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Addition of a Hot-Water Module to AccuRate

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NOMENCLATURE

A	house floor area (m^2)
A_c	area of solar collector (m^2)
ASR	absorbed Solar Radiation
BWU	bath water use (litres/day)
CE	annual emissions from house water heating system (kg/year)
CEE_f	carbon emission factor of electricity
CE_f	carbon emission factor
COP_c	conversion efficiency of the heater
COP_m	conversion coefficient of heat pump maintenance
CWT	cold water temperature (ºC)
DED	daily energy demand (MJ/day)
DST	daily shower time for each occupant (Min/person/day)
E	net total energy demand (GJ/year)
ECL	control electric loss (W)
EHPSMR	heat pump electric storage maintain rate
ESMR	maintain rate (MJ/day)
HLHWSV	heat loss from a water storage vessel (kWh/day);
HLPW	heat loss from pipe work (MJ/day)
HLSHWSV	heat loss from a solar hot-water storage vessel (kWh/day)
IWHSL	instant water heater start-up losses (MJ/day)
K_{inclin}	solar collector non-ideal orientation factor
K_{pl}	coefficient of pipe heat loss
K_s	system solar factor
L	storage vessel capacity (litres)
MS	solid fuel booster monthly saving (MJ/month)
NBR	number of bedrooms
NDM	number of days in month
NS	number of systems
NS_{bath}	number of systems with bath
NS_{shower}	number of systems with a shower
Occupants	number of house occupants
OWU	other water use (litres/day)
RESMR	reversed maintain rate (MJ/day)
RQtarget	emissions from a reference hot-water heating system (kg/year)
SFB	solid fuel booster energy saving (MJ/day)
SFR	shower flow rate (litres/minute)
SHR	shower heat recovery energy saving (MJ/day)
SHW	net solar gain (MJ/day)
SLPF	start-up loss per firing (kJ)
STPS	shower time for each shower system (Minutes/day)
SWT	storage water temperature
SWU	shower water use for the system (litres/day)
TDST	total daily shower time (Minutes/day)
TES	total energy savings (MJ/day)
TMF	temperature modification factor
T_o	monthly average ambient temperature (ºC)
TWR	tepid water return energy saving (MJ/day)

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EXECUTIVE SUMMARY

For house sustainability assessment and for helping home owners to determine the most appropriate actions to improve the environmental performance of a property, the Residential Buildings Group (RBG) of Department of Environment, Water, Heritage and the Arts (DEWHA) requires the addition of a hot-water module to the AccuRate software. The module calculates energy consumption and greenhouse gas emissions of the hot-water system used in the house based on user inputs.

CSIRO was engaged by RBG to implement the hot-water module in AccuRate. The project accomplished the following deliverables:

- A hot-water page has been implemented in the AccuRate user interface, containing the input data fields required which include details of the house hot-water system such as heater type, hot-water distribution type, storage tank size and location, fuel types, solar hot-water system, solid fuel booster, shower(s) and heat recovery etc;
- The calculations of energy consumption in the hot-water module are based on the WHAT HO spreadsheet tool and report, developed by BRANZ for EECA [1];
- CO_2-e emissions are calculated from the CO_2 intensities appropriate to the postcode for the fuel and electricity used;
- A hot-water report page has been added to AccuRate's summary report, showing annual energy consumption, CO_2-e emissions and star rating of the house hot-water system;
- A detailed hot-water system report is also available in AccuRate which describes the hot-water system(s) used in the house.

1. BACKGROUND

For house sustainability assessment and for helping home owners to determine the most appropriate actions to improve the environmental performance of a property, the Residential Buildings Group (RBG) of Department of Environment, Water, Heritage and the Arts (DEWHA) requires the addition of a hot-water module to the AccuRate software. The module will calculate energy consumption and greenhouse gas emissions of the hot-water system according to user inputs. CSIRO was engaged by RBG to implement the hot-water module in AccuRate.

The project includes the following deliverables:

- A hot-water page will be added to the AccuRate user interface, containing the input data fields required. Data entry will use the same style as the other pages.
- The user input data fields in the hot-water module will include heater type, hot-water distribution type, storage tank size and location, fuel source, solar hot-water system, solid fuel booster, shower(s) and heat recovery etc.
- The calculations of energy consumption in the hot-water module will be based on the WHAT HO spreadsheet tool and report, developed by BRANZ for EECA [1].
- CO_2-e emissions will be calculated from the CO_2 intensities appropriate to the postcode for the fuel and electricity used.
- A hot-water report page will be added to AccuRate's summary report, showing annual energy consumption, CO_2-e emissions and star rating of the house hot-water system.

This report details the implementation of the hot-water module in AccuRate.

2. HOT-WATER ENERGY CALCULATION METHODOLOGY

Based on WHAM (Water Heating Assessment Method) developed by BRANZ Ltd for AGO (Australian Green Office) [2] and WHAT (Water Heating Assessment Tool) for the DBH (Department of Building and Housing), BRANZ Ltd developed a water heating tool for New Zealand domestic construction, the WHAT HO! [3]. The methodology of WHAT HO! was recently extended to include Australian conditions by Burgess and Cogan [1]. The AccuRate hot-water module implementation described in the current report was based on Burgess and Cogan's work [1] and is only implemented for the AccuRate Australia version in this project.

As shown in Figure 1, the Australian/New Zealand standard Heated water systems – Calculation of energy consumption (AS 4234:2008 [4]) divides Australia into four climate regions for water heating based on the range of solar insolation and the temperature of reticulated potable water (based on ground temperatures). Regions (with examples of cities/towns) are as follows: region one (Rockhampton), region two (Alice Springs), region three (Sydney) and region four (Melbourne).

To determine a typical annual house-specific water heating energy demand, WHAT HO! [1] adopts the four climate regions for Australia as defined in AS 4234:2008 [4].

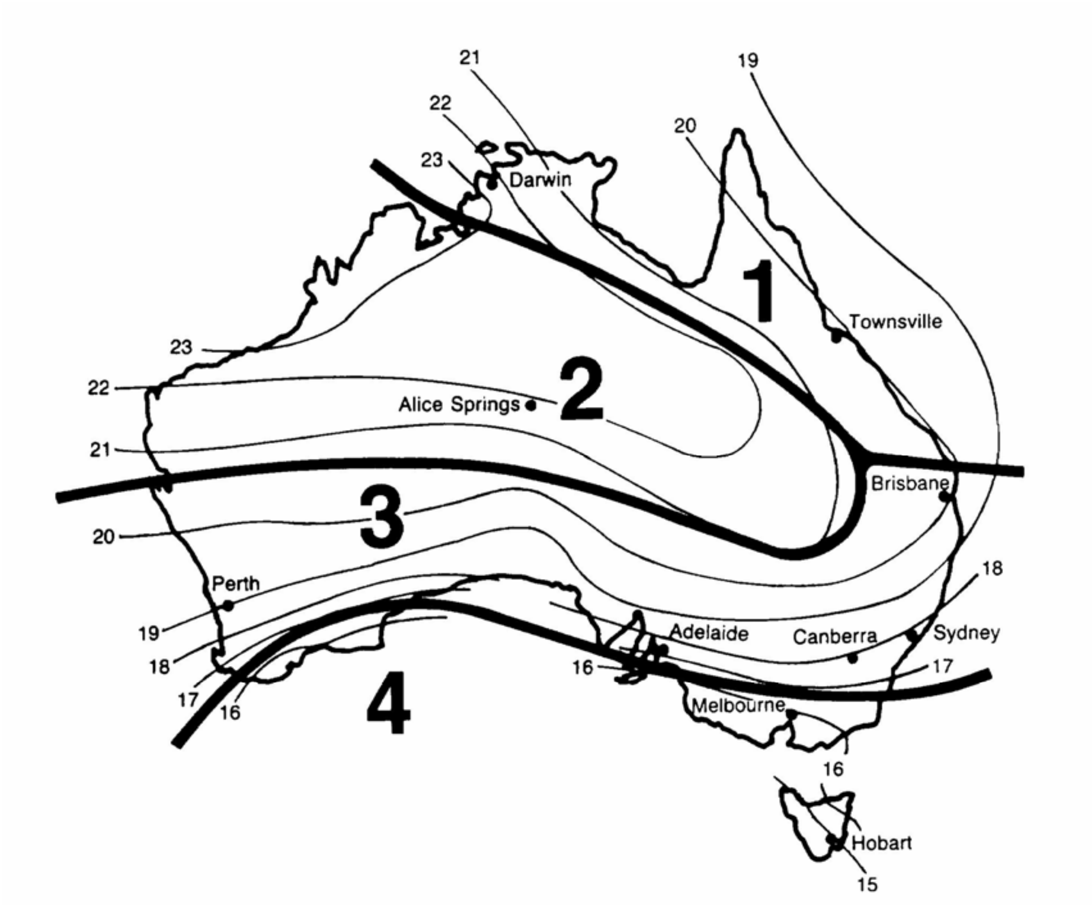

Figure 1. Climate regions for Australia (Source: Figure A1 of AS 4234:2008 [4])

Table 1 shows the overview of the WHAT HO! calculation procedure. The hot-water demand is estimated from the house size, the occupancy and assumptions about water use. The gross water heating energy needed is given by the gross volume of hot-water needed as supplied by the energy available from the selected fuel divided by the conversion efficiency of the fuel, less the gains from solar, solid-fuel boosters, and energy recovered from tepid water return and shower drain heat recovery systems. The net water heating energy is calculated from the energy used to heat the water plus the extra energy required to cope with losses which includes the energy required to keep the water hot and the pipe heat losses. The greenhouse gas emissions are then calculated as a mass of CO_2 in kg using the emissions factor for that fuel appropriate to the state (Table 17). The star rating of the house hot-water system is obtained by comparing the performance with a reference hot-water system.

Details of the hot-water energy calculation methodology have been described by Burgess and Cogan [1]. In this report, the formula and the parameters used in the hot-water module implementation in AccuRate are listed in Tables 2-15 for references:

Hot Water Demand
is dependent on
House size
and
Occupancy
and
Assumptions about water use
giving
Gross Volume of hot water needed

Losses
are given by
Energy used to keep water hot
plus
Pipe losses
equalling
Extra energy required

Gross Water Heating Energy
is given by
Gross Volume of hot water needed
provided by
Energy from selected fuel
divided by
fuel conversion efficiency
plus
Energy from solar
plus
Energy from wetback
plus
Energy recovered from shower drain
plus
Energy recovered from tepid water return
equals
Energy Used to heat water

Resulting in
Net Water Heating Energy
coming from
Energy Used to heat water
plus
Extra energy required

Then
Emissions
are given by
emissions factor for that fuel
times
Net water heating energy

Finally the
Water heating Rating
is given by
Emissions
benchmarked against
reference water heating system
and bounded by
best possible emissions system
and
worst feasible emission system

Table 1. Graphical overview of WHAT HO! evaluation method (Source: Table 1. of Burgess and Cogan [1])

Table 2 Formula used for the calculation of hot-water demand (Source: Burgess and Cogan [1])

Item Name and abbreviation	Formula	Comments
House occupant number (Occupants)	$Occupants = \max(1 + 0.66 \times NBR, A/50)$ (1)	Occupants is the number of house occupants; NBR is the number of bedrooms; *A* is house floor area (m^2)
Total Daily Shower Time (TDST)	$TDST = Occupants \times DST$ (2)	TDST is the total daily shower time (minutes/day); DST is the daily shower time for each occupant (minutes/person/day) (Default 7.1)
Shower Time for Each System with Shower(STPS)	$STPS = TDST / NS_{shower}$ (3)	STPS is the total shower time for each shower system (minutes/day); NS_{shower} is the number of systems with a shower
Shower Water Use for Each System with a shower (SWU)	$SWU = STPS \times SFR$ (4)	SWU is shower water use for each System with a shower; SFR is shower flow rate (refer to hot-water system given by manufacturers; alternatively using WELS Star Rating; default value is 9.5 litres/minute)
Bath water use for each bath system	$BWU = 135 \times Occupants / NS_{Bath}$ (5)	BWU is the daily bath water use (litres/day) for each system with a bath; NS_{bath} is the number of systems with a bath
Other water use	$OWU = (20 + 2.5 \times Occupants) / NS$ (6)	OWU is other water use per hot-water system (litres/day); NS is the number of hot-water systems

Table 3 Formula used for the calculation of heat losses (Source: Burgess and Cogan [1])

Item Name and abbreviation	Formula	Comments
Heat Losses from Pipe-Work (HLPW)	$HLPW = K_{pl} \times 0.0042 \times 40 \times \max(1,3 + Occupants^{0.75} - NS)/NS$ (7)	HLPW is the heat loss from pipe work (MJ/day) and $K_{pl.}$ the coefficient of pipe heat loss as shown in Table 7.
Instant water heater start-up losses (IWHSL)	If Start-up loss per firing (SLPF) is known $IWHSL = SLPF \times (7 + 4 \times Occupants)/1000$ (8) If Start-up loss per firing (SLPF) is unknown $SLPF = \frac{2 \times 4.2 \times (60 - CWT)}{COP_c}$ $IWHSL = SLPF \times (7 + 4 \times Occupants)/1000$ (9)	IWHSL is instant water heater start-up losses (MJ/day); SLPF is start-up loss per firing (kJ); CWT is the cold water temperature (ºC) (refer to Table 8) and COP_c is the conversion efficiency of the heater.
Heat Loss from a Solar Hot-water Storage Vessel (HLSHWSV)	Storage water temperature $SWT = CT + SHW/(0.0042L)$ (10) If storage vessel located indoor $TMF = (SWT - 20)/(60 - 20)$ (11) If storage vessel located outdoor $TMF = (SWT - T_o)/(60 - 20)$ (12) For $L \leq 90$ litres $HLSHWSV = 3.6TMF\,(0.0084L + 0.4)$ (13) For $L > 90$ litres $HLSHWSV = 3.6TMF\,(0.0048L + 0.72)$ (14)	HLSHWSV is heat loss from a solar hot-water storage vessel (MJ/day); SWT is the storage water temperature; SHW is net solar gain (MJ/day); L is the vessel capacity (litres); TMF is the temperature modification factor and T_o is the ambient air temperature as shown in Table 9.
Heat Loss from a Water Storage Vessel (HLHWSV)	If storage vessel located indoor $TMF = 1$ (15) If storage vessel located outdoor $TMF = (60 - T_o)/(60 - 20)$ (16) For $L \leq 90$ litres $HLHWSV = 3.6TMF\,(0.0084L + 0.4)$ (17) For $L > 90$ litres $HLHWSV = 3.6TMF\,(0.0048L + 0.72)$ (18)	HLHWSV is heat loss from a water storage vessel (MJ/day); L is the vessel capacity (litres); TMF is temperature modification factor and T_o is the ambient air temperature as shown in Table 9.

Table 4 Formula used for the calculation of energy savings (Source: Burgess and Cogan [1])

Item Name and abbreviation	**Formula**	**Comments**
Saving from solar hot-water heater (SHW)	$SHW = K_{inclin} \times K_s \times ASR \times A_c$ (19)	SHW is solar hot-water energy saving (MJ/day); K_{inclin} is the collector non-ideal orientation factor as listed in Table 10; K_s is system solar factor (see Table 11); ASR is absorbed solar radiation (given in Table 12); and A_c is area of solar collector (m^2).
Saving from solid fuel booster (SFB)	$SFB = MS / NDM$ (20)	SFB is solid fuel booster energy saving (MJ/day); MS is monthly saving (MJ/month) as listed in Table 13 and NDM is number of days in month.
Saving from shower heat recovery unit (SHR)	$SHR = 0.5 \times 0.0042 \times SWU \times (30 - CWT)$ (21)	SHR is shower heat recovery energy saving (MJ/day); SWU is shower water use for the system.
Saving from tepid water return (TWR)	$TWR = 4 \times 0.0042 \times \max(1, Occupants - NS) \times \max(1, 20 - CWT) / (K_{pl} \times NS)$ (22)	TWR is the tepid water return energy saving (MJ/day)
Total energy savings (TES)	$TES = SHW + SFB + SHR + TWR - HLPW - HLSHWSV$ (23)	TES is the total energy savings (MJ/day)

Table 5 Formula used for the calculation of maintenance rate (Source: Burgess and Cogan [1])

Item Name and abbreviation	**Formula**	**Comments**
Heat Pump Electric Storage Maintenance Rate (EHPSMR)	$EHPSMR = \mathrm{HLHWSV} / COP_m$ (24)	EHPSMR is heat pump electric storage maintain rate. HLHWSV – heat loss from the storage vessel; COP_m – conversion coefficient of heat pump maintenance (see Table 15)
Other Storage Water Heater Maintenance Rate (ESMR)	If the water heating system is part of a central heating system: $ESMR = \mathrm{HLHWSV} / COP_c$ (25) If the water heating system is not part of a central heating system, then: a) using manufacturer specified Maintenance Rate; b) if manufacturer specified Maintenance Rate is not available, using default values in Table 16.	ESMR is the storage maintain rate (MJ/day); HLHWSV – heat loss from the storage vessel (MJ/day); COP_c – coefficient of the heater conversion (default values refer to Table 16)

Table 6 Calculation of energy consumption (Source: Burgess and Cogan [1])

Item Name and abbreviation	**Formula**	**Comments**
Daily energy demand (DED)	$DED = 0.0042 \times [(SWU + BWU) \times (40 - CWT) + OWU \times (60 - CWT)]$ (26)	DED – daily energy demand (MJ/day) CWT – cold water temperature (ºC, refer to Table 8)
Electric Instantaneous Water Heater Systems	$E = \sum_{i=1}^{i=12} (DED_i + IWHSL - TES_i) \times NDM_i / 1000$ (27) If $DED_i + IWHSL - TES_i \leq 0, then DED_i + IWHSL - TES_i = 0$	E – net total energy demand (GJ/year) DED – daily energy demand (eq.(26) IWHSL - instant water heater start-up losses (MJ/day) (eq.9) TES – daily total energy saving (eq.23) NDM – number of days in month
Electric Water Storage Systems	$E = \sum_{i=1}^{i=12} (DED_i + HLHWSV_i - TES_i) \times NDM_i / 1000$ (28) If $DED_i + HLHWSV_i - TES_i \leq 0, then DED_i + HLHWSV_i - TES_i = 0$	HLHWSV is heat loss from hot-water storage vessel (eqs. 17 & 18)
Electric Heat Pump Storage Water Heater Systems	Energy for conversion $E_c = \sum_{i=1}^{i=12} (DED_i - TES_i) \times NDM_i / 1000 / COP_c$ (29) If $DED_i - TES_i \leq 0, then DED_i - TES_i = 0$ Energy for maintain $E_m = \sum_{i=1}^{i=12} EHPSMR_i \times NDM_i / 1000$ (30) $E = E_c + E_m$ (31) If $DED_i > TES_i$, then maintain rate EHPSMR is calculated by Eq. 24. Otherwise EHPSMR is given by	COP_c is conversion coefficient taken from Table 14 and maintain COP_m is given in Table 15.

	$$EHPSMR = \frac{DED + HLHWSV - TES}{COP_m} \quad (32)$$ If EHPSMR <0, then EHPSMR = 0	
Gas Instantaneous Water Heater Systems	$$E = \sum_{i=1}^{i=12} \frac{DED_i + IWHSL \times COP_c - TES_i}{1000 \times COP_c} \quad (33)$$ If $DED_i + IWHSL - TES_i \leq 0, then DED_i + IWHSL - TES_i = 0$	COP_c – conversion efficiency is obtained from the manufacturer and Table 16 gives the default values.
Gas, Oil and Coal Storage Water Heater Systems	Energy for conversion $$E_c = \sum_{i=1}^{i=12} \left(DED_i - TES_i\right) \times NDM_i / 1000 / COP_c \quad (34)$$ If $DED_i - TES_i \leq 0, then DED_i - TES_i = 0$ If $DED_i > TES_i$, then maintain rate ESMR is given in Table 5. Otherwise Reversed RESMR is given by $$RESMR = ESMR - \left(TES - DMD\right) / COP_m \quad (35)$$ If RESMR <0, then RESMR = 0 Energy for maintain $$E_m = \sum_{i=1}^{i=12} ESMR_i (RESMR_i) \times NDM_i / 1000 \quad (36)$$ $$E = E_c + E_m$$	ESMR is the maintain rate (MJ/day) RESMR is the reversed maintain rate (MJ/day)

Table 7 K_{pl} - the coefficient of pipe heat loss (Source: Burgess and Cogan [1])

Distribution system	Pipe-work insulation	Storage water heater	Instantaneous water heater
Non-circulating (normal)	Insulated	2	1.5
	Partially insulated	3	2.25
	Uninsulated	4	3
Circulating (Ring main)	Insulated	6	4.5
	Partially insulated	7	5.25
	Uninsulated	8	6

Table 8 Cold water temperature (°C) (Source: AS 4234:2008, Table A6)

Month	Region one	Region two	Region three	Region four
January	28	29	23	20
February	28	27	23	20
March	27	24	21	18
April	25	20	18	15
May	23	14	15	11
June	20	11	12	9
July	20	9	11	8
August	21	12	12	10
September	24	18	15	12
October	26	23	19	15
November	28	26	21	17
December	28	28	22	19

Table 9 Average Monthly Air Temperatures by Climate Region (Source: Burgess and Cogan [1])

Month	Region one	Region two	Region three	Region four
January	26.3	27.5	23.8	19.9
February	25.8	27.4	23.6	20.7
March	25.1	24.9	21.1	17.5
April	22.9	20.0	18.2	15.1
May	19.3	16.3	15.8	11.8
June	16.6	11.5	15.1	10.2
July	15.7	11.7	12	10.0
August	17.4	13.0	13.3	10.3
September	19.3	20.0	15.4	11.7
October	22.5	22.0	18.4	14.4
November	23.3	26.9	18.7	15.4
December	25.7	28.9	20	17.8

Table 10 K_{inclin}, collector non-ideal orientation factor (Source: Burgess and Cogan [1])

Bearing	Inclination from the horizontal					
	0º	20º	40º	60º	80º	90º
270º (West)	0.85	0.85	0.80	0.72	0.60	0.53
300º	0.85	0.92	0.92	0.86	0.73	0.65
330º	0.85	0.98	0.99	0.93	0.80	0.71
0º (North)	0.85	0.97	1.00	0.94	0.80	0.70
30º	0.85	0.94	0.95	0.88	0.74	0.65
60º	0.85	0.88	086	0.77	0.63	0.57
90º (East)	0.85	0.80	0.73	0.64	0.52	0.46

Table 11 Solar hot-water system factor –K_s (Source: Burgess and Cogan [1])

Circulation type	Collect type	
	Plate	Vacuum tube
Thermosiphon	0.475	0.57
Pump	0.45	0.54

Table 12 Solar radiation for each region (MJ/m^2-day) (Source: Burgess and Cogan [1])

Month	Region one	Region two	Region three	Region four
January	22.6	27.5	22.4	24.2
February	20.7	25.5	20.6	21.6
March	20.0	23.8	16.7	16.0
April	17.4	20.7	14.0	11.0
May	14.0	16.3	10.5	7.4
June	13.7	14.9	8.5	5.9
July	14.2	15.6	10.7	6.7
August	17.0	18.8	13.0	9.1
September	19.9	22.5	16.9	12.6
October	22.2	25.4	20.1	17.4
November	23.5	27.1	23.3	21.0
December	24.3	28.0	26.1	23.7

Table 13 solid fuel booster energy saving (MJ/month) (Source: Burgess and Cogan [1])

Location	Rockhampton	Alice Springs	Sydney	Melbourne
Jan				
Feb				
Mar				
April				
May				400
June			800	800
July			800	800
August			800	800
Sept				400
Oct				
Nov				
Dec				

Table 14 Heat pump water heater default COP_c for heating water (Source: Burgess and Cogan [1])

Month	Rockhampton	Alice Springs	Sydney	Melbourne
Jan	3.17	3.24	3.07	2.88
Feb	3.14	3.27	3.06	2.92
Mar	3.10	3.13	2.93	2.77
Apr	2.99	2.88	2.81	2.69
May	2.80	2.76	2.72	2.58
Jun	2.70	2.57	2.72	2.54
Jul	2.65	2.60	2.59	2.54
Aug	2.73	2.62	2.64	2.53
Sep	2.79	2.91	2.70	2.57
Oct	2.95	2.96	2.81	2.65
Nov	2.97	3.25	2.79	2.68
Dec	3.13	3.37	2.85	2.77

Table 15 Heat pump water heater default COP_m for maintaining water temperature (Source: Burgess and Cogan [1])

Month	Rockhampton	Alice Springs	Sydney	Melbourne
Jan	2.75	2.82	2.60	2.40
Feb	2.72	2.82	2.59	2.44
Mar	2.67	2.66	2.46	2.29
Apr	2.55	2.40	2.32	2.19
May	2.37	2.24	2.21	2.06
Jun	2.25	2.05	2.19	2.01
Jul	2.21	2.06	2.07	2.00
Aug	2.28	2.11	2.12	2.01
Sep	2.37	2.40	2.20	2.06
Oct	2.53	2.50	2.33	2.16
Nov	2.57	2.79	2.34	2.20
Dec	2.71	2.92	2.40	2.30

Table 16 Default conversion efficiency and maintenance rate (Source: Burgess and Cogan [1])

Type of water heater	Conversion efficiency (%)	Maintenance rate (MJ/Day)
Coal-fired	0.50	43.2
Gas system instantaneous	0.75	-
Gas system <200L storage	0.75	23.28
Gas system >=200L storage	0.70	30.24
Oil-fired	0.70	30.24

3. CO_2 EMISSION CALCULATION METHODOLOGY

The house annual carbon emission (kg CO_2-e) contributed by hot-water system(s) is calculated by Eq. (37)

$$CE = E \times CE_f + ECL \times CEE_f + \sum_{i=1}^{i=12} SFB_i \times CE_f \qquad (37)$$

Where:

- CE Carbon emission (kg/year)
- CE_f carbon emission factor for different fuel types (Table 17)
- ECL Control electric loss (user input date, the default value is 5 watts)
- CEE_f Carbon emission factor of electricity (Table 17)
- SFB_i monthly solid fuel booster energy saving (Table 13)

Table 17 Emission factors for different fuel sources (kg CO_2-e/GJ)

State	Electricity	Natural gas	LPG	Coal	Wood	Pellets	Oil
ACT	295	66.1	65.3	93.1	15.6	15.6	74.4
NSW	295	66.1	65.3	93.1	15.6	15.6	74.4
VIC	364	57.3	65.3	93.1	15.6	15.6	74.4
QLD	289	57.3	65.3	93.1	15.6	15.6	74.4
SA	272	70.7	65.3	93.1	15.6	15.6	74.4
WA	271	58.9	65.3	93.1	15.6	15.6	74.4
TAS	37	57.2	65.3	93.1	15.6	15.6	74.4
NT	221	57.1	65.3	93.1	15.6	15.6	74.4

Source: National Greenhouse Accounts (NGA) Factors (2008)

4. STAR RATING ALGORITHM

Burgess and Cogan [1] suggested a 10 star system given by Eq.(38):

$$StarRating = MAX\left(MIN\left(ROUNDDOWN\left(8 - \left(LN\left(CE / RQtarget\right) / LN\left(1.16\right)\right)\right), 20\right), 0\right) / 2 \tag{38}$$

Where the *StarRating* is the house hot-water system star rating, *CE* is the total annual CO_2 emissions from the hot-water heating system (kg/year), and *RQtarget* (kg/year) is the emissions from a reference hot-water heating system as specified in Table 18 with the identical house, occupancy and climate zone, however, modified by an efficiency requirement factor of 81% (*RQtarget* is 81% of the annual CO_2 emissions from the reference hot-water heating system).

Table 18 Reference hot-water heating system

Parameters	Value
Type	Gas storage
Fuel	LPG
Efficiency	75%
Maintenance rate	23.33 MJ/day (0.27kW)
Shower flow rate	9.5 L/min
Location	Indoor
Controls losses	5 W
Supplementary heating	None
Efficiency Requirement	81%

5. HOT-WATER MODULE IMPLEMENTATION

For the 69 climate zones in Australia, the corresponding climate regions for the hot-water module in AccuRate are given in Table 19.

Table 19 Climate regions classification for hot-water module in AccuRate

Hot-water climate region	Existing climate zones in AccuRate
One	1, 3, 5, 7, 19, 29, 32, 35, 36
Two	2, 4, 6, 30, 31, 33, 34, 37, 38, 39, 40, 41
Three	8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 24, 25, 27, 28, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 56, 57, 59, 65, 69
Four	21, 22, 23, 26, 55, 58, 60, 61, 62, 63, 64, 66, 67, 68

In the current commercial AccuRate version, climate zone, floor area (the size of the home) and bedroom numbers are already specified. Further information is required for the parameters which are not available in the current AccuRate user interface. As shown in Figure 2, using the same style as the other AccuRate input pages, a hot-water page was added to the AccuRate user interface, which contains the following input data fields:

- the degree of pipe insulation and the distribution system of hot-water;
- hot-water heater details: heater type, fuel type, storage tank volume (if applicable) and location, control system wattage, conversion efficiency and maintenance rate, whether or not connected to a central heating system;
- the shower system details (if known): system pressure, shower water flow rate (which can be user input or select WELS Star Rating), whether a drainage heat recovery system is present and whether tepid water return is installed;
- Solid fuel booster (if applicable) and its fuel type;
- Solar hot-water system details (if applicable): collector area, collector type, collector facing direction (azimuth) and slope (inclination from horizontal), storage tank volume and location, circulation type and control system wattage.

In the detailed calculation results as shown in Figure 3, each hot-water system is calculated separately, before the results are combined into the total house annual hot-water energy demand, house annual CO_2-e emissions due to heating hot-water and the house hot-water star rating which are shown at the top of the hot-water page.

Figure 4 shows the AccuRate summary report for the house hot-water system energy consumption, CO_2-e emissions and star rating. Details of the house hot-water system(s) are also described in the AccuRate detailed report as shown in Figure 5.

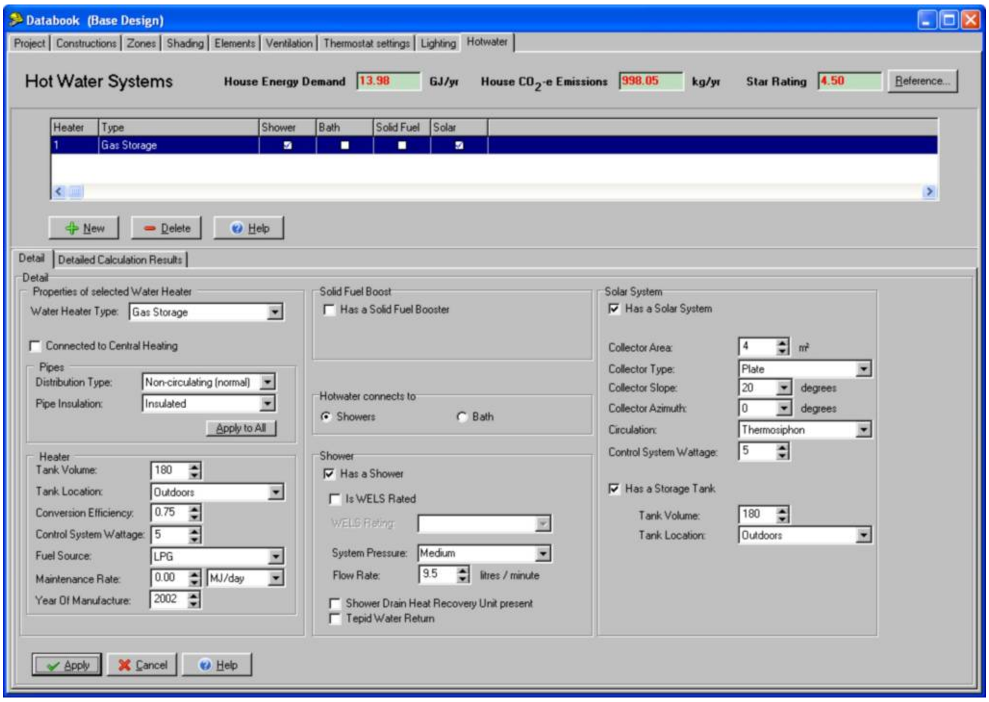

Figure 2. Hot-water page implemented in AccuRate

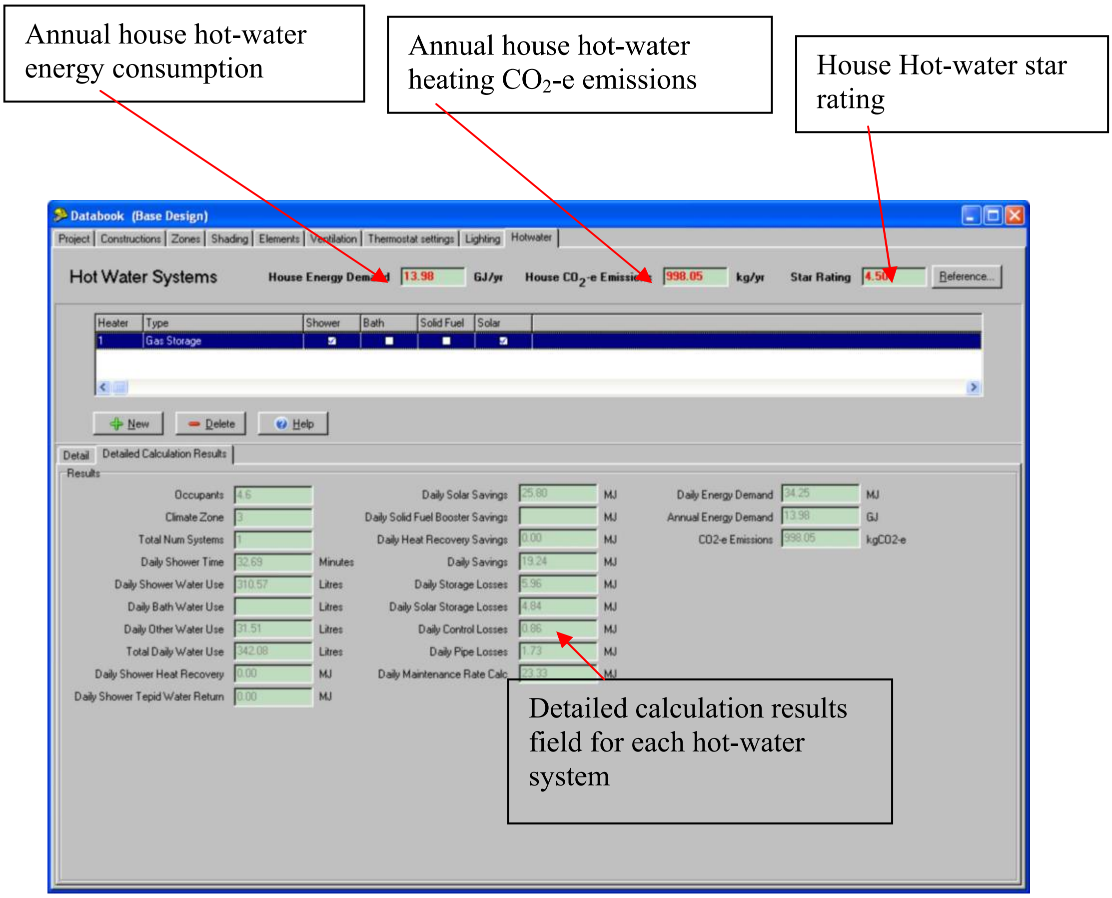

Figure 3. Hot-water page shows detailed calculation for individual heating system

AccuRate V1.1.4.1 User-defined thermostat settings Feb 2008

Nationwide House Energy Rating Scheme

Project Details	
Project Name:	
File Name: C:\AccuRateAUS\Nathers4\Projects\Example 1-storey house.PRO	
Postcode: 6000	**Climate Zone:** 13
Design Option: Base Design	
Description: Medium-sized single-storey house	

Client Details		
Client Name: AccuRate example: single-storey house		
Phone:	**Fax:**	**Email:**
Postal Address:		
Site Address:		
Council submitted to (if known by assessor):		

Assessor Details			
Assessor Name: Energy Partners, Dave Hodgkin			**Assessor No.**
Phone:	**Fax:**	**Email:**	
Assessment Date: 22/04/2009			**Time:** 4:33:
Project Code:			
Assessor Signature:			

CALCULATED HOT-WATER ENERGY REQUIREMENTS*	
Home Daily Hot Water Energy Demand (MJ/day)	34.25
Home Annual Hot Water Energy Demand (GJ/year)	13.98
Home Annual CO2-e Emissions (kg/year)	998.05

* These hot-water energy requirements have been calculated using a standard set of occupant behaviours and so do not necessarily represent the usage pattern or lifestyle of the intended occupants. They should be used solely for the purposes of rating the hot-water system. They should not be used to infer actual hot-water energy consumption or running costs. The settings used for the simulation are shown in the building data report.

Hot-Water Star Rating

★★★★☆ **4.5 STARS**

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Figure 4. Hot-Water summary report

	AccuRate V1.1.4.1 User-defined thermostat settings Feb 2008 Nationwide House Energy Rating Scheme	

Project Name:		
File Name: C:\AccuRateAUS\Nathers4\Projects\Example 1-storey house.PRO		
Postcode: 6000	**Climate Zone:** 13	
Client Name: AccuRate example: single-storey house		
Site Address:		
Design Option: Base Design		
Date: 22/04/2009	**Time:** 4:33:	**Page:** 22

Shading Schemes

	Eave		Other fixed shading		
Name	Projection (m)	Offset (m)	Projection (m)	Offset (m)	Monthly blocking factors (%)
Balcony	2.00	0.00	0.00	0.00	100,100,100,100,100,100,100,100,100,100,100,100

Ventilation

Footprint: vertical dimension (m)	Footprint: horizontal dimension (m)	Azimuth of highlighted facade (degrees)	Insect screens
11.5	19.3	0	N

Hotwater Summary

Home Daily Hot Water Energy Demand (MJ/day): 34.23
Home Annual Hot Water Energy Demand (GJ/year): 13.98
Home Annual CO2-e Emissions (kg/year): 998.05

Main Heater Details	**Main Heater Type:** Gas Storage
Distribution Type: Non-circulating (normal)	**Grade Of Insulation:** Insulated
Tank Volume: 180.0	**Tank Location:** Outdoors
Conversion Efficiency: 0.75	**Control System Wattage:** 5.0
Fuel Source: Wood	**Maintenance Rate:** 0.0000
Shower Details	
System Pressure: Medium	**Flow Rate:** 9.5
Heat Recovery System: No	**Tepid Water Return:** No
Solid Fuel Boost: Not installed	
Solar System Details	
Collector Area: 4	**Circulation:** Thermosiphon
Collector Plate: Plate	**Storage Volume:** 180
Location: Outdoors	**Control System Wattage:** 5

Lighting Summary

Total Home Annual Energy Consumed by Lighting (kWh): 1943.43
Total Home Average Illumination Power Density (W/m²): 8.45
Home Annual Lighting CO2-e Emissions (kg): 1897.98

Bed 1: Lighting

Consumption: 175.20	**Type:** Bedroom	**Length:** 3.81	**Width:** 3.81	**Height:** 2.40
Surface Reflection: Light	**Illumination Type:** Direct	**No. Luminations:** 2	**Lamp Wattage:** 25	**No. Lamps:** 4
Lamp Type: Incandescent GLS		**Dimming:** None	**Switching:** Manual	

Walk in Robe: Lighting

Consumption: 109.30	**Type:** Bedroom	**Length:** 2.16	**Width:** 2.16	**Height:** 2.40
Surface Reflection: Light	**Illumination Type:** Direct	**No. Luminations:** 2	**Lamp Wattage:** 25	**No. Lamps:** 4
Lamp Type: Incandescent GLS		**Dimming:** None	**Switching:** Manual	

Ensuite: Lighting

Consumption: 109.30	**Type:** Bedroom	**Length:** 2.76	**Width:** 2.76	**Height:** 2.40
Surface Reflection: Light	**Illumination Type:** Direct	**No. Luminations:** 2	**Lamp Wattage:** 25	**No. Lamps:** 4
Lamp Type: Incandescent GLS		**Dimming:** None	**Switching:** Manual	

Study: Lighting

Consumption: 0.00	**Type:** Other (daytime usage)	**Length:** 3.36	**Width:** 3.36	**Height:** 2.40
Surface Reflection: Light	**Illumination Type:** Direct	**No. Luminations:** 2	**Lamp Wattage:** 25	**No. Lamps:** 4
Lamp Type: Incandescent GLS		**Dimming:** None	**Switching:** Manual	

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Figure 5. Detailed report for house hot-water system(s)

6. CONCLUSIONS

A hot-water module has been implemented in AccuRate based on the WHAT HO spreadsheet tool and report, developed by BRANZ for EECA [1]. This project accomplished the following deliverables:

- A hot-water page has been implemented in the AccuRate user interface, containing the input data fields required which include details of the house hot-water system such as heater type, hot-water distribution type, storage tank size and location, fuel source, solar hot-water system, solid fuel booster, shower(s) and heat recovery etc;
- The calculations of energy consumption in the hot-water module are based on the WHAT HO spreadsheet tool and report, developed by BRANZ for EECA [1];
- CO_2-e emissions are calculated from the CO_2 intensities appropriate to the postcode for the fuel and electricity used;
- A new hot-water report page has been added to AccuRate's summary report, showing annual energy consumption, CO_2-e emissions and star rating of the house hot-water system(s);
- A detailed hot-water report is also available in AccuRate which describes the hot-water system(s) used in the house.

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4. Standards Australia/Standards New Zealand.,Heated water systems – Calculation of energy consumption. Australian/New Zealand Standard AS4234:2008.
5. National Greenhouse Accounts (NGA) Factors (2008) – Updating and Replacing the AGO Factors and Methods Workbook, published by the Department of Climate Change, available at www.greenhouse.gov.au, accessed on June 18th 2008.

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