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BULLETIN

WATER HEATING SYSTEMS

October 2014

- Water heating in an average New Zealand house accounts for around one-third of total energy use.
- Costs of purchase, installation, energy and maintenance should all be considered when selecting a water heating system.
- This bulletin replaces Bulletin 480 of the same name.

1.0 INTRODUCTION

1.0.1 New Zealand homes have traditionally used electric storage water heaters.

1.0.2 For new construction, systems are typically mains pressure. Low-pressure systems are still common and are often used as replacements for existing low-pressure systems.

1.0.3 Before replacing an old low-pressure water heater with a mains-pressure water heater, ensure the pipework including copper is suitable for the higher pressure. A mains-pressure system will require additional valves to be installed, and mixers may need to be replaced.

1.0.4 Electricity, natural gas, diesel, LPG, solar, a heat pump and a wetback linked to a solid-fuel burner can all be used to heat water. System selection and energy source will depend on available energy sources, regulatory compliance, economic viability and owner preference.

1.0.5 A hot water system will contain either:
- a storage cylinder with a water heater where water is heated and stored for future use, or
- a continuous-flow or instantaneous water heater where water is heated when required, or
- a combination of stored preheated water and an instantaneous water heater to raise the preheated water temperature at the time of demand.

1.0.6 With a new water heating system, consider:
- how many people the system will serve
- the household composition
- what heating source(s) to use
- for gas water heaters, whether an electricity connection is also required
- the upfront and on-going costs for the system
- the maintenance requirements.

1.0.7 This bulletin provides guidance on options for residential installations in New Zealand. It replaces Bulletin 480 of the same name.

2.0 ENERGY OPTIONS

2.1 ELECTRICITY

2.1.1 Electricity is a flexible energy source, but electricity companies are keen to limit electricity usage during peak periods (mornings and evenings) and prefer hot water storage systems that allow for the water heating to be interrupted at peak times (ripple control) or to be done at times of low overall demand such as overnight.

2.1.2 Advantages are:
- supply is available throughout the country using various energy resources, many of which are renewable
- electricity will typically be required for other uses
- the upfront cost for an electric hot water system is generally lower
- storage electric hot water systems can be connected to lower-priced overnight electricity, although this may require a change to the electrical metering.

2.1.3 Disadvantages are:
- electricity prices are rising
- instantaneous electric systems require a high-capacity electrical system, which may be restricted or more expensive to install.

2.2 GAS

2.2.1 Reticulated natural gas is available in parts of the North Island, or gas can be supplied as bottled LPG.

2.2.2 Advantages are:
- gas provides a high-capacity heating source that can reheat faster than electric tanks, while continuous-flow gas water heaters provide a greater flow of heated water than an instantaneous electric water heater
- where gas is used for other services within the home, the cost of gas can be lower than electricity.

2.2.3 Disadvantages are:
- gas supply may not be readily available
- gas is a finite energy source and has high CO_2 emissions.

2.2.4 Gas water heating systems require ventilation to provide for combustion. When installed internally, they require a flue.

2.3 WETBACK

2.3.1 A wetback loop in a solid-fuel burner will allow part of the heat to be transferred to water in the hot water tank.

2.3.2 Advantages are:
- wood is a renewable resource and may be available at low cost
- wetbacks can supplement solar, gas or electric storage water heaters.

2.3.3 Disadvantages are:
- some local authorities do not permit the installation of solid-fuel appliances, and the National Environmental Standards for Air Quality restrict the types of wood burners that may be used on properties less than 2 hectares in size
- not all solid fuel heaters can have a water jacket fitted
- water heating is seasonal
- the hot water tank should be above the solid fuel burner
- heat is lost from the wetback loop pipework
- the hot water system must be an open-vented low-pressure system or transfer the heat to the stored mains-pressure water via an open-vented coil via a roof penetration.

2.4 SOLAR WATER HEATING

2.4.1 Solar water heating uses a solar collector (panels or tubes) to transfer heat to water that is then stored in a hot water tank.

2.4.2 Advantages are:
- a clean, renewable energy resource
- well performing systems require little additional energy to operate.

2.4.3 Disadvantages are:
- more expensive to purchase and install
- solar energy is intermittent, requiring a secondary means of water heating (electricity, gas)
- available solar energy in winter is lower
- the design and installation requirements of componentry
- larger storage tanks.

2.5 HEAT PUMP WATER HEATING

2.5.1 An air-to-water heat pump water heater extracts heat energy from the outdoor air and transfers it to the water.

2.5.2 Heat pump water heaters must be capable of operating at low external temperatures. The low temperature performance is separated into:
- class A: for low ambient temperature operation without requiring auxiliary boosting
- class B: for low ambient temperature operation by auxiliary boosting or heat pump operation and auxiliary boosting
- class C: not suitable for operation at low ambient temperatures.

2.5.3 Advantages are:
- they use less electricity than electric storage water heaters
- as an electric system, they can be easily controlled and have a potential to be integrated with a solar photovoltaic (PV) system.

2.5.4 Disadvantages are:
- small households may not use enough water to allow the system to work efficiently
- some models of outdoor heat pump units can be noisy and can operate at unpredictable times
- in very cold weather, they may perform poorly or switch to a back-up element.

3.0 REGULATORY REQUIREMENTS

3.1 GENERALLY

3.1.1 The Energy Efficiency (Energy Using Products) Regulations 2002 apply to electric storage hot water tanks and to gas water heaters.

3.1.2 Under New Zealand Building Code clause G12 *Water supplies*, safe hot water must be provided at sanitary fixtures and appliances when intended for utensil and personal washing, showering or bathing (housing, retirement homes and early childhood centres only). Where hot water is provided, it must be:
- produced or stored in tanks that relieve excessive pressure in any situation and limit the temperature to avoid flash steam being produced in the event of a rupture
- delivered to personal hygiene fittings at a temperature that avoids the likelihood of scalding
- capable of being controlled to prevent the growth of *Legionella* bacteria.

3.1.3 G12 defines a storage water heater as "a water tank with an integral water heater for the storage of hot water". Acceptable Solution G12/AS1 Table 5 lists the types of water heaters typically installed and gives the standards and regulations covering these systems.

3.1.4 Verification Method G12/VM1 provides a design method for water supply systems to comply with G12. Water heating systems not following G12/AS1 or not having passed G12/VM1 must be submitted for consent as an alternative method.

3.1.5 Section 3.4 discusses the application of Building Code clauses B1, B2, E2, G12 and H1 for solar water heating systems.

3.1.6 A building consent is not required for the:
- repair and maintenance of an existing water heater
- replacement of an open-vented water storage heater connected to a supplementary heat exchanger
- replacement or repositioning of a water heater that is connected to or incorporates a controlled heat source.

3.1.7 All work must meet the requirements of the Building Code and be undertaken by an 'authorised person' such as a registered plumber.

3.2 PROTECTION FROM *LEGIONELLA*

3.2.1 Legionnaires' disease can be found in water systems and is a serious form of pneumonia that can be contracted from inhaling water mist contaminated with *Legionella* bacteria.

3.2.2 *Legionella* will grow in temperatures of 25–45°C. At 60°C and higher, *Legionella* bacteria are quickly killed.

3.2.3 To prevent the growth of *Legionella* bacteria, Acceptable Solution G12/AS2 6.14 requires that:
- there is a continuously energised heating element in the bottom 55% of the hot water tank with the thermostat set to at least 60°C
- water in the hot water tank is heated to 60°C once per day where the element is in the bottom 20% of the tank
- all of the stored water (in open-loop systems including the water in the solar collector) is heated to at least 60°C for at least 1 hour once per week.

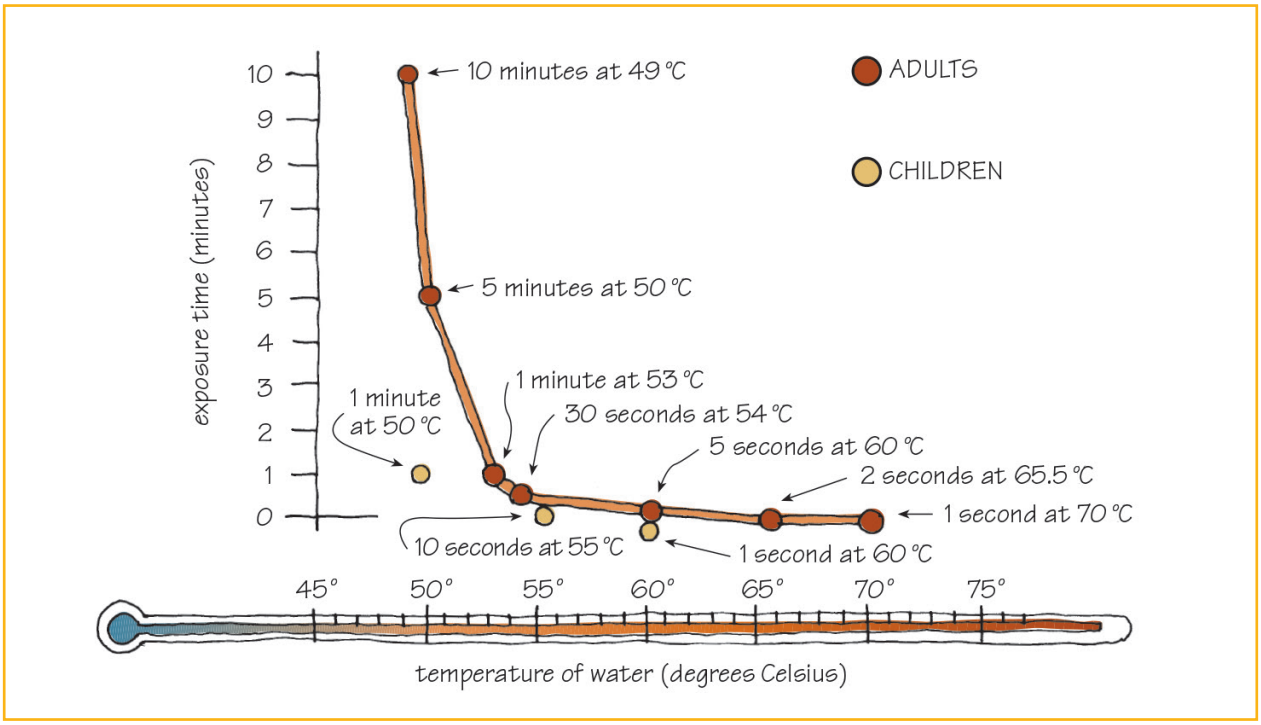

Figure 1. Time of exposure and water temperature at which full-thickness skin scalds occur.

3.3 SAFE WATER TEMPERATURES

3.3.1 As hot water temperature increases, it takes less time for serious burns to occur for skin in contact with the water (Figure 1).

3.3.2 Hot water delivery temperatures at fixtures for personal hygiene should be no greater than:

- 45°C for those at risk (young, the elderly or people with physical or intellectual disabilities, particularly those in institutional care)
- 55°C for everyone else.

3.3.3 Where water is heated above the required delivery temperature, reduce the temperature with a tempering valve to the correct delivery temperature.

3.4 SOLAR WATER HEATING

3.4.1 Under Acceptable Solution G12/AS2, solar systems must comply with G12/AS1 as appropriate, but following G12/AS2 provides compliance with clauses B1, B2, E2, G12 and H1.

3.4.2 The specific requirements of G12/AS2 include:

- the building has not been specifically designed to support a solar system
- the system is securely installed
- the roof pitch is less than 45°
- wind speeds do not exceed 50 m/s
- snow loading design complies with NZS 3604:2011 *Timber-framed buildings* or AS/NZS 1170 *Structural design actions* as appropriate
- the hot water storage tank must not be installed on or above the roof and when installed within the roof must have a maximum size of:
  - 200 L when installed in accordance with NZS 3604:2011 section 14, or
  - 450 L when installed in accordance with section 5 of AS/NZS 3500.4:2003 *Plumbing and drainage – Part 4: Heated water services*
- the solar collectors must:
  - have an area no greater than 4 m^2
  - have a maximum combined weight of 22 kg/m^2
  - be installed parallel to the roof cladding or, where the building is in a wind zone where the speeds do not exceed 44 m/s, at a pitch no greater than 45° to the horizontal in the same direction as that section of roof
- systems comply with AS/NZS 2712:2007 *Solar and heat pump water heaters – Design and construction*
- materials are compatible
- storage tanks are:
  - insulated
  - of sufficient size
- systems incorporate supplementary heating, *Legionella* and frost control
- weathertightness is maintained.

3.4.3 Solar systems outside the scope of G12/AS2 include solar collectors that are more than 4 m^2 or systems tested to an overseas standard. The system will therefore need to gain consent as an alternative method. MBIE guidance document *Solar water heaters – Guidance for suppliers, installers and building consent authorities* assists with the preparation and consideration of alternative methods for solar water heating systems. The guidance says to follow the Acceptable Solution wherever possible and to use the guidance document to explain how the performance criteria in the Building Code are achieved where the system differs from the Acceptable Solution.

4.0 WATER HEATING SYSTEMS

4.1 STORAGE WATER HEATERS – GENERAL

4.1.1 Storage water heater sizes range from 15 to 400 litres. Typical domestic water storage tanks are 480 mm or 610 mm diameter. Shorter or taller cylinders are available for restricted spaces.

4.1.2 Where a solar or wetback secondary heating source is used, a taller tank allows for cold water to be drawn from the tank at low level (the preheat area), heated and returned higher up (into the heated area).

4.1.3 Size the hot water storage tank for the maximum hot water demand. Additional volume may be required with a secondary heating source to provide sufficient preheat area within the tank.

4.1.4 Water in a storage tank is at higher temperatures and pressures than ambient. To prevent explosions, systems require:

- a vent pipe or a pressure-relief or temperature and pressure-relief (TPR) valve
- a water temperature thermostat
- an over-temperature energy cut-out switch at the water heater
- for valve-vented systems, an expansion valve on the cold water inlet connection.

4.1.5 It is common for gas units to be installed outside the building to dissipate exhaust gases. When installed internally, spaces must be well ventilated to remove exhaust gases. Proximity to interior/exterior openings, outdoor areas and neighbours needs to be considered when locating external units.

4.1.6 Storage heaters require additional energy to make up for standing losses as described in section 5.0.4.

4.1.7 Heat loss also occurs from the outlet pipe and valves attached to the cylinder. These should be insulated to minimise the heat loss. Heat loss from the storage tank itself is affected by its shape – a squatter tank will lose less heat than a tall slim tank.

4.1.8 Safe trays under the cylinder can prevent water damage occurring in the dwelling if the cylinder leaks or overflows.

4.2 ELECTRIC STORAGE WATER HEATERS

4.2.1 Electric water heaters (Figure 2) are generally installed internally, although external models are available.

4.2.2 The following water storage pressures and system layouts are typically associated with electric water heaters. The principles are similar to other hot water systems.

4.2.3 A low-pressure electric water heater:

- has a water pressure of up to 70 kPa (depending on pressure-reducing valve/feed valve or height of header tank)
- is supplied with mains water
- has its pressure reduced by a pressure-reducing valve or a header tank that has an air gap at the inlet
- has a copper (traditionally) or vitreous enamel-lined steel cylinder
- must have a water temperature thermostat linked to an energy cut-out switch at the water heater
- must have a method of relieving excess pressure, either using an open vent pipe or a pressure-relief valve in conjunction with a cold water expansion valve
- may incorporate a booster pump on the outlet side of the storage cylinder where pressure is poor.

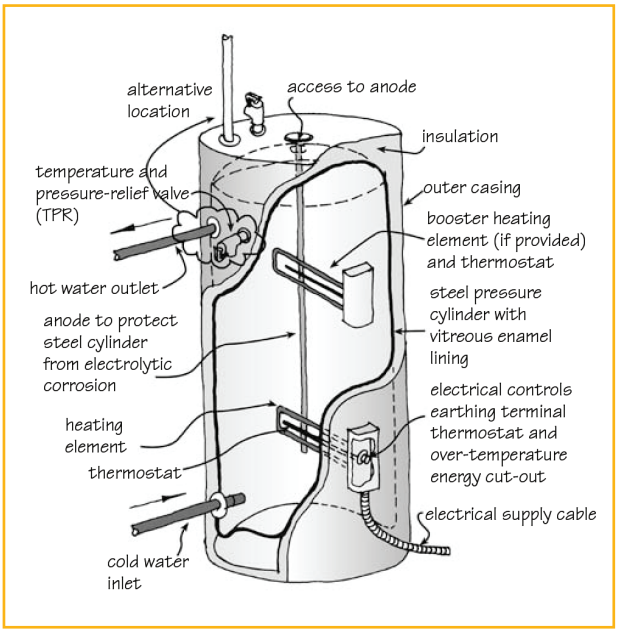

Figure 2. Schematic of an electric mains-pressure hot water storage heater. The upper booster heating element is usually not present.

4.2.4 A medium-pressure electric water heater with a hot water pressure-relief valve:

- has a water pressure up to 120 kPa
- can be located at ground floor level in a two-storey building and supply adequate pressure at all outlets
- cannot be directly connected to a wetback
- has a cylinder of copper (traditionally) or vitreous enamel-lined steel.

4.2.5 A mains-pressure electric water heater:

- has a controlled water pressure of 350–600 kPa
- can be located at any level in the building
- has a cylinder of steel with an enamel lining, which can withstand the pressure – such cylinders are typically rated to 75°C (for solar and wetback systems that may produce hotter water, tanks should be stainless steel)
- requires a temperature and pressure-relief (TPR) valve and cold water expansion valve
- requires a water thermostat connected to the electric element as well as an over-temperature cut-out (OTC)
- requires mains-pressure mixers and outlets
- may require more maintenance because of additional valve requirements and use of sacrificial anodes.

4.2.6 Electric storage water heater advantages are:

- a history of use
- a comparatively low upfront cost
- can heat the water with lower-cost night-rate electricity
- 2–3 kW elements are sufficient to heat the water.

4.2.7 Disadvantages are:
- size – they use valuable floor area
- running out of hot water if the storage capacity is not matched to demand
- cold water when subject to ripple control by the electricity network company
- a delayed timeframe for reheating.

4.3 GAS STORAGE WATER HEATERS

4.3.1 A gas storage water heater (Figure 3) compared to an electric unit:
- has quicker recovery times
- can generally use a smaller tank
- may have higher standing losses when installed externally and because of the heat lost with the water vapour expelled after combustion.

4.3.2 All gas storage and instantaneous water heaters should be serviced annually.

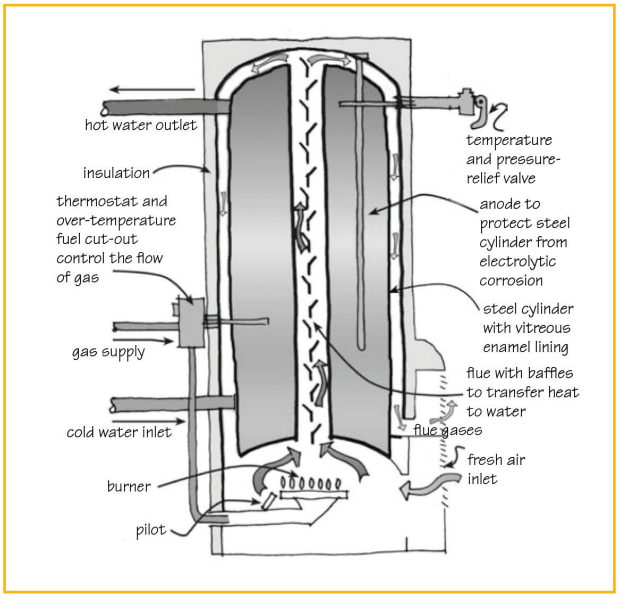

Figure 3. Schematic of an external gas hot water storage heater.

4.4 CONTINUOUS-FLOW WATER HEATERS – GENERAL

4.4.1 Continuous-flow water heaters only heat water that is being used and do not have a storage tank.

4.4.2 They have no standing heat losses, although there are start-up losses.

4.4.3 They require a large energy input in a short timeframe. Hot water supply depends on the heating system capacity, the incoming cold water temperature and the desired hot water temperature.

4.5 GAS CONTINUOUS-FLOW WATER HEATERS

4.5.1 A gas continuous-flow water heater (Figure 4) compared to a comparable electric water heater:
- can provide for multiple water uses within the household
- is suitable for larger households
- has a small start-up time delay before hot water is available
- is usually installed externally.

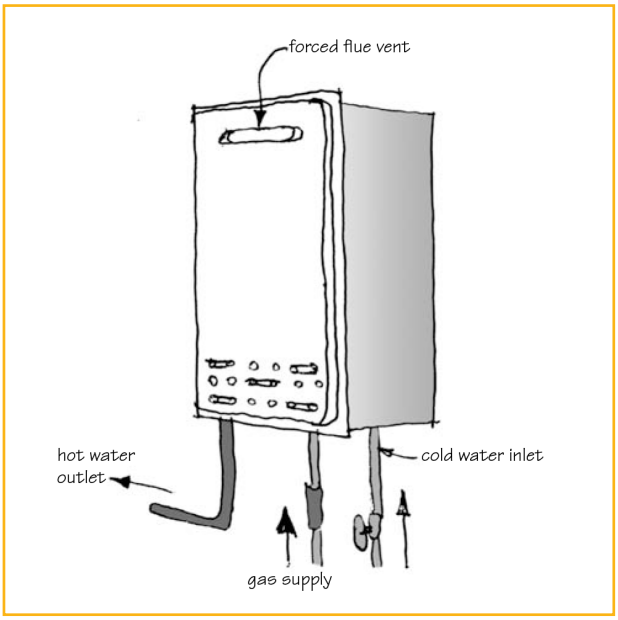

Figure 4. Continuous-flow gas water heater (external).

4.5.2 Modern electronically controlled systems can better match the heating requirements to the water flow rates than older units.

4.5.3 These heaters can be used with intermittent heating systems such as solar or wetbacks, but a storage tank is required for the preheated water.

4.6 ELECTRIC INSTANTANEOUS WATER HEATERS

4.6.1 Electric instantaneous water heaters (Figure 5) are not common but are useful where:
- a single or remote hot water outlet is required – larger units are available that service a number of outlets
- hot water use is intermittent such as a holiday home
- space is limited.

4.6.2 Electric instantaneous water heaters impose greater demand for electricity at peak times.

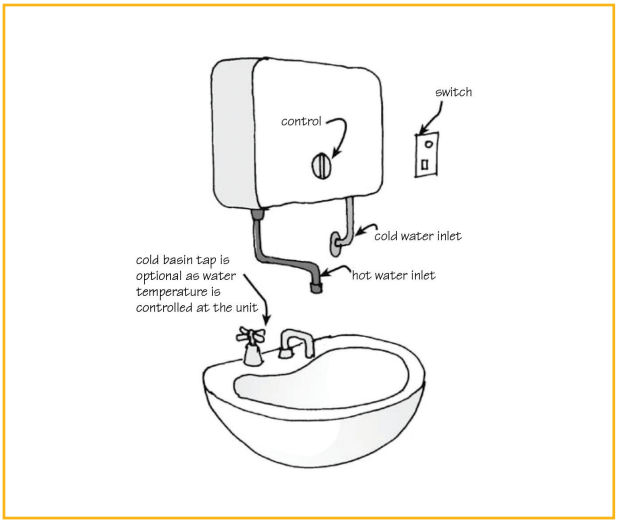

Figure 5. Single-unit instantaneous electric water heater.

5.0 OPERATING COSTS AND ENERGY USE

5.0.1 Hot water system selection should be based on both the upfront cost of the system and the on-going operating costs. EECA has a tool that estimates the costs of operating various water heating systems – see www.energywise.govt.nz/tools/water-heating.

5.0.2 The operating costs of a water heating system depend on the energy cost as well as the energy used by the hot water system.

5.0.3 The amount of energy used by a household for water heating can be difficult to predict as it depends on:

- occupant hot water use
- the water heating system used
- the hot water distribution system
- the incoming cold water temperature.

5.0.4 Energy is also used to recover the heat lost from keeping the water at the storage temperature (standing losses) and in the distribution system (from hot water turning cold, sitting in the pipes).

5.0.5 The energy needed to recover standing losses can be reduced by:

- improving the insulation levels of the hot water system
- reducing the hot water storage temperature
- having the system in a warmer environment (outdoor systems lose more heat than indoor systems).

5.0.6 Reduce the amount of purchased energy used to heat water by:

- reducing hot water use
- using a more efficient means of heating water (such as a solar or heat pump system).

5.0.7 Reduce the energy lost in the distribution system by:

- minimising the length and/or volume of the pipework
- adding and/or increasing the level of insulation of the pipework
- reducing the temperature of the water within the pipes.

5.0.8 Consumers can reduce hot water use by changing their hot water usage patterns (shorter showers) and by improvements to water fixtures to better manage the water flow (installing low-flow showerheads).

6.0 FURTHER INFORMATION

Acts and regulations

New Zealand Electrical Code of Practice (NZECP)
Gas Regulations
Energy Efficiency (Energy Using Products) Regulations
National Environmental Standards for Air Quality 2004 (including 2011 amendments)
Ministry for the Environment (2011). *Users' guide to the revised National Environmental Standards for Air Quality*: Updated 2014.
Building Code clause G12 *Water Supplies*: Acceptable Solutions G12/AS1 and G12/AS2
MBIE (2009). *Solar water heaters – Guidance for suppliers, installers and building consent authorities*
MBIE (2014). *Building work that does not require a building consent* (3rd edition)

Standards

AS/NZS 2712:2007 *Solar and heat pump water heaters – Design and construction*
AS/NZS 3000:2007 *Electrical installations* (known as the Australia/New Zealand Wiring Rules)
AS/NZS 3500:2003 *Plumbing and drainage* Parts 1, 2 and 4
AS/NZS 4692.1:2005 *Electric water heaters – Energy consumption, performance and general requirements*
AS/NZS 5125.1:2014 *Heat pump water heaters – Performance assessment – Part 1: Air source heat pump water heaters*
AS/NZS 60335.2.35:2013 *Household and similar electrical appliances – Safety – Part 2.35: Particular requirements for instantaneous water heaters*

NZS 4602:1998 *Low pressure copper thermal storage electric water heaters*
NZS 4606 *Storage water heaters* Parts 1, 2, 3
NZS 4613:1986 *Domestic solar water heaters*
NZS 5261:2003 *Gas installation*

Other references

BRANZ Bulletin 524 *Solar water heating*
BRANZ Bulletin 529 *Heat pump water heating*
BRANZ *Plumbing and Drainage Guide*
BRANZ Study Report 237 (2010). *The energy performance of heat pump water heaters*

Thompson, E., Ross, N., Howard, G., Duncan, J. and Garrood, M. *Heat Pump Water Heating Pilot Scheme*, EECA Technical Report, EECA.

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