

National Appliance and Equipment Energy Efficiency Program
Analysis of Potential for Minimum Energy Performance Standards

for

Miscellaneous Water Heaters

Prepared for the Australian Greenhouse Office

by

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Mark Ellis & Associates is a consultancy service specialising in the design, management and evaluation of sustainable energy policies and programs. MEA brings over 17 years experience in Europe and Australasia to the following areas of expertise:

- energy and greenhouse policy
- greenhouse modelling
- design of energy efficiency strategies
- implementation and management of energy efficiency programs
- energy information and advisory services
- green pricing schemes
- energy sector micro-economic reform
- low energy planning and building design
- environmental impacts of energy generation technologies and fuels

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GLOSSARY

Thermosyphon This type of system, also called 'gravity' or 'gravity-circulation', does not use a pump to circulate the heated fluid from the solar collectors to the water storage tank. Thermosyphoning is the natural occurrence of water circulation (hot water rising) that takes place when the storage tank is located below the solar collectors.

EXECUTIVE SUMMARY

This report covers the following types of water systems:

- Electric Instantaneous (little or no storage)
- Electric Storage Low Pressure (domestic)
- Electric boosted Solar (including systems without boosting)
- Electric Calorifiers (domestic & commercial)
- Heat Exchangers
- Gas Storage (domestic & commercial)
- Gas Instantaneous (domestic & commercial)
- Gas Calorifiers (domestic & commercial)
- Gas boosted Solar
- Electric Boiling Water Heaters (boiling water dispensers, mainly commercial uses)
- Water heaters using solid fuels (usually wood) with a storage tank

This report does not cover mains pressure electric storage water heaters as MEPS levels and timetables have been determined through a separate process.

Market Profile

It is estimated that the stock of domestic water heaters in Australia will be approximately 7 million units by 2001. The annual market for all types of water heaters and for all applications is approximately 600,000-700,000 units. Of these, installations in new dwellings comprise around 150,000 per annum. The annual market for commercial water heaters of all types is approximately 20,000-22,000 units. These figures exclude sales of boiling water heaters.

In the period 1976 to 1999 the distribution of water heater types in the total stock has changed, as shown in Table E1, with a substantial trend away from electric towards gas water heaters, and a fairly stable share for solar water heaters.

Table E1: Distribution of Stock of Domestic Water Heaters by Type, 1976 to 1999

Year	Electric	Gas	Solar	Other	None
1976	65.4%	24.0%	0.6%	9.2%	0.8%
1980	66.1%	23.6%	2.6%	5.4%	2.3%
1983	66.2%	24.3%	4.0%	4.1%	1.4%
1986	64.7%	26.2%	5.2%	2.9%	0.9%
1994	60.5%	32.6%	4.8%	2.1%	0.0%
1999	59.0%	35.0%	4.8%	1.2%	0.0%

Domestic Sector

It is estimated that the water heating technologies under review account for approximately 44% of the annual domestic water heater market in Australia.

Table E2: Summary of Market for Water Heater Types under Review, Domestic Sector, 1999/2000

Category	Annual Market		Number Installed 2000	
	Units	%	Units	%
Elec Inst	12,000	1.7%	144,000	2.1%
LP Electric Storage	9,000	1.3%	120,000	1.7%
Electric Solar	15,000	2.2%	320,000	4.6%
Elec Calorifier	6,000	0.9%	150,000	2.1%
Heat Exchange	18,000	2.6%	216,000	3.1%
Gas Storage	177,000	25.7%	1,775,000	25.3%
Gas Instantaneous	6,000	9.3%	640,000	9.1%
Gas Solar	500	0.1%	6,000	0.1%
Total	302,000	43.8%	3,430,000	49.0%
Domestic Water Heating	690,000		7,000,000	

Commercial Sector

It is estimated that the water heating technologies under review account for approximately 67% of the annual commercial water heater market in Australia. The remaining 33% of the market comprises electric storage and gas boilers.

Table E3: Summary of Market for Water Heater Types under Review, Commercial Sector, 1999/2000

Category	Annual Market		Number Installed 2000	
	Units	%	Units	%
Elec Inst	3,000	13.6%	36,000	10.9%
Electric Solar	1,200	5.5%	14,400	4.4%
Elec Calorifier	2,000	9.1%	50,000	15.2%
Heat Exchange	3,000	13.6%	36,000	10.9%
Gas Storage	5,400	24.5%	64,800	19.6%
Gas Instantaneous *				
Gas Solar	150	0.7%	1,800	0.5%
Total	14,750	67.0%	203,000	61.5%
Commercial Water Heating	22,000			

(* included in domestic data)

There is an additional market of approximately 50,000 boiling water units in Australia, with a stock of around 500,000 units.

The large majority of water heater types under review are manufactured in Australia by Australian owned companies. The market is supplied by at least 30 major companies.

Market Trends

Trends in the market for water heaters in Australia are summarised as follows:

- Low-pressure electric storage units Calorifiers and Heat Exchangers have small market shares which are likely to decline;
- Electric Instant boiling water units may possibly increase their market penetration in Australia;
- Instantaneous electric water heaters may maintain their small market share as housing densities increase in urban areas, giving rise to more units;
- Gas commercial storage may increase their market share, as availability of gas increases;
- Solar water heaters have a fairly static and small market share. This may change with the introduction of initiatives such as the Federal Government's 2% target.

Standards

Although most of the technologies under review are currently subject to standards (see following table), many of the MEPS levels no longer have much impact due to technology improvements. In additions, some of the test methodologies are not appropriate to particular technologies.

Table E4: Summary of Australia MEPS and Test Methodologies

Water Heater	MEPS	Test Methodology
Electric Instantaneous – commercial & domestic	N/A	N/A
Electric Low Pressure – domestic	AS/NZS1056.1: 1996	AS/NZS1056.1: 1996
Electric Solar – commercial & domestic	N/A	AS2984:1987, AS2813:1985, AS4234:1994, AS4445.1:1997
Electric Calorifier – commercial & domestic	AS1361: 1995 – AS1056.1, 2 & 4	AS1361: 1995 AS1056.1, 2 & 4
Heat Exchange – commercial & domestic	AS1361: 1995	AS1361: 1995
Gas Storage – commercial	AG102: 1998	AG102: 1998
Gas Calorifier – commercial & domestic	AG102: 1998, AS1361: 1995	AG102: 1998, AS1361: 1995
Gas Solar – commercial & domestic	AG102: 1998	AG102: 1998, AS2984: 1987, AS2813: 1985, AS4234: 1994, AS4445.1:1997

Standards and relevant test methodologies exist for most of these technologies overseas.

Greenhouse Emissions

Domestic Sector

The total energy consumption in 1999/2000 is estimated to be 13,880 GWh for the water heater types under review. Of this, gas usage (mains and LPG) accounts for 12,120 GWh (43.6 PJ) and electricity usage accounts for 1,760 GWh.

Greenhouse emissions from these technologies are estimated to be approximately 4,660 kt CO₂-e per annum. This is equivalent to approximately 29% of emissions due to hot water production in the domestic sector. The remaining 71% of emissions result from the use of mains pressure conventional electric storage water heaters.

Commercial Sector

The total energy consumption in 1999/2000 is estimated to be 654 GWh for the water heater types under review. Of this total, gas usage (mains and LPG) accounts for 393 GWh (1.41 PJ) and electricity usage accounts for 261 GWh.

Greenhouse emissions from these technologies are estimated to be approximately 358 kt CO₂-e per annum. This is equivalent to 45% of emissions due to hot water production in the commercial sector (not including boiling water heaters).

Emissions due to boiling water heaters in both the domestic and commercial sectors are calculated to be approximately 1.25 Mt CO₂-e in 1999/2000.

Table E5: Summary of Greenhouse Emissions, 1999/2000

Water Heater Category	Greenhouse Emissions kt CO₂-e / annum		
	Domestic	Commercial	Other
Electric Instantaneous	215.5	71.8	
LP Electric Storage	538.7		
Electric Solar	383.1	17.2	
Electric Calorifier	224.4	99.8	

Heat Exchange	323.2	71.8	
Gas Storage	2,186.4	96.6	
Gas Instantaneous	789.1		
Gas Solar	3.0	0.9	
Boiling Water Heaters			1,256.9
Total	4,663.3	358.1	1,256.9

Recommendations

The following recommendations are made:

Electric Instantaneous Water Heaters

MEPS are not recommended for these products at this time, although they should be considered again if either the market in Australia increases substantially, or effective standards are adopted overseas.

Electric Boiling Water Heaters

MEPS are recommended for these products and, in the absence of international MEPS standards which could be applied, Australia will be required to develop their own standards. However there is currently insufficient information on the performance of available appliances to assess an appropriate standard. Further investigation of the performance of a range of products, is therefore recommended.

It is further recommended that the existing Water Heater Standards Committee be formally asked to examine the options for developing appropriate test methods for electric boiling water heaters.

Electric Storage Water Heaters

It is recommended that the following electric storage water heaters should be required to meet minimum heat loss standards equivalent to the allowable losses from mains pressure hot water storage units that are currently enforced:

- Electric Low Pressure Water Heaters;
- Electric Boosted Solar Water Heaters (tank heat losses);
- Electric Calorifiers (domestic & commercial)
- Heat Exchangers

It is further recommended that the existing Water Heater Standards Committee be formally asked to examine the options for developing appropriate test methods for each of the water heater types where they currently do not exist.

At this stage it is not recommended that MEPS be considered for electric heat pump water heaters.

Gas Storage and Instantaneous

It is recommended that MEPS levels in AG102 are updated to equivalent levels to those due to come into force in the United States in 2003 (USA NOPR 2000). In addition, energy performance and requirements in AG102 should apply to all units up to 500 MJ/h.

It is also recommended that for instantaneous gas water heaters, the energy performance standard should include all input energy, ie. any electricity used for electronic ignition.

Additional Strategies

Recommendations for other activities to compliment those identified above include:

- Endorsement of GWA proposals regarding the labelling of gas water heaters;
- Investigation of the likely impact of a voluntary labelling scheme for commercial gas water heaters;
- provision of information relating to the relative running costs and greenhouse gas emissions for various water heaters. This should cover a range of water heating technologies, climates and usage patterns. We suggest that this information is placed on the www.energyrating.gov.au website and other appropriate places.

- 'best practice' promotions for commercial gas water heaters, including technology demonstrations, best practice guides and benchmarks for typical water heating consumption costs for different business types. It is also suggested that the development of such materials is completed in conjunction with relevant industry representatives or trade organisations.
- targeted information programs aimed at hot water installers, and the development of modules in existing training courses for the building trades. In both cases, governments are encouraged to work through appropriate industry representatives or trade organisations.

Greenhouse Reductions

It is assumed that there will be a small growth of approximately 3% over the forthcoming decade in energy consumption by most products under review, as result of increased stock levels and/or increased average consumption per unit. The proposed MEPS level are estimated to lead to a 10% reduction in consumption, compared to the base case.

The cumulative greenhouse savings in 2010 resulting from the implementation of MEPS is estimated to 360 kt CO₂-e. This is predicted to rise to 690 kt CO₂-e in 2015.

Analysis of Potential for Minimum Energy Performance Standards for Miscellaneous Water Heaters, excluding Electric Storage Water Heaters.

1. PURPOSE

The Australian Greenhouse Office as part of the National Appliance and Equipment Energy Efficiency Program (NAEEEP) has commissioned this report. The purpose of this report is to explore the potential for energy and greenhouse savings through improvements to commercial and residential water heating equipment used in Australia.

2. SCOPE

This report covers the following types of water systems:

- Electric Instantaneous (little or no storage)
- Electric Storage Low Pressure (domestic)
- Electric boosted Solar (including systems without boosting)
- Electric Calorifiers (domestic & commercial)
- Heat Exchangers
- Gas Storage (domestic & commercial)
- Gas Instantaneous (domestic & commercial)
- Gas Calorifiers (domestic & commercial)
- Gas boosted Solar
- Electric Boiling Water Heaters (boiling water dispensers, mainly commercial uses)
- Water heaters using solid fuels (usually wood) with a storage tank

This report does not cover mains pressure electric storage water heaters (also called non-vented displacement water heaters) as MEPS levels and timetables have been determined through a separate process.

3. PRODUCT DESCRIPTION

3.1 General

For the purposes of this document, a water heater can be defined as a product that uses a fuel – in this case gas, electricity and/or heat energy from the sun – to produce hot water for use on demand. Other fuels such as wood with the use of a boiler or heat exchanger can also be used to heat water in a storage tank. There are two main types of water heater: **storage** and **instantaneous**, both of which are discussed in this document.

Storage water heaters can be fuelled by gas, electricity and heat energy from the sun, solid fuels, or a combination of these. They generally heat and store water at a thermostatically controlled temperature ready for use (solid fuel and solar systems are potentially uncontrolled energy inputs and can result in the storage tank reaching boiling temperature). Instantaneous water heaters heat water upon demand, contain no significant water storage (generally less than 6 litres) and can be fuelled by gas or electricity. Although an instantaneous unit does not use heat energy from the sun directly, it can use water pre-heated by solar energy that has been stored in a tank or calorifier.

Common applications of commercial water heaters include use in kitchens, hospitals, laboratories, motels, multi-unit housing, hotels, factories, clubs and ablution blocks. Boiling water units are also very common in commercial establishments (especially offices).

This section contains a brief description of typical examples of the types of water heaters under review.

3.2 Electric Instantaneous (domestic and commercial)

Electric instantaneous water heaters are small units that produce hot water “instantly” or on demand without a storage tank. Commercial and domestic electric instantaneous water heaters operate using the same principles and components.

The components of an electric instantaneous water heater include a flow switch, cold water inlet, hot water outlet, electric resistance element and casing. Typically the elements are rated at between 6 kW to 13 kW and draw a large current when used. They generally require three phase power which limits their availability.

When mains pressure water is introduced to the unit the flow switch engages and this supplies electricity to the electric resistance element in the water heater. As cold water passes over the electric element it is heated and then flows from the unit ready for the end use. The extent of heating is determined by the size of the heating element and the water flow rate. Typically the output water temperature is regulated by adjusting the water flow rate and the output from the resistance heater. More sophisticated models are now available where sensors and controls can provide a constant outlet temperature when flow rate or water temperature varies. The element power is usually varied by some form of high speed switching such as a thyristor control.

3.2.1 Electric Boiling Water Heaters

These water heaters produce high temperature water, predominantly for use in kitchens in the commercial and domestic sectors. Unlike most hot water systems, boiling water units provide hot water which is primarily intended for human consumption (in the form of beverages). Units heat water gradually and store a small amount of water (from 2 to 90 litres), depending upon their intended delivery volume, at constant temperature. Some brands deliver water at 100°C while others deliver to just under boiling point ready for use. In the domestic sector, units are now available to be fitted under kitchen sinks to provide instant boiling water for drinks (although these are still uncommon).

3.3 Electric Low Pressure (domestic)

Low pressure water heaters typically comprise an insulated hot water tank (insulation may be high density rockwool blanket or polyurethane), inlet and outlet and a cold water header tank, usually all located at the highest practical mounting point in a dwelling, e.g., in a roof space. Sometimes the storage tank is mounted at floor level with a remote header tank mounted in the highest possible position. The header tank stores cold water from the mains which is in turn fed into the hot water tank, where water is heated by means of an electric resistance element. The exact pressure of the water at the point of supply depends on the relative height that the tank or header tank is mounted. The supply pressure increases approximately 10kPa per metre of height (giving a total hot water pressure of

typically 30kPa to 60kPa in a normal installation), so there is often a significant difference between the system pressure and the mains cold water supply pressure (normal mains pressure supply is typically 150kPa to 800kPa).

Low pressure units typically have long lives, sometimes 25 or more years, as they are generally of copper construction and do not experience the stress corrosion experienced by mains pressure tanks. Sizes available for domestic electric low pressure units range from around 100 litres up to around 400 litres and are fitted with electric elements ranging from 2 to 6 kW in power [Industry Pers. Comm. 2000]. While there is a range of off the shelf sizes available, units can be purpose built to suit a particular application.

3.4 Electric Solar (domestic and commercial)

The main components of solar water heaters are the solar collector and insulated storage tank; some systems also have a pump and control valves. In a domestic installation, cold water passes through the collector, which is commonly mounted on a rooftop, where the water absorbs heat from the sun. The heated water is either stored in a tank located adjacent to the collector ("close-coupled") or in a remote storage tank on the ground floor (or ground) or in a remote tank mounted above the solar panels in a roof space. For tanks that are mounted below the solar panels, small electric powered pumps are usually used to circulate water through the system. Where the tank can be mounted above the solar panels, water circulates naturally according to the 'thermosyphon' principle.

Types of collectors used in Australia include:

- Flat plate collectors essentially consist of an absorber plate (with integral passages for heat transfer fluid), a transparent cover, insulation and a casing; and
- Evacuated tube collectors which are made up of rows of parallel transparent glass tubes, each tube has a glass outer and inner tube that is covered with a coating that absorbs solar radiation. The air from between the inner and outer tubes is evacuated which eliminates conductive and convective heat loss.

Flat plate collectors are by far the most common type of collector used in Australia. Evacuated tubes are more expensive and have only recently become commercially available, although they are more suited to high temperature applications and colder climates.

Water heating using solar heat energy occurs during the day and the solar contribution varies substantially throughout the year depending on the climate and weather. To meet the requirements of householders without excessively large storage facilities and collector areas, most solar storage tanks have the capability to "boost" the hot water temperature. Boosting is typically carried out by means of a standard 2.4 kW electric resistance element (elements can range from 1.8 to 4.8 kW, however 2.4 is standard). Storage tank sizes available for electric solar units range from 180 litres upwards depending on the application. Boost elements can be designed and positioned to run on continuous tariff or on off peak, depending on the climate and usage patterns.

Some commercial solar water heaters use either mains or LPG as a boost fuel (see 2.9 below). In hot North and North-West parts of Australia, some solar water heaters are installed without any boost facility, although this is unusual.

Commercial application solar water heaters are generally designed to provide over 2,000 litres of hot water per day. A typical commercial installation will have an array of collectors on the roof and a heat store at ground level. The heat store consists of a closed circuit heat exchange system and a store of potable water. A series of potable water storage units are housed inside an outer shell. The space between the outer shell and the storage units is filled with water and used for heat transfer. The heat store water is circulated between the array and the store constantly transferring heat to the potable water in the store of potable water [Industry Pers Comm. 2000].

The number of electrical booster elements installed in a commercial system depends on the size of the system, however between three and ten 5 kW elements are common, providing a total booster capacity of between 15kW and 50kW [Industry Pers. Comm. 2000]. There are several standard sizes available for commercial solar units, however systems may also be made to specification.

3.4.1 Solar Boosted Heat Pump

There are two types of heat pump: a **compact** model and a **solar boosted** model. For the purposes of this document the solar boosted model will be discussed in detail.

The compact unit is usually located outside, and the evaporator panels are attached to the outside of the storage tank (wrapped around the tank), so the compact unit is one module. The evaporator panels collect energy from the atmosphere surrounding the installed unit. The solar boosted unit has separate evaporator panels that are located on (or as part of) a roof where they have better access to direct solar radiation and wind. Refrigerant circulates between the storage tank (usually mounted on the ground or inside) and the panels.

The separate solar boosted evaporator panels allow a heat pump to be used in any climate (the compact model is not recommended for temperatures below 10°C) and operate slightly more efficiently than a compact model. The solar panels provide the capacity to produce 12 litres of hot water per hour. The components of a solar boosted heat pump include a compressor, an insulated pressurised tank, condenser, externally located evaporator panels and refrigerant gas.

A heat pump water heater works like a refrigerator in reverse, pumping heat from the surrounding environment into the hot water tank. The solar/evaporator panels are usually located on a roof or the side of a building while the tank is located at ground level. The compressor, attached to the tank, pumps refrigerant gas through the solar/evaporator panels where it collects heat from the surrounding environment. Having passed through the solar/evaporator panels the gas is returned to the tank where it flows through a tube coiled around the outside of the tank. As the gas passes along the tube it transfers its heat to the water inside the tank and then is pumped back to the solar/evaporator panels where the cycle begins again. Heat pump water heaters tend to operate most efficiently during the day when temperatures are warmest, air movement greater and solar radiation is available. Because they don't need to rely on direct radiation, they can be effectively mounted in roofs that do not face north or where there is some shading. System efficiency is lowest at night under clear skies (black body irradiation) and temperatures are cooler, so these are not generally recommended for use with off peak electricity. The system efficiency also falls away as the hot water temperature increases, so a storage temperature of around 60°C is normally the maximum available.

Heat pump water heaters are sized from around 100 litres upwards and can be purchased off the shelf. For commercial applications heat pump units can be configured in multiples or combined with other systems to meet hot water demand [Industry Pers. Comm. 2000].

3.5 Electric Calorifier (domestic and commercial)

Calorifiers can be either low pressure or mains pressure insulated hot water storage systems. In a low pressure unit the components include an insulated (with high density rockwool blanket or polyurethane) stainless steel or copper tank, pressure and temperature relief valves, heat exchange coil and, in some systems, an optional electric resistance element [industry pers. comm. 2000]. In low pressure units hot water is circulated within the tank by the thermosyphon principle or a small circulating pump is used. There are two methods employed for heating water in a low-pressure calorifier.

In the first case, externally heated water is circulated through a heat exchange coil in the base of the storage tank. The water supplied to the user is the water contained within the tank, not the water in the coil. In the case of an electric calorifier, the external heat source would be an electric stove or boiler (other heat sources such as solid fuel stoves, open fire places, solar and gas boilers are commonly used). A heat exchange coil is only used when the external heat source or fuel type is not compatible with water or the application – e.g. if the fuel used is steam, or the heat source is a stove made from corrosive metal.

The second method is employed when a direct connection with the heat source can be established, that is when the fuel type and heat source are compatible (e.g. not steam or corrosive). No coil is used, and instead the water from the storage tank is circulated directly to the heat source where it collects heat and then travels back to the tank and is stored ready for use.

In the case of a mains pressure unit (i.e. one that supplies mains pressure hot water to the user, but that stores water at low pressure) the cold-water inlet is connected to mains pressure - as with any standard mains pressure water heater. On entering the inlet, cold water is then fed – still at mains-pressure - along a long copper coil that passes through a tank of water heated by an external source. The storage tank of water imparts its heat to the mains pressure water as it passes through the tank. The mains pressure unit operates in the same fashion as a heat exchange unit.

Both low and mains pressure units come in a range of sizes from approximately 100 litres upward. Calorifiers for domestic and commercial applications are available as an “off the shelf” purchase or as a specified product.

Calorifiers tend to be more expensive than simple hot water services. Their major application is when the heat source is potentially corrosive, such as in marine applications. They are also used in dairies.

It is worth noting that there appears to be little practical difference between calorifiers and heat exchangers, and the two classifications are used fairly indiscriminately both here and overseas. Industry sources suggest that calorifiers tend to hold more storage water than heat exchange units [industry pers. Comm. 2000].

3.6 Heat Exchange (domestic and commercial)

Domestic heat exchange units comprise an insulated (usually injected polyurethane), open vented copper tank; an electric resistance element (for domestic applications 1.8 – 4.8kW); a pressure relief and top up valve; a heat exchanger; overflow outlet and hot water outlet (industry pers. comm. 2000). Commercial units have the same components as a domestic unit, except they have multiple, smaller heat exchange units [industry pers. comm. 2000]. Sizes range from 90 litres upward and products are available either “off the shelf” or as a specified product.

Heat exchange units can be configured in one of two ways. In both cases, the hot water storage is held at low pressure (vented). In the first configuration, the hot water in the tank is not drawn off and cold water is passed through coils of copper tubing immersed in a tank of hot water. As water passes through the coil it becomes hot through a process of heat transfer. Cold water flows into the copper tube as hot water flows out providing a continuous flow of hot water at close to mains pressure (apart from friction losses). This configuration is preferred for multiple or unrestrained heat source inputs such as solar and wood boilers as the storage vessel is vented so direct heat transfer is possible and the tank can be filled with anti-freeze or anti-corrosion additives as required. Where uncontrolled heat inputs are used (eg solar or solid fuel) it is also normal for the outlet temperature to be controlled with a thermostatic mixing valve or tempering valve, as the hot water delivery can be close to boiling and can easily cause burns and damage appliances.

The second configuration is less common although used in selected circumstances. The hot water in the tank is drawn off in exactly the same method as a low pressure hot water system (i.e. hot water stored in the tank is drawn off and displaced by cold water at the bottom so the delivery pressure is determined by the elevation of the tank itself or its header tank). External heat sources increase the stored water temperature by circulation of hot water through the heat exchange coils. Unrestrained heat source inputs require separate venting in the heat exchange circuit.

There can be problems with hot water supply if demand is high and therefore it is strongly recommended that the flow rate for heat exchange units be set to 9 – 12 litres per minute [Saxon 2000]. This limit would depend upon the design of the individual unit.

3.7 Gas Storage (domestic and commercial)

The components of a gas storage unit include a gas burner, flue(s), a tank insulated with polyurethane (sides and top) and fibreglass around the base, with an inlet at the base of the tank and outlet near the top [industry pers. comm. 2000].

A typical gas storage unit contains a specified amount of water in an insulated tank designed to hold water at a specific pressure and temperature. When a tap is turned on cold water enters the bottom of the tank pushing the less dense hot water through the outlet at the top of the tank to the hot water tap. The gas burner underneath the tank can reheat water while it is flowing and between uses. There are at least four basic types of flues used, including, single, multiple, floater and semi floater.

One of the key requirements of gas storage units is the supply of sufficient surface area for heat transfer from gas combustion to stored water. The use of multiple fin flue tubes can increase the surface area for heat transfer by over 450% [Industry Pers. Comm. 2000]. Most storage water heaters have an adjustable thermostat in order to control the output temperature of hot water.

Sizes of domestic storage system are typically between 90 and 200 litres, although some larger models are now marketed towards very large homes. The following table illustrates the capacity of systems for different sized households.

Table 1: Typical Sizes for Gas Storage Water Heaters

Cylinder Size (litres)	Number of People Served
90	1 - 3 people
135	2 – 4 people
170	3 – 5 people
200	4 – 6 people
260	5 – 9 people

For commercial applications sizes for individual units range from a storage capacity of around 200 litres upwards. There is an existing product range, however manufacturers can make to specification if required.

Domestic units typically consume between 20 MJ/hour and 50 MJ/hour and are usually designed to heat a full tank of water in approximately one hour.

Hourly energy input for commercial units can range from approximately 50MJ to 200MJ, which produces approximately 10kW to 50kW of hot water energy, depending on the system installed. The quantity of hot water produced depends upon the required temperature and the type of gas used, however it is typically between 145 and 955 litres per hour [Industry Pers. Comm. 2000].

3.8 Gas Instantaneous (domestic and commercial)

Instantaneous, or continuous flow systems, are fed by mains pressure water, or occasionally by gravity fed systems with sufficient pressure (> 150kPa), and have no storage tanks. They are therefore compact and can be mounted on an outside wall using an inbuilt flue, or on an internal wall using an external flue. Commercial and domestic electric instantaneous water heaters operate using the same principles and components.

Demand for hot water draws cold water through the inlet pipe and heat exchanger. The flow of water activates the provision of gas to the burners which light beneath the heater exchanger, thereby heating the water as passes through. The degree to which water is heated may be controlled by the flow of water passing through the heat exchanger, and by the flow of gas to the burner. Modern sophisticated units have electronic controls which regulate the output temperature.

Gas ignition may be achieved by the use of a pilot light or electronic ignition.

Models are available which provide output flow rates from 2 to 24 litres per minute, depending on the desired temperature rise and the ambient water temperature. A rate of 24 litres per minute is based on a 25°C temp rise. Gas consumption is up to 200MJ/hr for units which achieve high flow rates.

There is little distinction between units designed for domestic and commercial applications. Small models are available for caravans and single outlet applications. Most domestic and commercial uses require multiple outlets and use one of the larger units. For commercial use, several continuous flow water heaters may be connected together to provided the desired output.

3.9 Gas Calorifier (commercial and domestic)

As per an electric calorifier, except that the fuel source is gas instead of electricity. It appears that there are currently no manufacturers or importers of gas calorifiers in Australia.

3.10 Gas Solar (commercial and domestic)

As per electric solar, except that a gas fired water heater acts as the “booster”, either on a rooftop storage tank or in a ground mounted tank.

Boosting for commercial gas solar systems can range between approximately 275 and 475MJ per hour, [Industry Pers. Comm. 2000].

4. IDENTIFICATION OF STAKEHOLDERS

This section identifies organisations which are considered stakeholders in the types of water heaters under review. This is not an exhaustive list.

4.1 Manufacturers

4.1.1 Electric Instantaneous

Hocking

Edson

4.1.2 Electric Instant Water Boilers

Birko

Southcorp (Rheem)

Whelan

Wilson

Zip

4.1.3 Electric Low Pressure (domestic)

Astra

Beasley

Edson

Hot Water Systems Australia

Wilson

4.1.4 Electric Solar

Southcorp (Solahart and Rheem)

Beasley

Edwards Energy

Hot Water Systems Australia

Solco

4.1.5 Solar Heat Pumps

Quantum

4.1.6 Electric Calorifiers (domestic & commercial)

Hot Water Systems Australia.

Edson

4.1.7 Heat Exchangers

Edson

Wilson

Saxon

4.1.8 Gas Storage (domestic & commercial)

Aqua-Max Pty Ltd

Beasley Industries Pty Ltd

BSP Enterprises Pty Ltd

Camec (Vic) Pty Ltd

Coromal Caravans Pty Ltd

Dux Manufacturing Ltd
Edwards Energy Systems Pty Ltd
Electrolux Leisure Pty Ltd
Hot Water Systems Australia Pty Ltd
Solahart Industries Pty Ltd
Southcorp Australia Pty Ltd (Trade Name: Rheem)
Southcorp Australia Pty Ltd (Trade Name: Vulcan)
Suburban Manufacturing Company - Agent: Coast To Coast RV Services

4.1.9 Gas Instantaneous (domestic & commercial)

Australian Gas & Electric Company
Douglas and Company
Dux Manufacturing Ltd
Hunt Heating (A Div of Hunt Engineering Pty Ltd)
Rinnai Australia Pty Ltd
Robert Bosch (Aust) Pty Ltd
Servgas Pty Ltd
Southcorp Australia Pty Ltd (Trade Name: Vulcan)
Sunshine General Industries Pty Ltd

4.1.10 Gas Calorifiers (domestic & commercial)

None Known

4.1.11 Gas Solar

Beasley
Edwards
Hot Water Systems Australia
Southcorp (Solahart)

4.2 Trade Associations

4.2.1 AEEMA.

AEEMA is the peak industry association representing local and international companies involved in the design, development and production of electrical and electronic products and systems in Australia. Membership of the association exceeds 385 (95% of the industry by turnover) and comprises companies of all sizes, from all areas of the value chain committed to the development of world-class industries in Australia. It is recognised as a highly successful focused industry association.

AEEMA's objective is to strengthen the competitive position of the Australian electrical and electronic industries in both domestic and international markets. Through close co-operation with government and other bodies AEEMA successfully focuses attention on the concerns of the Australian Electrical and Electronic industries - taking an active role in influencing and shaping public policies and providing invaluable support in the areas of standards, competitiveness and networking.

AEEMA's ***Electrical Consumer Equipment Group*** represents the following areas, and is probably the group most appropriate for water heaters:

- Cable Processors & Accessories Division;
- Rotating Electric Machines Division;
- Domestic Appliance Division.

4.2.2 Australian Gas Association (AGA)

The Australian Gas Association (AGA) is the national body representing around 1000 members including 290 corporate members involved in Australia's dynamic natural gas industry.

The Association conducts the majority of its business through committees comprising industry representatives. These include six Standing Committees:

- Gas Network Operators Committee
- Gas Retailers Committee
- Gas Transmission Committee
- Gas Production Committee
- Gas Appliance and Equipment Committee
- Environment, Health and Safety Committee

There are also two Technical Committees

- Gas Technical Standards Council
- Technical Development Committee

In addition, there are other associated Committees, Task Forces and Project Groups to address issues on marketing and communication; professional development and education; research and development; technical and code development.

4.2.3 Energy Development Association of Australia (formerly Energy Development Association of Queensland)

This is a Private Industry "not for profit" Association founded in 1970 and plays a vital role in providing services to meet a wide range of needs associated with the various sectors of the Electricity, Electrical and Electronics Industries in Queensland. Objectives include:

- To encourage the efficient and wise use of electrical energy and energy efficient appliances in all sections of the community through media exposure and the holding of exhibitions, demonstrations and lectures;
- To encourage research and development in all areas of endeavour in the electrical and electronic fields to ensure that the Industry continues to grow and prosper and provide electricity to its customers that reflects the benefits of the latest technology, but has due regard to the environment;
- To represent the view and interests of the Electrical and Electronics Industry;
- To encourage the development and acceptance of high standards of quality and performance of all electrical and electronic equipment and services.

4.2.4 Master Plumbers Association

The Master Plumbers' and Mechanical Services Association of Australia (MPMSAA) is a registered national employer organisation providing representation and extensive services for a broad base of 1500 members in all sectors of the plumbing and mechanical services contracting industry.

The MPMSAA member companies operate in general plumbing contracting and maintenance services as well as in specialised industry areas. These specialised areas include 200 member companies engaged in the heating and cooling sector, and another 200 member companies engaged in the metal roofing and wall cladding sector.

Member and Associate companies of the MPMSAA comprising major employers of plumbers who contract and tender to National Developers, Constructors & Builders in the commercial building and construction sector also participate in the **National Plumbing and Mechanical Construction Industry Association Inc.**

4.2.5 Sustainable Energy Industry Association (SEIA) - Australia

The organisation's objectives are many and extend from promoting the adoption and use of renewable energy and energy efficiency strategies by industry, commerce and domestic users to establishing task forces and forums to facilitate the exchange of information and to help maintain existing industry programs.

Areas of involvement for the SEIA include policy making, industry development, projects, standards and accreditation, education and training, research and development, marketing, sales, export, information, public relations, administration and the provision of general services to members.

Other defined objectives include:

- promoting the use of energy sources which help in the reduction of greenhouse gas emissions;
- transparent, non-discriminatory and which incorporate all foreseen costs;
- lobbying governments and providing representation on key government and industry committees;
- providing information to members about government initiatives and establishing alliances with other industry organisations and networks;
- the establishment of appropriate standards for equipment, practices and services; and establishing, applying and maintaining a code of ethics for all SEIA (Australia) Ltd members.

5. MARKET PROFILE

5.1 Background

Virtually all households have at least one water heater, so that by 2001 it is estimated that the stock of domestic water heaters will be approximately 7 million units. The annual market for all types of water heaters and for all applications is approximately 600,000-700,000 units. Of these, installations in new dwellings comprise around 150,000 per annum. The annual market for commercial water heaters of all types is approximately 20,000-22,000 units. These figures exclude sales of boiling water heaters.

Table 2 below summarises sales of major types of water heaters in Australia over the period 1988 to 1993. It shows that water heaters involving storage accounted for up to 96% of the annual market.

Table 2: Summary of Annual Market for Major Water Heater Types in Australia [GWA, 1993]

Units '000s	1988	1990	1992	1993
Electric				
MP Storage	270	289	306	331
LP Storage	11	25	23	21
Instantaneous	18	12	10	8
Total Electricity	299 (60%)	327 (60%)	339 (61%)	360 (61%)
Gas				
MP Storage	158	177	181	199
Instantaneous	22	20	17	16
Total Gas	180 (36%)	197 (36%)	198 (36%)	215 (36%)
Solar MP Storage	21 (4%)	19 (4%)	17 (3%)	20 (3%)
Total Supplies	500 (100%)	543 (100%)	554 (100%)	595 (100%)

Table 3 below shows the distribution of water heater types in the total stock, derived from data collected by ABS over the period November 1976 to 1999. It suggests a substantial trend away from electric towards gas water heaters, and a fairly stable share for solar water heaters.

Table 3: Distribution of Stock of Water Heaters by Type, 1976 to 1999

Year	Electric	Gas	Solar	Other	None
1976	65.4%	24.0%	0.6%	9.2%	0.8%
1980	66.1%	23.6%	2.6%	5.4%	2.3%
1983	66.2%	24.3%	4.0%	4.1%	1.4%
1986	64.7%	26.2%	5.2%	2.9%	0.9%
1994	60.5%	32.6%	4.8%	2.1%	0.0%
1999	59.0%	35.0%	4.8%	1.2%	0.0%

This trend is supported by sales trends, as reported by BIS Shrapnel and summarised in Table 4 below.

Table 4: Market Share of Water Heating Systems, 1995/6 and 1997/8. [BIS 1999]

	1995/96	1997/98
Electric Storage	41%	47%
Electric Instant	10%	3%
Gas Storage	24%	33%
Gas Instant	21%	14%
Solar	4%	2%
Total	100%	100%

Market information for each of the water heating technologies under review in this report is provided in the section below.

5.2 Electric Instantaneous

5.2.1 Commercial

Industry information suggests that the market for commercial electric instantaneous systems is less than 1% of the national market (i.e. <6,000 units). Systems typically have a life expectancy of around 12 years and on this basis installed stock is likely to be not more than 72,000 units. We estimate the annual market to be 3,000 units, with a stock of 36,000.

Commercial electric instantaneous systems are supplied by at least two companies in Australia, Hocking and Edson.

5.2.2 Domestic

Industry opinion is that these units have no greater than 2% of the national market and with a life expectancy of 12 years it is possible that there are up to 144,000 domestic units installed in Australia.

Manufacturers include, Hocking and Edson.

Table 5: Market Information: Electric Instantaneous Water Heaters, 1999/2000

Product	Approximate Market Share	Approximate Annual Market	Approximate Installed Stock
Commercial	<1%	3,000	36,000
Domestic	<2%	<12,000	Up to 144,000

5.2.3 Electric Boiling Water Heaters

Industry sources suggest that the annual market for instant boiling water units is around 50,000. This number is not part of the annual water heater market of 600,000-700,000 units.

The units last at least 10 years, so the number of installed units may be as much as 500,000. Most schools, offices, factories etc have some kind of instant boiling water unit.

Manufacturers include Birko, Southcorp (Rheem), Whelan, Wilson, Zip.

5.3 Electric Low Pressure

5.3.1 Domestic

Limited information is available on the market share for these systems. Industry has suggested that the share for electric low pressure units is no greater than 2%, which, using a 20 year average life expectancy, suggests that there are up to 240,000 installed units. We estimate that the annual market is approximately 9,000 units and the stock totals 180,000. The majority of these are sold as replacement units since very few units are sold for new homes (unless there is no mains pressure). There is still a significant installed base of low pressure units remaining in Victoria, where they accounted for 20% of storage units sales as recently as 1991[GWA 1993].

Astra, Beasley, Edson, Hot Water Systems Australia and Wilson supply Australia's domestic low-pressure electric units.

Table 6: Market Information: Electric Low Pressure Water Heaters, 1999/2000

Product	Approximate Market Share	Approximate Annual Market	Approximate Installed Stock
Domestic	<2%	9,000	Up to 180,000

5.4 Electric Solar

5.4.1 Commercial and Domestic

There are a number of suppliers of both domestic and commercial electric solar water heaters, most of whom sell both domestic and commercial units, with the domestic market comprising the majority of their sales. Manufacturers are listed in the table below.

Table 7: Manufacturers of Solar Water Heaters supplying the Australian Market

Company	Sector
Southcorp – Solahart and Rheem	Commercial and Domestic
Beasley	Commercial and Domestic
Edwards Energy	Commercial and Domestic
Quantum	Commercial and Domestic
Hot Water Systems Australia	Domestic
Solco	Domestic and unsure about commercial

Table 8: Market Share: Gas and Electric Solar Water Heaters [BIS Shrapnel, 1999.]

Company	Market Share
Rheem	6%
Solahart	79%
Others	15%

Note: Solahart and Rheem are brands owned by Southcorp.

Australia's annual production of solar water heaters is around 40,000 units per annum, of this approximately 50% are exported and the remaining 15,000 to 25,000 make up the Australian national market. [Morrison, 1998] [Ellis & C-S 1999].

The estimated number of installed units in the residential sector in 1998 is shown in Table 9. This is consistent with ABS data for 1999 which indicates a total stock for solar water heaters in the residential sector of 344,700. This is comprised of 317,100 electric-boosted units, 7,900 gas-boosted

units and 19,800 with no boosting [EES, 1999c]. ABS data and industry sources indicate that the current stock is static, or declining slightly, despite State-based programs designed to increase sales.

Table 9: Sales and Energy Contribution of All Solar Water Heaters in Australia [Ellis & Crawford-Smith, 1999]

	NSW	Australia
Total installed units by 1994	74,600	317,000
Estimated Sales in 1998	2,000	15,000
Estimated number of installed units by end 1998	About 74,000	About 317,000
Total estimated capacity contribution by installed units	210 MW	890 MW
Total estimated energy contribution from installed units	220 GWh	950 GWh

We estimate sales in the commercial sector of 1,200 units per annum. Using an average life expectancy of 12 years it is calculated that commercial installations of electric-boosted solar water heaters are approximately 14,400.

Table 10: Market Information: Electric Boosted Solar Water Heaters, 1999/2000

Product	Approximate Market Share	Approximate Annual Market	Approximate Installed Stock
Commercial	<1%	1,200	14,400
Domestic	<5%	Up to 15,000	320,000

It should be noted that the distribution of solar water heaters is not uniform throughout Australia, for climatic and other reasons. The following table shows penetration rates by States and Territories, from ABS research published in 1994 and 1999.

Table 11: Penetration of Residential Solar Water Heaters in Australia [ABS 1994, 1999]

State	NSW	VIC	QLD	SA	WA	TAS	ACT	NT	National
Penetration 1994	3.5%	0.8%	4.8%	3.3%	20.5%	0.6%	3.1%	57.5%	4.9%
Penetration 1999	2.7%	0.9%	5.9%	2.6%	19.6%	0.9%	3.4%	43.7%	4.8%

5.5 Electric Calorifier

5.5.1 Commercial

Industry information suggests that these systems comprise less than 1% of the national market and that installed stock would be no greater than 150,000 (based on a 25 year lifetime). We estimate an annual market of 2,000 units and a stock of 75,000 units.

A known manufacturer of commercial electric calorifier units in Australia is Edson, an Australian owned company.

5.5.2 Domestic

According to industry, calorifiers make up less than 1% of the national market. Based on a 25 year lifetime installed stock would not exceed 150,000.

Domestic electric calorifier units are supplied by at least one company in Australia, Hot Water Systems Australia.

Table 12: Market Information: Electric Calorifier Water Heaters, 1999/2000

Product	Approximate Market Share	Approximate Annual Market	Approximate Installed Stock
Commercial	<1%	<2,000	50,000
Domestic	<1%	<6000	Up to 150,000

5.6 Heat Exchanger

5.6.1 Commercial

Industry information suggests that commercial heat exchange units comprise less than 1% of the national market, with installed stock no greater than 72,000 (based on an average 12 year lifetime). We estimate an annual market of approximately 3,000 units, with a stock of 36,000.

Commercial heat exchange units are supplied by Saxon (a Brisbane based company) and Edson (a Melbourne based company).

5.6.2 Domestic

Industry sources suggest that domestic units make up approximately 3% of the national market. Based on a 12 year average lifetime installed stock could be up to 216,000 units.

Table 13: Market Information: Heat Exchange Water Heaters, 1999/2000

Product	Approximate Market Share	Approximate Annual Market	Approximate Installed Stock
Commercial	<1%	3,000	36,000
Domestic	<3%	<18,000	Up to 216,000

At least two companies, Saxon and Wilson, supply domestic heat exchange units in Australia.

5.7 Gas Storage

5.7.1 Commercial

It is calculated from industry information that gas storage units comprise less than 1% of the national market, and have a maximum installed stock of 57,000 (based on an average lifetime of 12 years). We estimate that an annual market of 5,400 units, with a stock of 65,000.

Table 14: Market Information: Gas Storage Water Heaters, 1999/2000

Product	Approximate Market Share	Approximate Annual Market	Approximate Installed Stock
Commercial	<1%	5,400	64,800

Southcorp is one of the leading suppliers of commercial gas storage units.

5.7.2 Domestic

Detailed modelling undertaken by EES et al for the Australian Greenhouse Office estimates the stock of all domestic gas water heaters in 2000 to be 2,414,000 [EES, 1999a]. This equates to gas water heaters being present in 35% of Australian households. The distribution of households depends upon the availability of gas to a large extent, although 3% of all households have LPG fuelled gas water heaters. The following table shows the proportion of households in each state which are estimated to use gas water heating (both mains and LPG).

Table 15: Proportion of Households in Each State Using All Forms of Gas Water Heating (AGO, 1999)

State	Proportion of Households in each State with Gas WH
NSW	21%
VIC	64%
QLD	13%
SA	47%
WA	55%
TAS	1%
NT	2%
ACT	30%

Using an estimated life of 10 years for gas water heaters, the estimated turnover in the domestic sector is 241,400 units in 2000.

Data on annual production, imports and exports of all gas water heaters provided by ABS (ABS, 1999), forecast that sales in 2000 are likely to be approximately 281,700 units. It should be noted that this figure includes sales for commercial applications (see above), estimated to be 5,400 units per year. In addition, there is considerable volatility from year to year in the sales data provided by ABS, which may reflect production cycles, ie. some of these 'sales' may be going to increasing stock levels amongst wholesalers and retailers, rather than actual sales to householders.

Analysis of sales data over time provided by both approaches, shows that there are points where the two converge, and that the trends are similar, which is consistent with the explanation given above. The following table shows data over time provided by both approaches.

Table 16: Sales Data for All Gas Water Heaters, 1988-2015

Market Sales (units)		
Year	ABS data	Est Turnover
1988	170,500	
1989	185,800	
1990	195,200	
1991	191,200	
1992	204,400	
1993	211,000	
1994	229,831	
1995	239,035	
1996	216,221	216,310
1997	238,160	222,179
1998	258,161	228,169
1999	267,065	236,940
2000	281,730	241,422
2001	249,155	246,743
2002		251,707
2003		256,759
2004		261,903
2005		267,139
2006		272,469
2007		277,600
2008		282,817
2009		288,122
2010		293,516
2011		299,062
2012		304,723
2013		310,503
2014		316,402
2015		322,425

The split between gas storage and gas instantaneous units is estimated using household survey data provided by ABS for the years 1986 and 1999 (see table below).

Table 17: Households Using Gas Storage or Gas Instantaneous Water Heaters, as a Proportion of All Water Heater Users

	1986		1999	
	Storage	Instantaneous	Storage	Instantaneous
NSW	61.3%	38.7%	76.6%	23.4%
VIC	72.4%	27.6%	82.3%	17.7%
QLD	46.0%	54.0%	54.7%	45.3%
SA	68.6%	31.4%	55.4%	44.6%
WA	29.1%	70.9%	60.4%	39.6%
TAS	100.0%	0.0%	14.3%	85.7%
NT	0.0%	0.0%	87.5%	12.5%
ACT	100.0%	0.0%	93.4%	6.6%
Australia	63.2%	36.8%	73.1%	26.7%

This indicates that gas instantaneous water heaters have reduced their overall share of the stock quite considerably between 1986 and 1999. This is consistent with sales information provided by BIS presented in Table 3 above.

Although the penetration rate of instantaneous gas water heaters has decreased during this period by 1.12% per year, it should be noted that through this period the penetration rate of all types of gas water heaters has increased as has the number of households, such that the stock of this type of water heater has not fallen substantially. On the other hand, considerable growth has occurred in the stock of gas storage units.

Anecdotal evidence, together with the introduction of new instantaneous brands and models on the market, suggest that this type of water heater is gaining in popularity. As a result it is estimated that the decline in penetration will not continue at the same rate. The following table show the actual penetration rates for the period 1986 to 1999, and the estimated penetration rate for the period 2000 to 2015, based on a decline of 0.5% per annum for instantaneous water heaters.

Table 18: Stock Share for Gas Water Heating Types, 1986-2015

Distribution of Domestic Gas Hot Water Heaters		
Year	Gas Storage	Gas Instantaneous
1986	63.2%	36.8%
1987	63.9%	35.9%
1988	64.7%	35.0%
1989	65.4%	34.2%
1990	66.1%	33.3%
1991	66.9%	32.5%
1992	67.6%	31.7%
1993	68.4%	31.0%
1994	69.1%	30.2%
1995	69.9%	29.5%
1996	70.7%	28.8%
1997	71.5%	28.1%
1998	72.3%	27.4%
1999	73.1%	26.7%
2000	73.5%	26.5%
2001	73.8%	26.2%
2002	74.2%	25.8%

2003	74.6%	25.4%
2004	75.0%	25.0%
2005	75.3%	24.7%
2006	75.7%	24.3%
2007	76.1%	23.9%
2008	76.5%	23.5%
2009	76.9%	23.1%
2010	77.2%	22.8%
2011	77.6%	22.4%
2012	78.0%	22.0%
2013	78.4%	21.6%
2014	78.8%	21.2%
2015	79.2%	20.8%

The forecasted stock levels, accounting for the number of households and the penetration rate of all gas water heating, is shown in the following table.

Table 19: Stock Levels of Gas Water Heating Types, 2000-2015

Year	Number of Stock	
	Gas Storage	Gas Instantaneous
2000	1,773,955	640,261
2001	1,822,123	645,309
2002	1,868,070	648,996
2003	1,915,096	652,496
2004	1,963,228	655,800
2005	2,012,489	658,898
2006	2,062,908	661,782
2007	2,112,263	663,735
2008	2,162,720	665,449
2009	2,214,302	666,914
2010	2,267,034	668,121
2011	2,321,423	669,197
2012	2,377,196	670,038
2013	2,434,392	670,634
2014	2,493,049	670,973
2015	2,553,208	671,043

Based on the information presented above, the stock of domestic storage gas water heaters is estimated to be 1,774,000 in 2000, with sales of 177,500 based on an average appliance lifetime of 10 years.

Table 20: Market Information: Gas Storage Water Heaters, 1999/2000

Product	Approximate Market Share	Approximate Annual Market	Approximate Installed Stock
Domestic	25.7%	177,500	1,774,800

The estimated share of the gas storage water heater market, by brand is shown in the following table.

Table 21: Gas Storage Eater Heater Market Share, by Brand, 1997/8 [GWA, 2000]

Brand	Market Share
Rheem	53%
Vulcan	22%
Dux	4%
Other	21%

5.7 Gas Instantaneous

5.8.1 Domestic and Commercial

As mentioned previously, the same instantaneous water heater products are designed for both domestic and commercial applications. As a result there is no information to differentiate sales by application. The preceding information therefore combines both sectors, and the results are shown in the following table.

Table 22: Market Information: Gas Instantaneous Water Heaters, 1999/2000

Product	Approximate Market Share	Approximate Annual Market	Approximate Installed Stock
Domestic & Commercial	9.3%	6,400	640,300

The estimated share of the gas instantaneous water heater market, by brand is shown in the following table.

Table 23: Gas Instantaneous Water Heater Market Share, by Brand, 1997/8 [GWA, 2000]

Brand	Market Share
Rinnai	38%
Vulcan	32%
Bosch	21%
Other	9%

5.9 Gas Calorifier

5.9.1 Domestic and Commercial

Information regarding the market for domestic or commercial gas calorifiers is unavailable. It is assumed that these are negligible.

5.10 Gas Solar

5.10.1 Commercial and Domestic

Edwards, Hot Water Systems Australia and Southcorp (Solahart) supply the Australian market with gas boosted solar units. Industry sources suggest that gas solar units make up less than 1% of the national market. ABS data indicates a total stock level in 1999 of 7,800 units [ABS4602.0].

We estimate sales in the commercial sector of 150 units per year, with a stock of approximately 1,800. In the domestic sector, we estimate annual sales of 500 units, with a stock not exceeding 6,000 units.

Table 24: Market Information: Solar Boosted Gas Water Heaters, 1999/2000

Product	Approximate Market Share	Approximate Annual Market	Approximate Installed Stock
Commercial	0.1%-1%	150	1,800
Domestic	<1%	500	Up to 6,000

5.11 Summary

5.11.1 Domestic Sector

It is estimated that the water heating technologies under review account for approximately 44% of the annual domestic water heater market in Australia. It is likely that the market share of calorifiers, low-pressure storage and heat exchangers will decline as the existing stock ages and requires replacement. These units account for around 5% of the market and in many cases will be replaced by more conventional types of systems.

Table 25: Summary of Market for Water Heater Types under Review, Domestic Sector, 1999/2000

Category	Annual Market		Number Installed 2000	
	Units	%	Units	%
Elec Inst	12,000	1.7%	144,000	2.1%
LP Electric Storage	9,000	1.3%	120,000	1.7%
Electric Solar	15,000	2.2%	320,000	4.6%
Elec Calorifier	6,000	0.9%	150,000	2.1%
Heat Exchange	18,000	2.6%	216,000	3.1%
Gas Storage	177,000	25.7%	1,775,000	25.3%
Gas Instantaneous	6,000	9.3%	640,000	9.1%
Gas Solar	500	0.1%	6,000	0.1%
Total	302,000	43.8%	3,430,000	49.0%
Domestic Water Heating	690,000		7,000,000	

5.11.2 Commercial Sector

It is estimated that the water heating technologies under review account for approximately 67% of the annual commercial water heater market in Australia. The remaining 33% of the market comprises electric storage and gas boilers.

Table 26: Summary of Market for Water Heater Types under Review, Commercial Sector, 1999/2000

Category	Annual Market		Number Installed 2000	
	Units	%	Units	%
Elec Inst	3,000	13.6%	36,000	10.9%
Electric Solar	1,200	5.5%	14,400	4.4%
Elec Calorifier	2,000	9.1%	50,000	15.2%
Heat Exchange	3,000	13.6%	36,000	10.9%

Gas Storage	5,400	24.5%	64,800	19.6%
Gas Instantaneous *				
Gas Solar	150	0.7%	1,800	0.5%
Total	14,750	67.0%	203,000	61.5%
Commercial Water Heating	22,000			

(* included in domestic data)

There is an additional market of approximately 50,000 boiling water units in Australia, with a stock of around 500,000 units.

Table 27: Boiling Water Heaters

Category	Annual Market		Number Installed 2000	
	Units	%	Units	%
Instant Boiling Water Heaters	50,000	100%	500,000	100%

6. INDUSTRY LINKS

The large majority of water heater types under review are manufactured in Australia by Australian owned companies. The market is supplied by at least 30 major companies.

6.1 Electric Water Heaters (non-solar boosted) under review

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.

6.2 Gas Water Heaters under review

Demand for gas storage water heaters is met by locally manufactured products, however approximately 45,000 instantaneous gas water heaters were imported in 1999, with a total value of \$16.7m [ABS, 2000]. The majority of imports were sourced from Japan.

Table 28: Major Imports of Instantaneous Gas Water Heaters (non-electric) 1999, by Country of Origin [ABS, 2000]

Country	Number (Units)
Italy	1,484
Japan	35,410
Portugal	4,421
United States of America	1,640

The trend for imports and exports for 1998 to 1999, and the forecast for 2000 and 2001, are shown in the table below.

There is considerable disparity between the total imports for 1999, despite the fact that both sets of data were provided by ABS, albeit independently. To date no plausible explanation has been found.

Table 29: Import & Export Trends for Instantaneous Gas Water Heaters

Year	Gas Instantaneous Exports	Gas Instantaneous Imports
	('000 Units)	('000 Units)
1988	9.0	21.5
1989	4.8	16.1
1990	1.1	19.8
1991	4.1	18.0

1992	9.8	22.2
1993	15.0	14.0
1994	3.6	10.1
1995	4.2	11.5
1996	9.1	15.8
1997	8.0	21.6
1998	7.0	20.0
1999	7.5	19.5
2000	8.0	20.0
2001	7.5	20.5

6.3 Solar Water Heaters

The annual production of Australian manufactured solar water heaters are approximately 40,000 units per annum, with approximately 50% being exported [Ellis & CC-S, 1999].

The import category “Instantaneous (excl. gas water heaters) or Storage Water Heaters (non-electric)” are presumed to comprise primarily solar water heaters, of which there were 460 units imported in 1999, with a total value of \$180,000. As shown in below, the majority of these were sourced from Japan and Korea.

Table 30: Major Imports of Instantaneous (excl. gas water heaters) or Storage Water Heaters (non-electric) e.g. Solar Water Heaters, 1999, by Country of Origin [ABS, 2000]

Country	Number (Units)
Japan	203
Korea, Republic of	200
United States of America	27

7. STANDARD DEVELOPMENT

7.1 Australia

This section summarises the existing Australian Standards relevant to the water heater types under review in this report, a summary of relevant standards is provided in the following table and details are provided in Appendix B.

Table 31: Summary of Australia MEPS and Test Methodologies

Water Heater	MEPS	Test Methodology
Electric Instantaneous – commercial & domestic	N/A	N/A
Electric Low Pressure – domestic	AS/NZS1056.1: 1996	AS/NZS1056.1: 1996
Electric Solar – commercial & domestic	N/A	AS2984:1987, AS2813:1985, AS4234:1994, AS4445.1:1997
Electric Calorifier – commercial & domestic	AS1361: 1995 – AS1056.1, 2 & 4	AS1361: 1995 AS1056.1, 2 & 4
Heat Exchange – commercial & domestic	AS1361: 1995	AS1361: 1995
Gas Storage – commercial	AG102: 1998	AG102: 1998
Gas Calorifier – commercial & domestic	AG102: 1998, AS1361: 1995	AG102: 1998, AS1361: 1995
Gas Solar – commercial & domestic	AG102: 1998	AG102: 1998, AS2984: 1987, AS2813: 1985, AS4234: 1994, AS4445.1:1997

NOTE: This table aims to provide a general guide to potentially relevant standards, however for more detail please refer to Appendix B.

7.1.1 Electric Boiling Water Heaters

Electric boiling water heaters are not currently covered by an existing Australian standard for performance and energy consumption, however the Water Heater Standards Committee, EL20, are developing an energy performance test methodology. There is no existing MEPS for these products.

7.1.2 Electric Low Pressure Storage Heaters

The standard AS/NZS 1056.1:1996 sets out a method for calculating the energy consumption of electric storage water heaters fitted with electric resistance water heaters. This includes vented and unvented systems, and those using a feed tank (low pressure).

Although the standard specifies maximum allowable heat losses for low-pressure electric storage water heaters (see table below), this is not currently a mandatory requirement in government legislation. The heat loss levels for low pressure units were not revised in 1996 when the MEPS levels for mains pressure units were made more stringent and mandatory.

Table 32: Water Heaters with an Attached Feed Tank (low pressure)

Rated Hot Water Delivery	Maximum Heat Loss, kWh/24hours
L	
100	2.6
125	2.8
160	3.1
200	3.4
250	3.7
315	4.1
400	4.4
500	4.8
630	5.2

It should be noted that these allowable heat losses are significantly higher than those allowed for mains pressure HWS units complying with MEPS.

- **Status**

Current, but is currently being reviewed by EL20, the Water Heater Standards Committee EL20.

- **International Relationships**

Similar in general approach to IEC 60379, but there are significant differences.

7.1.3 Solar Water Heaters

There are four Australian Standards relevant to solar water heaters, including one specifically related to heat pumps:

- **AS 2984-1987. Method of test for thermal performance (Outdoor test method):**

This standard sets out a method for determining the performance of a solar water heating system under natural outdoor conditions and prescribes a method of transforming the test results from the particular climate conditions of the test to long-term average conditions for the test location, or for other locations with similar solar irradiation conditions. The standard applies to solar water heaters that use an auxiliary heating system to satisfy loads under solar and non-solar input conditions. Solar collectors, close coupled and integral unit systems are examples of the types of solar water heaters that can be tested to this standard.

- **AS 2813-1985. Method of test for thermal performance (Simulator method):**

This standard sets out a method for determining the performance of solar water heater system under controlled conditions simulating an average day and a bad day weather day. The standard is suitable for testing solar collectors, close coupled, or integral unit systems for storage and instantaneous water heaters.

- **AS 4234-1994. Domestic and heat pump (Calculation of energy consumption):**

This standard sets out a method for determining the annual performance of domestic solar and heat pump water heaters using a combination of test results for component performance (determined under AS 2984) and a mathematical model to determine annual load cycle task performance ("Rating" software model which uses the TRNSYS modelling system).

- **AS/NZS 4445.1:1997 Solar heating - Domestic water heating systems - Performance rating procedure using indoor test methods:**

This Standard provides an indoor test method for rating solar domestic water heating for thermal performance under benchmark conditions. This Standard is identical with and reproduced from ISO 9459.1:1993.

- **Status**

Current. The Water Heater Standards Committee, EL20, are developing an energy performance test methodology (heat loss test) for solar water heater storage tanks. The performance tests for solar water heaters rests with committee CS/28.

7.1.4 Heat Exchange Water Heaters

Standard AS 1361-1995, Electric heat-exchange water heaters for domestic applications specifies requirements for electric heat-exchange water heaters having a heat-storage volume in the range of 45 L to 710 L, which heat potable water at mains pressure for domestic applications.

- **Brief Information**

This standard includes procedures for hot-water delivery and heat loss tests. The heat loss tests are completed over a 24 hour period.

- **Status**

Current. The Water Heater Standards Committee, EL20, are revising the energy performance test methodology to harmonise this with conventional storage systems.

- **International Relationships**

There are no related international standards.

7.1.5 Electric Calorifiers

There appears to be no specific Standards with respect to electric Calorifiers. However, considering there is little to distinguish a calorifier from a heat exchanger, it is possible that AS 1361-1995 applies.

7.1.6 Gas Storage Heaters

This standard, AG 102-1998, applies to new gas water heaters with natural draught or fan assisted combustion systems, constructed totally from new materials and components and intended for use with Natural Gas, Town Gas, Liquefied Petroleum Gas (LPG) and Tempered Liquefied Petroleum Gas (TLP) with a gas consumption not exceeding 500 MJ/h.

The standard specifies thermal efficiency, heat output and energy labelling requirements for storage water heaters and instantaneous water heaters.

- **Brief Information**

Storage water heaters with a gas consumption up to and including 50 MJ/h are required to meet the thermal efficiency, heat output and energy labelling requirements that are referred to in test 5.3.1 (a) of the code. Alternatively, storage water heaters with nominal gas consumption [WHAT DO YOU MEAN BY THIS TERM?] in excess of 0.5 MJ/h and instantaneous water heaters with gas consumption up to and including 250 MJ/h shall be tested to the method that is included in 5.3.1 (b) to the code.

Both tests use the same formula for measuring the thermal efficiency of storage and instantaneous heaters. Identical criteria for complying with AGA energy labelling and gas saving requirements also apply to storage and instantaneous water heaters (see below).

- **Thermal Efficiency Requirements**

Thermal efficiency of storage water heaters, instantaneous heaters and circulators operating at nominal gas consumption shall not be less than 70%.

In addition, the gas consumption required to maintain the average temperature of the water in a storage water heater at 45°C above ambient (called the maintenance gas consumption) shall not exceed the following:

$$M = 0.42 + 0.02V^{2/3} + 0.006R$$

M = Maintenance Gas Consumption in MJ/h

V = Nominal Capacity in Litres

R = Nominal Gas Consumption in MJ/h

- **Status**

Current. This standard is currently being revised under the Memorandum of Agreement between Standards Australia and the Australian Gas Association. The proposed new standard should be published in 2-3 months as an Australian standard. The standard will be published as AS/NZS 4552:2000 "Gas water heaters". The new standard will not be based on any international standards. It will incorporate amendments 1-2 to AG 102-1998. The energy efficiency and labelling conformance criteria will not change under the new standard.

7.2 Overseas

This section summarises existing overseas Standards relevant to the water heater types under review in this report. Table 31 provides a summary of relevant standards and further details are provided in Appendices C to K

Table 33: Summary of International MEPS and Test Methodologies

	Britain	Canada	Europe	Germany	Japan	New Zealand	South Africa	United States
Electric Instantaneous	-	-	-	-	-	-	-	CFR ▶ ●
Electric Low Pressure	BS3999.2 – 1991 ▶ ●	-	-	DIN 44532-100 ●	-	NZS 4602 ▶ ● & NZS 4606 ▶ ●	SABS 151 – 1992 ▶ ●	CFR ▶ ●
Electric Solar	-	Electric Storage Water Heaters ▶ ●	-	-	JIS A4111-1987 ▶ ●	-	-	CFR ▶ ● & SRCC 200-82 ● & ASHRAE-95-81 ●
Electric Calorifier	BS3999.2 – 1991 ▶ ●	-	-	-	JIS C9219-1992 ▶ ●	-	-	CFR ▶ ●
Heat Exchange	BS3999.2 – 1991 ▶ ●	-	EN1148-1999 ▶ ●	DIN 4753.2 – 1990 ▶ ●	JIS C9219-1992 ▶ ●	-	-	CFR ▶ ●
Gas Storage	-	Gas water heaters ▶ ●	-	-	-	-	-	CFR ▶ ● & Energy Policy Act – 1992 ▶ ●
Gas Calorifier	-	Gas water heaters ▶ ●	-	-	JIS S2109 – 1997 ▶	-	-	CFR ▶ ●
Gas Solar	-	Gas water heaters ▶ ●	EN26 – 1998 ▶ ●	-	JIS A4111-1987 ▶ ●	-	-	CFR ▶ ● & SRCC 200-82 ● & ASHRAE-95-81 ●

Please note: the standards listed above may apply only to an area of a water heater category and not to all systems within the category, please refer to appendices C to K for more detail.

- ▶ Signifies standard
 - Signifies that standard includes test methodology

8. GREENHOUSE EMISSIONS

8.1 Total Sector Emissions for Hot Water

8.1.1 Domestic Sector

Emissions due to water heating in the domestic sector are assumed to be 15.2 Mt CO₂-e in 1999/2000 [EES 1999a]. These do not include electric boiling water heaters.

8.1.2 Commercial Sector

Emissions due to water heating in the commercial sector are assumed to be 0.79 Mt CO₂-e in 1999/2000. This is 52% of emissions estimated from water heating and cooking [EMET & Solarch 1999].

8.1.3 Boiling Water Heaters

Emissions due to boiling water heaters in both the domestic and commercial sectors are calculated to be approximately 1.25 Mt CO₂-e in 1999/2000, based on the estimated number of installed units and an average consumption of 2,500 kWh per annum.

8.2 Total Emissions for Water Heater Types under Review

8.2.1 Domestic Sector

Emissions have been estimated using the market and stock data presented in Section 4. To determine energy consumption, average water heating consumption figures have been used, as shown in the table below [EES, 1999b].

It has been assumed that Low Pressure Electric Storage and Gas & Electric Solar units are used to meet the hot water demands of a typical household. In the case of the solar units, an average annual solar contribution of up to 60% has been assumed. Electric Instantaneous units tend to be used where there is a smaller demand for hot water. The boost energy required for Calorifiers and Heat Exchange units is less than an average household since a proportion of these will use additional energy sources such as wood fired boilers.

Table 34: Average Annual Energy Consumption per Unit, Domestic Sector

Category	kWh/a
Elec Instantaneous	1,500
Low Pressure Electric Storage	3,000
Electric Solar	1,200
Elec Calorifier	1,500
Heat Exchange	1,500
Gas Storage	5,100 (18,400 MJ)
Gas Instantaneous	4,800 (17,300 MJ)
Gas Solar	2,000 (7,200 MJ)

It should be noted that heat exchange units and calorifiers could be used in connection with solid fuel boilers or stoves. Where wood is used as the fuel source, the greenhouse intensity water heated by this means will be close to zero. It is therefore considered that the greenhouse gas estimates below are likely to be at the higher end of the likely range.

The total energy consumption in 1999/2000 is estimated to be 13,880 GWh for the water heater types under review. For electric solar units this includes only the electricity used to boost the system. Of the 13,880 GWh, gas usage (mains and LPG) accounts for 12,120 GWh (43.6 PJ) and electricity usage accounts for 1,760 GWh.

Greenhouse emissions from these technologies are estimated to be approximately 4,660 kt CO₂-e per annum. This is equivalent to approximately 29% of emissions due to hot water production in the domestic sector. The remaining 71% of emissions result from the use of mains pressure conventional electric storage water heaters. The following table shows the contribution of all water heater types to total emissions in 2000 resulting from domestic hot water tasks.

Table 35: Greenhouse Emissions by Technology as % of Domestic Sector Water Heating Emissions

Water Heater Category	Emission %
Elec Storage (Mains)	71.3%
Gas Storage	13.5%
Gas Instantaneous	4.9%
LP Electric Storage	3.3%
Electric Solar	2.4%
Heat Exchange	2%
Elect Calorifier	1.4%
Elec Inst	1.3%
Gas Solars	0%

8.2.2 Commercial Sector

Emissions from technologies under review in the commercial sector have been estimated using a similar methodology as above.

Most commercial applications for these water heater types are assumed to have a relatively small load, since heavy users of hot water are more likely to have specialised boilers or more economic forms of hot water production. The low sales figures of the types of water heater under review also suggest that users of large quantities of hot water, e.g. Hotels and Laundries, use other technologies.

As a result we have assumed similar levels of consumption per unit in the commercial sector, as in the domestic sector. While we estimate that most applications will use less hot water than implied by these figures, it allows for some heavy users of hot water.

Table 36: Average Annual Energy Consumption per Unit, Commercial Sector

Water Heater Category	KWh/a
Elec Inst	2,000
Electric Solar	1,200
Elec Calorifier	2,000
Heat Exchange	2,000
Gas Storage	6,000 (21,600 MJ)
Gas Solar	2,000 (7,200 MJ)

The total energy consumption in 1999/2000 is estimated to be 654 GWh for the water heater types under review. Of this total, gas usage (mains and LPG) accounts for 393 GWh (1.41 PJ) and electricity usage accounts for 261 GWh.

Greenhouse emissions from these technologies are estimated to be approximately 358 kt CO₂-e per annum. This is equivalent to 45% of emissions due to hot water production in the commercial sector (not including boiling water heaters).

The following table shows emissions from the water heaters under review, together with other types of water heaters in the commercial sector, and boiling water heaters. This is included to provide an overview of the sector.

Table 37: Greenhouse Emissions as % of Commercial Sector Water Heating Emissions

Water Heater Category	Emission %
Instant Boiling Water Heats	61.3%
Elec Calorifier	4.9%
Gas Storage	4.7%
Elect Instantaneous	3.5%
Heat Exchange	3.5%
Electric Solar	0.8%
Gas Solar	0%
Other	21.3%

Note: "other" includes packaged boilers, coal and petroleum fired water heaters, cogeneration plant.

8.2.3 Boiling Water Heaters

Emissions due to boiling water heaters in both the domestic and commercial sectors are calculated to be approximately 1.25 Mt CO₂-e in 1999/2000, based on the estimated number of installed units and an average consumption of 2,500 kWh per annum.

8.3 Summary of Emissions

The total annual greenhouse emissions resulting from the water heaters under review are 5,984 kt CO₂-e. Emissions by sector and technology are summarised in below.

Table 38: Summary of Greenhouse Emissions, 1999/2000

Water Heater Category	Greenhouse Emissions kt CO₂-e / annum		
	Domestic	Commercial	Other
Electric Instantaneous	215.5	71.8	
LP Electric Storage	538.7		
Electric Solar	383.1	17.2	
Electric Calorifier	224.4	99.8	
Heat Exchange	323.2	71.8	
Gas Storage	2,186.4	96.6	
Gas Instantaneous	789.1		
Gas Solar	3.0	0.9	
Boiling Water Heaters			1,256.9
Total	4,663.3	358.1	1,256.9

Table 39: Estimated Annual Greenhouse Emissions from Water Heaters under Review.

Category	KT CO₂-e/a
Domestic Water Heaters	4,663.3
Commerical Water Heaters	358.1
Boiling Water Heaters	1,246.9

9. ENERGY EFFICIENCY ISSUES

It is important to note that the major factor which effects the energy consumption (and hence greenhouse gas emissions) of most water heaters is the volume of hot water delivered. The efficiency of the water heater (or the heat losses) tend to be of secondary importance (in a relative sense). However, regulating hot water consumption is beyond the scope of this report so the main emphasis is on efficiency related issues.

9.1 Areas of Improvement

There are a number of general areas of improvement to the efficiency of water heaters including:

- Heat losses: primarily due to the transfer of heat from hot water stored in storage system; both via insulated areas and thermal bridges including pipes connected to the tanks;
- Heat losses due to the design of pressure and temperature valves in storage water heating systems;
- Standby losses due to pilot lights: in gas systems which require a pilot to be lit at all times;
- Burner efficiency and heat exchangers in gas systems.

Other factors affecting the efficiency of the system, but not directly associated with the water heater technology, include:

- Heat losses from pipes connecting the water heater to the point of use;
- The location of installed product, i.e. Where it is in relation to the point of use so as to minimise heat losses from pipe runs, including 'dead water losses';
- Impacts of product design on user behaviour, for example instantaneous electric units that rely on flow rate to modulate temperature may lead to use of more hot water than is required.

9.2 Means of Improvement

This section briefly describes the means of improving the energy efficiency for the water heater types under review. Further details of most of these issues are contained in the report: *Technical Study on Improving on Electric Water Heater Efficiency* [Energy Partners, 2000].

9.2.1 Reducing Heat Losses in Storage Systems (including solar)

The most common means to improved heat loss characteristics is through higher levels of insulation, achieved either by increasing the thickness of insulation used or by using a material with a high insulation value. It should be noted that the MEPS for domestic electric storage water heaters requires that units have heat losses not greater than those prescribed for given categories and sizes.

Heat losses also occur due to temperature 'bridges' through the layer of insulation around the storage tank, primarily as a result of penetrations through the insulation for water inlets and outlets, and temperature and/or pressure release valves. These are usually constructed of brass and have good thermal conductivity properties, resulting in the transfer of heat from the tank to the external environment.

9.2.2 Improving the Performance of Gas Storage Systems

Options for increasing the efficiency of gas storage water heaters include:

- Reduced heat loss from storage tanks and fittings (see above), and by cutting losses from flues by using dampers or other design strategies.
- Replacing the pilot light with electronic ignition. Increasingly, pilot lights are being replaced by electronic ignition systems, thereby eliminating most standby losses (although there will still be some consumption associated with mains powered electronic ignition - this can be quite high in poorly designed ignition systems). Bosch supply gas instantaneous HWS units with battery powered electronic ignition, and Solahart's ignition system uses low voltage power which can be installed by a non-electrician. In theory solar cells or various means of generating small amounts of electricity from heat could also be used to supply power for electronic ignition systems;
- Condensing the flue gases and removing them as a liquid, while extracting the latent heat of vaporisation; (this is already done on some of the most efficient equipment);

- Improving the design of the tank and burner to maximise heat transfer;
- Using a 'submerged' combustion chamber, so that the burner chamber is surrounded by water, allowing an inlet for air and a flue outlet (it should be noted that current designs tend to allow part of the tank to remain uninsulated in order to allow heat transfer from the gas burners and flue to the water tank);
- Heating water in an external heat exchanger and returning this to a highly insulated storage tank.

Connections

Temperature and Pressure release valves (often combined) often leak between 2%-5% of heated water in storage systems, and older valves may leak more than this [Pears 1998].

One means of overcoming this is to construct these valves using a material with lower thermal conductivity properties. Another option is to install a pressure valve on the inlet side (as well as some kind of back-up device on the hot side) so that the water released is cold water rather than hot water. This is done in parts of Australia where water quality is poor.

Although these connections are not part of the water heater package, water heater standards typically cover adjacent connections. It would therefore appear that there is scope for including immediate connections through MEPS. It is also possible to insulate T/PR valves although this is not common in Australia.

Location

The correct positioning of water heater systems can reduce pipe runs and thereby cut heat losses through pipes. However, in many cases the options for suitable locations are limited due to building openings, etc. In addition, in the case of retrofits, installation is considerably easier if the existing connections are used.

As above, the location of water heaters is dealt with in water heater standards, particularly in relation to flues for gas units and building openings.

9.2.3 Improving the Performance of Gas Instantaneous Systems

Gas instantaneous hot water systems are generally more efficient than storage systems with equivalent hot water delivery capacity, due to the fact that they have no standing losses (apart from pilot lights in some cases). For example, the average efficiency of AGA certified storage water heaters (by brand) is 57% under test conditions, while the average is 62% for certified instantaneous systems (for the AG102 defined task of delivering 37.7MJ of hot water per day). Since the average household requires less hot water than prescribed under AG102 test conditions, the average difference in efficiencies between system types is likely to be larger than 5%.

Instantaneous systems can achieve improved efficiencies through:

- Replacing the pilot light with electronic ignition. Increasingly, pilot lights are being replaced by electronic ignition systems, thereby eliminating most standby losses (although there will still be some associated with mains powered electronic ignition);
- The design and location of the gas burners, to ensure the maximum amount of heat is available to the heat exchange unit;
- The design of the heat exchanger, to transfer heat from the burner to the water flowing through the system.

9.2.4 Improving the Performance of Boiling Water Heaters

Many of the issues relating to the efficiency of gas storage water heaters also apply to boiling water heaters. They have standing losses due to the storage of high temperature water – indeed, unimpeded the rate of heat losses will be greater than for most storage systems due to the higher temperatures involved. Issues relating to burner and heat exchanger efficiencies are also relevant.

Many boiling water heaters are designed to be unobtrusive and the external size is therefore a major design criteria. Traditionally, size constraints have tended to limit the quantity of insulation material used, although some manufacturers have used materials with improved performance, and used better techniques to eliminate gaps in insulation.

Many units have metal delivery taps, and these will for a conduit for heat to dissipate from the storage tank. Some units now use plastic delivery spouts and keep the majority of the water delivery

mechanism within the unit's casing. It is likely that these measures will reduce heat losses although no tests appear to have been conducted to quantify these savings.

In the past, the overall efficiency of boiling water units does not appear to have been a priority in the design criteria, and there appears to be considerable potential for improvement.

10. APPROPRIATE MEPS FOR AUSTRALIA

10.1 Discussion of Trends

As part of the discussion regarding the appropriateness of MEPS for the types of water heaters under review, it is important to understand a number of trends in the market for water heaters in Australia. These are summarised as follows:

- Low-pressure electric storage units have a small market share and are likely to be replaced by alternative systems.
- Calorifiers/Heat Exchangers: although little is known about this market, it appears it may be declining.

On the other hand:

- Electric Instant boiling water units are likely to maintain and possibly increase their market penetration in Australia;
- Instantaneous electric water heaters may maintain their small market share as housing densities increase in urban areas, giving rise to more units. However, while instantaneous units are, in theory, well suited to small households, improved controls will be needed before they gain wide acceptance. A large number of instantaneous electric water heaters located in the same development (e.g. flats) can lead to significant increases in wiring costs (3 phase power) - their installation is generally resisted by developers and electricity utilities;
- Gas commercial storage may also increase their market share, as availability of gas increases in Australia;
- Solar water heaters have a fairly static and small market share. This may change with the introduction of initiatives designed to increase the contribution of renewable energy sources, such as the Federal Government's 2% target. Indeed, some industry groups are predicting a doubling or even greater increase in sales.

10.2 Discussion

10.2.1 Electric Instantaneous

The scope for improving electric instantaneous water heaters is small and, as a result, there are few precedents for MEPS on these products. In general terms, their efficiency is already high and there is little that can be done to increase this markedly.

10.2.2 Boiling Water Heaters

Boiling water units with storage capacity are increasing and there is considerable potential for improved efficiencies. In principle, there is no reason why these products should not meet heat loss standards which are equivalent to electric mains pressure storage water heaters, although it is recognised that this may be more difficult to achieve due to the higher storage temperatures involved (equivalent levels can be set to account for the temperature differences).

10.2.3 Electric LP Storage

Low-pressure electric storage units are already covered (as vented water heaters) in the Standard AS/NZS 1056.1:1991 (Amendment 3: 1996), although the allowable heat losses are lower than unvented units (these were not made more stringent in the 1996 amendment) and are currently voluntary. There was always a difference in the allowable heat loss between vented and unvented units and this is intended to reflect the larger number of connections on low-pressure units and differences in construction. However, it should be noted that in AS1056.1-1991 the same criteria applied to both low and mains pressure units, and there appears little reason why equivalent standards should not apply to low pressure units.

10.2.4 Solar Water Heaters & Heat Pumps

Although the standard AS2712 says that solar water heater tanks should meet or exceed the allowable heat loss in AS1056.1, this is not a mandatory requirement. However, as above, there is little reason why solar water heaters should be excluded. (Indeed, it could be argued that the current omission of electric-boosted solar water heaters may provide a loophole for certain electric storage water heaters).

Gas-boosted solar water heaters should be required to meet equivalent heat loss standards although the presence of a combustion heat exchanger and flue makes this requirement somewhat more complex.

An appropriate test method which takes account of the position of the element and to determine how to measure heat loss (i.e. whether the solar collector is attached), would need to be developed. It may be necessary to artificially heat the whole storage tank volume to a pre-set temperature (similar to AS1056.1) in order to determine an equivalent heat loss. AS1056 is being revised to specifically include solar water heater tanks within the scope for a heat loss test.

Testing for simple heat losses in Heat Pump hot water storage systems is not practical, as it is not possible to maintain steady state temperatures in the water heater without operating the refrigeration system, as this is the only means of heating the water. The whole system is designed to operate in an outdoor environment so normal laboratory tests are not applicable. No countries have applied MEPS to this technology, partly because of the difficulties in testing and partly because of the fact that sales and ownership levels are generally extremely low. The only practical MEPS approach would be for a performance standard to be determined on the whole system (collector panels, heat pump and storage) under a given climatic regime and for a pre-defined hot water deliver task. This would be possible with outdoor tests and simulations under AS4234.

10.2.5 Calorifiers/Heat Exchangers

There appears little justification why heat exchangers and calorifiers should not be required to meet equivalent MEPS standards to those for electric storage water heaters in AS 1056.1, although testing requirements will differ from those employed for mains pressure electric storage heaters.

Because the hot water delivery capacity is substantially lower for heat exchangers, compared to a displacement heater of the same physical volume, the standard may need to be expressed as maximum losses per litre stored (perhaps adjusted for the rated storage temperature). The issue of an equivalent hot water delivery capacity is being considered by the standards committee EL20.

Similarly, as the temperature of storage and rate of delivery can vary considerable in Calorifiers, standards may need to be expressed in terms of tank volume rather than hot water delivery capacity. The testing of all storage type heaters is complicated by the introduction of thermostatically controlled mixing valves on the outlet of water heaters with a high potential storage temperature (typical of many heater exchanger types).

10.2.6 Domestic and Commercial Gas Storage Water Heaters and Instantaneous Gas Storage Water Heaters

The standard AG102, and the associated labelling program, covers units (both storage and instantaneous) with outputs up to 500 MJ/h, although the energy performance standards do not currently apply to units above 50 MJ/h output. Although assessment of the impact of AG102 is limited, recent evaluation of the labelling program by George Wilkenfeld and Associates suggests that some improvement in the overall efficiency of gas water heaters has occurred between 1987 and the current time [GWA, 2000]. The efficiency of some models, and some types of water heaters, however, appears to have declined during this period.

Although GWA has not assessed the impact of the standard as such, the presence of star rating for gas storage appliances appears to have caused manufacturers to improve efficiencies to achieve the next whole star rating, where this is within reach [GWA, 2000].

In part, the reason why it is difficult to assess the impact of the current MEPS on gas water heaters is that it is no longer relevant to the range of products currently on the market. Technology improvements mean that the MEPS requirements are easily exceeded by the current range of products on the market.

Furthermore, it appears that the current Australian standard for gas storage water heaters is less stringent than the requirements in the United States, as shown by a comparison between the AGA standard and the current (1991) and future (CFR 2004) US MEPS levels for gas water heaters. The

following tables show the result of modelling these three standards on an equal basis for 90, 140, 200 and 250 litre gas storage water heaters, and a range of maintenance rates, using the TRNSYS* model. *Note: TRNSYS is a computer model used to simulate the performance of thermal energy systems

For 90 and 140 litre water heaters with maintenance rates below around 15 MJ/day, the AGA standard exceeds the current US standard. For these same water heaters with maintenance rates below around 10 MJ/day, the AGA standard would also exceed the proposed US MEPS level.

The AGA standard applied to larger water heaters, (200 and 250 litres), is more stringent than the current US level at maintenance rates below 25 MJ/day, and exceeds the proposed US MEPS level at maintenance rates below 17 MJ/day.

For the majority of other likely maintenance rates, the current and proposed US standards are more stringent than the AGA standard. It should be noted that the majority of storage water heaters on the market in Australia have a maintenance rate in the region of 15 MJ/day to 30 MJ/day.

Table 40: Comparison of Current AGA Standard, Current US MEPS levels and Proposed US MEPS levels,

90 litre Gas Storage Water Heater

Gas Maintenance Rate (MJ/day)	US MEPS 1991	CFR 2004	AGA
30	97.5	0	-
25	87	98	-
23.8	85	95	100
20	78.5	88	70
15	72	80	70
10	66	73	70
5	61.5	67	70
0	57.5	62.5	70

Table 41: Comparison of Current AGA Standard, Current US MEPS levels and Proposed US MEPS levels,

140 litre Gas Storage Water Heater

Gas Maintenance Rate (MJ/day)	US MEPS 1991	CFR 2004	AGA
35	99.7	-	-
30	90.5	-	-
27.36	85	98	100
25	81	93	70
20	74	83	70
15	68	76	70
10	63	69.5	70
5	58.5	64	70
0	55	60	70

Table 42: Comparison of Current AGA Standard, Current US MEPS levels and Proposed US MEPS levels,

200 litre Gas Storage Water Heater

Gas Maintenance Rate (MJ/day)	US MEPS 1991	CFR 2004	AGA
36.48			100
35	91		70
30	82	96	70
25	75	86	70
20	69	78	70
15	63.5	71	70
10	59	65.5	70
5	55	61	70
0	52.0	57.0	70

Table 43: Comparison of Current AGA Standard, Current US MEPS levels and Proposed US MEPS levels,

250 litre Gas Storage Water Heater

Gas Maintenance Rate (MJ/day)	US MEPS 1991	CFR 2004	AGA
43.44			100
40	94		70
35	84	98.5	70
30	76.5	88.5	70
25	70	80	70
20	64.5	73	70
15	60	67	70
10	56	62	70
5	52.5	58	70
0	49.5	54.5	70

For instantaneous gas water heaters, with electronic ignition (ie. no pilot), the thermal efficiency requirement in the AGA standard is equivalent to the energy factor required by the US MEPS. The following table shows the comparison between these standards for instantaneous water heaters with electronic ignition. As can be seen, for these types of water heaters, the AGA standard appears to exceed the current and proposed US MEPS levels. However, this may not be the case, as it should be noted that the US MEPS is calculated on the basis of total input energy, which can include the electrical energy used for electronic ignition, for example.

As gas pilots are phased out, and replaced by electronic ignition, and considering the greenhouse intensity of electricity vs. gas, this is an important issue worthy of consideration.

Table 44: Comparison of Current AGA Standard, Current US MEPS levels and Proposed US MEPS levels,

Instantaneous Gas Water Heaters, electronic ignition.

Instantaneous	Electronic Ignition/no pilot								
	0	5	10	15	20	25	30	35	40
US MEPS 1991	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615
CFR 2004	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
AGA	0.70	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Maintenance (MJ/day)	0	5	10	15	20	25	30	35	40

A further issue is that of the energy used to 'start-up' the water heater and whether the standard for instantaneous water heaters should be calculated inclusive of this. The US test method takes place over a 24hr period and includes six draw-offs over the first six hour period. The current AGA test methodology to determine energy labelling of gas water heaters does include factors to account for 19 draw-offs per day. As can be seen from the following table, this can have a significant impact on the

overall task efficiency. This figure shows the task efficiency for certified instantaneous water heaters listed by the AGA. Although all are required to have a burner efficiency of 70%, when taking into account the 'start-up' consumption the task efficiency can be reduced to 55% under test conditions. Clearly there is a considerable range in 'start-up' heat capacity amongst models currently on the market.

Table 45: Task Efficiencies Inclusive of 'Start-Up' Heat Capacity for a Range of Available Instantaneous Water Heaters

Daily Consumption (MJ/day)	Task efficiency
58.6	64%
60.4	62%
56.2	67%
57.0	66%
53.5	70%
53.4	71%
57.1	66%
55.0	69%
55.6	68%
57.1	66%
57.5	66%
56.2	67%
58.0	65%
64.1	59%
59.5	63%
59.5	63%
62.7	60%
60.8	62%
66.4	57%
67.3	56%
68.7	55%
60.5	62%
57.9	65%
59.1	64%
56.7	67%
59.4	63%
56.8	66%
54.6	69%
53.9	70%
60.4	62%
61.8	61%
61.8	61%
65.9	57%
65.9	57%
59.7	63%
67.9	55%
61.4	61%
67.9	55%
68.7	55%

The inclusion of the energy input for electronic ignition, and the 'start-up' energy in the methodology for calculating US MEPS levels may explain why the current and proposed MEPS levels are lower than those currently applying to instantaneous water heaters in Australia. Clearly these are both important issues in relation to overall efficiency and greenhouse emissions and worthy of consideration for inclusion in the AGA test methodology.

Given the increasing use of gas water heaters in both the domestic and commercial sector, an updating of the MEPS levels in AG102 is warranted. The commitment by the Australian Government that MEPS standards match world's 'best practice' would be fulfilled by the adoption of equivalent standards to those in the United States for gas storage water heaters.

Since AG102 already includes products rated up to 500 MJ/h, but MEPS and labelling requirements only apply to products up to 50MJ/hour, it would also appear reasonable to extend the current energy performance requirements to the full range of units covered. This would mean that most commercial scale water heaters would be required to conform.

10.3 Recommendations

The following recommendations are made:

10.3.1 Electric Instantaneous Water Heaters

MEPS are not recommended for these products at this time, although they should be considered again if either the market in Australia increases substantially, or effective standards are adopted overseas.

10.3.2 Electric Boiling Water Heaters

MEPS are recommended for these products and, in the absence of international MEPS standards which could be applied, Australia will be required to develop their own standards. One option is for the adoption of equivalent levels to those pertaining to electric storage water heaters (adjusted for volume and storage temperature). At this stage, there is insufficient information on the performance of available appliances to assess whether this is an appropriate standard. Further investigation of the performance of a range of products, is therefore recommended, including the monitoring of products under test conditions, in order to establish an appropriate MEPS level.

It is further recommended that the existing Water Heater Standards Committee EL20 be formally asked to examine the options for developing appropriate test methods for electric boiling water heaters (this item is on the EL20 work program but is currently not high priority).

10.3.3 Electric Storage Water Heaters

It is recommended that the following electric storage water heaters under review in this report should be required to meet minimum heat loss standards equivalent to the allowable losses from mains pressure HWS units that are currently enforced:

- Electric Low Pressure Water Heaters;
- Electric Boosted Solar Water Heaters (tank heat losses);
- Electric Calorifiers (domestic & commercial)
- Heat Exchangers

This could be achieved by expressly including these types of water heaters within AS1056.1.

It is further recommended that the existing Water Heater Standards Committee EL20 be formally asked to examine the options for developing appropriate test methods for each of the water heater types where they currently do not exist.

At this stage it is not recommended that MEPS be considered for electric heat pump water heaters due to their small overall contribution to greenhouse emissions and the complexity in defining a performance standard.

10.3.4 Gas Storage and Instantaneous

It is recommended that MEPS levels in AG102 are updated to equivalent levels to those used in the United States. The US water heater current standards are due to be replaced by 2004, and since any new MEPS level in Australia would require a lead-in period for consultation prior to introduction, this suggests that the levels adopted in Australia should be equivalent to those due to come into force in 2004 (USA NOPR 2000). In addition, energy performance requirements in AG102 should apply to all units covered by the standard, ie. up to 500 MJ/h.

It is also recommended that for instantaneous gas water heaters, the energy performance standard should include all input energy, ie. any electricity used for electronic ignition.

10.4 Other Programs to Strengthen Demand for Energy Efficient Equipment and Reduce Greenhouse Emissions

10.4.1 Discussion

Minimum energy performance standards are designed to remove the poorest performing appliances from the market. While this has considerable benefit over time as the appliance stock is replaced, this type of program is not designed to maximise greenhouse emission reduction. In addition to behavioural changes, this can be achieved by a customer selecting:

- the most efficient technology available, and
- the lowest greenhouse intensity fuel.
- In some cases, further demand side responses, eg. additional insulation, may be also enable energy service requirements to be met without increasing greenhouse emissions.

In general for water heaters, the additional capital cost of a high efficiency water heater compared to a similar, but lower efficiency product, is small, and would be recouped in savings on running costs over the appliance lifetime. This is true for water heaters using the same fuel, but not for example in a comparison between an electric storage and solar water heater where the difference in capital cost is larger than would normally be met by reduced bills.

The fact that lower efficiency water heaters are still purchased may be a sign that customers do not value future savings (or simply cannot afford the capital premium), or that they are not sufficiently well informed. This might include a lack of knowledge about the efficiency of particular products, or a failure to understand that more efficient products pay for themselves over time. In general, appliance labelling programs are designed to improve customer understanding of the relative efficiencies of different products and their financial benefits. Labelling of gas water heaters has also helped to increase sales of efficient appliances, and current research suggests that there is considerable scope for upgrading and promoting this program to provide increased benefits [GWA 2000].

In some segments of the water heater market other market failures mean that less efficient appliances are selected. For example, in the rental housing market and large parts of the commercial building market, water heaters are purchased by the builders or building owners who have a tendency to select products on the basis of low first-cost. Tenants, who pay for the fuel consumption and would therefore have an interest in higher efficiency products, are typically excluded from purchasing decisions (sometimes because they are not identified at the time of construction). A similar situation may arise in the case of private household developers, who receive no direct benefit from the installation of efficient water heaters.

Many selections of domestic water heaters are influenced by hot water installers. A study of NSW installers showed that, of the many factors which determine the advice provided to householders by this group, efficiency was generally a low priority. Issues such as low first-cost, ease of installation, reliability and low call-back rates were generally more important [MEA, 2000]. In addition, the study suggested that many installers did not have sufficient understanding of efficiency and greenhouse issues to be able to advise customers accurately.

As highlighted at the beginning of this section, the second selection criteria with a bearing on overall greenhouse emissions is water heaters which use low greenhouse intensive fuels. Indeed, the switching of fuels, for example from electric to gas or solar, has the potential to have a greater impact on emissions than the selection of the most efficient appliance within a given fuel type. Amongst the factors which inhibit fuel switching are:

- The lack of reticulated gas supplies;
- The low cost of off-peak electricity;
- The lack of inclusion of environmental externalities in fuel prices;
- The lack of understanding by consumers and intermediaries of the greenhouse benefits of fuel switching;
- The fact that the majority of water heaters are installed as a result of failure of the existing system. The requirement for a quick turnaround provides pressure for the replacement of 'like for like';
- Preferences amongst installers for particular fuels and water heater manufacturers.

Many of these issues are complex and would not ordinarily justify intervention by governments unless there was evidence of market failure. For example, the market is currently determining the provision of reticulated gas in Australia and the expansion of the network over the past few years is evidence that where there is perceived economic demand, the players in that market will move to ensure supply.

Off-peak electricity pricing was originally developed to reflect the lower electricity generating costs during the night, and exclude all or most system capital costs on the assumption that electricity consumption during off-peak periods does not contribute to the need for new network capacity.

As such, off-peak electricity is able to provide hot water services at a cost which is competitive with the provision of hot water by gas. However, there are now questions as to whether off-peak electricity is a form a predatory pricing design solely to maintain market share at the expense of gas [SEDA, 1999a]. This stems from the assertion that some off-peak water heaters use peak time boosting via a second element, that some timers are faulty and therefore are switched on during peak periods, and that low off-peak tariffs encourage the use of other electro-technologies for household applications (eg. cooking, space heating), which contribute significantly to system peak demand.

It should be noted that if off-peak electricity prices did contain an increased network component, then the option of switching to gas hot water services, with a consequential reduction in greenhouse emissions, would be made more attractive.

The same would apply if environmental externalities were to be included in the price of energy. However, at the current time, there is no commitment by the Australian Government to pursue such a strategy. A number of State programs are currently in existence which provide a financial incentive for the installation solar water heating. These incentives could be said to make up for the lack of fully cost-reflective energy pricing in so far as they reduce the payback period for water heaters with a low greenhouse impact. The SEDA Water Heater Program is an example of this type of program, whereby a \$500 discount is offered off the capital cost of a solar or heat pump water heater. The cost of this discount is shared between SEDA and participating companies from the water heater industry.

For consumers, or intermediaries, who wish to compare the efficiency, running costs and greenhouse emissions of different types of water heaters, there is currently no single authoritative source of information. Some State based organisations provide information, as do some utilities, however this is not necessarily widely available or comprehensive. While labels for individual water heaters may at some time be sufficiently harmonised across all types to facilitate direct comparison, there are considerable difficulties involved which means that this is unlikely to occur in the near future. However, one alternative is to provide independent information, disseminated for example through a website such as 'www.energyrating.gov.au' which enables water heaters of different types, operating under a variety of conditions, to be compared.

This information may also be targeted towards hot water installers as part of an education/training program designed to ensure that they are able to accurately advise customers.

The issue of hot water breakdowns and the disincentive this provides for fuel switching is one which commercial interests have been attempting to tackle for some time. Some gas providers have trialed a system for those households with access to, but not yet connected to, mains gas, of providing bottled gas until mains supply is connected. This has not proven particularly attractive to customers. Other products, such as the retro-fitting of solar collectors to existing electric storage water heaters have also been trialed elsewhere. The aim of this approach is to reduce the capital cost of conversion and to encourage fuel switching at a time other than that of system breakdown.

Clearly there are a range of issues here, some of which may require action by governments in conjunction with other stakeholders. Further consultation with the industry should be undertaken to understand what type of programs are appropriate, however potential programs could include the following:

10.4.2 Information

Although there are MEPS for electric storage water heaters in Australia, currently there is no mandatory labelling program, and it is understood that there are no plans for its introduction. Since labelling is not proposed for electric storage water heaters, which are the source of the great majority of emissions, it would be difficult to justify the introduction of a labelling program for other electric water heaters.

The existing gas water labelling scheme applies to products which consume up to an including 50MJ/hr. In the commercial sector, where there is serious market failure, it is unlikely that labelling will work as effectively and mandatory labelling is not recommended at this stage. However, if MEPS is

extended to cover commercial gas water heaters, a voluntary labelling scheme could be encouraged so that high efficiency products could gain market benefit.

MEPS have been recommended for boiling water heaters. At this stage it is understood that there are a range of product efficiencies on the market, which indicates that they would be appropriate for labelling. However, since the majority are installed as fittings in commercial buildings, building owners may not be influenced by information on efficiency and running costs. Further investigation of the range of products and markets is recommended in order to decide whether labelling is appropriate.

To assist consumers and intermediaries to compare the performance and attributes of different types of water heaters, we recommend that information relating to the relative running costs and greenhouse gas emissions for various water heaters is provided. This should cover a range of water heating technologies, climates and usage patterns. We suggest that this information is placed on the www.energyrating.gov.au website and other appropriate places.

10.4.3 Promotions

Implementation of MEPS and labelling programs are considerably enhanced through the promotion of the benefits of increased efficiency, preferably targeted at purchasers. Labelling in particular requires consumers to comprehend the label, or labels. It is therefore recommended that governments work with the relevant organisations and utilities to ensure that the existing labelling program is adequately promoted.

GWA has made a number of specific proposals with regard to the labelling from for gas water heaters, which we endorse [GWA, 2000]. These include:

- Monitoring of efficiency trends for gas water heaters;
- Monitoring of consumer awareness of labelling;
- Establishment of supporting communications for gas water heating label;
- Addition of gas water heaters to www.energyrating.gov.au;
- Stars (on the label) to be presented in half star steps.

In the absence of a commercial gas water heater labelling program, 'best practice' promotions targeted at specifiers and existing building owners should also be considered. This might include technology demonstrations, best practice guides and benchmarks for typical water heating consumption costs for different business types. In particular, these could target business types for which hot water is a significant proportion of the total energy bill, such as laundries. It is also suggested that the development of such materials is completed in conjunction with relevant industry representatives or trade organisations, to ensure that materials are appropriate and disseminated throughout the industry.

Hot water installers have a significant influence on the model, brand and type of water heaters installed, particularly in the residential sector. In the short term, targeted information programs should be considered. In the longer term, the development of modules in existing training courses for the building trades, for example through TAFE, should be considered. This approach has been trialed in some States and materials are already available [SEDA, 1999b]. In both cases, governments are encouraged to work through appropriate industry representatives or trade organisations.

11. GREENHOUSE REDUCTIONS

The total energy consumption accounted for from the water heaters under review is estimated to be 15,715 GWh per annum in 2000, equivalent to 6,268 kt CO₂-e. Energy consumption, and greenhouse emissions, are estimated to rise by an average of 1.5% and 1.7% per annum respectively over the period to 2015. Emissions in 2015 are estimated to be 8,130 kt CO₂-e.

Table 46: Estimated Business As Usual Greenhouse Emissions, 2000-2015

Year	Total Emissions ktCO₂-e
2000	6,268.3
2001	6,323.9
2002	6,484.7
2003	6,650.3
2004	6,707.1
2005	6,820.6
2006	6,935.8
2007	7,052.9
2008	7,172.0
2009	7,293.0
2010	7,416.1
2011	7,552.6
2012	7,692.0
2013	7,834.6
2014	7,980.2
2015	8,129.1

In estimating the impact of the proposed MEPS, the following assumptions have been made:

- That MEPS will be applied to those product recommended in the previous section, effective from 2005;
- That energy consumption of gas water heaters increases during this period, as discussed in Sections 5.7 and 5.8;
- It is assumed that there will be a small growth over the forthcoming decade in energy consumption by all other products under review, as result of increased stock levels and/or increased average consumption per unit. The net impact of this is assumed to 3% growth per annum;
- That the greenhouse intensity of electricity supply will reduce slowly over the next decade;
- The impact of MEPS will be a 10% reduction in consumption, compared to the base case.

The cumulative greenhouse savings in 2010 resulting from the implementation of MEPS is estimated to 360 kt CO₂-e. This is predicted to rise to 690 kt CO₂-e in 2015.

Table 47: Estimated Cumulative Annual Greenhouse Emission Savings as a result of implementing MEPS

Year	Impact of MEPS (ktC02)	
2000	-	0
2001	-	0
2002	-	0
2003	-	0
2004	-	0
2005	58	58
2006	59	118
2007	60	178
2008	61	239
2009	62	301
2010	63	364
2011	64	429
2012	65	494
2013	66	560
2014	68	628
2015	69	697

12. ECONOMIC IMPLICATIONS

Incremental increases in water heater efficiency generally are highly cost effective, since most of the technology improvements involved are not complex. In this case, the majority of improvements have already been made to mains-pressure electric storage heaters (or are in the process of being adopted), and many of the techniques developed, such as improved tank insulation, are readily transferable.

This should mean that on-costs are small per unit and that these are covered by fuel savings to customers over a short period.

13. IMPLEMENTATION

13.1 MEPS Timetable

It is understood that NAEEEC proposes to recommend to ANZMEC the following target timeframe for the introduction of MEPS, giving industry an appropriate period of notice to undertake any necessary modifications to production procedures. This proposed timeframe may be modified to take into account specific circumstances that may arise not foreseen at this time.

1.	<p>Development Stage</p> <p>Following the publication of this initial desk-top review of the energy impacts of mandatory and / or voluntary measures, the following steps will occur</p> <p>An industry expert will work to refine the initial MEPS proposals.</p> <p>Cost/benefit analysis of potential legislative options.</p> <p>Industry and stakeholder consultation on potential legislative proposals.</p> <p>Development of Australian and New Zealand Standards for inclusion in regulations.</p> <p>Ministerial approval required before introduction of any new regulations.</p>	<p>Timetable</p> <p>Commenced from July 2000 and completed by July 2002</p>
2.	<p>Notification Stage</p> <p>Period of notification will depend on the level of manufacture undertaken in Australia. Longer periods would apply if Australian industry required to undertake substantial development or re-tooling</p>	<p>The Australian standard will be published by July 2002 containing the MEPS levels and the MEPS will come into effect from July 2005</p>
3.	<p>Duration Stage</p> <p>This is the 'stability period' in which no changes to regulations are made (i.e. MEPS levels unchanged).</p>	<p>Commenced from July 2005 and scheduled for reconsideration by July 2010</p>

13.2 Strategy for public consultation

We understand that stakeholder participation in the process will be mainly through having representation on the project steering committee that NAEEC has established, together with involvement in the normal consultation process undertaken during the Regulatory Impact Statement process.

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Tas, 2000 *Review of Energy Rating Requirements and Methods of Test in Gas Water Standard AG.102*. Report prepared for the Australian Greenhouse Office by Ibrahim Tas, Senior Scientist, AGL Gas Networks.

APPENDIX A: MAILING LIST OF INTERESTED PARTIES

1. Aquamax, Geoff Nanscowen – 03 9532 2200
2. Astra, Mario Tuntar – 03 9555 2940
3. Beasley, Darcy Dolman – 08 8340 2299
4. Bosch, Ian Beets – 03 9541 7931
5. Dux, Chris Duffus – 02 9580 1066
6. Edson, Andrew Whitney – 03 9548 1133
7. Hocking, Ross Hocking – 02 9559 4811
8. Hot Water Systems Australia, Bill Riach – 03 9315 1533
9. Raypak, Alan Worthington – 03 9535 3333
10. Rinnai, Andrew Gleeson – 03 9271 6665
11. Saxon, Craig Holmes – 07 3265 5133
12. Southcorp, Peter Faase – 02 9748 5400
13. Wilson, Frank Harper – 03 9874 4222
14. Zip, Murray Pope – 02 9796 3100
15. Quantum, Michael Fraser – 02 4956 8882
16. Southcorp, Peter Faase – 02 9748 5400
17. Whelan -Laurie Whelan Industries, PO Box 1021 Geelong 3220 tel 03 5221 7399
18. Wilson - 11 Argent Place Ringwood 3134 tel 03 9874 4222

A.1 Storage Water Heaters

A.1.1 Stakeholders and Industry Organizations

Australian Electrical and Electronic Manufacturers Association (AEEMA)

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Australian Gas Association

National Office

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Phone: 02 6247 3955 Facsimile: 02 6272 1566

Australian Greenhouse Office

John Gorton Building

GPO Box 621, Canberra ACT 2601

Phone: 02 6274 1888 Facsimile: 02 6274 1795

Australian Industry Group

Contact: National Manager Trade Policy

GPO Box 817, Canberra ACT 2601

Electricity Supply Association of Australia

PO Box A2492, Sydney South NSW 2001

Phone: 02 9233 7222 Facsimile: 02 9233 7244

Energy Development Association of Australia

The Secretary. Level 1 - Taringa Circle, 165 Moggill Road, TARINGA QLD 4068

Ph.: (07) 3217 7533 Fax.: (07) 3217 7544

Email: info@eda.org.au Web: <http://www.eda.org.au>

The Master Plumbers' and Mechanical Services Association of Australia

525 King Street, West Melbourne, Victoria 3003

Telephone (03) 9329 9622 Fax (03) 9329 5060

The National Plumbing and Mechanical Construction Industry Association Inc.

Chairman: Mr Barry Cooper

A.1.2 Regulators

Technical Adviser to NAEEEEC

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NSW Ministry of Energy and Utilities

National Appliance and Equipment Energy Committee

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Victorian Office of the Chief Electrical Inspector

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Qld Dept of Mines and Energy

Electrical Safety Branch

Contact: Alan Faulks, Electrical Approvals

61 Mary Street, PO Box 194, Brisbane QLD 4000

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WA Office of Energy

Contact: Chairman, Electrical Approvals

20 Southport Street, Leederville WA 6007

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Contact: Chairman, Electrical Approvals

4th Floor JAPE Building

GPO Box 1921, Darwin NT 0801

Phone: 08 8294 7111 Facsimile: 08 8927 212

Aurora Energy

Contact: Chairman, Electrical Approvals

4 Elizabeth Street, Hobart TAS 7001

Phone: 03 6230 5855 Facsimile: 03 622 33279

ACT Dept of Urban Services

Electrical Approvals Division

Chairman: Electrical Approvals

GPO Box 158, Canberra ACT 2601

Phone: 02 6207 5111 Facsimile: 02 6207 6229

A.1.3 Testing Interests

The most likely source of Testing Laboratory interests would be NATA and through certification bodies e.g. QAS. Their contact details are included below.

NATA

7 Leeds Street, Rhodes NSW 2138

Phone: 02 9736 8222 Facsimile: 02 9743 5311

Internet: <http://www.nata.asn.au>

Quality Assurance Services

1 The Crescent Homebush NSW 2150

PO Box 1055, Strathfield NSW 2135

Phone: 1300 65 4646 Facsimile: 1300 65 4949

Internet: <http://www.qas.com.au>

A.1.4 Individual Manufacturers of Storage Water Heaters

ACE Hot Water Systems

3 Trolley Crt, Hope Valley SA 5090

Ph: 08 263 9577 Facsimile: 08 8263 1722

Beasley Industries Pty Ltd

PO Box 104, Hindmarsh SA 5007

Ph: 08 8340 2299 Facsimile: 08 8340 0829

Birko Australia

26 Victoria Crescent, Abbotsford, Victoria 3067

Phone: 03 9419 4333 Facsimile: 03 9419 4921

Dux Manufacturing

Product Manager

PO Box 209, Moss Vale NSW 2577

Phone: 02 4868 3177 Facsimile: 02 4969 2014

Edson

7 Fury Court, Clayton, Victoria 3168

Phone : 03 9548 1133 Facsimile: 03 9558 5329

James Hardies Industries Pty Ltd

Locked Bag 24, Milperra, NSW 1891

Phone: 02 9774 0155 Facsimile: 02 9772 3877

Kambrook Group Australia

44 Fenton Street, Huntingdale Vic 3166

Phone: 03 9265 2222 Facsimile: 03 9543 5308

Peter Sachs Industries Pty Ltd

212 Zilmere Road, QLD 4034

Phone: 07 3265 5133 Facsimile: 07 3265 5781

Reliance Manufacturing Company Pty Ltd

PO Box 305, Fortitude Valley, QLD 4006

Phone: 07 3252 3646 Facsimile: 07 3252 9391

Simons W and Simons (Aust) Pty Ltd

124 Paramatta Road, Camperdown NSW 2050

Phone: 02 9516 1966 Facsimile: 02 9517 1668

Southcorp Water Heaters

Water Heating Division

PO Box 6, Rydalmere, NSW 2116

Phone: 02 9684 9432 Facsimile: 02 9898 0418

Whelan (Laurie Whelan Industries)

PO Box 1021 Geelong 3220

Phone: 03 5221 7399

Wilson

11 Argent Place Ringwood Vic 3134

Phone 03 9874 4222

Zip Heaters (Australia) Pty Ltd

Private Bag 80, Bankstown, NSW 2200

Phone: 02 9796 3100 Facsimile: 02 9796 3858

A.2 Solar Water Heaters

A.2.1 Contact Details for Stakeholders and Industry Organizations

Australian and New Zealand Solar Energy Society (Represented by Solahart Industries)

(See contact details for Solahart Industries under the heading for manufacturers).

Australian Industry Group

Contact: National Manager Trade Policy

GPO Box 817, Canberra ACT 2601

Australian Greenhouse Office

John Gorton Building

GPO Box 621, Canberra, ACT 2601

Phone: 02 6274 1888 Facsimile: 02 6274 1795

Energy Research Centre

Contact: Mr T Lee

GPO Box 4, Canberra, ACT 2601

Ph: 02 6249 2751 Facsimile: 02 6429 3816

Energy Development Association of Australia

The Secretary. Level 1 - Taringa Circle, 165 Moggill Road, TARINGA QLD 4068

Ph.: (07) 3217 7533 Fax.: (07) 3217 7544

Email: info@eda.org.au Web: <http://www.eda.org.au>

Sustainable Energy Industry Association (SEIA)

Ground Floor, Construction House, 217 Northbourne Avenue, TURNER ACT 2612. PO Box 411, DICKSON ACT 2602

Chief Executive Officer: David Abba

Phone: (02) 6230 1562 Fax: (02) 6230 0273 email: ceo@seia.com.au

A.2.2 Regulators

NSW Ministry of Energy and Utilities

Research Funding and Technology

Contact: Mr Malcolm Williams

Phone: 02 9901 8840 Phone 02 9901 8403

Energy Efficiency Victoria

Contact: Mr Ken Guthrie

Ground Floor, 215 Spring Street, Melbourne, Vic 3000

Phone: 03 9655 3266 Facsimile: 03 9655 3255

A.2.3 Individual Manufacturers of Solar Water Heaters

AB & S Solar Industries Pty Ltd

Contact: Mr R.H.Cooper

29 Shafton Street, Huntingdale, Vic 3166

Phone: 03 9543 7249 Facsimile: 03 9562 9547

ACE Hot Water Systems

3 Trolley Crt, Hope Valley, SA 5090

Ph: 08 263 9577 Facsimile: 08 8263 1722

Beasley Industries Pty Ltd

PO Box 104, Hindmarsh, SA 5007

Ph: 08 8340 2299 Facsimile: 08 8340 0829

Hocking Water Heater Co Pty Ltd

415-421 Illawarra Road, Marrickville, NSW 2204

Phone: 02 9959 4811 Facsimile: 02 9558 6948

Solahart Industries Pty Ltd

Contact: Mal Hayes

112 Pilbarra Street, Welshpool, WA 6106

Phone: 1800 63 8495 Facsimile: 08 9353 4101

Soutcorp Water Heaters Pty Ltd

Contact: Mr B Bourke

13 Rachel Close, Silverwater, NSW 2128

Phone: 02 9748 5400 Facsimile: 02 9648 4202

SVP Industries Pty Ltd

Contact: Michael Turner

George Town, TAS 7253

Phone: 03 6382 1844 Facsimile: 03 6382 3011

Zane Solar Systems Australia Pty Ltd

3440 Pacific Highway, Springwood, QLD 4127

Phone: 07 3208 9811 Facsimile: 07 3808 4870

A.3 Gas Water Heaters

A.3.1 Stakeholders and Industry Organizations

Australian Gas Association

National Office

7 Moore Street, Canberra ACT 2601

Phone: 02 6247 3955 Facsimile: 02 6272 1566

Australian Greenhouse Office

John Gorton Building

GPO Box 621, Canberra ACT 2601

Phone: 02 6274 1888 Facsimile: 02 6274 1795

The Master Plumbers' and Mechanical Services Association of Australia

525 King Street, West Melbourne, Victoria 3003

Telephone (03) 9329 9622 Fax (03) 9329 5060

The National Plumbing and Mechanical Construction Industry Association Inc.

Chairman: Mr Barry Cooper

A.3.2 Regulators

Australian Gas Association

National Office

7 Moore Street, Canberra ACT 2601

Phone: 02 6247 3955 Facsimile: 02 6272 1566

A.3.3 Testing Interests

The most likely source of Testing Laboratory interests would be NATA and through certification bodies e.g. QAS. Their contact details are included below.

NATA

7 Leeds Street, Rhodes NSW 2138

Phone: 02 9736 8222 Facsimile: 02 9743 5311

Internet: <http://www.nata.asn.au>

Quality Assurance Services

1 The Crescent Homebush, NSW 2150

A.3.4 Contact Details for Manufacturers of Gas Water Heaters

AIRA Pty Ltd

144 Colchester Rd, Kilsyth, Vic 3137

Phone: 03 9728 5566 Facsimile: 03 9761 4732

AUSTCROWN Pty Ltd

D61,1 World Trade Centre

Phone: 03 9629 3363 Facsimile: 03 9629 3828

Bowin Manufacturing Pty Ltd

37-39 Chard Road, Brookvale, NSW 2100

Phone : 02 9938 5433 Facsimile: 02 9939 2025

ELGAS Limited

Milsons Point, New South Wales 2061.

Tel : + 61 2 9927 3200 ; Local Call: 61 131 161 –

Hocking Water Heater Co Pty Ltd

415-421 Illawarra Road, Marrickville, NSW 2204

Phone: 02 9959 4811 Facsimile: 02 9558 6948

James Hardies Industries Pty Ltd

Locked Bag 24, Milperra, NSW 1891

Phone: 02 9774 0155 Facsimile: 02 9772 3877

Maxco Industries Pty Ltd

8 Bennett St, Mortlake, New South Wales 2137.

Phone: 02 9736 1633 Facsimile: 02 9736 1338

A.4 Water Heaters using Heat Exchangers

A.4.1 Stakeholders and Industry Organizations

Australian Greenhouse Office

John Gorton Building, GPO Box 621, Canberra ACT 2601

Phone: 02 6274 1888 Facsimile: 02 6274 1795

Australian Industry Group

Contact: National Manager Trade Policy

GPO Box 817, Canberra ACT 2601

Heat Exchange Manufacturers Association

Contact: Peter Holmes

P.O. Box 82, Virginia, QLD 4014

Phone: 07 3265 5133 Facsimile: 07 3265 5781

The Master Plumbers' and Mechanical Services Association of Australia

525 King Street, West Melbourne, Victoria 3003

Telephone (03) 9329 9622 Fax (03) 9329 5060

The National Plumbing and Mechanical Construction Industry Association Inc.

Chairman: Mr Barry Cooper

A.4.2 Regulators

Energy Efficient Strategies Division

Contact: Lloyd Harrington (Director)

PO Box 515, Warragul, Victoria 3820

Phone: 03 5626 6333 Facsimile: 03 5626 6442

E-Mail: lloydh@ozemail.com.au

NSW Ministry of Energy and Utilities

National Appliance and Equipment Energy Committee

Contact: Tim Aldrich

PO Box 536, St Leonards, NSW

Phone: 02 9901 8837 Facsimile: 02 9901 8403

A.4.3 Contact Details for Manufacturers of Heat Exchange Water Heaters

Dux Manufacturing

Product Manager

PO Box 209, Moss Vale, NSW 2577

Phone: 02 4868 3177 Facsimile: 02 4969 2014

Heat Exchangers International Ltd

Units 8 and 9, Mt Waverley, Victoria 3149

Phone: 03 9588 8877 Facsimile: 03 9558 8250

E-Mail: sales@hei.com.au

Peter Sachs Industries Pty Ltd

212 Zilmere Road, QLD 4034

Phone: 07 3265 5133 Facsimile: 07 3265 5781

APPENDIX B: AUSTRALIAN STANDARDS

This Appendix identifies relevant standards that apply, or may apply to the types of water heaters under review in this report. The following table provides a summary of Australian Standard coverage and MEPS recommendations.

Table B1: Summary of Australian MEPS and Test Methodologies.

Water Heater	MEPS	Test Methodology
Electric Instantaneous – commercial & domestic	N/A	N/A
Electric Low Pressure – domestic	AS/NZS1056.1:1996	AS/NZS1056.1:1996
Electric Solar – commercial & domestic	N/A	AS2984:1987, AS2813:1985, AS4234:1994
Electric Calorifier – commercial & domestic	AS1361:1995 – AS1056.1, 2 & 4	AS1361:1995 AS1056.1, 2 & 4
Heat Exchange – commercial & domestic	AS1361:1995	AS1361:1995
Gas Storage – commercial	AG102:1998	AG102:1998
Gas Calorifier – commercial & domestic	AG102:1998, AS1361:1995-	AG102:1998, AS1361:1995
Gas Solar – commercial & domestic	AG102:1998	AG102:1998, AS2984:1987, AS2813:1985, AS4234:1994

B.1 AS 1056.1-1991 Storage water heaters - General requirements

B.1.1 Scope

Specifies general construction and performance requirements for electric storage water heaters of 25 L to 630 L rated hot water delivery. (Requirements for gas water heaters are specified only by reference to Code AG 102 published by AGA/ALPGA.) To be read in conjunction with AS 1056.2 or AS 1056.3 as appropriate. Includes method of test for determination of standing heat loss and rated hot water delivery capacity.

B.1.2 Brief Information

MEPS levels are specified in this standard in terms of maximum allowable heat loss as shown below.

Table B2: Electric Water Heaters – Maximum Heat Loss

1 Rated Hot Water Delivery	2 Maximum Heat Loss, kWh/24hours (see note 1)			4
	3 Water Heaters without an Attached Feed Tank		Water Heaters with an Attached Feed Tank	
	Unvented (see note 2)	Vented		
L				
25	1.4	1.4		
31.5	1.5	1.5		
40	1.6	1.6		
50	1.7	1.7		
63	1.9	1.9		
80	1.47	2.1		
100	1.61	2.3	2.6	
125	1.75	2.5	2.8	
160	1.96	2.8	3.1	
200	2.17	3.1	3.4	
250	2.38	3.4	3.7	
315	2.66	3.8	4.1	
400	2.87	4.1	4.4	
500	3.15	4.5	4.8	
630	3.43	4.9	5.2	

Source: AS1056.1:1991 Amendment 3, 5 August 1996, Table 2.1

Notes:

1. These values apply to water heaters with a single heating unit and may be increased by 0.2 kWh/24hr for each additional heating element.
2. The values in column 3 may be used instead of the values in column 2 for unvented water heaters without an attached feed tank that are manufactured in Australia before 1 October 1999 or imported before 1 October 1999.

The values for unvented water heaters without an attached feed tank may be increased by 0.2 kWh/24hr for each temperature or temperature/pressure relief valve mounted on a hot-water fitting, but not for any valve mounted on a cold water fitting.

The standard is mandatory for electric water heaters without an attached feed tank (unvented displacement or mains pressure types) through government regulations, but the requirements for low-pressure units are not yet included in government regulations.

B.1.3 Status

Current. This standard was prepared by Standards Australia's Committee on Electric Water Heating Appliances (EL20). The standard is currently under revision.

B.1.4 International Relationships

No related standards, although parts are similar in principle to IEC 60379.

B.2 AS 1056.2-1985 Storage water heaters - Specific requirements for water heaters with single shells

B.2.1 Scope

Specifies constructional requirements for water containers (shells) made of single materials, viz. plastics, copper or copper alloys, or stainless steel. Gives recommendations on maximum water temperature and specifies routine and type test schedules.

B.3 AS 1056.3-1991 Storage water heaters - Specific requirements for water heaters with composite shells

B.3.1 Scope

Specifies constructional requirements for water containers (shells) made of composite materials, viz. steel with a copper or copper alloy insert (inner liner), or steel with a bonded inner lining of vitreous enamel or of plastics material. Gives recommendations on maximum water temperatures, specifies methods of testing the quality of inner linings, and also routine and type test schedules.

B.4 AS/NZS 1056.4:1997 Storage water heaters - Daily energy consumption calculations for electric types

B.4.1 Scope

Sets out a method for calculating the energy consumption of electric storage water heaters fitted with electric resistance heating units. This Standard is not applicable to gas water heaters, solar water heaters, and heat exchangers or heat pumps. The Standard is based on known performance characteristics of electric storage water heaters under static conditions (i.e. standing heat losses with no delivery) and provides an estimate of actual in-use heat losses for a wide range of hot water energy delivery volumes. Standing heat loss to AS1056.1 is used as the primary input but details of draw-off profile and energisation profile is also required. Actual heat loss and delivered energy allow calculation of total energy consumption for steady state conditions.

AS 2535-1986 Solar collectors with liquid as the heat-transfer fluid - Method for testing thermal performance

Sets out a method for determining the thermal performance characteristic of all classes of solar collectors operating with liquid as the heat-transfer fluid. The thermal performance characteristic may be used to estimate collector performance when subjected to different ambient conditions and load requirements.

B.5 AS 2984-1987 Solar water heaters - Method of test for thermal performance - Outdoor test method

B.5.1 Scope

Sets out a method of determining the thermal performance of a solar water heater under natural outdoor conditions and prescribes a method of transforming the test results from the particular climate conditions of the test to long-term average conditions for the test location, or to other locations.

B.6 AS 2813-1985 Solar water heaters - Method of test for thermal performance - Simulator method

B.6.1 Scope

Sets out a method of determining the thermal performance of a solar water heating system under controlled conditions which simulate an average day and a bad weather day. Means of using the results of this test to predict thermal performance under other operating conditions are given in an appendix.

This standard sets out a method for determining the performance of solar water heater system under controlled conditions simulating an average day and a bad day weather day. The solar tests are completed on solar only and average day tests. Alternatively, the non-solar tests are completed on bad weather days. The average and non-solar tests are completed under controlled conditions for six day periods.

The standard is suitable for testing solar collectors, close coupled, or integral unit systems for storage and instantaneous water heaters.

The standard assumes that that climate, total load demand and times of demand during the day and the temperature of the hot water system will influence the energy efficiency of solar water heaters.

B.6.2 Brief Information

The solar only, average and non-solar heating tests are used to evaluate the efficiency, energy capacity and solar fraction levels of water heaters. The efficiency levels are expressed in terms of MJ/d. Total daily demand tests for continuous and instantaneous water heaters when they are tested to off-peak and continuous average day and non-solar tests are included.

The standard is suitable for water heaters that have efficiency ratings of 19 MJ/m² d and 30 MJ/m² d.

B.6.3 Status

Current. This standard was prepared by Standards Australia's CS/28 committee on solar waters in response to a request from the Australian and New Zealand section of the International Solar Energy Society. The current standard does not supersede any previous standard. The CS/28 committee is revising AS 2813-1985. No proposed publication date for the standard has been determined.

B.6.4 International Relationships

No related international standards. Is this related to ISO 9459-1:1993 Solar heating - Domestic water heating systems - Part 1: Performance rating procedure using indoor test methods?? (probably not - talk to Morrison)

B.7 Solar Water Heaters. AS 4234-1994. Domestic and heat pump – Calculation of energy consumption

B.7.1 Scope

Sets out a method of determining the annual performance of domestic solar and heat pump water heaters using a combination of test results for component performance and a mathematical model to determine annual load cycle task performance. Together with the Standard a software disk is provided. It contains a program for evaluation of energy consumption of the solar water heaters under testing.

Component performance is determined in accordance with AS2984 or AS2813. The software program is called "RATING" and uses the TRNSYS finite element thermodynamic model to calculate hourly performance in accordance with ambient conditions and draw offs. The model can also be used on water heaters using conventional fuels.

B.7.2 Brief Information

The standard includes a method for assessing annual energy savings of a solar water heater compared to a conventional storage or instantaneous water heaters. This standard sets out a method for determining the performance of a solar water heating system using information determined under natural outdoor conditions and prescribes a method of transforming the test results from the particular climate conditions of the test to long-term average conditions for the test location, or for other locations with similar solar irradiation conditions. The standard applies to solar water heaters that use an

auxiliary heating system to satisfy loads under solar and non-solar input conditions. Solar collectors, close coupled and integral unit systems are examples of the types of solar water heaters that can be tested to this standard.

The non-solar test and solar tests use the drawn-off sequences that are included in table 2.1 to the standard. The tests are carried out between 7.00 am-18.00 pm, with the maximum load being applied at 7.00 am.

The solar test uses 4 Australian climatic zones to calculate the following:

- The measured system capacity of collectors, close coupled and integral units (Measured in E_1 MJ/D and E_2 MJ/d)
- The nominal system capacity of collectors, close coupled and integral units. (Measured in MJ/d)
- The continuous off-peak supply of energy (Measured in MJ/d)
- Average daily temperature °C
- Average ambient temperature ° C per day.

Procedures for calculating energy savings for solar heaters as compared to conventional electric water heaters are also included in the standard.

B.7.3 Status

Current. Standards Australia's CS/28 committee on solar water heaters prepared this standard. The standard does not supersede any previous standards. The committee is currently revising the standard. The new standard will be a joint Australian/New Zealand standard. The standard should be published in 2-3 months.

B.7.4 International Relationships

No related standards.

AS/NZS 4445.1:1997 Solar heating - Domestic water heating systems - Performance rating procedure using indoor test methods

This Standard provides an indoor test method for rating solar domestic water heating for thermal performance under benchmark conditions. This Standard is identical with and reproduced from ISO 9459.1:1993.

B.8 Gas Water Heaters. AG 102-1998. Approval requirements for gas water heaters

B.8.1 Scope

This standard applies to new gas water heaters with natural draught or fan assisted combustion systems, constructed totally from new materials and components and intended for use with Natural Gas, Town Gas, Liquefied Petroleum Gas (LPG) and Tempered Liquefied Petroleum Gas (TLP) with a gas consumption not exceeding 500 MJ/h.

The standard specifies thermal efficiency, heat output and energy labelling requirements for storage water heaters and instantaneous water heaters.

B.8.2 Brief Information

Storage water heaters with gas consumption up to and including 50 MJ/h are required to meet the thermal efficiency; heat output and energy labelling that are referred to in test 5.3.1 (a) to the code. Alternatively, storage water heaters with nominal gas consumption in excess of 0.5 MJ/h and instantaneous water heaters with gas consumption up to and including 250 MJ/h shall be tested to the method that is included in 5.3.1 (b) to the code.

Both tests use the same formula for measuring the thermal efficiency of storage and instantaneous heaters. The test methodology uses the 'gross heating value' of gas, which is equivalent to the 'higher heating' value specified in US standards, as opposed to the European tests which tend to be based on the 'net heating' value. Similar criteria for complying with AGA energy labelling and gas saving requirements also apply to storage and instantaneous water heaters (see below).

B.8.3 Thermal Efficiency Requirements

Thermal efficiency of storage water heaters, instantaneous heaters and circulators operating at nominal gas consumption shall not be less than 70%.

The gas consumption required to maintain the average temperature of the water in a storage water heater at 45°C above ambient shall not exceed the following:

$$M = 0.42 + 0.02V^{2/3} + 0.006R$$

M = Maintenance Gas Consumption in MJ/h

V = Nominal Capacity in Litres

R = Nominal Gas Consumption in MJ/h

For labelling of instantaneous gas water heaters, the test process includes calculation of the 'start-up capacity' of each water heater, based on 19 draw-offs per day. This is included in the formula for quantifying the annual energy consumption.

When the above tests have been completed, storage and instantaneous water heaters can be labelled according to the AGA's star gas approval scheme.

It should be noted that the test conditions are equivalent to raising 200 litres per day from 15°C to 60°C, at an ambient temperature of 20°C, ie. a useful energy output of 13,760 MJ/yr.

B.8.4 Status

Current. This standard is currently being revised under the Memorandum of Agreement between Standards Australia and the Australian Gas Association. The proposed new standard should be published in 2-3 months as an Australian standard. The standard will be published as AS/NZS 4552:2000 "Gas water heaters". The new standard will not be based on any international standards. It will incorporate amendments 1-2 to AG 102-1998. The energy efficiency and labelling conformance criteria will not change under the new standard. Currently, AG 102-1998 includes information on quality assurance, production testing and certificates of conformity. This information will not be included in AS/NZS 4552:2000.

B.8.5 International Relationships

No related international standards.

B.9 Heat Exchange Water Heaters. AS 1361-1995. Electric heat-exchange water heaters for domestic applications

B.9.1 Scope

This standard specifies requirements for electric heat-exchange water heaters having a heat-storage volume in the range of 45 L to 710 L, which heat potable water at mains pressure for domestic applications.

B.9.2 Brief Information

This standard includes procedures for hot-water delivery and heat loss tests. The heat loss tests are completed over a 24 hour period.

B.9.3 Status

Current

B.9.4 International Relationships

There are no related international standards.

RELATED AUSTRALIAN STANDARDS

B.10 AS/NZS 3500.4.2:1997 National Plumbing and Drainage - Hot water supply systems - Acceptable solutions

B.10.1 Scope

Specifies the requirements for the installation of domestic type water heaters using potable water. It includes aspects of the installation from, and including, the valves on the cold water inlet to any cistern or water heater and the downstream fixtures and fittings. The Standard applies to new installations as well as alterations, additions and repairs to existing installations.

B.11 SAA MP52-1997 Manual of authorization procedures for plumbing and drainage products

B.11.1 Scope

Provides detailed information on the authorisation procedures for plumbing products based upon the national StandardsMark, WaterMark and TypeTest Mark certification schemes administered by Standards Australia through its approved Certifying Body. These certification marks form the basis of the National Certification of Plumbing and Drainage Products Scheme Types 1 to 3, respectively.

B.12 AS 1308-1987 Electric water heaters - Thermostats and thermal cut-outs

B.12.1 Scope Specifies revised terminology and requirements for thermostats, thermal cutouts (TCOs) and combined units; also a clip template to provide interchangeability between clip-mounted units. Provides guidance on temperature settings and introduces the concept of 'scale offset' to allow for differences between the specified standard test tank and the water heater to be controlled. A minimum cut-out temperature of 60 degrees Celsius is specified on health grounds.

B.13 AS 3498-1995 Authorisation requirements for plumbing products - Water heaters and hot-water storage tanks

B.13.1 Scope

Specifies basic safety and public health related requirements for water heaters and hot-water storage tanks that are intended for connection to a potable water supply, such as water heaters designed for connection to cold water supply mains, including storage water heaters, heat-exchange water heaters, hot-water storage tanks with an external energy source, instantaneous water heaters and boiling-water dispensers.

B.14 AS 4020(Int)-1994 Products for use in contact with water intended for human consumption with regard to their effect on the quality of water

B.14.1 Scope

Specifies requirements for the suitability of products for use in contact with water intended for human consumption. Appendices set out test methods to determine those substances in water extracts that may be of concern to public health. These methods include sampling, taste, appearance, growth of micro-organisms, toxic substances and metals content. [This is a final standard now - 1999]

B.15 AS 3855-1994 Suitability of plumbing and water distribution systems products for contact with potable water

B.15.1 Scope

Specifies basic requirements for plumbing and water distribution systems products in contact with hot or cold potable water, or both.

APPENDIX C: INTERNATIONAL STANDARDS (ISO)

C.1 ISO 9459-1:1993 Solar heating – Domestic water heating systems. Part 1: Performance rating procedure using indoor test methods

C.1.1 Scope

This part of ISO 9459 establishes a uniform indoor test method for rating solar domestic water heating systems for thermal performance using benchmark conditions. The standard uses solar-only, solar pre-heat and solar-plus supplementary tests to test the energy performance of hot water systems.

C.1.2 Brief Information

The energy output from solar heat collectors and auxiliary heating is measured when heaters are tested to solar-only, solar pre-heat and solar-plus supplementary systems. The daily energy that is consumed from pumps, controls and solenoid valves is also assessed.

C.1.3 Status

Current

C.1.4 International Relationships

ISO 9459-2:1995 and ISO 9459-3:1995 are related.

C.2 ISO 9459-2:1995 Solar heating – Domestic water heating systems. Part 2: Outdoor test methods for system performance characterization and yearly performance prediction of solar-only systems

C.2.1 Scope

This part of ISO 9459 establishes test procedures for characterising the performance of solar domestic water heating systems operated without auxiliary boosting and for predicting annual performance in any given climatic and operating conditions, but only for an evening drawn-off.

C.2.2 Brief Information

The standard uses a 6 hour solar test to assess the drawn-off volume from solar water heaters. The standard also refers to a tank heat loss coefficient method to measure the energy that may be lost overnight in a solar water heater.

C.2.3 International Relationships

ISO 9458-1:1993 and ISO 9459-3:1995 are similar.

C.3 ISO 9459-3:1997 Solar heating – Domestic hot water systems. Part 3: Performance test for solar plus supplementary systems

C.3.1 Scope

This part of ISO 9459 establishes test procedures for characterising the performance of solar domestic water heating systems operated without auxiliary boosting, and for predicting annual performance in any given climatic and operating conditions, but only for an evening draw-off.

The test procedures in this part of ISO 9459 do not require the solar water heating system to be subjected to freezing conditions. Consequently, the energy consumed or lost by a system while operating in the freeze-protection mode will not be determined.

C.3.2 Brief Information

The procedures for calculating energy savings using the solar-plus tests are included in section 2.8 to the standard. In order to calculate energy savings, solar heaters are tested for a minimum of 25 periods. The following factors are calculated over the 25 test periods:

- Average daily energy load
- Mean hot water drawn-off temperature

- Mean cold water supply temperature
- Average daily ambient temperature
- Average daily irradiance
- Solar Fractions

C.3.3 Status

Current

C.3.4 International Relationships

Similar to ISO 9459-1:1993 and ISO 9458-2:1995.

C.4 IEC 60379:1987 Methods for Measuring the Performance of Electric Storage Water Heaters for Household Purposes”

C.4.1 Scope

States and defines the principal performance characteristics of electric storage water-heaters which are of interest to the user and to describe the standard methods for measuring these characteristics. This standard is concerned neither with safety nor with performance requirements.

This standard does not apply to:

- Water-heaters using other sources of energy (e.g. solar energy);
- Water-heaters with more than one heated volume;
- Water-heaters without thermal insulation.

C.4.2 Summary of test procedure

IEC 60379-87 is essentially a method for measuring the performance of electric storage water heaters. It is not applicable to heat pump or solar units or those with more than one heated volume. The main performance measures determined under the test procedure are:

- Static capacity based on volume of water;
- Standing heat loss per 24 hours (no draw off) at an air hot water temperature differential of 45°C (ambient air of 20°C and hot water at 65°C);
- Hot water output, defined as a capacity of X litres at Y °C, is determined from a measurement of water temperatures for a draw off equal to the rated capacity;
- Reheating time is determined from cold to first thermostat cutout and corrected back to a temperature rise of 50°C (cold water at 15°C and hot water at 65°C);
- Mixing factor is determined by comparing the hot water temperature without cold replenishment to the hot water temperature with cold replenishment.

C.4.3 Details

The main variables determined in this test procedure are standard heat loss test and the hot water output. Heat loss is determined at the tank thermostat temperature for a whole number of thermostat cycles over a period of not less than 48 hours. The heat loss value is then corrected back to a temperature rise above ambient of 45°C (ambient air of 20°C and hot water at 65°C).

Hot water output test: the flow rate is determined from the tank size as follows:

- 2 L/min for tanks less than 10 L
- L/min for tanks from 10 L to 50 L
- L/min for tanks from 50 L to 200 L
- 5% of the rated capacity per minute for tanks > 200 L

The thermostat temperature is selected and the tank allowed to heat up to temperature. Once the thermostat has cut out, the power is disconnected and a hot water volume equal to the rated capacity of the tank is drawn off. The temperature is measured continuously during the draw off and the average temperature is determined.

IEC60379-87 is really only suitable for use in determining the characteristics of electric storage water heaters. It cannot be used for other types of electric water heaters (e.g. instantaneous electric, heat pump, solar) nor is it suitable for use with other fuel types. The standard also has limitations in that it is unable to directly determine the energy consumption of water for a specified hot water delivery profile (task efficiency). Task efficiency is particularly important for non-electric water heater types and solar and heat pump water heaters.

APPENDIX D: NEW ZEALAND STANDARDS

D.1 Electric Storage Water Heaters (vented and unvented) [EES 1999b]

D.1.1 Program coverage

The New Zealand standards NZS4602 and NZS4606 set out maximum standing heat losses for electric storage water heaters of the vented and unvented types, as well as a range of other requirements relating to construction. The heat loss levels were made more stringent in 1988, but manufacturers were under no obligation to comply with them. In 1991 the Electricity Development Association (EDA) introduced a “Water Mark” label, which indicated whether a water heater complied with the new heat loss levels (“Class A”) or with less stringent heat losses (Classes B to D).

The label is effectively an endorsement label for Class A water heaters rather than a full comparative label, since it does not explain the entire range of ratings. The label is voluntary, although compliance among Class A product is high because of the publicity support given to the program by the EDA and the electricity utilities. There are now few Class B products on the market, and virtually no Class C or D.

D.1.2 Criteria and requirements

The standing heat loss limits in NZS 4602 and Water Mark Classes are shown in the following Table.

Table C1: Maximum heat losses, electric storage water heaters, New Zealand

Storage volume litres	Maximum Allowable Standing Heat Loss (kWh/day) for Water Mark Classes			
	A (a)	B	C	D
135	1.4	1.8	2.8	3.2
180	1.6	2.0	3.2	3.6
225	1.8	2.3	3.6	4.0
270	2.0	2.56	4.0	4.6
360	2.5	3.2	5.0	5.8
450	2.9	3.7	5.8	6.7

(a) Corresponds to maximum allowable standing heat loss in NZS4602-1988

There is a proposal to amend the New Zealand *Building Code* to require new electric water heaters to comply with the heat loss limits in NZS 4602 (i.e. Water Mark Class A). The *Code* would oblige the dwelling owner (i.e. the builder in the case of speculative or project housing) to install MEPS-compliant water heaters at the time of construction or refurbishment. The *Code* would also require replacement water heater installations to be brought up to the same standards.

If this change were made without introducing water heater MEPS under the *Energy Efficiency Act*, it would continue to be lawful to sell non-compliant water heaters, but effectively unlawful to install them.

D.1.3 Test procedures

The test procedure is set out in NZS4602.1 and NZS4606.1.

APPENDIX E: CANADIAN STANDARDS

Canada's Energy Efficiency Act was passed by Parliament in 1992 provides for the making and enforcement of regulations concerning minimum energy performance levels for energy-using products, as well as the labelling of energy-using products and the collection of data on energy use.

The first *Energy Efficiency Regulations* came into effect in February 1995, following extensive consultations with the provincial governments, affected industries, utilities, environmental groups and others. These Regulations establish energy efficiency standards for a wide range of energy-using products, with the objective of eliminating the least energy-efficient products from the Canadian market.

The following regulations apply to products relevant to this report.

E.1 Electric Storage Water Heaters

E.1.1 Scope

Applies to stationary electric storage tank water heaters with a capacity of not less than 50 litres (11 imperial gallons) and not more than 450 litres (100 imperial gallons) that are intended for use on a pressure system. It is not known whether this standard also applies to calorifiers and heat exchange units.

E.1.2 Criteria and requirements

Table E1: Canadian MEPS for Electric Storage Water Heaters

Product Class	Maximum allowable standby loss (W)
50 to 270 litres	$61 + 0.20 \times V$
271 to 450 litres	$0.472 \times V - 12.5$

Where V = Volume of storage tank in litres. W = Watts

E.1.3 Test Standard

CAN/CSA-C191.1-M90

E.1.4 Requirements for the energy efficiency report

- type of product (electric water heater);
- brand name;
- model number;
- manufacturer;
- name of the organization or province that carried out the water heater verification and authorized the verification mark that will be affixed to the water heater;
- volume of the storage tank in litres;
- rated watt input; and
- standby loss in watts.

E.2 Gas Water Heaters

E.2.1 Scope

Applies to stationary gas-heated water containers with a capacity of not less than 76 litres (20 US gallons) and not more than 380 litres (100 US gallons) that use propane or natural gas and that have an input rating of not more than 21.97 kW (75 000 Btu/h).

E.2.2 Criteria and requirements

Table E2: Canadian MEPS for Gas Storage Water Heaters

PRODUCT CLASS	MINIMUM EF February 3, 1995
Input rating less than or equal to 21.97 kW (75 000 Btu/h)	0.62 - 0.0005V

Where EF = Energy factor calculated as a dimensionless quantity. V = Volume of storage tank in litres.

E.2.3 Test Standard

CAN1-4.1-M85

E.2.4 Requirements for the energy efficiency report

- type of product (gas water heater);
- brand name;
- model number;
- manufacturer;
- name of the organization or province that carried out the gas water heater verification and authorized the verification mark that will be affixed to the water heater;
- volume of the storage tank in litres;
- input rating;
- recovery efficiency;
- energy factor calculated as a dimensionless quantity; and
- whether propane or natural gas is the fuel used.

E.3 Oil-fired Water Heaters

E.3.1 Scope

Applies to oil-fired water heaters that have an input rating of not more than 30.5 kilowatts (0.75 US gallons per hour) and storage capacity of not more than 190 litres (50 US gallons).

E.3.2 Criteria and requirements

Table E3: Canadian MEPS for Oil-Fired Water Heaters

PRODUCT CLASS	MINIMUM EF February 3, 1995
Input rating less than or equal to 30.5 kW (0.75 US gallons per hour)	0.59 - 0.0005V

Where EF = Energy factor calculated as a dimensionless quantity. V = Volume of storage tank in litres.

E.3.3 Test Standard

CAN/CSA-B211-M90

E.3.4 Requirements for the efficiency report

- type of product (oil-fired water heater);
- brand name;
- model number;
- manufacturer;

- name of the organization or province that carried out the water heater verification and authorized the verification mark that will be affixed to the water heater;
- volume of the storage tank in litres;
- input rating;
- recovery efficiency; and
- energy factor calculated as a dimensionless quantity.

E.4 Internal water-loop heat pumps

E.4.1 Scope

The Regulations cover water-source heat pumps that are factory-built single packages or split-system matching assemblies that are intended for installation in internal water-loop systems and which do not exceed 40 kW (135,000 BTU/hr) in cooling or heating capacity.

E.4.2 Criteria and requirements

The MEPS levels summarised in the Table below became mandatory in February 1998.

Table E4: MEPS levels for internal water-loop heat pumps, Canada

Product Class/Function	Minimum EER(BTU/Wh)	Minimum COP(W/W)
Cooling	10.0	2.9(a)
Heating		3.8(b)

Source: NRCan (1999) (a) Cooling MEPS is expressed in BTU/WH; COP value is calculated for information only. (b) Excludes any supplementary heat.

E.4.3 Testing Standard

CAN/CSA-C655-M91.

APPENDIX F: UNITED STATES STANDARDS

F.1 Code of Federal Regulation: Domestic Water Heaters

F.1.1 Scope

The Code of Federal Regulations (CFR) cover the following types of electric water heaters, where water heater means a product which utilises oil, gas, or electricity to heat potable water for use outside the heater upon demand, including:

(a) Storage type units which heat and store water at a thermostatically controlled temperature, including gas storage water heaters with an input of 75,000 Btu per hour or less, oil storage water heaters with an input of 105,000 Btu per hour or less, and electric storage water heaters with an input of 12 kilowatts or less;

(b) Instantaneous type units which heat water but contain no more than one gallon of water per 4,000 Btu per hour of input, including gas instantaneous water heaters with an input of 200,000 Btu per hour or less, oil instantaneous water heaters with an input of 210,000 Btu per hour or less, and electric instantaneous water heaters with an input of 12 kilowatts or less; and

(c) Heat pump type units, with a maximum current rating of 24 amperes at a voltage no greater than 250 volts, which are products designed to transfer thermal energy from one temperature level to a higher temperature level for the purpose of heating water, including all ancillary equipment such as fans, storage tanks, pumps, or controls necessary for the device to perform its function.

F.1.2 Criteria and requirements

The first US MEPS for water heaters was introduced in January 1990, under CFR Part 430, and was designed for testing using a heat up test (to get recovery efficiency) followed by a 48 hour standby test to determine standby losses. The test was changed to the current 24 hour 'simulated' use test on October 17, 1990 and took effect on April 15, 1991, which accounts for the different standards in the following table. In April 2000, the U.S. Department of Energy issued a notice of proposed rulemaking (NOPR) which proposed to increase the stringency of the standard. The final rule, CFR Part 430 issued on January 17, 2001, for implementation from January 20, 2001, is shown in the following table.

The standard is defined in terms of an Energy Factor, which is "a measure of water heater overall efficiency" and is essentially the overall task efficiency for the delivery of 64.3 US gallons over a 24 hour period [EES 1999b].

Table F1: US MEPS for Domestic Water Heaters

Product class	Energy factor, as of Jan. 1, 1990	Energy factor, as of April 15, 1991	Energy factor, as of January 17, 2001 (for implementation January 20, 2004)
1. Gas Water Heater	0.62 - (0.0019 x Rated Storage Volume in gallons)	0.62 - (0.0019 x Rated Storage Volume in gallons)	0.67 - (0.0019 x Rated Storage Volume in gallons).
2. Oil Water Heater	0.59 - (0.0019 x Rated Storage Volume in gallons)	0.59 - (0.0019 x Rated Storage Volume in gallons)	0.59 - (0.0019 x Rated Storage Volume in gallons)
3. Electric Water Heater	0.95 - (0.00132 x Rated Storage Volume in gallons)	0.93 - (0.00132 x Rated Volume Storage in gallons)	0.97 - (0.00132 x Rated Storage Volume in gallons)
4. Tabletop Water Heater *	0.95 - (0.00132 x Rated Storage Volume in gallons)	0.93 - (0.00132 x Rated Volume Storage in gallons)	0.93 - (0.00132 x Rated Storage Volume in gallons)
5. Instantaneous Gas Water Heater	0.62 - (0.0019 x Rated Storage Volume in gallons)	0.62 - (0.0019 x Rated Storage Volume in gallons)	0.67 - (0.0019 x Rated Storage Volume in gallons).
6. Instantaneous Electric Water Heater	0.95 - (0.00132 x Rated Storage Volume in gallons)	0.93 - (0.00132 x Rated Volume Storage in gallons)	0.93 - (0.00132 x Rated Storage Volume in gallons)

Note: The Rated Storage Volume equals the water storage capacity of a water heater, in gallons, as specified by the manufacturer.

* Tabletop Water Heater means a water heater in a rectangular box enclosure designed to slide into a kitchen countertop space with typical dimensions of 36 inches high, 25 inches deep and 24 inches wide.

The test methodology for compliance is based on the 'higher heating' value of gas, which is the same as the 'gross calorific' value used in the AGA test methodology in Australia. For instantaneous gas water heaters, the US test method takes place over a 24hr period and includes six draw-offs over the first six hour period. In addition, US MEPS is calculated on the basis of total input energy, which can include the electrical energy used for electronic ignition, for example.

Further discussion of the US test methodology for gas water heaters and comparison with the Australian procedure is contained in a report prepared for the Australian Greenhouse Office [Tas, 2000].

F.2 Commercial Water Heaters

F.2.1 Scope

MEPS requirements under the Energy Policy and Conservation Act (EPCA) 1992 apply to commercial water heaters where:

- The term "storage water heater" means a water heater that heats and stores water within the appliance at a thermostatically controlled temperature for delivery on demand. Such term does not include units with an input rating of 4000 Btu per hour or more per gallon of stored water.
- The term "instantaneous water heater" means a water heater that has an input rating of at least 4000 Btu per hour per gallon of stored water.
- The term "unfired hot water storage tank" means a tank used to store water that is heated externally.

F.2.2 Criteria and requirements

The following standards took effect on 1 January 1994:

Table F2: Requirements under EPCA 1992, Implemented from 1994

Category	Energy Efficiency Descriptor	Requirement
Electric storage water heaters *	maximum standby loss	$0.30 + (27/\text{Measured Storage Volume (in gallons)})$
Gas- and oil-fired storage water heaters with input ratings of 155,000 Btu per hour or less *	maximum standby loss	$1.30 + (114/\text{Measured Storage Volume (in gallons)})$
	minimum thermal efficiency	78%
Gas- and oil-fired storage water heaters with input ratings of more than 155,000 Btu *		be $1.30 + (95/\text{Measured Storage Volume (in gallons)})^*$
	minimum thermal efficiency	78%
Instantaneous water heaters with a storage volume of less than 10 gallons	minimum thermal efficiency	80%
Instantaneous water heaters with a storage volume of 10 gallons or more	minimum thermal efficiency	77%
	maximum standby loss	$2.30 + (67/\text{Measured Storage Volume (in gallons)})$
Unfired hot water storage tanks *	maximum heat loss	6.5 Btu per hour per square foot of tank surface area

* Note: Storage water heaters and hot water storage tanks having more than 140 gallons of storage capacity need not meet the standby loss requirements if the tank's surface is thermally insulated to R 12.5 (imperial units R2.2 metric)

F.2.3 Amendment to Rule, 2001

On January 12, 2001, the Department of Energy announced amendments to Rule CFR Part 431, with regard to some categories of commercial water heaters, for implementation from the October 29, 2003. The new standards are shown in the following Table.

Table F3: US MEPS Level for Commercial Water Heaters, from 2003

Equipment Type	Energy Efficiency Descriptor	January 2001 (for implementation from October 2003)
Gas Storage Water Heater	Min. Thermal Efficiency	80%
	Max. Standby Loss *	$Q/800 + 110\sqrt{Vr}$ (Btu/hr)
Gas Instantaneous Water Heater	Min. Thermal Efficiency	80%
	Max. Standby Loss *	$Q/800 + 110\sqrt{Vr}$ (Btu/hr)
Oil Storage Water Heater	Min. Thermal Efficiency	78%
	Max. Standby Loss *	$Q/800 + 110\sqrt{Vr}$ (Btu/hr)
Oil Instantaneous Water Heater	Min. Thermal Efficiency	78%
	Max. Standby Loss *	$Q/800 + 110\sqrt{Vr}$ (Btu/hr)
Unfired Hot Water Storage Tanks	Minimum Insulation Requirement	R 12.5

Q = the Nameplate rating in Btu/hr.

Vr = is the rated volume in gallons.

F.2.3 Testing standards and procedures

Under CFR430, electric water heaters are tested to CFR Part 430 Subpart B Appendix E. Under the Energy Policy Act 1992, water heater test procedures are referenced to ASHRAE 90.1 (updated in 1999), which in turn references ANSI Z21.10.3 (which is for gas water heaters, but presumably sets test conditions).

F.3 Solar Energy Standards Act (1996) Florida

The Solar Energy Standards Act of 1976, Section 377.705. Florida Statutes, directs the Florida Solar Energy Center (FSEC) to develop and promulgate standards for solar energy systems manufactured or sold in the state; to establish criteria for testing performance of solar energy systems; and to maintain the necessary capability for testing or evaluating performance of solar energy systems.

In 1978 the Legislature amended the act to require, effective January 1, 1980, that all solar energy systems manufactured or sold in the state meet the standards established by FSEC and display accepted results of approved performance tests in a manner prescribed by FSEC.

FSEC's solar collector certification program, begun in October 1976, provides a standard test method, minimum quality standard, and a performance rating method for solar collectors. To expand the program coverage, standards have been written which address testing, rating, design, and installation of total systems that use solar energy to heat domestic water and swimming pools.

F.3.1 Domestic hot water systems

For solar systems that have been tested and rated based on ASHRAE 95-81 and SRCC 200-82, the QNET rating value will be used as the system rating value. For solar systems only tested at FSEC, an equivalent QNET will be calculated by FSEC and will be used as the system rating value.

For solar systems that have only had solar collector tests, the system rating value will be calculated as the FSEC Collector Intermediate Temperature Rating.

F.3.2 Pool heating systems

The pool system will be the FSEC Low Temperature Rating of the collector. Included with the statement of system performance rating will be the following statement:

"Specified system performance is an estimate only and is not guaranteed. It is based on collector test results, typical water usage, and typical Florida climatic conditions. Actual solar contribution can vary and is dependent on the weather, the user, and proper system installation and maintenance."

APPENDIX G: JAPANESE STANDARDS

G.1 JIS A4111-1987 Solar water heater for dwellings

G.1.1 Scope

This Japanese Industrial Standard specifies the requirements for solar water heaters that are used to supply hot water to detached dwellings.

G.1.2 Brief Information

The standard includes a method for quantifying the amount of heat that is collected. The following parameters are measured in the formula :

- The temperature at the centre of the test heat insulating tank
- The feed water temperature
- Effective hot water quantity taken
- Effective heat collecting area
- Specific heat at constant pressure of water
- Density of water

G.1.3 Status

Current

G.1.4 International Relationships

No related standards.

G.2 JIS C9219-1992. Electric storage tank water heaters

G.2.1 Scope

This Japanese standard outlines the requirements for household push-up type electric water heaters. These heaters have a maximum working pressure not exceeding 100 kPa (kg/fcm²), have a rated power of not less than 10 kw and mainly use midnight electric power.

G.2.2 Brief Information

The standard includes a heating performance test for electric storage water heaters. The tests assess the following:

- Energy efficiency
- Heat-up temperature
- Temperature of water before current is applied.
- Power consumption

G.2.3 Status

Current

G.2.4 International Relationships

No related international standards

G.3 JIS S2109-1997 Gas burning water heaters for domestic use

G.3.1 Scope

This standard covers domestic water heaters that use LPG or natural gas.

APPENDIX H: EUROPEAN STANDARDS

H.1 EN 1148:1999 Heat exchangers – Water-to water heat exchangers for district heating – Test procedure for establishing the performance data

H.1.1 Scope

This standard applies to series-produced water-to-water heat exchangers for district heating appliances, and its purpose to establish uniform methods to test and ascertain the following:

- Product identification
- Performance characteristics
- Pressure drop

H.1.2 Brief Information

The heat exchangers that are described in this standard are tested to three separate test loads. The tests are completed on water heaters that use primary and secondary inlet temperatures. The capacity of the heat exchangers is assessed according to the fluid flow properties of the exchangers.

H.1.3 Status

Current

H.1.4 International Relationships

Transnational European standard. All member countries of the European Union have adopted the standard.

Further discussion of the European Standards and test methodologies for gas water heaters and comparison with the Australian procedure is contained in a report prepared for the Australian Greenhouse Office [Tas, 2000].

H.2 EN 26:1998 Gas-fired instantaneous water heaters for the production of domestic hot water, fitted with atmospheric burners

H.2.1 Scope

This European standard defines the specifications and test methods concerning the construction, safety, rational use of energy and fitness for purpose and also the classification and marking of gas-fired instantaneous water heaters for the production of domestic hot water.

H.2.2 Brief Informatin

For instantaneous water heaters it is required that the efficiency, based on the net calorific value (lower heating value), shall not be less than:

- 84% for appliances with a nominal heat input exceeding 10 kW (36MJ/h)
- 82% for appliances with a nominal heat input not exceeding 10 kW.

H.3 EN89:1997 Gas-Fired Storage Water Heaters for Sanitary Use

H.3.1 Brief Informatin

For storage gas water heaters it is required that the efficiency, based on the net calorific value (lower heating value), shall not be less than:

- 84% for all appliances, except condensing appliances;
- 98% for condensing appliances

The requirement for maintenance consumption is as follows:

For appliances of any nominal capacity with a heating-up time not less than 45 minutes, and for appliances with a nominal capacity up to 200 L with a heating-up time less than 45 minutes:

$$q = 11V^{2/3} + 0.015 Q_n$$

For appliances with a nominal capacity exceeding 200 L with a heating-up time less than 45 minutes:

$$q = 9V^{2/3} + 0.017 Q_n$$

where:

q = maintenance consumption, (W)

V = nominal capacity, (dm³)

Q_n = nominal heat input, (W).

The maintenance consumption is taken as 250 W, if the value given by the above formulas, as applicable, is lower.

H.4 prEN 13202:1998

This European Standard applies to domestic hot water gas appliances (water heaters or combination boilers) that have:

- a heat input not exceeding 70 kW (250 MJ/h) and
- a capacity not exceeding 300 L.

APPENDIX I: GERMAN STANDARDS

I.1 DIN 4753:Part 11:1990 Water heaters and hot water systems for drinking and service water. Indirect heat exchangers. Requirements, testing and marking.

I.1.1 Scope

This standard specifies requirements and methods of test for indirect heat exchangers. Compliance with the requirements specified here is intended to ensure that drinking water cannot be polluted even when water pollutants are used as the heat exchange medium.

I.1.2 Brief Information

This standard does not include details on energy consumption or efficiency tests for water heaters. These tests may be included in DIN 4753:Part 1:1988. Water heaters and water heating installations for drinking water and service water". Unfortunately this standard has not been translated into English.

I.1.3 Status

Current

I.1.4 International Relationships

No related international standards.

I.2 DIN 44532-100:1989 Electrical water heaters: Methods to be used for measuring the energy consumption of thermal storage water heaters and for the purpose of information consumers of it

I.2.1 Scope

The purpose of this standard is to define the methods to be used for measuring the energy consumption of thermally insulated storage water heaters and for informing consumers of it. This standard applies to thermally insulated storage water heaters from one of the classes mentioned in clause 4 of IEC 60379 (3rd edition) without limitation of their rated capacity.

I.2.2 Brief Information

Unfortunately the standard is only published in German.

I.2.3 Status

Current.

I.2.4 International Relationships

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Equivalent to IEC 60379:198. Similar to BS 3999:Part 2:1991.

It is considered unlikely that this standard is applicable to the types of water heaters under review in this report.

APPENDIX J: BRITISH STANDARDS

J.1 BS 3999:Part 2:1991 Methods of measuring the performance of household electrical appliances. Part 2: Thermal storage water heaters

J.1.1 Scope

This standard applies to electric storage water heaters for household purposes. This standard does not apply to:

- Water-heaters using other sources of energy (e.g. solar energy)
- Water-heaters with more than one heated volume.

- Water-heaters without thermal insulation.

J.1.2 Brief Information

This standard uses the standard loss and hot water output tests that are defined in IEC 60379:1987. The British standard refers to mixing factor and cyclic temperature variation tests that are not included in the IEC standard. These tests should not influence the energy performance of heaters.

J.1.3 Status

Current

J.1.4 International Relationships

Equivalent to IEC 60379:1987 and DIN 44532:100:1989.

APPENDIX K: SOUTH AFRICAN STANDARDS

K.1 SABS 151:1992 Fixed electric storage water heaters

K.1.1 Scope

This standard specifies the characteristics of thermostatically controlled fixed electric storage water heaters intended for domestic use and for operation on a.c. supplies at voltages not exceeding 250 V to earth.

K.1.2 Brief Information

The standard uses the 24 hour standing loss test to measure the energy efficiency of storage water heaters. The energy consumption, mean water temperature and cyclic variation temperature variations for storage water heaters are measured through the standing loss test.

K.1.3 Status

Current

K.1.4 International Relationships

No related international standards.