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SOLAR HOT WATER AND HEAT PUMP BOOSTER ENERGY CALCULATION METHODOLOGY

PART A: CALCULATION METHODOLOGY FOR SOLAR WATER HEATERS AND HEAT PUMP WATER HEATERS WITH A VOLUMETRIC CAPACITY OF UP TO AND INCLUDING 700 LITRES

This methodology document is to be used to calculate the energy consumption for solar water heaters (SWH) or heat pump water heaters (HPWH) with a volumetric water storage capacity of up to and including 700 litres for the purposes of the Green Star –Greenhouse Gas Emissions Calculator for Green Star – Industrial v1, Green Star – Healthcare v1, Green Star – Education v1, and Green Star – Public Building PILOT tools.

The annual energy consumption for a solar water heater or heat pump water heater is the boost energy required by the SWH or HPWH to deliver a prescribed load.

The boost energy required by the system to deliver a prescribed load profile (the **total annual auxiliary boost energy**) is calculated in accordance with Australian Standard AS4234 (with the TRNSYS thermal modelling software*) with the exception of a number of TRNSYS input parameters that are defined below.

This methodology also describes the treatment of dual element tanks and manual controls for the purposes of boost energy calculation.

* If project teams wish to use an alternative piece of software to TRNSYS, they should submit a CIR explaining the software's equivalent capacity to model the required parameters.

Treatment of Dual Element Tanks
For systems where a bottom element is, or can be, fitted in the tank (e.g. a dual element tank) the bottom element is to be used for Green Star calculation purposes. The minimum boost time for a bottom element shall be nominal off-peak times of 11pm to 6am.

Some tank designs may be modified by the installer to insert an element at the bottom of the tank even if this element has been blanked off. If a model uses a tank that can have the bottom element connected, the GBCA requires that the bottom element be used to determine boost energy consumption.

One-Shot Boosting
One-shot boosting is a manual control that allows a default boost mode (such as off-peak boosting) to be overridden so that the user can satisfy a short term high demand for hot water.

Where the system automatically resets to the default boosting mode within 24 hours of the user changing the boost mode, the one-shot boosting can be ignored for the purposes of Green Star boost energy calculation.

Where the system does not automatically reset to the default boosting mode within 24 hours of the user changing the boost mode, the boosting mode activated by the manual control must be considered to be active at all times for the purposes of boost energy calculation.

Boost Energy Calculation Methodology

1. Use the following TRNSYS input parameters to calculate the **total annual auxiliary boost energy** (MWh) for the solar water heater using Version 14 or later of the TRNSYS computer modelling package:

    a. Solar collector efficiency parameters determined in accordance with AS/NZS2535.

    b. Air source heat pump Coefficient of Performance (COP) and power consumption performance shall be determined from full system tests in a calorimeter chamber. The performance shall be correlated using methods described in Morrison et al (2004) or other methods approved by the GBCA.

    c. Tank heat loss is determined in accordance with AS/NZS4692.1 or AS1056 test procedure.

    d. Modelling shall be carried out using a simulation time step of 0.1 hours or less.

    e. Solar collector slope = the installed slope of the collectors.

    f. Solar collector azimuth = the installed azimuth of the collectors.

    g. Use Table 1 to determine the hot water load (small, medium or large) based on the size of the solar storage tank.

    h. Use Table 2 to determine which climate zone the system is installed within.

    i. Peak loads for each climate zone and product size are provided in Table 3.

    j. Monthly usage patterns are provided in Table 4.

    k. Monthly cold water temperatures for each zone are provided in Table 5.

l. Length of piping between storage tank and solar collectors for a pumped circulation system shall be the manufacturer's specification or 10 metres (each way), whichever is larger.

   Length of piping between pumped circulation solar preheat tank and a separate series connected auxiliary booster shall be the manufacturers specification or five metres, whichever is larger.

   Length of piping between a thermosiphon solar pre-heater and a separate series auxiliary booster shall be the manufacturer's specification or 10 metres, whichever is larger.

m. The thermostat setting for the purpose of the rating shall produce a minimum temperature of 60 degrees Celsius at the hot water delivery point after each heating cycle.

n. Boosting may be continuously available, or at standard off-peak tariff times or limited by a local controller in order to separate the boost time from the solar operation times.

   If off-peak boosting or other time limits on auxiliary boosting are employed then the product must be able to deliver the selected load under the no-solar climate conditions specified in AS4234. Under no-solar conditions the minimum delivery temperature of any draw-off must be greater than or equal to 40 degrees Celsius (40°C). If the product fails to meet this condition then a lower load condition shall be used or the boost volume increased until the required condition is satisfied.

o. Weather data to be used for the climatic zones should be sourced from AS4234.

2. By default, the AS4234 software reports auxiliary boost energy as average daily kilojoules for each month. Multiply average daily kilojoules by the number of days in each corresponding month. Sum the monthly totals to determine **total annual auxiliary boost energy**.

   For systems with electric boosters, convert kJ to MWh.

Table 1: Hot Water Rating Loads		
Hot water load	*Single tank product with solar and auxiliary inputs to the one tank*	*Solar preheat product with series-connected instantaneous booster and two tank products*
Large	Tank volume equal to or greater than 400 L	Preheat tank volume equal to or greater than 200 L
Medium	Tank volume less than 400 L and greater than 220 L	Preheat tank volume less than 200 L and greater than 110 L
Small	Tank volume equal to or less than 220 L	Preheat tank volume equal to or less than 110 L

Table 2: Climate zones based on postcode								
Postcode range			Postcode range			Postcode range		
From	To	Zone	From	To	Zone	From	To	Zone
0200	0299	3	3750	3898	4	5231	5261	3
0800	0862	1	3900	3900	3	5262	5263	4
0870	0872	2	3902	3996	4	5264	5270	3
0880	0909	1	4000	4419	3	5271	5291	4
1001	2914	3	4420	4420	1	5301	6256	3
3000	3381	4	4421	4428	3	6258	6262	4
3384	3384	3	4454	4454	1	6271	6318	3
3385	3387	4	4455	4468	3	6320	6338	4
3388	3396	3	4470	4475	2	6341	6341	3
3399	3413	4	4477	4477	1	6343	6348	4
3414	3424	3	4478	4482	2	6350	6353	3
3427	3451	4	4486	4488	3	6355	6356	4
3453	3453	3	4489	4493	2	6357	6395	3
3458	3462	3	4494	4615	3	6396	6398	4
3463	3465	3	4620	4724	1	6401	6439	3
3467	3469	4	4725	4725	2	6440	6440	2
3472	3520	3	4726	4726	1	6441	6444	3
3521	3522	4	4727	4731	2	6445	6452	4
3523	3649	3	4732	4733	1	6460	6640	3
3658	3658	4	4735	4736	2	6642	6725	2
3659	3660	3	4737	4824	1	6726	6743	1
3661	3661	4	4825	4829	2	6751	6799	2
3662	3709	3	4830	4895	1	6800	6997	3
3711	3724	4	5000	5214	3	7000	8873	4
3725	3749	3	5220	5223	4	9000	9729	3

Table 3: Peak winter hot water energy load for each zone (MJ/day)			
Location	*Peak Load (MJ/day)*		
	Large system	*Medium system*	*Small system*
Zone 1 – Adelaide	60	40	24
Zone 2 – Alice Springs	61.3	40.9	24.5
Zone 3 – Adelaide	60	40	24
Zone 4 – Melbourne	63	42	25.2

Table 4: Monthly hot water energy usage patterns for each zone (Fraction of Peak Month Load)												
Location	*Monthly Usage Pattern (Ratio of peak month)*											
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Zone 1	0.69	0.69	0.67	0.74	0.80	0.87	0.98	1.00	0.94	0.93	0.84	0.76
Zone 2	0.44	0.50	0.58	0.69	0.86	0.94	1.00	0.92	0.75	0.61	0.53	0.47
Zone 3	0.69	0.69	0.67	0.74	0.80	0.87	0.98	1.00	0.94	0.93	0.84	0.76
Zone 4	0.68	0.68	0.73	0.81	0.92	0.97	1.00	0.95	0.89	0.81	0.76	0.70

Table 5: Monthly cold water temperatures												
Location	*Cold Water Temperatures (°C)*											
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Zone 1	20.53	20.79	21.46	18.86	16.73	14.21	10.34	9.79	11.82	12.27	15.36	18.14
Zone 2	29.00	27.00	24.00	20.00	14.00	11.00	9.00	12.00	18.00	23.00	26.00	28.00
Zone 3	20.53	20.79	21.46	18.86	16.73	14.21	10.34	9.79	11.82	12.27	15.36	18.14
Zone 4	20.00	20.00	18.00	15.00	11.00	9.00	8.00	10.00	12.00	15.00	17.00	19.00

Please contact the GBCA if you have any questions and check the GBCA website (www.gbca.org.au) regularly to ensure that you are using the latest version of this methodology.

PART B: CALCULATION METHODOLOGY FOR SOLAR WATER HEATERS AND HEAT PUMP WATER HEATERS WITH A VOLUMETRIC CAPACITY OF OVER 700 LITRES

This methodology is to be used to calculate the booster energy consumption for solar water heater (SWH) or heat pump water heaters (HPWH) with a volumetric water storage capacity of over 700 litres.

The boost energy required by the system to deliver a prescribed load profile (the **total annual auxiliary boost energy**) is calculated in accordance with Australian Standard AS4234 (with the TRNSYS thermal modelling software*) with the exception of a number of TRNSYS input parameters that are defined below.

This methodology also describes the proper treatment of dual element tanks and manual controls for the purposes of **total annual auxiliary boost energy** calculation.

Treatment of Dual Element Tanks

For systems where a bottom element is, or can be, fitted in the tank (e.g. a dual element tanks) the bottom element is to be used for Green Star calculation purposes. The minimum boost time for a bottom element shall be nominal off-peak times of 11pm to 6am.

Some tank designs may be modified by the installer to insert an element at the bottom of the tank even if this element has been blanked off. If a model uses a tank that can have the bottom element connected, the GBCA requires that the bottom element be used to determine boost energy consumption values.

One-Shot Boosting

One-shot boosting is a manual control that allows a default boost mode (such as off-peak boosting) to be overridden so that the user can satisfy a short term high demand for hot water.

Where the system automatically resets to the default boosting mode within 24 hours of the user changing the boost mode, the one-shot boosting can be ignored for the purposes of Green Star boost energy calculation.

Where the system does not automatically reset to the default boosting mode within 24 hours of the user changing the boost mode, the boosting mode activated by the manual control must be considered to be active at all times for the purposes of the **total annual auxiliary boost energy** calculation.

Boost Energy Calculation Methodology

1. Use the following TRNSYS input parameters to calculate the total annual auxiliary boost energy (MWh) for the solar water heater using Version 14 or later of the TRNSYS computer modelling package:

    a. Solar collector efficiency parameters determined in accordance with AS/NZS2535.

    b. Air source heat pump Coefficient of Performance (COP) and power consumption performance shall be determined from full system tests in a calorimeter chamber. The performance shall be correlated using methods described in Morrison et al (2004).

* If project teams wish to use an alternative piece of software to TRNSYS, they should submit a CIR explaining the software's equivalent capacity to model the required parameters.

c. Tank heat loss determined using the ORER Heat Loss Test Procedure for Solar Water Heaters with a Hot Water Storage Tank Greater than 630 Litres (http://www.orer.gov.au/householders/heatloss.html).

d. Modelling shall be carried out using a simulation time step of 0.1 hour or less.

e. Solar collector slope = the installed slope of the collectors.

f. Solar collector azimuth = the installed azimuth of the collectors.

g. Use Table 2 to determine which climate zone the system is installed within.

h. Peak winter hot water load for solar water heaters and solar boosted heat pump water heaters is set at 10 MJ/(m^2 aperture area)/ day.

Air source heat pump water heaters

Peak winter load for annual performance assessment is 60% of the maximum no-solar load capacity. The maximum no-solar load capacity is the largest hot water energy delivery that can be achieved with outlet temperatures greater than 40 degrees Celsius (40°C). The no-solar capacity is determined for July (maximum winter load) using the modelling package with the daily load pattern specified in Table 7 and the AS4234 no-solar conditions for the applicable climate zone (radiation = 0, ambient temperature = 10°C, relative humidity = 60%, cold water temperature = 9°C).

i. Hot water usage, daily and seasonal, is provided in Tables 6 and Table 7.

j. Cold water temperatures for each zone are provided in Table 8.

k. Length of piping between storage tank and the closest corner of the solar collector array for a pumped circulation system shall be the manufacturer's specification or 25 metres (each way), whichever is larger. The length of the return pipe shall account for additional piping length associated with reverse return plumbing.

The length of piping between the 'pumped circulation solar preheat tank' and the 'series auxiliary booster' shall be the manufacturers specification or 10 metres, whichever is larger.

The length of piping between the 'thermosiphon solar preheater' and the 'series auxiliary booster' shall be the manufacturer's specification or 25 metres, whichever is larger.

The diameter of all connecting piping shall be equal to the manufacturer's specifications.

l. The thermostat setting for the purpose of the calculation shall produce a minimum temperature of 60°C at the hot water delivery point after each heating cycle.

m. Boosting may be continuously available, or at standard off-peak tariff times or limited by a local controller in order to separate the boost time from the solar operation times.

If off-peak boosting or other time limits on auxiliary boosting are employed then the product must be able to deliver the selected load under the no-solar climate conditions specified in AS4234. Under no-solar conditions the minimum delivery temperature of any draw-off must be greater than or equal to 40°C. If the product fails to meet this condition

then a lower load condition shall be used or the boost volume increased until the required condition is satisfied.

n. Weather data to be used for the climatic zones should be sourced from AS4234.

2. By default, the AS4234 software reports auxiliary boost energy as average daily kilojoules for each month. Multiply average daily kilojoules by the number of days in each corresponding month. Sum the monthly totals to determine total annual auxiliary boost energy.

   For systems with electric boosters, convert kJ to MWh.

Table 6: Monthly hot water energy usage patterns for each zone (fraction of peak month load)

Location	*Monthly Usage Pattern (ratio of peak month)*											
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Zone 1	0.69	0.69	0.67	0.74	0.80	0.87	0.98	1.00	0.94	0.93	0.84	0.76
Zone 2	0.44	0.50	0.58	0.69	0.86	0.94	1.00	0.92	0.75	0.61	0.53	0.47
Zone 3	0.69	0.69	0.67	0.74	0.80	0.87	0.98	1.00	0.94	0.93	0.84	0.76
Zone 4	0.68	0.68	0.73	0.81	0.92	0.97	1.00	0.95	0.89	0.81	0.76	0.70

Table 7: Daily hot water energy usage patterns for all zones (as fraction of daily load)

Time of day	7-8	8-9	11-12	13-14	15-16	16-17	17-18	18-19
Fraction of load	0.150	0.150	0.100	0.100	0.125	0.125	0.125	0.125

Table 8: Monthly cold water temperatures

Location	*Cold Water Temperatures (°C)*											
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Zone 1	20.53	20.79	21.46	18.86	16.73	14.21	10.34	9.79	11.82	12.27	15.36	18.14
Zone 2	29.00	27.00	24.00	20.00	14.00	11.00	9.00	12.00	18.00	23.00	26.00	28.00
Zone 3	20.53	20.79	21.46	18.86	16.73	14.21	10.34	9.79	11.82	12.27	15.36	18.14
Zone 4	20.00	20.00	18.00	15.00	11.00	9.00	8.00	10.00	12.00	15.00	17.00	19.00

References

AS/NZS4692.1-2005, Electric water heaters, Part 1: Energy consumption performance and general requirements.

AS/NZS2535-2007, Test methods for solar collectors - Thermal performance of glazed liquid heating collectors including pressure drop (ISO 9806-1:1994, MOD), Standards Australia.

TRNSYS 15 User Manual, Kline, S.A. et al (1998), University of Wisconsin Solar Energy Laboratory.

TRNSYS Extensions for Australian Solar Products (TRNAUS). Solar Thermal Energy Laboratory, School of Mechanical & Manufacturing Engineering, University of NSW. Report 2007-7.3, http://solar1.mech.unsw.edu.au/glm/trnaus/trnaus.pdf.

AS4234-1994, Solar water heaters, Domestic and heat pump – Calculation of energy consumption, Standards Australia.

Morrison G.L. and Litvak A., Condensed solar radiation database for Australia, http://solar1.mech.unsw.edu.au/glm/trnaus/tmy99.pdf.

Morrison G.L., Anderson T. and Behnia M. (2004) Seasonal performance rating of heat pump water heaters, ISES Solar World Congress conference 2002, also Solar Energy V76, 147-152, 2004.

Office of the Renewable Energy Regulator (ORER), REC calculation methodology for solar water heaters and heat pump water heaters with a volumetric capacity up to and including 700 litres, Version 13 (updated January, 2008).

Office of the Renewable Energy Regulator (ORER), REC calculation methodology for solar water heaters and heat pump water heaters with a volumetric capacity over 700 litres, Version 10 (updated January, 2008).