

SA/SNZ MP 104:2021



Miscellaneous Publication

**Modelling of heated water systems in  
accordance with AS/NZS 4234:2021,  
using TRNSYS**



currently in review, click buy full version

SA/SNZ MP 104:2021

This Joint Australian/New Zealand Miscellaneous Publication was prepared by Joint Technical Committee CS-028, Solar Heating and Cooling. It was approved on behalf of the Council of Standards Australia on 19 May 2021 and by the New Zealand Standards Executive on 08 April 2021.

This Miscellaneous Publication was published on 25 June 2021.

The following are represented on Committee CS-028:

Australian Building Codes Board  
Australian Industry Group  
Australian Institute of Refrigeration Air Conditioning and Heating  
Clean Energy Council  
Consumer Electronics Suppliers Association  
CSIRO  
Energy Efficiency & Conservation Authority of New Zealand  
Gas Appliance Manufacturers Association of Australia  
James Cook University  
New Zealand Green Building Council  
Smart Energy Council  
Solar Association of New Zealand  
Swimming Pool and Spa Association of Australia  
University of New South Wales  
University of South Australia

This Miscellaneous Publication was issued in draft form for comment as DR SA/SNZ MP 104:2020.

#### **Keeping Standards up-to-date**

Ensure you have the latest versions of our publications and keep up-to-date about Amendments, Rulings, Withdrawals, and new projects by visiting:

[www.standards.org.au](http://www.standards.org.au)

[www.standards.govt.nz](http://www.standards.govt.nz)

ISBN 978 1 76113 361 9

Miscellaneous Publication

**Modelling of heated water  
systems in accordance  
with AS/NZS 4234:2021,  
using TRNSYS**

First published as SA/SNZ MP 104:2021.

© Standards Australia Limited/the Crown in right of New Zealand, administered by the New Zealand Standards Executive 2021

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher, unless otherwise permitted under the Copyright Act 1968 (Cth) or the Copyright Act 1994 (New Zealand).

## Preface

This Miscellaneous Publication (MP) was prepared by the Joint Standards Australia/Standards New Zealand Committee CS-028, Solar Heating and Cooling.

The objective of this document is to provide software tools to support the application of AS/NZS 4234:2021, *Heated water systems — Calculation of energy consumption*, for evaluating the annual energy performance of water heaters, to determine the standardized annual purchased energy use.

This document is accompanied by additional files for use with third party software. The additional files may be obtained on purchase of the document in the following manner:

- (a) USB Flash drive containing a Zip file, for hard copy purchasers.
- (b) Zip file for online purchasers, to be downloaded from the website of purchase.

Delivery methods for the additional files may change over time.

Standards Australia Limited accepts no responsibility arising out of or in connection with the use of the additional files or access to any third-party software.

# Contents

<b>Preface</b> .....	<b>ii</b>
<b>Section 1 Scope and general</b> .....	<b>1</b>
1.1 Scope.....	1
1.2 Application.....	2
1.3 Normative references.....	2
1.4 Terms and definitions.....	3
<b>Section 2 Performance evaluation</b> .....	<b>4</b>
2.1 General.....	4
2.2 TRNSYS deck examples.....	4
2.3 TRNSYS source code.....	5
2.4 Nonlinear solar collector efficiency characterization.....	5
2.5 Incidence angle modifier.....	5
2.5.1 General.....	5
2.5.2 Symmetric collectors.....	6
2.5.3 Data table of incidence angle modifier values.....	6
2.5.4 Collectors with north-south and east-west symmetry.....	6
2.5.5 Incidence angle modifier map.....	6
2.5.6 Collectors with east-west symmetry only.....	6
2.6 Collector configuration.....	6
2.6.1 General.....	6
2.6.2 Collector heat removal via heat pipe.....	6
2.6.3 Thermosiphon systems with collector loop heat exchanger.....	7
2.6.4 Serpentine riser solar collector.....	7
2.6.5 Thermal cut-off valve in the thermosiphon loop.....	7
2.7 Storage tank options.....	7
2.7.1 Over-temperature relief valve.....	7
2.7.2 One-shot boosting.....	7
<b>Section 3 TRNSYS modelling</b> .....	<b>8</b>
3.1 General.....	8
3.2 Deck layout.....	8
3.3 Simulation results.....	8
3.3.1 Annual performance output.....	8
3.3.2 Energy balance.....	9
3.3.3 Runtime graph.....	9
3.4 Solar collector area.....	9
3.5 Default maximum tank temperature settings for collector loop pump controller.....	9
3.6 Piping models.....	9
3.6.1 Duct tubes.....	9
3.7 Instantaneous gas heater modelling.....	10
3.8 PV powered water heater modelling.....	10
3.9 Thermal stratification in storage tanks.....	11
3.9.1 Pumped circulation loops.....	11
3.9.2 Measurement and documentation of pump flow rate and power.....	11
3.9.3 Controller cycling and simulation stability.....	11
3.10 TRNSYS modelling parameters for thermosiphon solar water heaters.....	12
3.10.1 General.....	12
3.10.2 Thermosiphon flow restriction valves.....	12
3.11 Legionella control.....	13
3.12 Calibration of heat pump parameters against test data.....	13
3.12.1 General.....	13
3.12.2 Integral heat pump condenser temperature difference.....	13
3.12.3 Low temperature operation penalty factor.....	13
3.13 Units.....	13
3.14 Rounding of numerical results.....	13

3.15	Batch execution of TRNSYS rating calculations .....	13
<b>Section 4</b>	<b>Sample input files for use with TRNSYS</b> .....	<b>15</b>
4.1	General.....	15
4.2	Climate zone Include files .....	16
<b>Bibliography</b>	.....	<b>17</b>

Currently in preview, click buy full version

# Miscellaneous Publication

## Modelling of heated water systems in accordance with AS/NZS 4234:2021, using TRNSYS

### Section 1 Scope and general

#### 1.1 Scope

This Miscellaneous Publication (MP) details application of the TRNSYS modelling software to support assessment of the annual energy performance and CO<sub>2</sub> equivalent emission of water heaters to AS/NZS 4234:2021 requirements.

The performance evaluations use a combination of test results for component performance and a mathematical model of the complete product to determine the standardized annual purchased energy use. The procedure is applicable to electric, gas and solar water heaters with integral boosting or preheating into a conventional storage or instantaneous water heater and to heat pump water heaters. For solar and heat pump water heaters, displaced purchased energy relative to reference water heaters is also calculated.

For products not covered in the application of AS/NZS 4234:2021 and this document, or if it is not possible to model the product using the TRNSYS software, such products may be tested under AS 2984 to obtain an annual performance assessment.

Performance is determined for a range of climatic conditions using models implemented for use in the TRNSYS version 15 simulation package.

The modelling given in this document may be applied to the following water heaters:

- (a) Electric and gas storage water heaters.
- (b) Electric and gas instantaneous heaters.
- (c) Solar water heaters with —
  - (i) flat plate, concentrating or evacuated tubular solar thermal collectors;
  - (ii) solar photovoltaic collectors;
  - (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 dual electric element(s);
  - (vii) storage tanks with internal gas boosting; and
  - (viii) 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 wraparound, or in-wall embedded tank condensers; and
  - (iii) external condensers, circulating water into one or more tanks.

Example TRNSYS deck files for the following systems are provided with this document:

- (A) Horizontal tank thermosiphon solar water heater with in-tank electric booster.
- (B) Horizontal tank thermosiphon solar water heater with series instantaneous gas booster.
- (C) Pumped circulation solar water heater with in-tank electric booster.
- (D) Pumped circulation solar water heater with series instantaneous gas booster.
- (E) Pumped circulation solar water heater with series instantaneous electric booster.
- (F) Conventional electrical storage water heater.
- (G) Conventional gas storage water heater.
- (H) Conventional gas instantaneous water heater.
- (I) Standalone air source heat pump.
- (J) Integral air source heat pump with wraparound tank condenser.
- (K) Pumped circulation solar water heater with standalone air source heat pump as primary booster and in-tank electric element as secondary booster.
- (L) Electric water heater with indirect coupled photovoltaic (PV) electricity supply.
- (M) Standalone air source heat pump with indirect coupled PV electricity supply.

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

NOTE 1 Sample decks are suitable for modelling both flat plate and evacuated tube thermal collectors.

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 Appendix G; AS 2984) may assist in TRNSYS model development and to assess the accuracy of some TRNSYS inputs and some simulation outputs.

NOTE 3 AS 4552—2005 has been replaced by AS/NZS 5263.1.2:2016; however, energy performance tests to AS 4552—2005 are acceptable for use with this document, i.e. SA/SNZ MP 104.

## 1.2 Application

This document outlines procedures for determining the annual energy performance of water heaters. These annual performance models are developed for use with the TRNSYS modelling package.

NOTE The TRNSYS software is not supplied with the software examples included with this document.

## 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 2984, *Solar water heaters—Method of test for thermal performance—Outdoor test method*

AS 4552, *Gas fired fuel 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 4234, *Heated water systems — Calculation of energy consumption*

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*

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

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

#### **1.4 Terms and definitions**

For the purpose of this document, the terms and definitions given in AS/NZS 4234:2021 apply.

## Section 2 Performance evaluation

### 2.1 General

The task performance simulation for AS/NZS 4234:2021 uses the TRNSYS simulation program (version 15) and extensions developed for new product features. TRNSYS is a transient system simulation program developed by the Solar Energy Laboratory at The University of Wisconsin. TRNSYS has gained worldwide acceptance as a result of its modular configuration and the availability of the FORTRAN source code in the public domain. The modular nature of the code means that it can be readily extended to include new energy devices and systems. The software required for the implementation of AS/NZS 4234:2021 is available from The University of Wisconsin.<sup>[1]</sup>

Extensions to TRNSYS for thermosiphon solar water heaters, specialized heat exchangers and controllers have been developed by the Solar Thermal Energy Laboratory at The University of New South Wales<sup>[2]</sup> and others. The University of New South Wales extensions to TRNSYS are referred to in this document as the TRNAUS software. TRNAUS version 19 or later is required to run some of the simulations defined in this document.

The standardized annual energy use of water heaters shall be determined using the TRNSYS 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.

### 2.2 TRNSYS deck examples

Example TRNSYS input files (deck files) for the following water heaters are supplied with this document. These decks were used to produce the performance data in Table 3.1 of AS/NZS 4234:2021.

- (a) Thermosiphon\_elec.dck — Horizontal tank thermosiphon solar water heater with in-tank electric booster.
- (b) Thermosiphon\_gas.dck — Horizontal tank thermosiphon solar water heater with series instantaneous gas booster.
- (c) Pump\_elec.dck — Pumped circulation solar water heater with in-tank electric booster.
- (d) Pump\_inst\_gas.dck — Pumped circulation solar water heater with series instantaneous gas booster.
- (e) Pump\_inst\_elec.dck — Pumped circulation solar water heater with series instantaneous electric booster.
- (f) Separate\_HP.dck — Standalone air source heat pump.
- (g) Integral\_external\_HP.dck — Integral air source heat pump with wraparound tank condenser.
- (h) Pump\_HP\_boost.dck — Pumped circulation solar water heater with standalone air source heat pump as primary booster and in-tank electric element as secondary booster.
- (i) PV\_elec.dck — Electric water heater with indirect coupled PV electricity supply.
- (j) Separate\_HP\_PV\_Powered.dck — Standalone air source heat pump with indirect coupled PV electricity supply.
- (k) Electrical\_storage.dck — Conventional electrical storage water heater.
- (l) Gas\_storage.dck — Conventional gas storage water heater.
- (m) Gas\_instantaneous.dck — Conventional gas instantaneous water heater.