

AS/NZS 4234:2021



Australian/New Zealand Standard™

# Heated water systems — Calculation of energy consumption



AS/NZS 4234:2021

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- Gas Appliance Manufacturers Association of Australia
- James Cook University
- New Zealand Green Building Council
- Smart Energy Council
- Solar Association of New Zealand
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Australian/New Zealand Standard™

# **Heated water systems — Calculation of energy consumption**

Originated as AS 4234—1994.  
Jointly revised and designated AS/NZS 4234:2008.  
Third edition 2021.

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## Preface

This Standard was prepared by the Joint Standards Australia/New Zealand Committee CS-028, Solar Heating and Cooling, to supersede AS/NZS 4234—2008.

The objective of this document is to provide methodologies to quantify the energy consumption of heated liquid systems and calculate energy savings relative to reference heaters.

Changes to the previous edition are as follows:

- (a) Additional water heating technologies based on PV water heating, variable speed heat pumps and commercial applications are included
- (b) The reference water heater systems used to quantify energy savings have been updated to current MEPS requirements; the main change being the increase from 3 star to 4 star for the gas reference water heater.
- (c) The typical meteorology year weather records have also been updated.
- (d) References to third-party software have been removed.
- (e) New requirements for assessing the suitability of software packages for the application of this document.

The performance evaluation procedure defined in this document has been designed to provide a means of evaluating the annual task performance of heated water systems.

Testing of solar and heat pump water heating systems under outdoor conditions is defined in AS 2984, *Solar water heaters—Methods of test for thermal performance—Outdoor test method*. Outdoor testing requires a long test period (8–10 weeks) due to the need to obtain stable inputs for a range of operating conditions. The major drawback of outdoor testing is that the tests must be repeated for every variation of system configuration offered by the supplier. The procedure defined in this document overcomes the time and cost limitations of using the outdoor test standard AS 2984.

The performance evaluations are based on modelling annual performance in a range of climatic conditions using a simulation program. Performance criteria are specified for simulation programs that can be used to implement the requirements of this document.

Typical meteorological year weather data files for Australia are now based on Bureau of Meteorology satellite data from 1990 to 2016. The new weather data records indicate higher solar radiation levels in Zones 1 and 4 and higher ambient temperatures in all zones compared to the terrestrial weather data (1967 to 1987) used in previous versions of this document.

**NOTE** Weather data files for five Australia climate zones and two New Zealand climate zones are supplied with the purchase of this document.

The weather data files for the five climate zones in Australia are supplied free of charge to users of the document by Exemplary Energy Partners. For users of the document wishing to use weather data for other sites, additional weather data files can be obtained from [www.exemplary.com.au/solar\\_climate\\_data/solar-radiation-data.php](http://www.exemplary.com.au/solar_climate_data/solar-radiation-data.php)

This document evaluates the performance of water heating technologies such as Solar Thermal Collectors, Heat pumps, photovoltaic arrays, thermal storage tanks (which can incorporate integral gas or electric resistance element boosting) and in-line supplementary heating utilizing gas or electric energy sources.

The terms “normative” and “informative” are used in Standards to define the application of the appendices to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

Where *shall* is used in this Standard, this indicates that a requirement is to be followed strictly in order to conform to the Standard. Where *should* is used, it is to be interpreted as a recommendation; a recommendation is not required to be followed in order to conform to the Standard.

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# Australian/New Zealand Standard

## Heated water systems — Calculation of energy consumption

### Section 1 Scope and general

#### 1.1 Scope

This document sets out a method for evaluating the annual energy performance of water heaters using a combination of test results for component performance and mathematical models to determine the standardized annual supplementary energy use.

This document may be used for both domestic and commercial systems, including recirculated hot water systems. For commercial applications, the systems modelled may deliver heat through fluids other than water.

The procedures may be used for solar and heat pump water heaters (HPWHs) with or without integral gas or electric boosting and may be coupled to conventional storage or instantaneous water heater(s) when used as solar pre-heater(s). Solar energy sources considered are —

- (a) solar irradiance which is used in solar thermal collector applications;
- (b) photovoltaic array applications; and
- (c) air-sourced heat that is used for heat pump applications.

The calculations in this document also cover the displaced purchased energy relative to reference water heaters.

NOTE Solar and solar-boosted HPWH types not covered in this document may be tested under AS 2984 to obtain an annual performance assessment.

This document does not include product design or operation requirements, however for the purpose of rating it does specify minimum savings and water temperature delivery requirements used to select simulated thermal load size.

#### 1.2 Application

The procedure in this document uses mathematical models to assess annual water heating systems; hence the application of the procedure is restricted by the availability of suitable mathematical models. The analysis required by this document is based on numerical simulation of water heaters powered by conventional electrical and gas energy, solar energy and heat pumps.

The numerical simulation model shall use the weather data, hot water load levels, electrical load data and modelling requirements specified in this document.

The operating conditions and product configurations to be used for evaluating the annual energy performance of a water heater are defined in this document.

This document may be used for evaluating the following water heaters:

- (a) Electric and gas storage water heaters.
- (b) Electric and gas instantaneous water heaters.
- (c) Solar water heater systems with a combination of any of the following:
  - (i) Flat plate, concentrating or evacuated tubular solar collectors.
  - (ii) Photovoltaic arrays.
  - (iii) Thermosiphon or pumped fluid circulation through the solar collectors.

- (iv) Collector loop heat exchangers in a thermosiphon loop.
- (v) Horizontal or vertical water storage tanks.
- (vi) Storage tanks with single or multiple electric element(s).
- (vii) Storage tanks with internal gas boosting.
- (viii) Storage tanks with heat pump boosting.
- (ix) Storage tanks with delivery side heat exchangers.
- (d) Solar preheaters in series with electric or gas storage or instantaneous boosters.
- (e) Solar-boosted heat pump water heaters with —
  - (i) solar collectors acting as the refrigerant evaporator;
  - (ii) water cooled condenser; and
  - (iii) in-tank electric booster.
- (f) Air-source heat pump water heaters with —
  - (i) internal tank condensers;
  - (ii) external wrap-around, or in-wall embedded tank condensers; and
  - (iii) external condensers, circulating water into one or more tanks.

Other water heater configurations incorporating the above components may also be modelled.

NOTE 1 If it is not possible to model the product using a simulation program, then the product may be rated using AS 2984.

NOTE 2 In some instances, test data produced through physical test procedures that measure the performance of a system when it delivers hot water (e.g. AS/NZS 5125.1:2014 or AS 2984) may assist in developing a simulation program to assess its accuracy.

### 1.3 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

NOTE Documents referenced for informative purposes are listed in the Bibliography.

AS 3498, *Safety and public health requirements for plumbing products — Water heaters and hot-water storage tanks*

AS 4552, *Gas fired water heaters for hot water supply and/or central heating*

AS/NZS 2535.1, *Test methods for solar collectors, Part 1: Thermal performance of glazed liquid heating collectors including pressure drop (ISO 9806-1:1994, MOD)*

AS/NZS 2712, *Solar and heat pump water heaters—Design and construction*

AS/NZS 4692.1, *Electric water heaters, Part 1: Energy consumption, performance and general requirements*

AS/NZS 4692.2, *Electric water heaters, Part 2: Minimum Energy Performance Standard (MEPS) requirements and energy labelling*

AS/NZS 5033:2014, *Installation and safety requirements for photovoltaic (PV) arrays*

AS/NZS 5125.1:2014, *Heat pump water heaters—Performance assessment, Part 1: Air source heat pump water heaters*

AS/NZS 5263.1.2, *Gas appliances, Part 1.2: Gas fired water heaters for hot water supply and/or central heating*

NZS 4218:2009, *Thermal insulation—Housing and small building*

ISO 9806, *Solar energy — Solar thermal collectors — Test methods*

IEC 61853-1, *Photovoltaic (PV) module performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating*

ASHRAE 23.1-93, *Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Pressures of the Refrigerant*

EN 12975-2, *Thermal solar systems and components — Solar collectors — Part 2: Test methods*

EN 13771-1, *Compressors and condensing units for refrigeration — Performance testing and test methods — Part 1: Refrigerant compressors*

EN 50193-1, *Electric instantaneous water heaters — Methods for measuring the performance — Part 1: General requirements*

*New Zealand Building Code G12/AS2*

## 1.4 Terms and definitions

For the purposes of this document, the terms and definitions below apply.

### 1.4.1

#### **absorber**

device within a collector for absorbing radiant energy and transferring this energy as heat into a fluid

### 1.4.2

#### **auxiliary equipment**

those parts of a solar or heat pump water heater system that use purchased electrical energy, other than resistive heating units or heat pump package (compressor and integral controls, pumps and fans)

### 1.4.3

#### **collector**

device containing an absorber and intended for installation either as a unit or as part of an array of units

### 1.4.4

#### **collector aperture**

net area available for transmission of solar radiation through the outer air/cover interface; for unglazed collectors, the net plan area of the absorber

Note 1 to entry: The aperture width for different collector types is illustrated in AS/NZS 2535.1.

### 1.4.5

#### **collector inclination**

angle between aperture surface of the collector and the horizontal

### 1.4.6

#### **commercial liquid heating system**

liquid heater with a storage volumetric capacity over 700 L or a system designed for providing fluid heating for non-domestic purposes

Note 1 to entry: A system may use either drinking water or recirculated fluid for energy storage, heat transfer or fluid delivery to point of use. These systems can comprise of a number of domestic solar hot water systems coupled together.

**1.4.7****domestic water heater**

water heater with a storage volumetric capacity of less than or equal to 700 L

Note 1 to entry: System may use either drinking water or recirculated fluid as energy storage and heater transfer; however, supplies drinking water to point of use.

**1.4.8****electricity supply****1.4.8.1****continuous**

continuously available electricity supply

**1.4.8.2****limited time**

electric supply available at limited times, as follows:

<*night rate*> electricity supply available at restricted night hours

<*extended off-peak*> electricity supply available during extended hours

Note 1 to entry: See [Appendices A](#) and [B](#) for typical availability times.

**1.4.9****evacuated tubular collector**

evacuated collector employing transparent tubing (usually glass) with an evacuated space between the tube wall and the absorber

Note 1 to entry: The absorber may consist of an inner tube or another shape, with means for removal of the thermal energy.

**1.4.10****heat pump water heater**

water heater using vapour compression cycle and incorporating a compressor, an evaporator and a condenser that delivers heat to the water either directly or indirectly

**1.4.10.1****heat pump water heater, air-source**

heat pump water heater with an evaporator collecting energy from latent and sensible heat from the atmosphere

**1.4.10.2****heat pump water heater, integral**

heat pump water heater with the condenser connected as an integral part of tank or mounted inside the tank

Note 1 to entry: Heat is delivered to the water in the tank by free convection over the tank wall or condenser tubing inside the tank.

**1.4.10.3****heat pump water heater, solar-boosted**

heat pump water heater with an evaporator exposed to the sky that collects solar radiation, sensible heat from the atmosphere and latent energy due to atmospheric condensation

**1.4.10.4****heat pump water heater, standalone**

heat pump water heater without integrated storage

Note 1 to entry: Heat is delivered to water flowing through the condenser.

Note 2 to entry: The heat pump may be configured as a single pass that heats to the required temperature or a multi-pass that heats the water in stages.

**1.4.11****hot water load**

amount of thermal energy drawn from the system as hot water

Note 1 to entry: Energy is computed relative to the cold-water inlet temperature.

**1.4.12****incidence angle**

angle between the direct radiation and the outward normal from the plane considered (e.g. from the collector aperture)

**1.4.13****irradiance**

radiation incident on a surface, that is the quotient of the radiant flux incident on the surface and the area of that surface, or the rate at which radiant energy is incident on a surface per unit area of the surface (Unit: W/m<sup>2</sup>)

**1.4.14****irradiation**

incident energy per unit area of a surface, found by integration of irradiance over a specified time interval, often an hour or a day (Unit: MJ/m<sup>2</sup> per specified time interval)

**1.4.15****low temperature operation penalty**

performance penalty due to frosting and defrost functions for heat pump products claimed to be suitable for low temperature operation

**1.4.16****multiple elements**

electric elements at different levels in the tank

Note 1 to entry: Each element may be connected to a different electric supply or be operated under local control.

**1.4.17****net PV power**

net power available from a photovoltaic source that can be utilized for water heating

**1.4.18****packaged system**

system with a fixed configuration, sold as a ready-to-install kit containing all system components

**1.4.19****photovoltaic (PV) array**

assembly of electrically interconnected PV modules, PV strings or PV sub-arrays comprising all components up to the d.c. input terminals of the inverter or other power conversion equipment or d.c. loads

Note 1 to entry: Does not include the PV array foundation, tracking apparatus, thermal control, and other such components.

Note 2 to entry: A PV array may consist of a single PV module, a single PV string, or several parallel connected strings, or several parallel-connected PV sub-arrays and their associated electrical components.

[SOURCE: AS/NZS 5033:2014, 1.4.47, adapted]

**1.4.20****photovoltaic (PV) module**

smallest complete environmentally protected assembly of interconnected cells

[SOURCE: AS/NZS 5033:2014, 1.4.53]

**1.4.21****photovoltaic water heater**

electric water heater where the energy is primarily derived from photovoltaic modules

Note 1 to entry: The electricity is supplied to either electric resistive heating or air-sourced heat pumps. Where the PV electricity is insufficient, the supplementary energy may be supplied from conventional sources.

**1.4.21.1****direct coupled photovoltaic water heater**

photovoltaic water heater where the electrical power from PV modules feeds directly to a heating device associated with a storage tank

**1.4.21.2****indirect coupled photovoltaic water heater**

photovoltaic water heater where the electrical power from PV modules feeds to an inverter that interacts with the electrical distribution network. The net PV power is then fed to a heating device associated with a storage tank

**1.4.22****process heat system**

system where the fluid is heated as part of a primary or closed loop heating system, and the heat energy is generally transferred through a secondary heat-exchanger to meet the load

**1.4.23****reference water heater**

conventional water heater used to define annual purchased energy use for the purpose of computing energy savings of other products

**1.4.24****standardized annual energy use**

annual purchased energy use of a water heater, operating under specified reference weather and load conditions

**1.4.25****sidearm heat exchanger**

heat exchanger external to the storage tank that transfers heat from a hydraulic circuit including the solar collectors or a heat pump to a separate hydraulic circuit that includes the storage tank

**1.4.26****storage tank**

vessel including fittings, in which the heated water is stored

Note 1 to entry: Sometimes referred to as a container, cylinder or tank in other referenced standards.

**1.4.27****supplementary energy**

gas or electrical energy used by a solar or heat pump water heater to directly heat the water by a gas burner, electrical resistive heating unit and/or heat pump package (compressor and integral controls, pumps and fans) that is supplied from a source external to the modelled system

**1.4.28****tank modelling****1.4.28.1****fixed inlet position**

fluid flows into the storage tank and mixes with the contents of the tank node immediately level with the inlet fitting

**1.4.28.2****variable inlet position**

fluid flows into the storage tank and rises or falls to the level of the tank node with the closest temperature to the inlet flow

**1.4.29****tank nodes**

horizontal sections of a storage tank where the fluid temperature is considered to be constant

Note 1 to entry: Tank nodes are used in the simulation program to model thermal stratification in the storage tank.

**1.4.30****thermal capacity**

thermal power output of a heat pump

**1.4.31****water heater with heat pump supplementary heating**

solar thermal water heater with primary hot water generation derived from solar thermal collectors, the remainder derived from energy supplied from heat pump or immersion element where heat pump cannot operate

**1.5 Notation**

The following symbols are used in this document:

|                  |   |                                                                                                                                                                                                                                                        |
|------------------|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $a, b, c, p$     | = | correlation coefficients for solar collector efficiency as per AS/NZS 2535.1, ISO 9806 or EN 12975-2 or heat pump COP or power coefficients as per AS/NZS 5125.1:2014 (subscripts are used where more than one coefficient is included in an equation) |
| $B_r$            | = | annual purchased energy used by the reference water heater (MJ/y)                                                                                                                                                                                      |
| $B_e$            | = | annual electrical energy used by auxiliary equipment (MJ/y)                                                                                                                                                                                            |
| $B_s$            | = | annual supplementary energy for a solar or heat pump water heater (MJ/y)                                                                                                                                                                               |
| $C_p$            | = | specific heat capacity of water (kJ/kg.K)                                                                                                                                                                                                              |
| $e_n$            | = | electrical power use during gas burner operation (W)                                                                                                                                                                                                   |
| $e_{sm}$         | = | electrical power use during standby (W)                                                                                                                                                                                                                |
| $E$              | = | thermal efficiency of gas water heater (%)                                                                                                                                                                                                             |
| $f_R$            | = | purchased energy savings relative to the reference water heater                                                                                                                                                                                        |
| $G_b$            | = | beam irradiance on the collector aperture (W/m <sup>2</sup> )                                                                                                                                                                                          |
| $G_L$            | = | relative long wave irradiance ( $\lambda > 3 \mu\text{m}$ )                                                                                                                                                                                            |
|                  | = | $G_s - \sigma T_a^4 \left( \text{W/m}^2 \right)$                                                                                                                                                                                                       |
| $G_s$            | = | long wave thermal irradiance ( $\lambda > 3 \mu\text{m}$ ) (W/m <sup>2</sup> )                                                                                                                                                                         |
| $G_T$            | = | total solar irradiance on the collector aperture (W/m <sup>2</sup> )                                                                                                                                                                                   |
| $H$              | = | heat output of a gas water heater (kW)                                                                                                                                                                                                                 |
| $K_{T\alpha}$    | = | solar collector incident angle modifier                                                                                                                                                                                                                |
| $K_{NS}, K_{EW}$ | = | bi-axial incidence angle modifiers                                                                                                                                                                                                                     |
| $M$              | = | maintenance gas consumption rate (MJ/h)                                                                                                                                                                                                                |
| $N$              | = | daily number of start-up events of an instantaneous gas water heater                                                                                                                                                                                   |

|               |   |                                                                             |
|---------------|---|-----------------------------------------------------------------------------|
| $P$           | = | pilot flame gas consumption for instantaneous gas heater (MJ/h)             |
| $R$           | = | determined gas consumption rate (MJ/h)                                      |
| $S$           | = | start-up heat capacity (MJ)                                                 |
| $s$           | = | heat pump compressor speed as a proportion of rated compressor speed        |
| $t$           | = | duration of test (h)                                                        |
| $T$           | = | collector fluid temperature (°C)                                            |
| $T_a$         | = | ambient temperature (°C)                                                    |
| $T_{aeff}$    | = | effective ambient temperature (°C)                                          |
| $T_{db}$      | = | thermostat dead band (K)                                                    |
| $T_{ifr}$     | = | defrost cycle activation temperature (°C)                                   |
| $T_{pre}$     | = | temperature delivered by a solar pre heater (°C)                            |
| $\bar{T}_w$   | = | mean temperature of water in the storage tank (°C)                          |
| $\bar{T}$     | = | mean collector fluid temperature (°C)                                       |
| $T_{set}$     | = | thermostat setting (°C)                                                     |
| $T_{sky}$     | = | sky temperature (°C)                                                        |
| $u$           | = | surrounding air speed over the solar collector (or evaporator) (m/s)        |
| $UA$          | = | tank heat loss coefficient × tank inner core surface area (W/K)             |
| $\alpha$      | = | unglazed collector hemispherical absorber absorptance, short wave           |
| $\varepsilon$ | = | unglazed collector hemispherical absorber emittance, long wave              |
| $\eta$        | = | solar collector efficiency                                                  |
| $\theta$      | = | incidence angle relative to the collector aperture normal (degrees)         |
| $\sigma$      | = | Stefan–Boltzmann constant ( $5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$ ) |

## Section 2 Component testing

### 2.1 Scope of section

This Section specifies the determination of component characteristics based on —

- (a) physical testing; and
- (b) geometric and material property data.

The component performance data are combined with atmospheric conditions, hot water loads and, where applicable, domestic electrical loads in a simulation package to determine the annual solar and supplementary energy consumptions.

For solar water heaters, this document is limited to systems capable of being separated into a solar collector component and a storage vessel component for the purpose of testing.

### 2.2 Water heater technology types

#### 2.2.1 Solar thermal collector systems

Solar thermal water heaters use a solar thermal collector to absorb solar radiation and a fluid circulation system to transfer heat to the storage tank.

The types of solar thermal collector systems are as follows:

- (a) Thermosiphon solar water heaters that utilize thermal buoyancy of fluid to circulate fluid between the solar collector and the storage tank with —
  - (i) drinking water fluid in collector array (direct); or
  - (ii) heat exchange fluid in collector array (indirect).
- (b) Split solar water heaters that utilize hydraulic pumping power to circulate fluid between the collector and the storage tank with —
  - (i) drinking water fluid in collector array (direct); or
  - (ii) heat exchange fluid in collector array (indirect).

Supplementary heating may utilize any of the following technologies and may be integral in the storage tank or an in-series storage system or an in-series instantaneous system:

- (A) Electric resistive heating.
- (B) Gas combustion heating through heat exchanger(s).
- (C) Air-source heat pump.

#### 2.2.2 Pump flow and power consumption

##### 2.2.2.1 General

Where hydraulic pumping power is consumed, the pump power shall be determined using either [Clause 2.2.2.2](#) or [2.2.2.3](#).

A report shall be prepared setting out the measurement or calculation of pump flow rate and power. The report shall include the following:

- (a) A description of the product configuration tested, which includes:
  - (i) *For a solar thermal water heater* — description of solar collector loop including collector model(s), number of each collector, series or parallel connection, pump model(s), piping length and diameter.
  - (ii) *For a standalone heat pump* — description of heat pump water recirculation loop including heat exchanger model(s), the number of each heat exchanger, series or parallel connection, pump model(s), piping length and diameter.
- (b) A detailed description of the measurement or calculation procedure used, including schematic diagram or photograph of set-up.
- (c) If measured rather than calculated, measuring equipment used.

NOTE The hydraulic resistance of fluid in a storage tank is deemed negligible; hence, a common storage tank may be used to test multiple system collector combinations.

The test shall be undertaken with the temperature of the circulating fluid to be within 10 K of the laboratory ambient temperature.

#### 2.2.2.2 Constant speed pumps

The flow rate and pump power use in pumped circulation systems shall be measured in a system assembled with 10 m of pipe length each way from the heat source to the tank/pump. For standalone heat pumps, the length shall be a minimum of 10 m and the maximum length specified in the installation manual. The diameter used in the test shall be as specified in the installation manual, or DN15 if no diameter is specified. For systems with site-specific flow adjustment, the flow control device specified in the installation manual for this piping length shall be installed and set to the specified flow rate.

#### 2.2.2.3 Variable speed pumps

The flow rate and pump power in systems using variable speed pumps shall be tested in accordance with [Clause 2.2.2.2](#) with measurements taken at a minimum of three approximately equally spaced flow rates over the controlled flow range.

#### 2.2.3 Air-source heat pump systems

Air-source heat pump systems consist of evaporator(s), compressor(s), condenser(s) and expansion control devices in single-stage or multi-stage configurations. The heat pump primary heat source is ambient air with the compressor powered by electricity.

The types of air-source heat pump water heaters are as follows:

- (a) Integral air-source heat pump water heaters with —
  - (i) condenser in tank; or
  - (ii) condenser on the outside of the tank in contact with tank wall.
- (b) Standalone air-source heat pump water heaters with —
  - (i) once-through circulation of water from a tank (usually stratified) to deliver water at the required final temperature in one pass through the heat pump; or
  - (ii) recirculation of water from a tank to the heat pump and back to the tank until it reaches the required final temperature.

Where the recirculation of water using a hydraulic fluid pump is utilized and the pump can be operated separately to the compressor, the performance of the pump shall be evaluated in accordance with [Clause 2.2.2](#). The energy consumed by the recirculating pump when the compressor is not operating shall be included in the simulation energy analysis.

NOTE Some frost protection modes are an example of events where the recirculating pump may operate without the compressor.

## 2.2.4 Photovoltaic water heaters

Photovoltaic water heaters consist of photovoltaic arrays supplying electrical energy to a hot water storage tank. Heating of the storage tank can be either through a resistive element or an air-source heat pump.

Where an air-source heat pump with variable capacity is utilized, performance characteristics shall be evaluated in accordance with [Clause 2.7.1](#).

Electrical transmission paths from PV panels to storage tank may be either direct coupled or indirect coupled (see [Clause 1.4.21.1](#) and [1.4.21.2](#)).

All systems shall be modelled to have maximum power point tracking (MPPT) capabilities embedded within either the inverter(s) or optimizer(s).

Energy efficiency of in-line control devices including MPPT and regulators/diverters shall have performance characteristics tested as specified by the California Energy Commission Inverter Weighted Average.

NOTE See Bibliography for a link to website.

Supplementary heating of photovoltaic systems shall be any of the following methods, being integral in-storage tank or in-series post storage or in-series instantaneous boosting:

- (a) Heat pump using grid power.
- (b) Resistive element heating using grid power.
- (c) Gas combustion heating.

## 2.3 Storage tank types

### 2.3.1 Electric resistive heated, unboosted and heat pump storage tanks

For electric resistive heated, unboosted and heat pump storage tanks, the following performance factors shall be evaluated:

- (a) The standing heat loss:
  - (i) For domestic systems using AS/NZS 4692.1.
  - (ii) For commercial systems using either the method in [Appendix E](#) or the methodology from AS/NZS 4692.1.
- (b) The volumetric capacity.

Components that are permanently attached to the tank shall not be removed.

NOTE Attached components include items such as —

- (a) an integral heat pump in a heat pump water heater;
- (b) a standalone heat pump mounted on the tank of a heat pump water heater; or

- (c) an external collector loop heat exchanger for a pumped circulation solar water heater.

During annual performance simulation, thermal stratification in the storage tank shall be evaluated throughout the day and used to quantify the variation of tank heat loss with time (see [Clause 4.2](#)). The effect of mixing during load draw-off, conduction between hot and cold layers in the tank and heat loss variation due to non-uniform insulation thickness on the tank shall be accounted for in determining thermal stratification and tank heat loss.

The temperature of the water supplied or removed through a dip (or snorkel) tube shall be the tank temperature at the level of the dip (or snorkel) tube end inside the tank. Details of the location of dip (or snorkel) tubes in a tank shall be as shown in tank drawings.

NOTE For a tank with a dip tube or snorkel tube inside the tank, the heat transfer between the stored tank water and the water flowing inside the dip tube is usually small compared to the heat capacitance rate of the water flowing through the tube and may be neglected in the modelling.

### 2.3.2 Gas-boosted storage vessels

The following performance factors shall be evaluated using the test methods in AS/NZS 5263.1.2 or AS 4552:

- (a) Thermal efficiency (%).
- (b) Determined gas consumption rate (MJ/h).
- (c) Maintenance gas consumption (MJ/h).
- (d) Storage capacity (L).
- (e) Electric power consumption in standby mode (W).
- (f) Electric power consumption in normal mode (W).

NOTE The electrical power consumption test methods described in AS/NZS 5263.1.2 are applicable to instantaneous water heaters. If the gas-boosted storage water heater utilizes an electrical power source, the same principles may be used to evaluate the electrical power usage.

Heat loss from storage tanks incorporating raised level gas boosting from either an internal or external burner shall be determined by direct measurement using a specially configured tank that is maintained at uniform temperature during heat loss testing. A special electric element installed for the purpose of the heat loss test, as specified in AS/NZS 4692.1, shall be deemed acceptable.

## 2.4 In line water heater types

### 2.4.1 Instantaneous gas water heaters

The following performance factors shall be evaluated using the test methods in AS/NZS 5263.1.2 or AS 4552:

- (a) Thermal efficiency (%).
- (b) Determined gas consumption rate (MJ/h).
- (c) Pilot gas consumption (MJ/h).
- (d) Start-up heat capacity (MJ/event).
- (e) Electrical power consumption in standby mode (W).
- (f) Electrical power consumption in normal mode (W).

### 2.4.2 In line instantaneous electric water heater

The following performance factors shall be determined:

- (a) Thermal efficiency (%), which shall be determined using the method in EN 50193-1. If no test report is available, a default value of 97 % shall be used.
- (b) Heat output (kW), which shall be determined by the maximum electrical power consumption of the appliance.
- (c) Start-up heat capacity (MJ/event), which shall be determined by assessing the stored water volume of the appliance and calculating the energy required to increase the stored water temperature by 45 K.
- (d) Electric power used during standby (W), which shall be determined by measuring the power draw while there is no water flowing through the appliance.
- (e) Control electrical power (W) is any electrical load that is consumed when the heater is operational that is not used to directly heat the water:
  - (i) If there are no additional inductive electrical loads when there is water flowing through the appliance, the electric power shall be used during standby measured in Item (d) above.
  - (ii) If there are additional control inductive loads during operation, such loads shall be included in the measurement of electrical power used during operation.

## 2.5 Solar-boosted heat pump storage water heaters

The following performance factors shall be evaluated:

- (a) Heat pump compressor capacity and input power shall be evaluated using ASHRAE 23.1-93 or EN 13771-1 for evaporator refrigerant temperatures covering the range from -15 °C to 30 °C (at least four test temperatures) and condenser refrigerant temperatures covering the range from 30 °C to 70 °C (at least four test temperatures).
- (b) Thermal efficiency (sensible heat) of an evaporator exposed to solar radiation shall be evaluated using [Clause 2.6.1](#).
- (c) Energy gain due to condensation on the unglazed evaporator shall be evaluated using ambient dry and wet bulb temperatures and a mass transfer coefficient for condensation on the evaporator determined from the convective heat transfer coefficient evaluated using [Clause 4.14.4](#).
- (d) Energy loss from an unglazed solar evaporator operating at night shall include the effect of sky temperature [[Equation 4.6.1\(2\)](#)].
- (e) Frosting on the evaporator and energy consumed during heat pump defrost cycles using [Clause 4.8.6](#).

## 2.6 Solar collector

### 2.6.1 Collector efficiency

The efficiency of solar collectors shall be evaluated using AS/NZS 2535.1, ISO 9806 or EN 12975-2.

The collector efficiency shall be characterized using the following equations or equations specified in AS/NZS 2535.1, ISO 9806 or EN 12975-2:

Glazed flat plate collectors:

$$\eta = a_1 - a_2 \frac{\bar{T} - T_a}{G_T} - a_3 \frac{(\bar{T} - T_a)^2}{G_T} \quad 2.6.1(1)$$

Concentrating collectors:

$$\eta = a_1 - a_2 \frac{\bar{T} - T_a}{G_b} - a_3 \frac{(\bar{T} - T_a)^2}{G_b} \quad 2.6.1(2)$$

Evacuated tubular collectors:

$$\eta = b_1 - b_2 \frac{\bar{T} - T_a}{G_T} - b_3 \frac{\left[ (\bar{T} + 273)^4 - (T_a + 273)^4 \right]}{G_T} \quad 2.6.1(3)$$

Unglazed collectors:

$$\eta = c_1 - (c_2 + c_3 u) \frac{\bar{T} - T_a}{G_T + \frac{\varepsilon}{\alpha} G_L} \quad 2.6.1(4)$$

The coefficients  $a$ ,  $b$ ,  $c$  in [Equations 2.6.1\(1\)](#), [2.6.1\(2\)](#), [2.6.1\(3\)](#) and [2.6.1\(4\)](#) have positive values. Negative coefficients shall not be accepted in the calculations specified in this document.

The solar collector area used with [Equations 2.6.1\(1\)](#), [2.6.1\(2\)](#), [2.6.1\(3\)](#) and [2.6.1\(4\)](#) shall be the value used in determination of the coefficients by the solar collector test laboratory.

NOTE [Equation 2.6.1\(3\)](#) is the preferred function for evacuated tubular collectors, however, [Equation 2.6.1\(1\)](#) is acceptable if the test data from the solar collector test report is not available for the purpose of computing the coefficients in [Equation 2.6.1\(3\)](#).

## 2.6.2 Incidence angle modifier

### 2.6.2.1 General

The incidence angle modifier shall be measured as specified in AS/NZS 2535.1, ISO 9806 or EN 12975-2.

### 2.6.2.2 Flat plate collectors

For flat plate collectors with a single glass cover and cover to absorber spacing less than 40 mm, a default incidence angle modifier coefficient of  $d = 0.06$  may be used, as follows:

$$K_{\tau a} = 1 - d \left( \frac{1}{\cos \theta} - 1 \right) \quad 2.6.2.2$$

### 2.6.2.3 Evacuated tubular collectors

Biaxial incidence angle modifiers for evacuated tube collectors shall be used. Values for both transverse and longitudinal incidence angle modifiers shall cover the incidence angle range from 0° to 90°. Both modifiers shall be 1 at 0° and 0 at 90°. If measured biaxial optical data for an evacuated tube array is

not available, then the default incidence angle coefficient ( $d = 0.06$ ) shall be used in [Equations 2.6.1\(1\)](#) and [2.6.1\(3\)](#).

NOTE [Equation 2.6.1\(3\)](#) is the preferred function for evacuated tubular collectors; however, [Equation 2.6.2.2](#) is acceptable if the test data from the solar collector test report is not available for the purpose of computing the coefficients in [Equation 2.6.1\(3\)](#).

### 2.6.3 Collector efficiency correction for shadowing due to impact guard

If an impact guard is required to be added to a collector to pass the impact test requirements of AS/NZS 2712 and the collector efficiency test was completed without an impact guard, then the collector efficiency shall be corrected for —

- (a) normal incidence shadowing due to the impact guard; and
- (b) incidence angle modifier of impact guard as specified in [Appendix D](#).

NOTE An impact guard cannot be used on PV panels as shadowing of PV panels can result in a significant loss of output.

## 2.7 Air source heat pump

### 2.7.1 Heat pump COP and electric power use

#### 2.7.1.1 General

The heat pump COP and electric power use shall be evaluated in accordance with [Clause 2.7.1.2](#) or [2.7.1.3](#).

#### 2.7.1.2 Fixed speed compressor heat-pumps

The heat pump COP and electric power use shall be evaluated in accordance with the requirements of AS/NZS 5125.1:2014.

#### 2.7.1.3 Variable speed compressor heat-pumps

Variable speed heat pumps are speed controlled using control functions such as —

- (a) a continuous function algorithm based only on water inlet temperature, ambient temperature and humidity;
- (b) discrete speed switching (for example on the basis of the level of energy storage in the tank and time of day or defrost cycling);
- (c) electric input power limited (for example direct connection to a photovoltaic array); or
- (d) combination of some or all of the above functions.

Variable speed heat pumps that use a control system that varies the compressor speed in a continuous manner as a function of water inlet temperature, ambient temperature and humidity may be characterized by a single set of AS/NZS 5125.1:2014 COP and Power correlations; no speed adjustment factors for Power and COP or additional tests are required.

Variable speed heat pumps that use a control system that switches compressor speeds in a discrete manner shall be evaluated in accordance with AS/NZS 5125.1:2014 for a range of constant speed operation modes as specified in [Clause 2.7.2](#) or use the default speed derating factors in [Table 2.7.1.3](#)

Variable speed heat pumps that have a default operating mode where the compressor speed varies in a continuous manner as a function of water inlet temperature and ambient temperature and humidity but has occasional discrete controller-based speed setting periods of operation shall be evaluated by direct testing for a range of constant speed operation modes as specified in [Clause 2.7.2](#) or by using default

derating factors in [Table 2.7.1.3](#) for the periods where the speed setting is not directly controlled by water inlet temperature and ambient temperature and humidity.

The performance factors for heat pumps that vary the compressor speed due to limited input power shall be determined —

- (a) in accordance with AS/NZS 5125.1, testing for a range of compressor speeds as specified in [Clause 2.7.2](#); or
- (b) by using the default derating factors in [Table 2.7.1.3](#).

If the optional *Power* consumption and *COP* adjustment factors are used rather than direct testing, then the AS/NZS 5125.1:2014 rated *Power* and *COP* functions shall be modified as a function of compressor speed as follows:

- (i) For power consumption, using the *Power* adjustment factor  $q$  from [Table 2.7.1.3](#), according to the following equation:

$$Power = Power_{rated} \times q \quad 2.7.1.3(1)$$

where

$$Power_{rated} = \text{power consumption at rated condition}$$

EXAMPLE For operation at 120 % rated condition ( $s = 1.2$ ):

$$Power = Power_{rated} \times 1.24$$

- (ii) For *COP*, using the *COP* adjustment factor  $n$  from [Table 2.7.1.3](#), according to the following equation:

$$COP = COP_{rated} \times n \quad 2.7.1.3(2)$$

where

$$COP_{rated} = \text{COP determined at rated condition}$$

EXAMPLE The *COP* for operation at 120 % of rated condition ( $s = 1.2$ ):

$$COP = COP_{tested} \times 0.92$$

NOTE For  $s = 1$  the equations for *COP* and *Power* reduce to the equivalent equations from AS/NZS 5125.1:2014 as follows:

$$COP_{rated} = \left[ a_0 + a_1 X + a_2 X^2 + a_3 (T_{wet} - T_{dp}) \right] \quad 2.7.1.3(3)$$

$$Power_{rated} = \left[ p_0 + p_1 Y + p_2 Y^2 + p_3 T_a \right] \quad 2.7.1.3(4)$$

where

|                 |   |                                                                                                                                                                                                                                      |
|-----------------|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $a_i$ and $p_i$ | = | coefficients as specified in AS/NZS 5125.1:2014 test report                                                                                                                                                                          |
| $X$             | = | $(T_w - T_a)$ or $(T_{wi} - T_a)$ as specified in AS/NZS 5125.1:2014 test report                                                                                                                                                     |
| $Y$             | = | $T_w$ or $T_{wi}$ as specified in AS/NZS 5125.1:2014 test report                                                                                                                                                                     |
| $COP$           | = | coefficient of performance                                                                                                                                                                                                           |
| $Power$         | = | total electric power input (kW)                                                                                                                                                                                                      |
| $T_a$           | = | ambient air temperature (°C)                                                                                                                                                                                                         |
| $T_{dp}$        | = | air dew point temperature (°C)                                                                                                                                                                                                       |
| $T_{wet}$       | = | air wet bulb temperature (°C)                                                                                                                                                                                                        |
| $T_w$           | = | <i>average water temperature in condenser for standalone heat pump, mean of inlet and outlet water temperatures (°C), for integral heat pump, mass weighted average temperature of tank segments adjacent to condenser coil (°C)</i> |
| $T_{wi}$        | = | inlet water temperature to condenser for standalone heat pumps (°C)                                                                                                                                                                  |

**Table 2.7.1.3 — Power and COP adjustment factors**

| $\frac{\text{Controlled speed}}{\text{Rated speed}} (s)$                                                                                                                                                                                                                                                                                                                                                    | 0.6  | 0.7  | 0.8  | 0.9  | 1 | 1.1  | 1.2  | 1.3  | 1.4  | 1.5  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|---|------|------|------|------|------|
| <b>Power adjustment factor (<math>q</math>)</b>                                                                                                                                                                                                                                                                                                                                                             | 0.64 | 0.74 | 0.84 | 0.94 | 1 | 1.14 | 1.24 | 1.34 | 1.44 | 1.54 |
| <b>COP adjustment factor (<math>n</math>)</b>                                                                                                                                                                                                                                                                                                                                                               | 0.1  | 0.4  | 0.7  | 0.85 | 1 | 0.95 | 0.92 | 0.83 | 0.75 | 0.65 |
| Linear interpolation shall be used to calculate adjustment factors for selectable speed settings that fall in between the specified fractional values<br>The minimum value of $s$ shall be 0.6 or the minimum value specified in the operation manual if this is greater than 0.6<br>The maximum value of $s$ shall be 1.5 or the maximum value specified in the operation manual if this is less than 1.5. |      |      |      |      |   |      |      |      |      |      |

## 2.7.2 Additional tests for variable capacity compressors

The performance of variable compressor speed air-source heat-pump systems shall be evaluated using the methodology of AS/NZS 5125.1:2014 for at least four extra values of  $s$  other than 1. The extra values of  $s$  shall include the minimum and maximum compressor speeds allowed by the unit controller, and values of speed approximately midway between 1 and the minimum and maximum values.

A means to enable the compressor speed to be locked at the required value for each test condition shall be used.

The *COP* and *Power* for each tested speed shall be characterized by AS/NZS 5125.1:2014 correlations as given in the following equations:

$$COP = \left[ a_0 + a_1 X + a_2 X^2 + a_3 (T_{\text{wet}} - T_{\text{dp}}) \right] \quad 2.7.2(1)$$

$$Power = \left[ p_0 + p_1 Y + p_2 Y^2 + p_3 T_a \right] \quad 2.7.2(2)$$

where the symbols in [Equations 2.7.2\(1\)](#) and [2.7.2\(2\)](#) are as defined in [Clause 2.7.1.3](#).

Linear interpolation with *s* shall be used for the coefficients *a*<sub>0</sub> to *a*<sub>3</sub> and *p*<sub>0</sub> to *p*<sub>3</sub> to calculate the *Power* and *COP* for conditions between the tested conditions.

NOTE [Table 2.7.2](#) shows a template table to be populated with coefficients *a*<sub>0</sub> to *a*<sub>3</sub> and *p*<sub>0</sub> to *p*<sub>3</sub> for the speed fractions covering the operating range of the heat pump. The Table may then be used to calculate *COP* and *Power* as shown in [Equations 2.7.2\(1\)](#) and [2.7.2\(2\)](#) for each value of *s*, including values that can be linearly interpolated between tested values of *s*.

**Table 2.7.2 — Template table for *a*<sub>0</sub> to *a*<sub>3</sub> and *p*<sub>0</sub> to *p*<sub>3</sub> coefficients from AS/NZS 5125.1:2014 test results**

| Fraction, <i>s</i>                              | <i>a</i> <sub>0</sub> | <i>a</i> <sub>1</sub> | <i>a</i> <sub>2</sub> | <i>a</i> <sub>3</sub> | <i>p</i> <sub>0</sub> | <i>p</i> <sub>1</sub> | <i>p</i> <sub>2</sub> | <i>p</i> <sub>3</sub> |
|-------------------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| <i>s</i> <sub>1</sub> = <i>s</i> <sub>min</sub> |                       |                       |                       |                       |                       |                       |                       |                       |
| <i>s</i> <sub>2</sub>                           |                       |                       |                       |                       |                       |                       |                       |                       |
| <i>s</i> <sub>3</sub> = 1                       |                       |                       |                       |                       |                       |                       |                       |                       |
| <i>s</i> <sub>4</sub>                           |                       |                       |                       |                       |                       |                       |                       |                       |
| <i>s</i> <sub>5</sub> = <i>s</i> <sub>max</sub> |                       |                       |                       |                       |                       |                       |                       |                       |

### 2.7.3 Testing requirements for commercial heat pump water heaters

Because of the difficulty of testing large standalone heat pumps with large storage tanks, such heat pump water heaters may be tested according to AS/NZS 5125.1:2014 with the storage tank omitted. A temperature-controlled water supply shall be used to control the inlet water temperature to the heat pump. The energy produced by the test unit shall be measured with a flow meter and temperature sensors on the water inlet and outlet of the heat pump.

NOTE Where units are modular in design, the test data from one module may be applied to systems comprised of multiple identical modules.

## 2.8 Domestic water heater configuration

The system configuration parameter data listed in [Appendix C](#) shall be used in the modelling.

NOTE Additional data may be needed for some systems.

For solar water heaters (both thermal and PV collectors), the solar collector inclination and azimuth shall be as specified in [Appendix A](#) for Australia or [Appendix B](#) for New Zealand.

For solar water heaters and heat pump water heaters that require boosting, at least one of the following supplementary boost supply and control options shall be specified in the performance model:

- (a) Electric in-tank boosting (continuous or time limited supply) including multiple elements with each element operated on different electric supply options.
- (b) Heat pump boosting of a solar thermal collector water heater.
- (c) Gas in-tank boosting.

- (d) Gas or electric storage water heater in series with solar or heat pump preheater.
- (e) Series instantaneous gas or electric booster with the solar heater operating as a preheater.

NOTE The timing of grid electrical supplementary boosting may be set to night rate tariff times, extended off-peak times, continuous boosting or set by a local controller. The supplementary boost controller may vary supplementary input to the tank in response to solar radiation conditions, stored energy level in the tank, load demand and other conditions.

## Section 3 Performance evaluation of domestic water heaters

### 3.1 Performance evaluation simulation program

Simulation programs for use with this document shall produce annual energy use evaluations within 0.5 % lower and 3 % higher of the values shown in —

- (a) [Table A.10\(A\)](#) and [Table B.10](#) for all conventional water heaters; and
- (b) [Table 3.1](#) for all solar and heat pump water heaters when analysed in climate zone 3 using medium level domestic water and electrical loads.

Component parameters and product configurations listed in AS/NZS 4234 Supp 1 shall be used as inputs for confirmation of the suitability of a simulation program.

The standardized annual energy use of water heaters shall be determined using the simulation program with a computational time step of 0.02 h or less to determine the annual purchased energy use for the specified load and environmental conditions.

The chosen time step shall be an exact divisor of the 0.1 h load period.

**Table 3.1 — Standardized annual energy in solar water heater technologies**

| Heater type                                                             | Technology type               | Solar input                                        | Boost location   | Boost fuel | Solar energy delivered to tank<br>GJ/Annum | Purchased energy<br>GJ/Annum |
|-------------------------------------------------------------------------|-------------------------------|----------------------------------------------------|------------------|------------|--------------------------------------------|------------------------------|
| Thermosiphon SWH with in-line instantaneous gas boost                   | Thermosiphon                  | Collector direct to tank                           | Post tank        | Gas        | 9.59                                       | 7.65                         |
| Thermosiphon SWH with in-tank electric boost                            | Thermosiphon                  | Collector direct to tank                           | Integral to tank | Electric   | 8.72                                       | 5.61                         |
| Pumped SWH with in-line instantaneous gas boost                         | Pumped                        | Collector direct to tank                           | Post heater      | Gas        | 9.42                                       | 8.59                         |
| Pumped SWH with in-line instantaneous electric boost                    | Pumped                        | Collector direct to tank                           | Post heater      | Electric   | 9.61                                       | 5.63                         |
| Pumped SWH with in-tank electric boost                                  | Pumped                        | Collector direct to tank                           | Integral to tank | Electric   | 9.24                                       | 5.84                         |
| Heat pump water heater — integral with in-tank electric boost           | Heat pump                     | Air source heat pump                               | Integral to tank | Electric   | 8.66                                       | 5.34                         |
| Heat pump water heater — standalone with in-tank electric boost         | Heat pump                     | Air source heat pump                               | Integral to tank | Electric   | 8.46                                       | 5.81                         |
| PV powered heat pump water heater — standalone with grid electric boost | PV electric powered heat Pump | Air source heat pump-standalone and PV electricity | Integral to tank | Electric   | Electricity from PV 4.14                   | 3.52                         |
| PV powered SWH with grid electric boost                                 | PV electric                   | PV electricity and grid boost                      | Integral to tank | Electric   | Electricity from PV8.97                    | 5.69                         |

**Table 3.1** (continued)

| Heater type                                  | Technology type | Solar input                                         | Boost location                             | Boost fuel | Solar energy delivered to tank<br>GJ/Annum | Purchased energy<br>GJ/Annum                         |
|----------------------------------------------|-----------------|-----------------------------------------------------|--------------------------------------------|------------|--------------------------------------------|------------------------------------------------------|
| Pumped SWH with heat pump — standalone boost | Pumped          | Collector direct to heater and air source heat pump | Flow circulation from standalone heat pump | Electric   | Solar input 12.0 Heat pump input 10.6      | 2.62<br>Electricity used by heat pump and solar pump |

### 3.2 Weather data

The weather data used for the simulation shall be typical meteorological year records for the locations specified in [Appendix A](#) for Australia or [Appendix B](#) for New Zealand.

The performance shall be based on hourly values for the following variables:

|                               |                                                                                       |
|-------------------------------|---------------------------------------------------------------------------------------|
| Ambient temperature           | (all systems)                                                                         |
| Global horizontal irradiation | (solar water heaters, PV water heaters and solar-boosted heat pumps)                  |
| Beam irradiation              | (solar water heaters, PV water heaters and solar-boosted heat pumps)                  |
| Dew point temperature         | (solar water heaters, PV water heaters and heat pumps)                                |
| Wind speed                    | (solar-boosted heat pumps, and solar water heaters incorporating unglazed collectors) |
| Cloud cover                   | (solar-boosted heat pumps, and solar water heaters incorporating unglazed collectors) |

### 3.3 Domestic thermal energy loads

The annual energy use evaluation shall be carried out using the peak daily thermal energy loads and seasonal and daily variations of load, as specified in [Appendix A](#) for Australia or [Appendix B](#) for New Zealand.

The thermal energy load is distributed within each day using the daily load pattern, and the load is varied each month using the seasonal load pattern. The simulation program shall be configured so that the load is specified in terms of energy withdrawn.

The load shall be selected such that the system performance satisfies [Clauses 3.5](#) and [3.6](#) for domestic systems and [Clause 5.5.2](#) for commercial systems. The same load shall be used for performance evaluation in all selected climate zones unless each result reported includes a clear statement of the zone and the load used in the evaluation.

### 3.4 Domestic electrical energy consumption

The annual energy use evaluation when considering an indirect coupled PV water heater shall be carried out using the household electrical consumption as specified in [Clause A.7](#) for Australia or [Clause B.7](#) for New Zealand. The electrical load shall be selected such that it corresponds to the selected peak daily thermal energy load according to [Table A.6.1](#) for Australia or [Table B.6.1](#) for New Zealand.

### 3.5 Domestic hot water load selection

#### 3.5.1 Water heaters with grid electric or gas supplementary heating

For all zones in Australia, if a large, medium or small load is selected from [Table A.6.1](#) when modelled in zone 3, the system shall achieve a minimum 60 % annual energy saving relative to a reference water heater of same boost fuel type supplying the same load.

For all zones in New Zealand, if a medium or small load is selected from [Table B.6.1](#) when modelled in zone 5, the system shall achieve a minimum of 50 % annual energy saving relative to a reference water heater of same boost fuel type supplying the same load. If a large load is selected from [Table B.6.1](#) when modelled in zone 5, the system shall achieve a minimum of 60 % annual energy saving relative to a reference water heater of same boost fuel type supplying the same load.

If a very small load is selected from [Table A.6.1](#) or [Table B.6.1](#) as applicable, there is no minimum annual energy saving requirement.

NOTE AS/NZS 4692.2 has additional requirements for containers of electric-boosted solar water heaters that achieve less than 50 % annual energy savings.

#### 3.5.2 Water heaters with heat pump supplementary heating

For Australia, a water heater that incorporates both a solar thermal collector and a heat pump shall be analysed using the weather data specified in [Clause A.4](#) if the heat pump delivers less than 50 % of the total energy input into the stored water when analysed in zone 3. If, the heat pump energy input to the stored water is greater than 50 % of the total energy input into the stored water in climate zone 3, then the weather data in [Clause A.5](#) shall be used.

For New Zealand, a water heater that incorporates both a solar thermal collector and a heat pump shall be analysed using the climatic data in [Clause B.4](#) if the heat pump delivers less than 50 % of the total energy input into the stored water when analysed in zone 5. If using the weather data in [Clause B.4](#) the heat pump energy input to the stored water is greater than 50 % of the total energy input into the stored water in zone 5, the weather data in [Clause B.5](#) shall be used.

### 3.6 Water temperature

#### 3.6.1 Control of temperature

The model shall simulate the temperature control strategy that is programmed into any controller and/or specified in installation manual.

#### 3.6.2 Legionella control

If a temperature control strategy is used to inhibit the growth of legionella, the temperature control strategy of the water heater shall conform to AS 3498, when the system is intended to be installed in Australia and with Section G12/AS2 of the New Zealand Building Code, when the system is intended to be installed in New Zealand.

If a solar preheat tank is connected to an in-line instantaneous gas or electric booster then for legionella control, as specified in AS 3498, the drinking water shall be heated to a minimum of 70 °C when the solar preheat tank outlet temperature is less than 55 °C. The instantaneous booster may be bypassed if the preheat tank outlet temperature is greater than 55 °C and the preheat tank water supplied directly to the load.

#### 3.6.3 Minimum delivery temperature

The system shall be capable of satisfying a minimum delivery temperature of 45 °C during the simulation of the standardized annual operation with the selected load and for all selected zones.