heaters purchased after 2012.
- It is assumed that the regulation is fully effective in 2007, but that sales of more efficient units are growing through 2005 and 2006.
- Annual savings start to fall away after 2024 as the water heaters acquired in the period to 2012 are retired and replaced.

FIGURE 4.1 PROFILES OF GREENHOUSE EMISSIONS, WITH AND WITHOUT THE MEPS: UNITS INSTALLED 2004-2012



- Figure A2.1 in appendix 2 presents the corresponding profile for energy consumption for both scenarios. The two profiles are very similar, only difference being that greenhouse emissions grow more slowly. This reflects the expectation that the greenhouse intensity of electricity generation will decline over time, mainly due to fuel switching from coal to gas and an increasing share of renewables.

The total savings of electricity and greenhouse gas are about 487 GWh and 487 $ktCO_2$-e respectively. At their peak in 2012, energy use and greenhouse emissions would be reduced by 15% relative to the BAU projections for the standing losses from miscellaneous heaters *supplied in the period 2004-2012*. However, the transition to more efficient water heaters would be incomplete at this stage, since currently supplied water heaters may not be finally retired until 2030 or later. The savings would continue to increase to about 25% of the projected levels if the regulation is maintained indefinitely. In the longer term, however, it is increasingly difficult to know how the regulation would differ from the normal processes of technological change and efficiency improvement.

The TESAW labelling provisions are assumed to contribute relatively little to the total energy savings, only 2%. Certainly, a minority of users buy “high efficiency” products as a matter of principle. However, a conservative estimate is appropriate in view of uncertainty about the take-up of this marketing option by suppliers to the relatively small markets that are under consideration.

4.2 Impact on users

Table 4.1 presents estimates of benefits and costs from the perspective of users. The main assumptions are as follows.

- The impact on miscellaneous heaters has been modelled in terms of 9 basic models listed in the table, comprising 4 sizes of the vented type and 5 sizes of the heater exchanger type.
- The installed cost has been estimated from industry sources.

TABLE 4.1 BENEFIT COST ANALYSIS – USER PERSPECTIVE

Size (litres)*	*Baseline sales (2003)*	*Installed cost ($)*	*Increase in installed cost ($)*	*Value of annual energy savings ($/year)*	*Lifetime value of energy savings ($)*	*Benefit/cost ratio*
			Vented type			
160	400	800	120	17	217	1.8
250	600	920	138	21	264	1.9
315	600	990	149	24	295	2.0
400	400	1,050	158	26	318	2.0
			Heat exchanger type			
70	750	630	95	23	285	3.0
140	7500	765	115	19	241	2.1
180	4500	805	121	21	262	2.2
280	4500	935	140	24	293	2.1
400	750	1,180	177	19	232	1.3
			Aggregate costs and benefits			
All	20,000		$9.3 million		$19.4 million	2.1

Note:

* The size of vented types is measured by the 'rated delivery' of the unit, whereas the size of heat exchanger types is measured by the capacity of the storage unit.

- The increase in the installed cost has been put at 15% for all units. This covers the cost of additional foam insulation, more metal for the outside case, larger cartons, increased costs of transport and storage, and increases in installation cost where the new unit does not fit easily in to the space occupied by the unit that it replaces.
- The energy savings have been estimated as the reduction in the heat losses required by the MEPS. However, the reductions that would be observed under test conditions have been discounted by 25% to allow for certain differences between test conditions and in-use conditions.
- The value of energy savings have been estimated on the assumptions that mid-sized heaters are on extended off-peak tariffs, smaller heaters are on standard tariffs, and larger heaters are on full off-peak tariffs. For heater exchanger units, the difference in tariffs largely accounts for the relatively high returns to small units and relatively low returns to the largest units.

On these assumptions, the aggregate benefits and costs are $19.4 million and $9.3 million, yielding a net present value of $10.1 million and a benefit/cost ratio of 2.1. Appendix 2 provides a more detailed explanation of the assumptions. There is one exception; the 15% estimate for the increase in installed cost is discussed here.

Increase in the installed cost of water heaters

To estimate the increase in the installed cost of lower loss water heaters, we rely on two previous studies of regulatory impacts.

Australian study

The cost issue has been addressed in a previous RIS (GWA 2001) dealing with the regulation of small (<80 litres rated delivery) water heaters of the mains pressure type. The same analysis was presented in a subsequent revision to that document (GWA 2003). The analysis is in two stages, first dealing with impacts on the retail price, then dealing with additional costs of overcoming dimensional constraints.

The findings with respect to the retail price are summarised in table 4.2, extracted from appendix 5 of the earlier document. Note the following:

- The estimates are based on analysis of a sample of 5 small heaters with rated delivery in the range 18-50 litres. The estimates in table 4.2 are averages across the five units.
- It is assumed that heat losses are reduced to the required level by increasing the thickness of foam insulation, adding to both the diameter and the height of the unit.
- The estimates allow for increased materials (more foam, more metal for the outside casing, longer fittings and larger carton), the increased cost of storage and transport, plus the capital cost retooling production lines.
- A separate estimate is provided for the increase in retail price that can be sustained after the cost of retooling has been recovered, which is assumed to happen after the first several years. These (smaller) increases are shown in the final column of table 4.2.
- A mark-up factor of 1.7 has been applied to allow for the mark-ups that would be applied at the wholesale and retail stages.
- The estimates of interest to this RIS are presented in bold, corresponding top a 30% reduction in heat losses. The estimated increase in retail prices is 12-15%. It would be somewhat less relative to the installed cost of the unit.

Additionally, installation costs are further increased where the new (larger) heater cannot be accommodated in the existing space. Either the space is enlarged or the heater is relocated. Drawing on an earlier dimensional study (NTS 1999) GWA find that that this is a significant additional cost, but affecting only a minority of heaters – specifically, and extra $350 for 2% of sales. The overall effect is to add about $7 to the average cost of installation and to add about 2% to the average retail price of a water heater.

TABLE 4.2 AUSTRALIAN ESTIMATES OF REGULATORY IMPACT ON THE RETAIL PRICE OF SMALL WATER HEATERS

% reduction in heat loss, relative to BAU	*Including retooling costs*		*% increase on BAU price, excluding retooling costs*
	Retail price ($/unit)	*% increase, relative to BAU retail price*	
20%	420.17	11.9%	9.1%
30%	**432.60**	**15.2%**	**12.5%**
40%	449.96	19.8%	17.1%
50%	475.81	26.7%	24.0%
Memo: BAU retail price	375.50	-	-

US study

The estimates reported in table 4.3 have been extracted from the Technical Support Document published by the USDoE (Department of Energy), which provides regulatory impact analysis of options for the regulation of residential water heaters. To quote from the document, the table shows …

> *…, for all standard sizes, the difference in total installed cost for each design option compared to the 2003 baseline for electric water heaters. Variations in total installed cost include variations in manufacturing cost, mark-up, and installed cost. An additional installation cost is added for water heaters with 3" insulation for a fraction of housing units to account for the removal and re-installation of doorjambs. This is shown in the figure for design options that include 3" insulation.* (USDoE 2000: page 9-89).

A 190 litre water heater would be regarded as average in the US.

The estimates of interest to this RIS are presented in bold. Based on discussions with industry, the general expectation is that foam insulation will need to be increased to 50-60 mm, which approximates 2-2.5 inches. In broad terms, therefore, these estimates indicate that the installed cost would increase by about 20%.

TABLE 4.3 US ESTIMATES OF REGULATORY IMPACT ON AVERAGE INSTALLED COST OF RESIDENTIAL WATER HEATERS ($US)

Design option	*Average manufacturing costs*	*Average retail price*	*Average total installed cost*	*% increase relative to baseline*
2003 baseline	114	220	385	-
Heat traps	117	227	392	1.8%
Tank bottom insulation	121	235	400	3.9%
2" insulation	**143**	**278**	**446**	**15.8%**
2.5" insulation	**155**	**300**	**486**	**26.2%**
Plastic tank	179	347	535	39.0%
3" insulation	193	375	615	59.7%

Reasons for the 15% estimate adopted here
It is important to note that both previous Australian and US studies have factored in a significant mark-up factor of about 1.7. This means that an additional manufacturing cost of $1.00 is converted into a $1.70 increase in the retail price, but without any explicit accounting for the additional resource costs that would actually be incurred by wholesalers and retailers. Certainly, there would be some additional costs of storage and transport. However, these are only part of the costs of wholesale and retail operations and, based on the explicit estimates of additional transport and storage costs incurred by the manufacturer, the mechanical application of mark-up factors yields very generous allowances for the additional costs actually incurred by wholesalers and retailers.

Also, analysis of pricing information published by Energex indicates that the difference between 'low loss' and standard units is approximately 10%.

For the purposes of the draft RIS, therefore, the increase in installed cost is put at 15%, which is about 25% less the figure indicated by the US study.

Sensitivity analysis
Table 4.4 presents the results of sensitivity analysis for reasonable variations in key parameters. The cost/benefit ratio remains comfortably above 1 in all cases.

With respect to the discount rate, it is worth noting that investments in low loss water heaters are extremely low risk. Hot water is a basic service and it is reasonable to expect that better insulated heaters will continue to deliver reductions in heat losses regardless of what is happening in the rest of the economy. These appliances are almost never turned off in any household. A discount rate of 5% is very reasonable in those circumstances, and rate of 10% is quite unreasonable.

TABLE 4.4 SENSITIVITY ANALYSIS – USER PERSPECTIVE

Parameter	*Variation*	*Present values ($ million)*	*Benefit/cost*

		Costs	*Benefits*	*Net benefit*	*ratio*
Base case		9.3	19.4	10.1	2.1
Market growth					
	-10%/year	7.0	14.5	7.5	2.1
Ratio of in-use heat losses to losses observed under test conditions					
	65%	9.3	16.8	7.5	1.8
	85%	9.3	22.0	12.6	2.4
Electricity prices					
	10% higher	9.3	21.3	12.0	2.3
	10% lower	9.3	17.4	8.1	1.9
Increase in installed cost					
	20%	12.4	19.4	7.0	1.6
	10%	6.2	16.8	10.6	2.7
Discount rate					
	0%	11.1	37.1	26.0	3.3
	10%	7.9	11.3	3.3	1.4
Asset life					
	15 years	9.3	17.0	7.7	1.8

4.3 Impact on government

The impact of the proposals on the taxpayer will be minimal. Not only is NAEEEP a relatively inexpensive program from the viewpoint of taxpayers, but the majority of these costs would be incurred under BAU conditions. Once the proposed measures have been developed and implemented, there are no additional costs that can be attributed to the proposal.

On the first point the ongoing costs of administering the MEPS initiative are of the order of $2M per year at most. This allows for the equivalent of two full-time staff members in each of the regulatory authorities of the larger states, a somewhat smaller resource commitment from the smaller states, and ongoing work by AGO staff at the national level.

On the second point, the ongoing program of registration, monitoring and check testing would be required for the purposes the existing MEPS for water heaters. The additional cost of extend the program to include the remaining 6% of the market would be less than $5,000 and can be safely ignored for the purposes of the RIS.

4.4 Impact on suppliers

A number of manufacturers were surveyed informally to identify impacts. There seem to be two broad groups.

Two manufacturers, one each from Queensland and Victoria, comprise the first group and supply about 90% of the market for miscellaneous water heaters. They are already quite comfortable with the proposed MEPS, having developed energy efficient product that they believe to be substantially compliant. They expect to make some further adjustments when subjected to laboratory tests, but there is no anxiety on that score.

The remaining 10% of the market is supplied by a number of smaller manufacturers. There are four operations in Victoria and South Australia, each making 250 – 750 units per year. In addition, industry contacts mentioned a number of even smaller suppliers that appear to be little more than backyard operations and operate from regional centres. While most of the smaller manufacturers were not aware of the proposals at the time they were interviewed for the purposes of this RIS, they considered that they would be able to make the appropriate

adjustments. However they questioned whether the effort was justified for a market that is already very small and is projected to decline further.

Manufacturers are not totally reliant on the market for water heaters falling within the scope of the proposal. Some make commercial and industrial heaters to a variety of specifications, with the Victorian dairy industry being a large market. Others have developed niche markets in non-electric storage systems, for connection to solar panels and combustion stoves.

Regarding trade issues, all of the suppliers identified in the original scoping study (MEA 2001) are domestic manufacturers; none are importers. In our discussions with suppliers regarding the commercial impact of the proposal, none expressed concern about import competition or competitiveness of exports. The general impression that trade issues are not significant is reinforced by the findings the AGO's initial investigation of the market for miscellaneous heaters (MEA 2001). MEA found that … *There is little available information on the trade in electric water heater types under review, however it is estimated that the great majority are manufactured in Australia* (MEA 2001: page 24).

In discussions with manufacturers we also raised the issue of upfront costs, such as the costs of design, testing, registration and retooling. As already indicated, the larger manufacturers indicated that they had already worked through the issues and that further costs would be relatively small. Smaller manufacturers considered that their costs would be in the range $10,000 to $20,000. Given the progress that has already been made, it appears that the further upfront costs by the industry as a whole would not be greater than $150,000.

4.5 National benefits and costs

Table 4.5 presents the results of benefit/cost analysis from a national perspective, which differs from the user perspective on two matters. First the upfront cost to suppliers is included as separate costs that are not passed onto users. The second matter is more significant and relates to the avoidable cost of electricity.

To explain, the cost of electricity consists of the cost of electricity generation (including the energy lost as heat in transmission and distribution), the cost of network services (poles, wires and substations for transmission and distribution of electricity) and the market costs associated with functions such as metering, billing and advertising. These costs are recovered in the tariffs charged to users and users rightly look to the tariff schedules to determine the value of energy savings. From the perspective of the broader community, however, some of these costs are not avoidable. That is, they cannot be reduced by energy saving measures. Market costs are the obvious but relatively minor example, since market costs generally account for less than 5% of average costs.

Less obviously, the large fixed costs of providing network services means that the marginal cost of providing additional network capacity is considerably less than the average costs. Based on a recent report to the Australian Building Codes Board[5] (ABCB), the marginal network cost of a general increase in energy use might be reasonably put at about 30% of average network costs, although considerable uncertainty attaches to any such estimate. This proportion should be further reduced for appliances that contribute relatively little to peak loads. Water heaters fall into this category. By definition, any heater on an off-peak tariff contributes nothing to peak loads on electricity networks.

To a degree, these considerations are already factored into off-peak tariffs, which are up to 50% less than standard tariffs. However, a further discount may reasonably be applied. Accordingly, the estimates in table 4.5 assume that the avoidable cost of electricity used by

[5] Atech (2003), *A Financial Analysis Procedure for Energy Efficiency in Buildings*, Report to the Australian Building Codes Board

TABLE 4.5 COSTS, BENEFITS & SENSITIVITY ANALYSIS FROM A NATIONAL PERSPECTIVE

Parameter	*Variation*	*Present values ($ million)*			*Benefit/cost ratio*
		Costs	*Benefits*	*Net benefit*	
Base case		9.5	12.7	3.2	1.3
Market growth					
	-10%/year	7.1	9.5	2.4	1.3
Ratio of in-use heat losses to losses observed under test conditions					
	65%	9.5	11.0	1.5	1.2
	85%	9.5	14.4	4.9	1.5
Electricity prices					
	10% higher	9.5	14.0	4.5	1.5
	10% lower	9.5	11.4	2.0	1.2
Increase in installed cost					
	20%	12.6	12.7	0.1	1.0
	10%	6.4	11.0	4.6	1.7
Discount rate					
	0%	11.3	24.3	13.1	2.2
	10%	8.1	7.4	-0.7	0.9
Asset life					
	15 years	9.5	11.1	1.7	1.2

water heaters is only 5 cents/kWh. The net present value of the proposal is reduced to $3.2 million, and the benefit /cost ratio to 1.3.

As reported in table 4.5, the proposal becomes marginal for a discount rate of 10%. Otherwise the returns are positive for reasonable variations in key parameters.

5 Consultation

GWA (2003) provides an exhaustive chronology of previous reports and consultations, giving considerable exposure to water heaters MEPS over the last decade. The earliest reports and consultations date back to 1993. However most this work was in relation to mains pressure units. Detailed work on miscellaneous heaters has a shorter history, starting with an AGO-commissioned technical study undertaken by Energy Partners in association with Sustainable Solutions Pty Ltd and the University of New South Wales (EP et al 2000). The consultative activities undertaken since then are as follows:

May 2000	AGO publishes *Technical Study on Improving on Electric Water Heater Efficiency* (EP et al 2000), dealing with electric water heaters generally but including specific aspects of the design of low pressure and heat exchange types.
March 2001	AGO publishes *Analysis of Potential for Minimum Energy Performance Standards for Miscellaneous Water Heaters* (MEA 2001), profiling the market and identifying issues and stakeholders.
October 2001	AGO publishes *Consideration of Miscellaneous Electric Water Heaters For Minimum Energy Performance Standards* (NAEEEP 2001), outlining plans for improving the efficiency of electric water heaters not covered by existing MEPS.
2001 - 2004	Development of consolidated standards for mains pressure, vented and heat exchange water heaters, due to be finalised before the end of 2004.
March 2004	Informal industry discussions for the purposes of this RIS.
23 June 2004	Discussion and final resolution of outstanding issues with affected manufacturers and standards committee members, Melbourne.

Proposed consultations

The following further consultations are planned for 2004.

- The AGO will send out copies the draft RIS to known interested parties, advertise its availability, and hold public meetings if there is demand.
- Written comments will be received until <<…>>
- NAEEEC will determine its response to the comments and revise the final RIS as appropriate.

6 Conclusion and recommended option

Table 6.1 provides a summary statement of the two options considered in this RIS against the objectives of the proposed regulation. It is recommended that:

1 States and Territories implement the proposed mandatory minimum energy performance standards for miscellaneous electric water heaters.

2 Existing State and Territory regulations governing appliance energy labelling and MEPS be amended to implement the proposed standards for miscellaneous electric water heaters.

TABLE 6.1 ASSESSMENT SUMMARY

Objective	*BAU option*	*Proposed MEPS*
Reduction in greenhouse emissions	The outlook is for declining emissions of greenhouse gasses, reflecting the contracting market for miscellaneous types of water heaters.	Greenhouse emissions from the targeted water heaters will be reduced by about 2% in 2012, rising to 7.5% over the longer term.
Cost effective for users	Most users continue to minimise capital costs, but largely ignore the potential to reduce 'whole of life' costs by improving energy efficiency.	Total benefits exceed total costs by a significant margin. The benefit/cost ratio for most users would be in the range 2.0 – 2.4. There would be few losers because even those who use hot water sparingly cannot avoid standing losses. Only those with very low energy costs would be financially worse off.
Minimise adverse effects on manufacturers and suppliers	The business as usual scenario is for continued decline of this relatively small market.	Manufacturers accounting for at least 90% of the market seem to be well prepared for the proposed MEPS. They have already developed some energy efficient product, although they have more work to do. The remaining manufacturers say they can make the appropriate changes, but question the value of imposing these requirements on a small and declining market.
Minimise potential for confusion or ambiguity	No confusion or ambiguity	Although some suppliers were still unaware of the proposals when interviewed for this RIS, they readily understood the nature of the proposals and the required response in terms of product redesign.

7 Implementation and review

State and Territory legislation is required to give legal effect to the national scheme for mandatory energy labeling and performance standards. This creates potential for additional costs and inconvenience to industry for inconsistencies in the operations of the various regulatory agencies to create. NAEEEC published a set of administrative guidelines to minimize those risks (NAEEEC 2000). The Guidelines are not legally binding but they are intended to guide State and Territory regulatory agencies to facilitate uniform and consistent practice across the individual jurisdictions, delivering consistent outcomes for all affected products irrespective of the product or jurisdiction.

Key elements of the scheme are as follows:

- The technical details of the MEPS are contained in Australian Standards that are incorporated by reference into the State and Territory legislation. The Standards do not vary between States. The format and content of Australian Standards are also familiar to industry, as are the operations of Standards Australia.
- Changes to the technical detail in Standards are subject to transition periods that are negotiated between industry and government.
- To minimize trade barriers, State and Territory regulatory agencies support a policy of adopting international standards wherever appropriate.
- Grandfathering arrangements are adopted, allowing reasonable time for the phase out of non-complying stock.
- All States and Territories accept the registration of an appliance or equipment undertaken in another State.
- State and Territory regulatory agencies have set target time periods within which they aim to process applications.
- Proposed changes in administrative and operating practice are subject to consultation between states.
- Compliance monitoring takes the form of a program of check testing by accredited laboratories.
- Equipment is selected for check testing on the basis of risk factors rather than randomly. The risk factors are as follows:
    - history of success and failure in check tests;
    - age of models, with newer models given greater attention, reflecting the prospect of longer life in the market;
    - high volume sales;
    - claims of high efficiency;
    - complaints from third parties.
- There are several sanctions. There is a shaming option involving publication of failed brands or models in the AGO annual report. The second option is deregistration by the state authorities, subject to show cause procedures. Subsequent sale of deregistered appliances would be a criminal offence. Re-registration of models that are subject to MEPS is subject to new registration tests. The third option involves legal action by the Australian Consumer and Competition Commission but is highly unlikely.
- Standard statistical criteria are applied to deal with normal variation in the performance of equipment selected for check testing. (A sample of only one is selected initially, with a further sample of three selected if the first fails.)

- Laboratories that produce misleading test results may also be denied further registration business.
- In due course the introduction of more stringent MEPS will also be handled nationally. That is likely to be in 2012. Further increases in the stringency level at that time will be subject to the same processes of industry consultation and a RIS.
- NAEEEC holds a consultation forum each year, providing an opportunity for stakeholders to raise concerns about the operation of the Standards or the Guidelines.

The check-testing and sanctions regime is obviously critical. Currently, check-testing expenditure (on all products) is running at about $350,000 per year, and accounts for about 25% of NAEEEC's budget. The 2002 program included 160 laboratory tests, 126 tests as part of the standards development program and 34 as part of the enforcement program. There were 12 instances where the claimed energy efficiency was not supported by testing conducted at NATA accredited laboratories. State regulators subsequently deregistered six products, and negotiated acceptable outcomes including re-labelling of another four products.

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APPENDIX 1: PROPOSED MINIMUM ENERGY PERFORMANCE REQUIREMENTS

Technical background

Heat losses

The energy in a hot water storage tank can be lost in three ways. First, there is energy of the water drawn-off by the user in the form of hot water – in the shower, laundry or kitchen. Second, some energy is lost as the heated water moves along the pipe from heater to user. Third, energy also is lost through the shell and external fittings of the heater itself. The proposed measure addresses only the third form of energy loss, called standing heat loses. The heater needs to be insulated and otherwise designed to ensure that the standing heat loss that is observed over 24 hours under standard test conditions does not exceed the required maximum allowable level.

For compliance purposes, heat losses are measured under the test conditions prescribed by Australian Standard AS1056.1 *Storage Water Heaters: General Requirements*. Briefly, these test conditions are that:

- The water is the storage tank is maintained at a constant temperature of 75^{O}C over a 24 hour period.
- The temperature of the surrounding air is kept at 20^{O}C.
- The test is conducted in a space that is protected from draughts.
- The unit is isolated from the usual pipes, requiring that the inlet and outlet pipes be disconnected, plugged and lagged.

The water heater heat loss test methods for Australia and New Zealand have historically been separate, but work over several years has resulted in a joint test method which is due to be published in late 2004 or early 2005. The basic parameters are simular to the previous AS1056 requirements, but considerable work has been undertaken to improve the reproducibility of the test method through use of continuous measurements, corrections and analytical techniques.

However, the heat losses that are observed under test conditions in a laboratory are somewhat different to that that would actually occur in use. Consider that:

- The average temperature of the water in the storage tank will often be less than its maximum. This reduces the rate of heat loss, since the rate of loss varies directly with the temperature difference between storage water and surrounding air. This difference is narrowed as cold water is added after each draw-off, and endures for extended periods in heaters operating on off-peak tariffs. Since hot water rises, this means that insulation on the bottom and lower sides of the tank would be less effective in use than under test conditions.
- The temperature of the surrounding air may vary significantly from 20^{O}C. On the upside, for example, heat losses from units installed in ceiling space would be reduced by the higher temperatures in the ceiling during summer.
- Heat losses are accelerated by exposure to wind and weather, affecting units that are stalled outside the house.
- The rate of heat loss at inlets and outlets is higher in use than under test conditions, due to the high conductivity of the connecting pipe and cycling of hot water into the pipe caused by convection in some cases.

Storage configurations

Existing MEPS arrangements currently vary somewhat according to the storage configuration. The types are as follows:

- *Displacement storage units:* These are designed to hold a useful quantity of hot water that is directly heated. Cold water replaces the hot water as it is drawn off and

reheating continues after the flow has ceased. There are two sub-types for regulatory purposes:
    - *Unvented displacement storage units:* These heaters are closed to the atmosphere and operate at mains pressure. These units are already subject to mandatory MEPS and are not addressed in this RIS.
    - *Vented displacement storage water heaters:* The water in these units is not at mains pressure, generally requiring that the unit be placed in ceiling and gravity-fed to the user. Otherwise a remote header tank may be installed at a high point, creating adequate pressure in a unit installed at floor level. These 'low-pressure' units are currently subject to non-mandatory or recommended MEPS and the proposal is to bring them into line with the MEPS applying to unvented units, and to make them mandatory.
- *Heat exchanger water heaters, sometimes referred to as indirect storage units:* The tank in this type of unit contains static heated water (or other fluid) and a heat exchanger, the latter usually being a coil of copper tubing. Cold water passes through the heat exchanger at mains pressure and takes heat from the stored water. The stored water is then reheated. These units are currently subject to non-mandatory or recommended MEPS and the proposal is to reduce these MEPS levels to a level that is equivalent to the MEPS applied to unvented units, and to make these MEPS mandatory.

Heating configurations
Most water heaters are both a heating device and a storage device. They are electric or gas fired, with the heat applied directly to the stored water. There are two other broad options however. The water may be heated externally, in a solar panel or combustion stove, and transferred to the tank for storage prior to use. Or a heat transfer medium may be heated externally and passed through a heater exchanger to transfer heat to the stored water. The latter are sometimes called calorifiers.

Heating methods can be used in various combinations. For example the vast majority of solar units have supplementary electric or gas heating, since solar radiation is not always adequate. Similarly, most units hooked up to a combustion stove would have supplementary (or complementary) electric, gas or solar heating.

Finally, heat pumps may be used to collect ambient energy from the latent and sensible heat of the atmosphere for transfer to the storage tank. These units can also be solar boosted, by exposing the evaporator to direct solar radiation.

Capacity of water heaters
MEPS allow larger heat losses for larger units, but with maximum heat losses increasing less than proportionally with size. This is because the exposed area of a heater increases less than proportionately with its volume, and it is the exposed area that largely determines the rate of heat loss.

The further complication is that the capacity of a storage water heater can be measured in two ways. The first is simply the storage or volumetric capacity of the tank, and is used to measure the capacity of the 'indirect storage' or 'heat exchanger' types. The second measure is the unit's 'rated hot water delivery' and is used to measure the capacity of direct storage types. This is the amount of water the heater can deliver on standby mode, before a significant (12-14°C) drop in temperature. This may be as little as two-thirds of the storage capacity for poorly designed units, rising to 95% for well designed units in the case of displacement water heaters.

The ratio of rated delivery to storage capacity would be somewhat less for heat exchanger types, reflecting the need for higher temperatures throughout the storage tank to achieve an acceptable level of heat transfer through the heat exchanger. The hot water output capacity of

a heat exchanger type is very different to a displacement water heater and these types cannot be easily compared directly.

Development of Standards

Electric water heaters

The energy efficiency of electric water heaters is currently addressed by two Australian Standards, as amended since initial publication - AS1056.1-1991: *Storage water heaters - General requirements* and AS1361-1995: *Electric heat-exchange water heaters - For domestic applications.* These relate to the direct storage and indirect storage (heat exchanger) types respectively. Currently, the relevant standards committee is to working to develop a new regulatory standard for both types of electric water heater. The MEPS requirements will be contained in AS/NZS 1056.5: *Water Heaters – Minimum Energy Performance Standards Requirements*.

The values presented in the proposed revision have been increased to take account of the changed conditions in the forthcoming AS/NZS1056.1 for testing for loss of heat, primarily the addition of quick connects on the inlet and outlet. The change in the test does not constitute a technical change to the MEPS level.

Gas-fired water heaters

The design and construction of gas-fired water heaters is addressed by AS 4552-2000: *Gas water heaters.* The rate of heat loss from the storage tank is effectively governed by maximum requirements imposed on the rate of gas consumption needed to maintain the average temperature of the water at 45°C above ambient. This requirement is unchanged in current drafts of proposed revisions to this standard – see DR 04156: *Gas fired water heaters for hot water supply and or central heating.*

Solar and heat pump water heaters

The design and construction of solar and heat pump water heaters is addressed by AS/NZS 2712:2002: *Solar and heat pump water heaters - Design and construction.* It imposes no heat loss requirements on the storage tanks of such units provided there is no integral supplementary heating, that is, electric or gas booster. In the presence of integral supplementary heating, however, the requirements for maximum allowable heat loss are those contained in AS 1056.1 and AS 4552, that is, the corresponding standards for electric and gas-fired water heaters.

Combustion stove

None of the existing standards apply specifically to storage units connected to combustion stoves.

Scope of the proposed MEPS

The proposed regulation applies to unvented storage water heaters and heat exchanger water heaters *that are heated solely by electricity*, and currently falling within the scope of the following standards:

- AS1056.1-1991: *Storage water heaters - General requirements*
- AS1361-1995: *Electric heat-exchange water heaters - For domestic applications*

Existing and proposed MEPS

Vented storage water heaters.

Table A1.1 presents the MEPS schedules for vented water heaters. These values apply to water heaters with a single heating unit and may be increased by 0.2 kWh/24 hours for each additional heating unit (element). The values may also be increased by 0.3 kWh/24 hours for an attached feed tank, and by 0.2 kWh/24 hours for each temperature or temperature/pressure relief valve mounted on a hot part of the tank, but not for any valve mounted on a cold water fitting.

Heat exchanger types
The MEPS for heat exchanger types are calculated by the following equations, where V is the storage volume in litres:

Existing recommended maximum heat loss (kWh/day)	=	$.6099 \times V^{0.3261}$
Proposed mandatory maximum heat loss (kWh/day)	=	$.4269 \times V^{0.3261}$

The values from these equations apply to water heaters with a single heating unit and may be increased by 0.2 kWh/24 hours for each additional heating unit, by 0.3 kWh/24 hours for an attached feed tank, by 0.2 kWh/24 hours for an expansion relief valve and by 0.1 kWh/24 hours for each other water fitting (excluding a drain fitting). For purposes of comparison, table A1.2 shows the results of these formulas applied to the size categories that are used in the existing standard for heat exchanger types.

Table A1.1 MEPS for vented type water heaters

Rated hot water delivery (L)	*Existing recommended maximum heat loss (kWh/day)*	*Proposed mandatory maximum heat loss, from 1 October 2005 (kWh/day)*
25	1.46	1.04
31.5	1.56	1.11
40	1.66	1.18
50	1.76	1.25
63	1.96	1.39
80	2.16	1.53
100	2.36	1.67
125	2.56	1.81
160	2.86	2.02
200	3.16	2.23
250	3.46	2.44
315	3.86	2.72
400	4.16	2.93
500	4.56	3.21
630	4.96	3.49

Table A1.2 MEPS for heat exchanger type water heaters

Heat-storage volume (L)	*Existing recommended maximum heat loss (kWh/day)*	*Proposed mandatory maximum heat loss, from 1 October 2005 (kWh/day)*
45	2.11	1.48
56	2.27	1.59
71	2.45	1.71
90	2.65	1.85
112	2.84	1.99
140	3.06	2.14
180	3.32	2.32
224	3.56	2.49
280	3.83	2.68
355	4.14	2.90
450	4.47	3.13
560	4.80	3.36
710	5.19	3.63

New Zealand standards
The New Zealand MEPS levels are already more stringent than the proposals outlined in tables A1.1 and A1.2. Whereas the Australian proposal is to reduce the maximum heat loss by 30% relative to the current level, the New Zealand requirement is 40-50% lower.

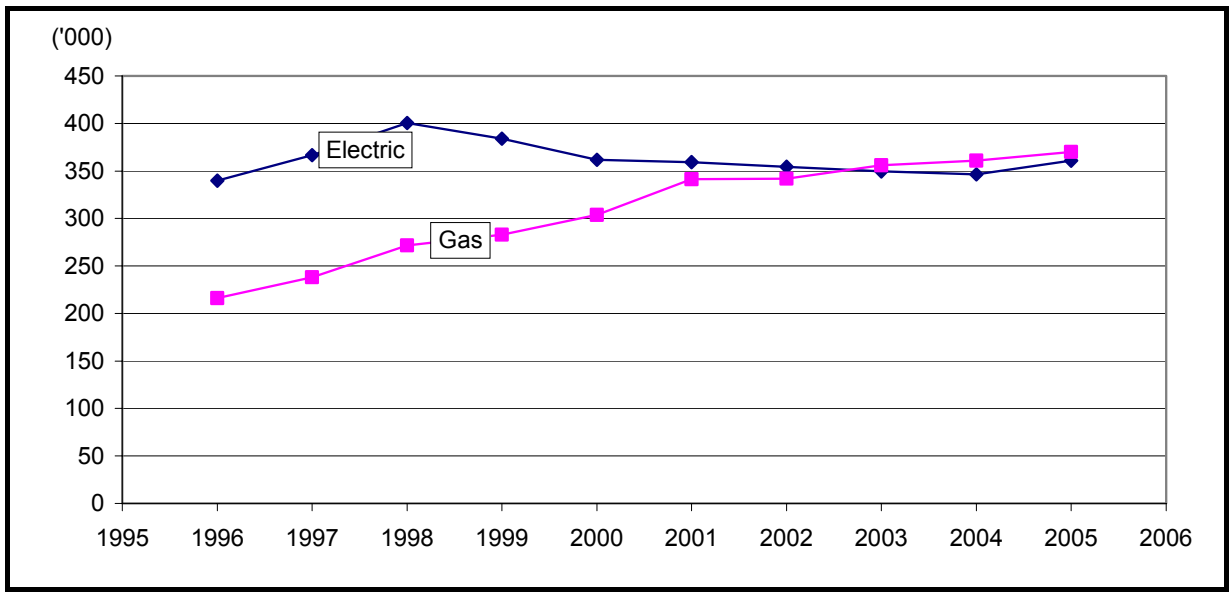
On 1 February 2003 the New Zealand government introduced a temporary exemption to the TTMRA with respect to MEPS requirements for electric storage water heaters. It intends to continue those exemption arrangements until 1 February 2005. After that date it is expected that the normal provisions of Trans Tasman Mutual Recognition Arrangement will apply (i.e. products lawfully sold in either country will be able to be sold in both countries).

APPENDIX 2: BENEFIT/COST ASSUMPTIONS

Market analysis

Figure A2.1 presents estimates of 'domestic supplies' of electric and gas water heaters, defined as domestic production plus imports minus exports. On these estimates, about 705,000 hot water heaters are sold into the residential market each year, including instantaneous heaters and solar water heaters with electric or gas boost. The long run rate of growth is about 2% per year and the general trend is for an increasing market share to gas heaters.

Figure A2.1 Household appliance market for hot water heaters



Source: BIS-Shrapnel 2003

The water heaters that are the subject of this RIS account for only a small percentage of those sales – about 3.1%. And 90% of those are of the heat exchanger type. Table A2.1 presents our baseline estimate of sales in 2003. Note the following:

- The estimates for total sales are somewhat less than those presented in a 2001 report to the AGO (MEA 2001). The main difference is for sales of vented storage heaters. These were previously put at 9,000/yr (in 1999/2000), compared with the estimate of 2,000/yr in table A2.1. Discussions with the main suppliers indicate that 2,000/yr is a maximum figure.
- The estimates of market share by size are based on discussions with the main suppliers and counts of the number of models in each size range.
- A steady sales decline has been forecast, at 5% per year. This would reduce sales to 63% of their current level in 10 years, and to 38% of their current level in 20 years. Industry contacts have cited a number of reasons for the poor outlook for sales of these heaters:
    - The market is restricted entirely to replacement sales. Virtually all new houses have access to pressurised water, if necessary by attaching a pump to the water supply, which severely restricts the market for the vented or low pressure types.
    - Plumbers receive much of the blame for the decline of sales, particularly gravity-fed units. They are familiar with the mains pressure units and tend to recommend them as a replacement. They are reluctant to work in the ceiling when the alternative is to install a mains pressure unit on the floor level or outdoors.
    - Gas-fired and solar water heaters are strongly favoured by building codes and other elements of greenhouse and energy efficiency policy.

- Some suppliers have developed high efficiency models, sales of which have been put at 10% of the total. Several forces are at work. It is partly anticipation of regulatory changes, partly a response to market demands, and partly a spillover from other markets that are more demanding, the market for solar heaters in particular. Other suppliers are still operating to old standards required by the (then) State Electricity Commissions.
- The estimates of unit costs have been obtained from industry price lists and include GST and the cost of installation. At these prices total annual expenditure is estimated at $16.8 million, $14.9 million of which is for units of the heat exchanger type. This includes installation and GST.

Table A2.2 Baseline assumptions about market size & composition - 2003

	Vented storage	*Heat exchanger*	*Total*	*Installed cost ($/unit)*
Total domestic sales - 2003	2,000	18,000	20,000	
By sector				
Residential	2,000	16,000	18,000	
Commercial	0	2,000	2,000	
By rated delivery (litres)				
160	400			800
250	600			920
315	600			990
400	400			1,050
By storage capacity (litres)				
70		750		630
140		7500		765
180		4500		805
280		4500		935
400		750		1,180
Other parameters				
Sales growth (%/year)	-5%	-5%	-5%	
Non-complying units (%)	85%	85%	85%	
Installed in the ceiling (%)	67%	0%		
Annual expenditure ($M)	1.9	14.9	16.8	

Other relevant aspects of the market are as follows:

- Queensland is the main market for heat exchanger types, but with some sales into Victoria and Tasmania. This reflects the higher temperature of the cold water supply, which reduces the demand for transfer of heat from the heated storage. They are most commonly installed outside, or under houses on high blocks, and it is generally easy to accommodate the increased bulk of more efficient heaters.
- The vented types are sold mainly into Victoria and South Australia, with some sales into Tasmania and NSW. These are usually installed in ceilings or, less commonly, outside. Very few are installed in cupboards within the house. The increased bulk of more efficient heaters can be problematic for ceiling installation, requiring some customers to make do with smaller capacity units.
- Both vented and heat exchange types tend to be somewhat cheaper than mains pressure units. They also last longer – up to 20-30 years. This is essentially because they don't have to withstand mains pressure, allowing the tank to be made of copper rather than steel and a more straightforward design.
- However, the costs of installation can be higher, at least when installed in the ceiling. Some roofing may have to be removed; battens and rafters may have to be cut.

- Heat exchanger types cannot take full advantage of off-peak tariffs, since efficient heat transfer requires relatively high temperatures to be maintained through the tank.

Energy savings and greenhouse reductions

Reduction in energy use

It is assumed that the required energy efficiencies will be achieved by adding extra insulation to the sides and top of each unit. Adding the following further assumptions, it is a simple matter to calculate the energy savings:

- Non-complying units are borderline compliant with the existing recommended MEPS.
- The non-complying units will achieve borderline compliance with the proposed mandatory MEPS.
- The test conditions approximate the actual operating conditions.

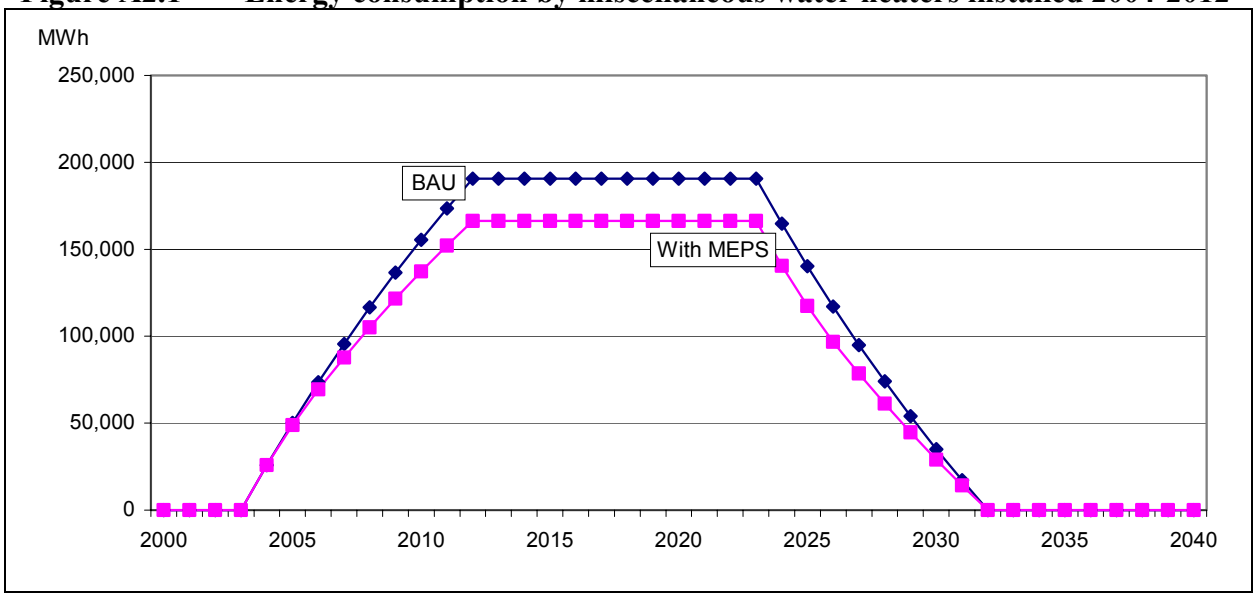
The first two of these assumptions are probably reasonable. The third assumption is problematic, however, for the reasons given in appendix 1. In particular, heat losses will be reduced for significant re-heat periods after water is drawn off, particularly in off-peak systems. This is because heat losses vary directly with the difference in temperature. Some guidance on this issue is provided by AS/NZS 1056.4:1997 *Storage water heaters - Daily energy consumption calculations for electric types.* The indicative figuring reported in Appendix A of that standard suggests that, for off-peak systems that provide heating between 11pm and 7am, in-use savings are 50-95% of the savings observed under test conditions, depending on the size of the unit, the amount of water drawn off, and the draw-off profile. For example, in-use savings are higher for the evening draw-off than for the morning draw-off. For the purposes of this RIS, in-use energy savings have therefore been put at 75% of the savings that would be observed under test conditions. This is a conservative assumption since most units are actually on extended off-peak tariff, which means that there will be some reheating during the day.

It is also recognised that some heaters operate in favourable heat loss environments - in ceiling spaces in particular. However, other heaters operate in less favourable conditions – such as exposure to wind and rain, and in cooler environments. Also, the set-point temperature of the stored water may be set higher or lower than the 75^{o}C assumed for the test, with consequent increases and decreases in the rate of heat loss. (According to industry sources, manufacturers set heat exchanger units to 80^{o}C, which would significantly increase the rate of heat loss.) For the purposes of this RIS it is assumed that these variations average out and that the test conditions are a reasonable approximation of the average conditions experienced in use.

Figure A2.1 presents the resulting profile of energy consumption by miscellaneous water heaters in the period to 2040. The energy savings are represented by the gap between the BAU (business as usual) and 'With MEPS' schedules. Note that:

- *Life of the regulation:* The figure refers the energy consumption by units purchased in the period to 2012. 2012 is a convenient end point. It is not only the final year of the first commitment period under the Kyoto Protocol, it is also reasonable to suppose that MEPS for water heaters would be given fresh consideration by 2012. It is unreasonable to assume that decisions taken know would have impacts beyond 2012.
- *Life of the water heaters:* A uniform asset life of 20 years has been assumed for all miscellaneous water heaters. This errs on the conservative side, since the industry view is that unpressurised units have a life of 25-30 years. However it is recognized that assets lives tend to be shortened by premature replacement with mains pressure units.
- *Ramp-up period:* Suppliers are assumed to achieve full compliance in 2007, with a ramp-up to full compliance in the years 2005 and 2006.

Figure A2.1 Energy consumption by miscellaneous water heaters installed 2004-2012



Dollar value of energy savings
The annual dollar value of the energy savings grows to about $1.8 million, reaching its maximum level in 2012 and maintained at that level till 2024 before tailing off. (Obviously, these savings follow the profile mapped out by the gap between the BAU and 'With MEPS' schedules in figure A2.1.) The present value of these savings, discounted at 5%/year, is $19.4 million.

Table A2.2 reports estimates of marginal tariffs that have been used in this calculation. They have been calculated with reference to the energy tariffs in the key markets (Victoria and South Australia for vented storage heaters, and Queensland for heat exchanger type), and with reference to industry estimates of the mix of standard, off-peak and extended off-peak tariffs.

Table A2.2: Marginal electricity tariffs

Retailer	*Standard domestic*	*Extended off peak*	*Off-peak*	
	Marginal tariffs(cents/kWh)			
Energex (Queensland)	11.41	7.72	5.26	
TXU (Eastern Victoria)	13.03	8.03	6.96	
Powercor (Western Victoria)	15.06	7.69	6.76	
ETSA Utilities (South Australia)	15.09	7.04		
Unit type and capacity	*Weights (%)*			*Weighted average tariff (cents/kWh)*
Vented storage units - averaged with reference to South Australian and Victorian country tariffs				
160	100%			7.59
250	100%			7.59
315	100%			7.59
400	100%			7.59
Heat exchanger units – with reference to Queensland tariffs				
70	100%	0%	0%	11.41
140	0%	100%	0%	7.72
180	0%	100%	0%	7.72
280	0%	90%	10%	7.47
400	0%	0%	100%	5.26

Greenhouse emissions
The profile of greenhouse emissions has a shape that is similar to that shown in figure A2.1for energy savings. And the units are approximately the same, since each MWh of electricity generates about 1 tonne of greenhouse gas emissions. The coefficient adopted in this RIS is a weighted average of the emissions coefficients reported by GWA in an earlier RIS for water heaters (GWA 2001: appendix 3). The emissions coefficient for Queensland has a weight of 90%, with weights of 6% and 4% assigned to Victoria and South Australia respectively.

The emissions intensity of electricity is assumed to decline at an average rate of 0.5% per year over the period of the projection, reflecting favourable changes in the mix of fuel used to generate electricity.

Increase in the installed cost of water heaters

The cost estimates are explained in section 4.2 of the report.