REFERENCES

Agyenim, F. Kinght, I. and Rhodes, M. 2010. Design and Experimental Testing of Performance of an Outdoor LiBr/H_2O Solar Thermal Absorption Cooling System with Cold Store, Solar Energy, 84: 735-744.

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). 2001. Refrigerants, Atlanta, America.

Burapha, M. and Kiatsiriroat, T. 2008. Simplified Model of Solar Water Heating with Heat Pump Assisted, The journal of industrial technology, 2: 15-23.

Chaiyat, N. and Chaichana, C. 2008. Conf. Drying Room from Geothermal Energy, In: Proceeding of Seminar on Heat and Mass Transfer in Thermal Equipments, 8: 87-91.

Chaiyat, N. and Kiatsiriroat, T. 2010. Recovering and Upgrading Waste Heat of Air-Conditioner by Combining R-123 Vapor Compression Heat Pump, Conf. Heat and Mass Transfer in Thermal Equipments, Thailand, 9: 1-5.

Chaiyat, N, and Kiatsiriroat, T. Experimental Study and a Simplified Model of a 10 kW_{th} Solar-Absorption Heat Transformer, Conf. Heat and Mass Transfer in Thermal Equipments, Thailand, 10: 1-5.

Duffie, J.A. and Beckman, W.A. 1980. Solar engineering of thermal processes, English.

Feuerecker, G. Scharfe, J. Greiter, I. Frank, C. and Alfeld, G. 1993. Measurement of thermophysical properties of LiBr-solutions at high temperatures and concentrations, International Absorption Heat Pump Conference ASME, 31: 493-499.

Florida Solar Energy Center. 2004. Solar Collector Test Report No. 00100.

Kaita, Y. 2000. Thermodynamic properties of lithium bromide-water solutions at high temperatures, Int J of Refrigeration, 24: 374-390.

Keith, E. Herold, R.R. and Sanford, A.K. 1996. Absorption Chillers and Heat Pumps, America.

Khairulin, R.A. Gruzdev, V.A. Stankus, S.V. and Verba, O.I. 2006. Experimental study of the density of aqueous solutions of lithium bromide at temperature of up to 250 in the range of mass concentrations from 30 to 65 %. Thermophysics and Aeromechanics, 13: 575-583.

Kiatsiriroat, T. Bhattacharya, S. and Wibulswas, P. 1986. Upgrading Heat by a Reversed Absorption Heat Pump. Appl Therm Eng, 25: 175-186.

Krungthai Bank Public Company Limited. 2010. Minimum Retail Rate (MRR), Online, http://www.ktb.co.th, July.

NIST (National Institute of Standards and Technology), Inc. (REFPROP Version 7). 2000. Thermodynamic Properties of Refrigerants and Refrigerant Mixtures Software, America.

Provincial Electricity Authority. 2010. The rate of electricity cost, Online, http://www.pea.co.th/, July.

RETScreen Data. 2010. NASA Surface meteorology and Solar Energy, Online, http://eosweb.larc.nasa.gov/sse/RETScreen/, July.

Rivara, W. Cerezo, J. and Martines, H. 2009. Energy and Exergy Analysis of an Experimental Single-Stage Heat Transformer Operating with the Water/Lithium Bromide Mixture, Energy Research, 34: 1121-1131.

Sanguantrakarnkul, P. 2006. Projection of a Solar Water Heating System for Abattoir, M. Eng. thesis, Chiang Mai University, Thailand.

Sencan, A. Yakut, K.A. and Kalogirou, S.A. 2005. Exergy Analysis of Lithium Bromide/Water Absorption System. Renewable Energy, 30: 645-657.

Sotsil, S.S. and Rosenberg, J.R. 2009. Improvement of recovery energy in the absorption heat transformer process using water-Carrol^{TM} for steam Generation. Int. Conf. Chemical & Process Engineering, Italy, 9.

Sozen, A. 2003. Effect of Irreversibilities on Performance of an Absorption Heat Transformer Used to Increase Solar Pond's Temperature, Renewable Energy, 29: 501-515.

Thai Meteorological Department. 2010. The ambient temperature at Chiang Mai, Online, http://www.tmd.go.th/thailand.php, July.

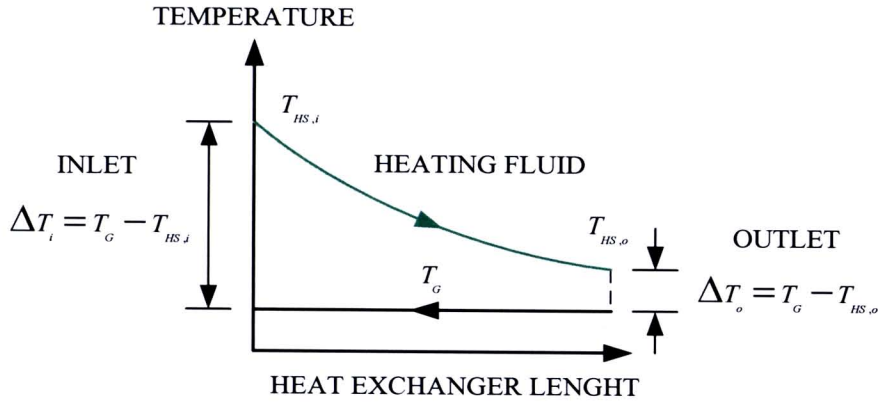
Wongratanaphisan, T. Kiatsiriroat, T. and Vorayos, N. 2003. Solar ethanol distillation, Conf. Research Result Seminar on Renewable Energy. Thailand.

Xuehu, Ma. Jiabin, Chen. Songping, Li. Qingyun, Sha. Aiming, Liang. Wei, Li. Jiayan, Zhang. Guojun, Zheng. and Zhihao, Feng. 2002. Application of absorption heat transformer to recover waste heat from a synthetic rubber plant. Appl Therm Eng, 25: 797-806.

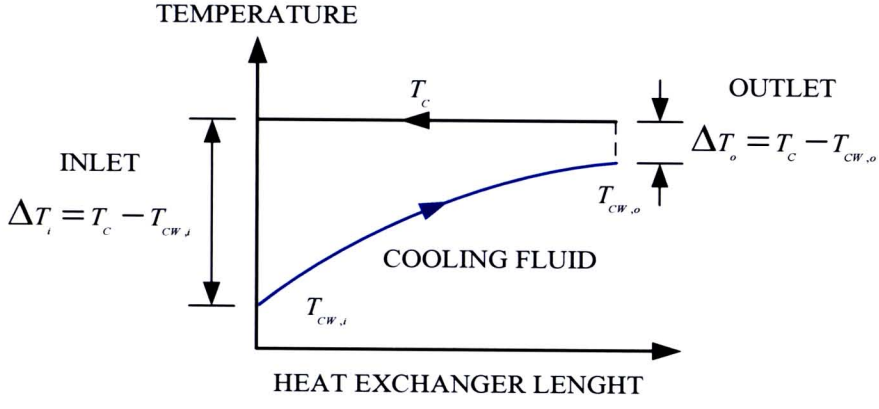
APPENDICES

APPENDIX A Temperature Profiles of Main Components in the AHT Cycle

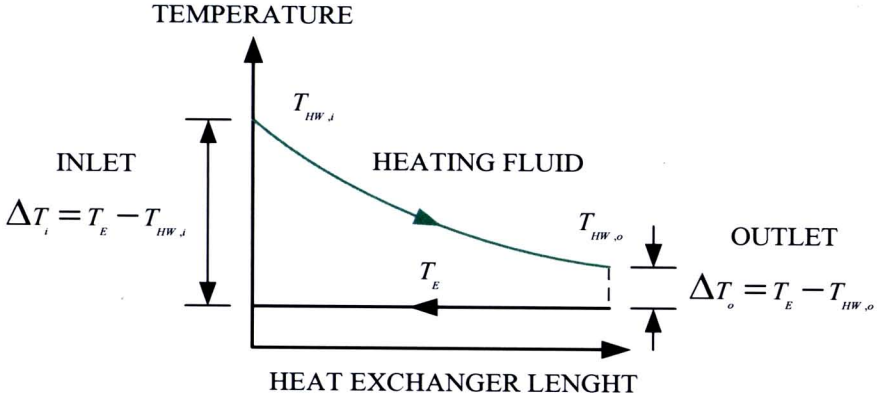
The temperature profiles of generator, condenser, evaporator, absorber and heat exchanger in the AHT system are used to calculate the entering and leaving temperature of working fluid in the AHT cycle are as follows:



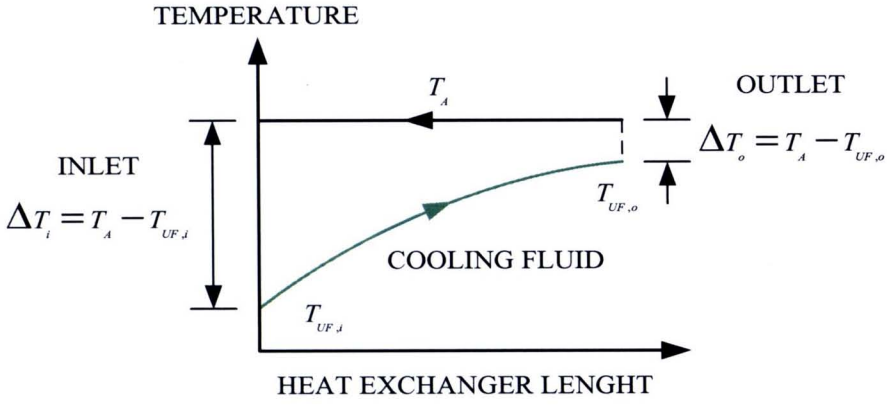
Generator



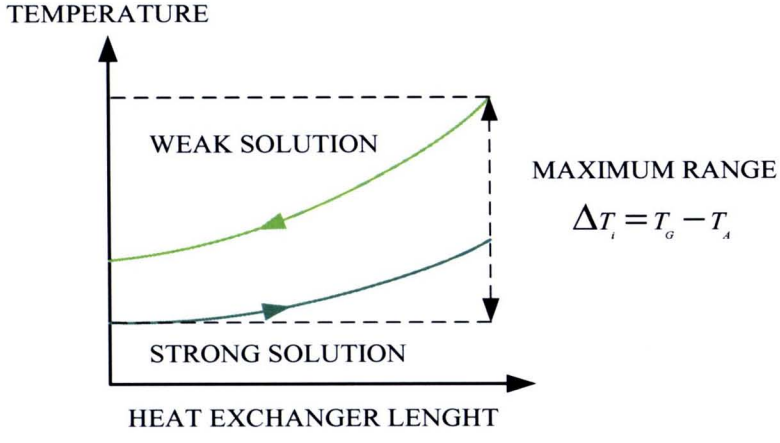
Condenser



Evaporator



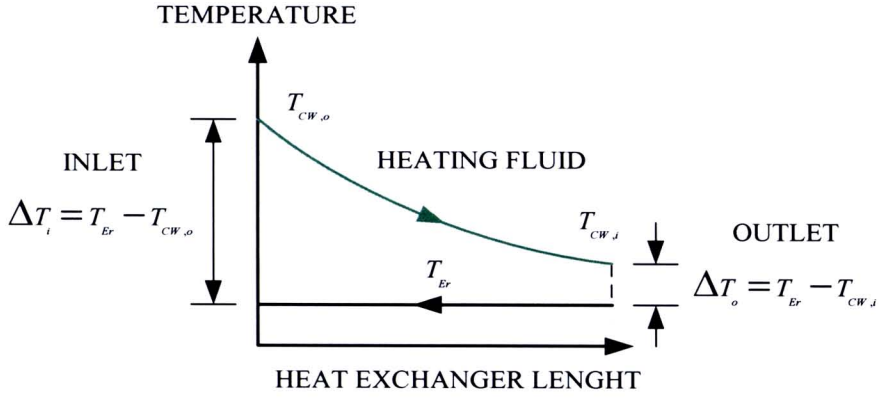
Absorber



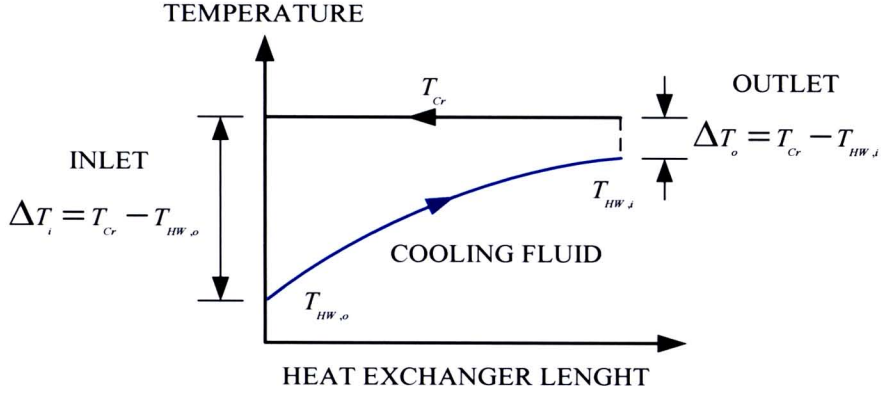
Heat exchanger

APPENDIX B Temperature Profiles of Main Components in the VCHP Cycle

The temperature profiles of condenser and evaporator in the VCHP system are used to calculate the entering and leaving temperature of working fluid in the VCHP cycle are as follows:



Evaporator$_r$



Condenser$_r$

APPENDIX C Properties of Lithium Bromide-Water Solutions

Enthalpy-Concentration and Temperature for Lithium Bromide-Water Solutions, (ASHRAE, 2001).

For Concentration $x < 40$ %LiBr

Solution temperature range $15 < t < 165$ °C

$$h = 21.4817157 - 2.38366711X + 3.90458186t + 0.03625001X^2 + 5.25010607 \times 10^{-4} t^2 - 0.0369249939tX, \text{ kJ / kg}$$

For Concentration $40 \leq x < 70$ %LiBr

Solution temperature range $15 < t < 165$ °C

$$h = \Sigma_0^4 A_n X^n + t\Sigma_0^4 B_n X^n + t^2 \Sigma_0^4 C_n X^n, \text{ kJ / kg}$$

Where

$A_0 = -2024.33$	$B_0 = 18.2829$	$C_0 = -3.7008214$ E-2
$A_1 = 163.309$	$B_1 = -1.1691757$	$C_1 = 2.8877666$ E-3
$A_2 = -4.88161$	$B_2 = 3.248041$ E-2	$C_2 = -8.1313015$ E-5
$A_3 = 6.302948$ E-2	$B_3 = -4.034184$ E-4	$C_3 = 9.9116628$ E-7
$A_4 = -2.913705$ E-4	$B_4 = 1.8520569$ E-6	$C_4 = -4.4441207$ E-9

Solution Temperature-Refrigerant Temperature and Saturation Pressure, (ASHRAE, 2001).

For Refrigerant $-15 < t' < 110$ °C

Solution temperature $5 < t < 175$ °C

Concentration $45 < X < 70$ %LiBr

$$t = \Sigma_0^3 B_n X^n + t' \Sigma_0^3 A_n X^n, \ ^\circ C$$

$$t' = (t - \Sigma_0^3 B_n X^n) / \Sigma_0^3 A_n X^n, \ ^\circ C$$

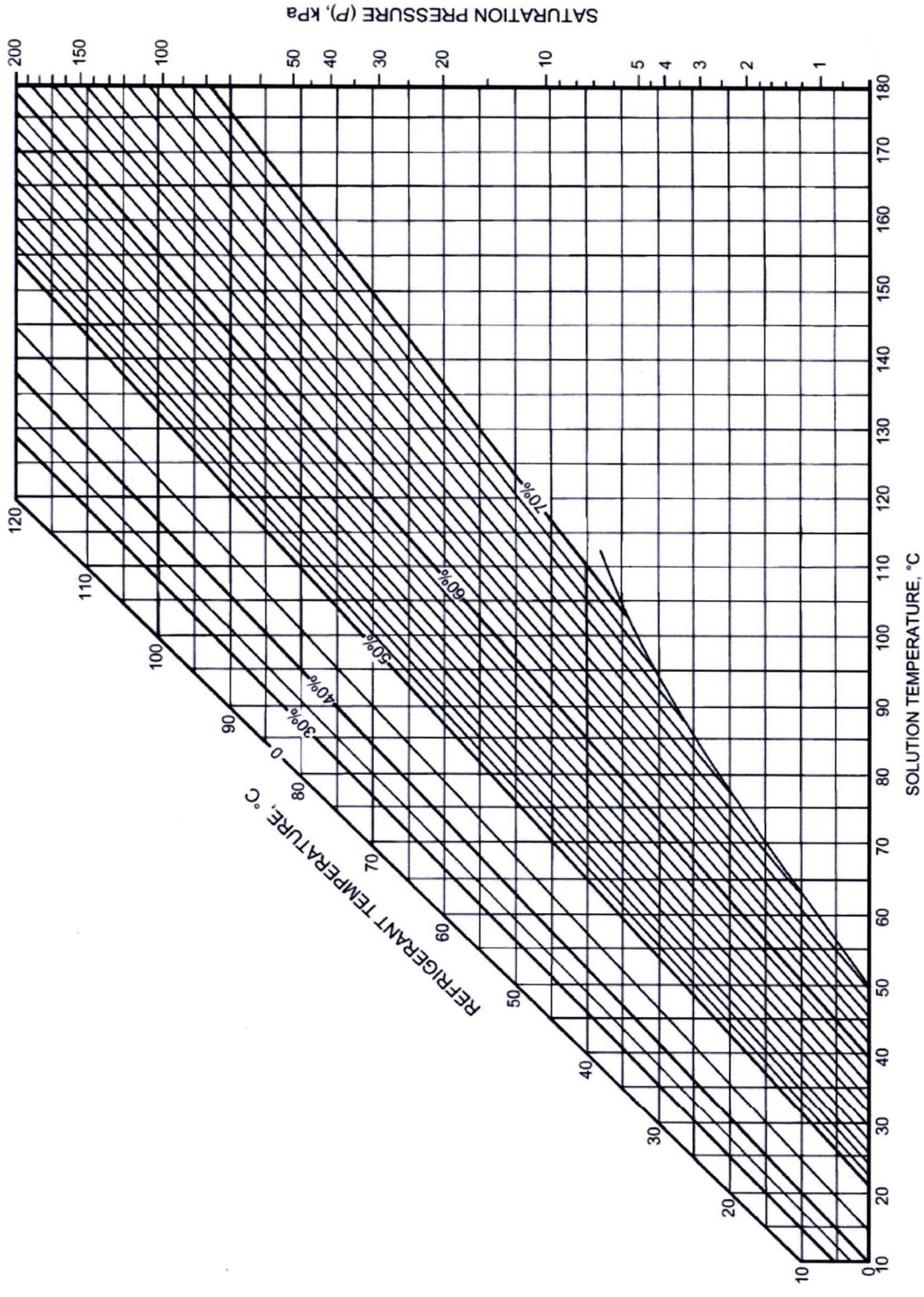
$$\log P = C + D / T' + E / T'^2, \ P = kPa; \ T' = K$$

$$T' = \frac{-2E}{D + [D^2 - 4E(C - \log P)]^{0.5}}$$

Where

$A_0 = -2.00755$	$B_0 = 124.937$	$C = 7.05$
$A_1 = 0.16976$	$B_1 = -7.71649$	$D = -1596.49$
$A_2 = -3.133362$ E-3	$B_2 = 0.152286$	$E = -104095.5$
$A_3 = 1.97668$ E-5	$B_3 = -7.9509$ E-4	

Equilibrium Chart for Aqueous Lithium Bromide Solutions, (ASHRAE, 2001).



Density of Lithium Bromide-Water Solutions, (Khairulin et al., 2006).

For Solution temperature $t < 250\ ^{\circ}C$

Concentration $30 < X < 65$ %LiBr

$$\rho(t,m) = \rho_0(t)[1 + d_0(t)m + d_1(t)m^{1.5} + d_2(t)m^2],\ kg/m^3$$

$$m = w/M_s(1-w),\ mole/kg$$

$$d_j(t) = \sum_{i=0}^{4} C_{ji}t^i$$

$\rho_0(t)$ = Density of pure water, kg/m^3

$M_s = 0.086845,\ kg/mole$

Table C.1 The value of Coefficients C_{ji}

j/i	0	1	2	3	4
0	6.9979 E-2	-9.36591 E-5	1.1770035 E-6	-2.829722 E-9	7.963374 E-12
1	-7.30855 E-3	1.78947 E-5	-3.458841 E-8	-8.88725 E-10	1.085224 E-12
2	1.811867 E-4	-1.9292 E-6	-1.565022 E-8	2.082693 E-10	-3.761121 E-13

Heat Capacity of Lithium Bromide-Water Solutions, (Kaita, 2000).

For Solution temperature $40 < t < 210\ ^{\circ}C$

Concentration $40 < X < 65$ %LiBr

$$Cp = (A_0 + A_1 X) + (B_0 + B_1 X)t,\ kJ/kg \cdot ^{\circ} C$$

Where

$A_0 = 3.462023$ $B_0 = 1.3499\ E\text{-}3$

$A_1 = -2.679895\ E\text{-}2$ $B_1 = -6.55\ E\text{-}6$

Entropy of Lithium Bromide-Water Solutions, (Feuerecker, 1993).

For Solution temperature $40 < t < 210\ ^{\circ}C$

Concentration $40 < X < 65$ %LiBr

$$S = \sum_{i=0}^{3} \sum_{j=0}^{3} B_{ij} X^j T^i,\ kJ/kg \cdot K$$

Table C.2 The value of Coefficients B_{ij}

i	B_{i0}	B_{i1}	B_{i2}	B_{i3}
0	5.127558 E-01	-1.393954 E-02	2.924145 E-05	9.035697 E-07
1	1.226780 E-02	-9.156820 E-05	1.820453 E-08	-7.991806 E-10
2	-1.364895 E-05	1.068904 E-07	-1.381109 E-09	1.529784 E-11
3	1.021501 E-08	0	0	0

APPENDIX D Data of the Solar Radiation and the Ambient Temperature of Chiang Mai, Thailand

Table D.1 The average solar radiation of Chiang Mai, Thailand, (RETScreen Data, 2010).

Month	Jan	Feb	Mar	Apr	May	Jun
I_T $(MJ/m^2 \cdot d)$	17.82	20.34	21.71	22.36	19.69	16.88
Month	Jul	Aug	Sep	Oct	Nov	Dec
I_T $(MJ/m^2 \cdot d)$	15.66	15.23	15.77	15.73	15.84	16.45

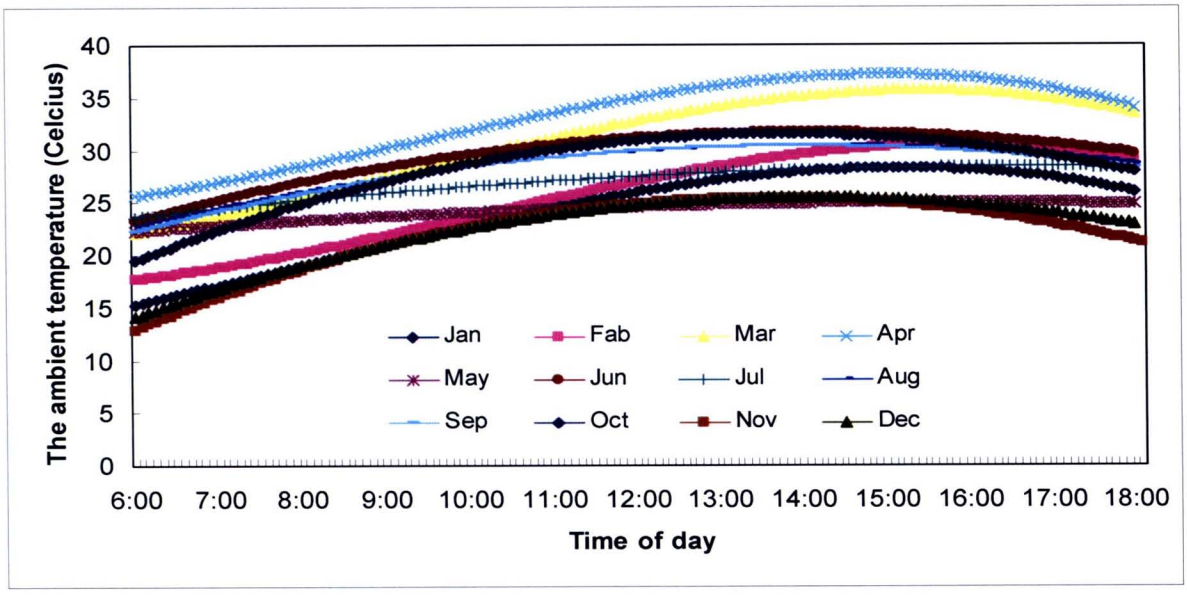


Figure D.1 The ambient temperature of Chiang Mai, Thailand, (Thai Meteorological Department, 2010).

APPENDIX E Experimental Procedures and Results

The constructed absorption heat transformer system are tested its thermal performances to upgrade heat from the installed flat-plate solar collectors. The details of the positions of the measuring sensors and the testing procedures are given as follows:

Experimental Procedures and the Data Records of solar-AHT

Figure E.1 shows the measuring positions of the sensors for the solar-AHT with supplied heat from solar water heating system. The objective of this experiment is to find out the thermal performances of the heat transformer system. The details of the instruments and the testing procedure are shown in Table E.1-E.4 and the details of the data records are shown in Table E.5-E.10.

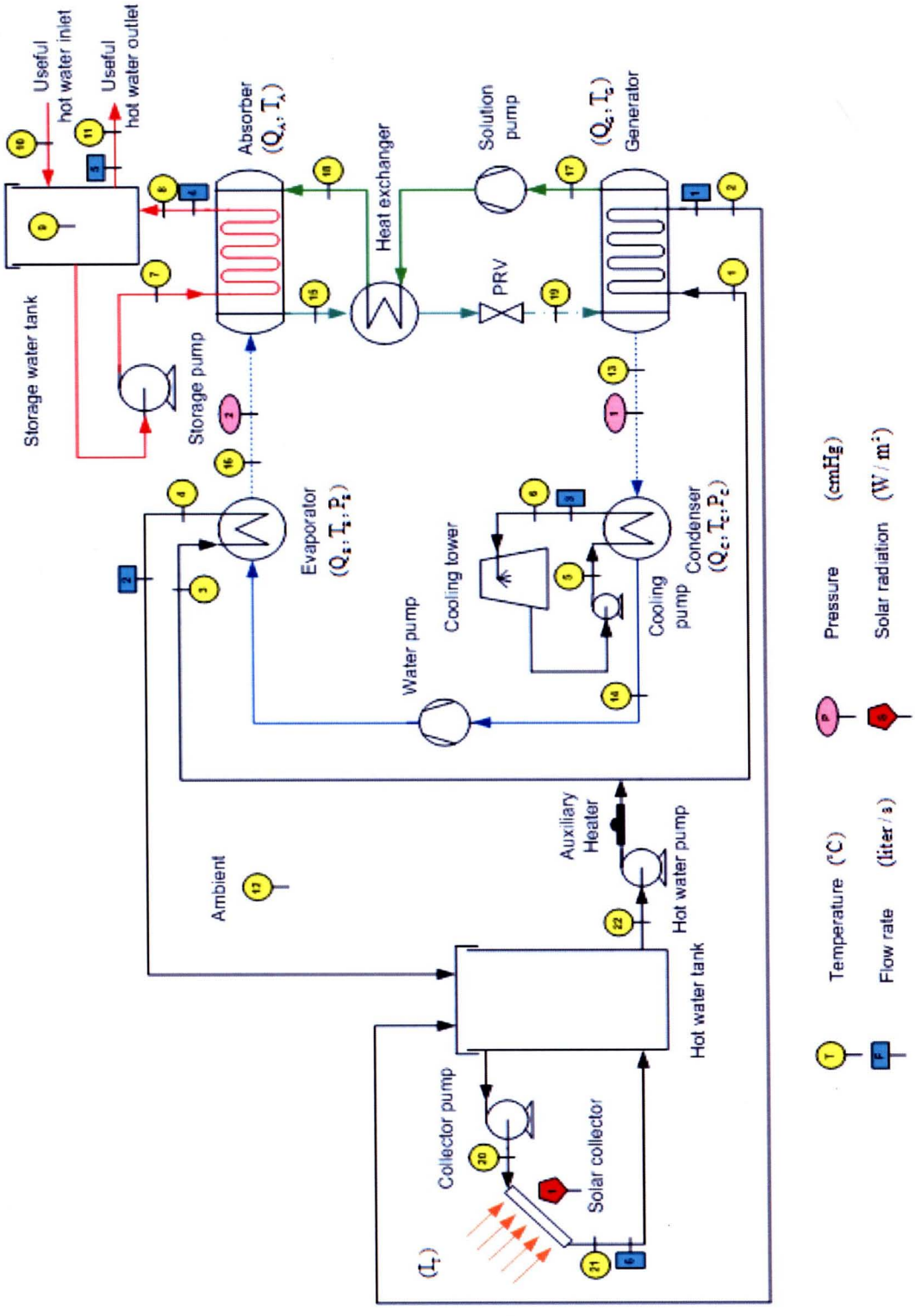


Figure E.1 Measuring positions of a solar-Absorption Heat Transformer (solar-AHT) in the experiment.

Experimental Procedures

Table E.1 Descriptions of the temperature records of the solar-AHT.

Temperature (°C)	Position	Frequency	Instrument
1. Hot water entering generator	Number 1		
2. Hot water leaving generator	Number 2		
3. Hot water entering evaporator	Number 3		
4. Hot water leaving evaporator	Number 4		
5. Cooling water entering condenser	Number 5		
6. Cooling water leaving condenser	Number 6		
7. Useful water entering absorber	Number 7		
8. Useful water leaving absorber	Number 8		
9. Useful water in storage tank	Number 9	Record	1. Computer
10. Useful water entering storage tank	Number 10	continuously	2. Data logger
11. Useful water leaving storage tank	Number 11	every 5 min	3. Thermo
12. Refrigerant leaving condenser	Number 12	for 1.5 h.	couple
13. Refrigerant entering evaporator	Number 13		
14. Weak solution leaving absorber	Number 14		
15. Weak solution entering generator	Number 15		
16. Strong solution leaving generator	Number 16		
17. Strong solution entering absorber	Number 17		
18. Hot water entering solar collectors	Number 18		
19. Hot water leaving solar collectors	Number 19		
20. Hot water leaving hot water tank	Number 20		

Table E.2 Descriptions of the pressure records.

Pressure (cmHg)	Position	Frequency	Instrument
1. Refrigerant entering condenser 2. Refrigerant leaving evaporator	Number 1 Number 2	Record continuously every 5 min for 1 h.	Pressure gage

Table E.3 Descriptions of water flow rate records.

Flow rate (l/s)	Position	Frequency	Instrument
1. Water leaving generator	Number 1	Record continuously every day.	Flow meter
2. Water leaving evaporator	Number 2		
3. Water leaving condenser	Number 3		
4. Water leaving absorber	Number 4		
5. Water leaving storage tank	Number 5		
6. Water leaving solar collector	Number 6		

Table E.4 Descriptions of the electric power records.

Parameters	Position	Frequency	Instrument
1. Power (kW)	Power supply of the AHT system	Record continuously every 5 min for 1 h.	Power logger

Data records

Table E.5 The electrical consumption and pressure of the AHT on 14/10/2010.

Time	$T_{HW,i}$ (°C)	$T_{CW,i}$ (°C)	$T_{UG,o}$ (°C)	P_H (cmHg)	P_L (cmHg)	W_1 (kW)	W_2 (kW)	W_3 (kW)	W_{AHT} (kW)
11:02:00	66.2	26.8	62.1	-63	-70	0.647	0.669	0.72	2.036
11:06:00	66.2	26.8	62.5	-63	-70	0.712	0.665	0.731	2.108
11:10:00	66.1	27.1	63.1	-62	-70	0.71	0.71	0.782	2.202
11:19:00	65.8	26.7	66.6	-62	-70	0.712	0.708	0.782	2.202
11:24:00	65.6	26.8	67.5	-61	-70	0.723	0.704	0.784	2.211
11:30:00	65.6	26.9	68.7	-60	-70	0.69	0.686	0.771	2.147
11:36:00	66.2	26.7	69.4	-60	-70	0.718	0.786	0.718	2.222
11:41:00	66	26.5	70.6	-60	-70	0.769	0.702	0.749	2.22
11:53:00	66.4	26.8	71.8	-59	-70	0.753	0.72	0.761	2.234
12:13:00	68.1	27	74.2	-58	-70	0.702	0.716	0.774	2.192
12:30:00	69.5	26.7	75.7	-57	-70	0.714	0.712	0.739	2.165
13:45:00	74.9	27.6	83.4	-52	-70	0.712	0.71	0.755	2.177
Average	67.2	26.9	-	-	-	0.714	0.707	0.756	2.176

Table E.6 The volume flow rate of the solar-AHT.

Hot water leaving a set of solar collector

Bigger volume 20.00 gallon

75.71 liter

Times	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
21/9/2010	168	0.45	27.04	0.82	988.04	0.45
21/9/2010	169	0.45	26.88	0.82	988.04	0.44
21/9/2010	170	0.45	26.72	0.81	988.04	0.44
Average	169.00	0.45	26.88	0.82	988.04	0.44

Note : * At water temperature around 50 Celcius

Hot water leaving the AHT evaporator

Bigger volume 75.71 liter

Time	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
21/9/2010	373	0.2030	12.1783	0.3702	971.79	0.1972
21/9/2010	375	0.2019	12.1133	0.3683	971.79	0.1962
21/9/2010	373	0.2030	12.1783	0.3702	971.79	0.1972
Average	373.67	0.2026	12.1566	0.3696	971.7904	0.1969

Note : * at water temperature around 80 Celcius

Hot water leaving the AHT generator

Bigger volume 75.71 liter

Time	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
21/9/2010	325	0.2329	13.9769	0.4249	971.79	0.2264
21/9/2010	320	0.2366	14.1953	0.4316	971.79	0.2299
21/9/2010	320	0.2366	14.1953	0.4316	971.79	0.2299
Average	321.67	0.2354	14.1225	0.4294	971.7904	0.2287

Note : * at water temperature around 80 Celcius

Hot water leaving the AHT condenser

Bigger volume 75.71 liter

Time	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
21/9/2010	60	1.2618	75.7082	2.3017	992.22	1.2520
21/9/2010	60	1.2618	75.7082	2.3017	992.22	1.2520
21/9/2010	60	1.2618	75.7082	2.3017	992.22	1.2520
Average	60.00	1.2618	75.7082	2.3017	992.2164	1.2520

Note : * at water temperature around 40 Celcius

Hot water leaving the AHT absorber

Bigger volume 75.71 liter

Time	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
21/9/2010	195	0.3882	23.2948	0.7082	961.89	0.3735
21/9/2010	195	0.3882	23.2948	0.7082	961.89	0.3735
21/9/2010	195	0.3882	23.2948	0.7082	961.89	0.3735
Average	195.00	0.3882	23.2948	0.7082	961.8879	0.3735

Note : * at water temperature around 95 Celcius

Volume of upgraded water in storage tank

Glycol-Water (140/60) 200.00 liter

Hot water leaving the storage tank

Bigger volume 19.50 liter

Time	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
8/10/2010	1243	0.0157	0.9413	0.0286	961.89	0.0151

Note : * at water temperature around 95 Celcius

Table E.7 The data record of the solar-AHT on 15/10/2010 (Non-used hot water in tank).

Time	T1	T2	T3	T4	T5	T6	T7	T8
	('C)	('C)	('C)	('C)	('C)	('C)	('C)	('C)
13:45:12	71.5	60.9	71.7	56.4	26.1	27.2	59.3	67.6
13:50:12	72.6	61.6	72.9	58.5	27	28.4	59.7	69.5
13:55:12	73.9	62.3	74.2	60	27.4	29	63.6	71.3
14:00:12	74.5	62.5	74.6	61.9	27.2	30.1	67.4	74
14:05:12	75.2	63	75.3	63.3	27	29.9	68.8	75.4
14:10:12	75.7	62.6	75.8	63.4	27.3	29.8	70.9	76.4
14:15:12	75.9	62.9	76.1	64.7	27.3	29.8	73.3	78.3
14:20:12	76.3	62.8	76.5	64.4	27.2	30.2	74.2	78.8
14:25:12	76.9	63.2	77	65.8	27.4	30.2	75.8	80.2
14:30:12	77.1	63.3	77.3	66.9	27.2	30.1	77.1	81.3
14:35:12	77.6	63.6	77.7	68.5	27.2	30.2	77.9	81.8
14:40:12	78.2	63.9	78.3	67.1	27	29.7	79.2	82.5
14:45:12	78.3	64.3	78.5	69.7	27	29.7	80.2	83.2
14:50:12	78.4	63.5	78.6	67	27.2	30.3	80.6	83.6
14:55:12	78.4	63.4	78.6	68.5	27.4	30.4	81.5	84.8
15:00:12	78.8	64.1	79	68.3	27.5	30.5	81.9	85.1
15:05:12	78.6	64.8	78.9	70.8	26.8	29.5	82.6	85
15:10:12	78.4	64.4	78.5	67.5	26.7	29.7	83.3	85.5
15:15:12	78.2	64.5	78.4	68.5	26.6	29.7	83.4	86.5
15:20:12	78.1	64.6	78.3	65	26.5	30.1	83.5	86.2
15:25:12	78	64.8	78.1	68.2	26.9	30	84.6	87.5

Table E.7 The data record of the solar-AHT on 15/10/2010 (Non-used hot water in tank, Continued).

Time	T9	T10	T11	T12	T13	T14	T15	T16
	('C)	('C)	('C)	('C)	('C)	('C)	('C)	('C)
13:45:12	65.5	38.4	40.8	36	60.7	31.3	71	52.8
13:50:12	70.3	41.1	42	36.3	61.5	31.7	73.2	55.6
13:55:12	72.6	42.1	41.8	33.6	61.9	32.2	75.1	57.3
14:00:12	74.5	41.9	41.1	34	62	32.2	77.1	58.8
14:05:12	77.2	42.9	41	33	62.3	32.3	78.3	60.2
14:10:12	78.6	43.9	41.1	34.6	61.8	36.5	79.2	60.9
14:15:12	80.1	45	40.7	34.7	62.2	36.2	80.6	62.1
14:20:12	81.8	46.6	40.8	34.3	62.2	37.5	80.9	62
14:25:12	82.8	47.3	40.5	35.1	62.7	37	82.3	63.5
14:30:12	84.2	47.1	38.2	32	63.2	36.5	83.1	64.3
14:35:12	85.3	46.9	38	34.5	63.6	36	83.5	64.5
14:40:12	85.9	47.2	37.2	32.8	64.2	35.6	84.1	65.3
14:45:12	86.8	47.1	37.9	32.1	64.7	35.2	84.7	65
14:50:12	87.1	48.9	37.2	32.7	64	35.7	84.8	65.1
14:55:12	87.9	49.5	38.1	33.7	63.7	35.5	86.3	66.3
15:00:12	89	49.7	38.6	34.5	64.5	35.3	86.4	66.2
15:05:12	89.3	49.5	35	31.7	65.2	35	86.1	65.5
15:10:12	89.5	50.3	32.7	32.1	64.7	34.6	86.6	66
15:15:12	90.2	50.9	32	32	64.5	34.4	87.9	67.2
15:20:12	91.2	50.1	31.4	30	65	35.5	87	64.7
15:25:12	91.5	51.5	30.9	30.2	65.2	35	88.8	66.7

Table E.8 The data record of the solar-AHT on 15/10/2010 (Non-used hot water in tank).

Time	T17	T18	T19	T20	T21	T22	I_T
	('C)	('C)	('C)	('C)	('C)	('C)	(W/m^2)
13:45:12	58.30	65.10	62.70	58.10	61.60	59.40	1,020.81
13:50:12	59.00	66.80	63.80	58.80	63.40	60.40	1,109.98
13:55:12	59.40	67.90	64.70	59.90	64.10	61.40	954.78
14:00:12	59.50	69.20	65.20	60.50	64.40	61.90	1,025.69
14:05:12	59.70	69.80	65.60	61.20	64.90	62.70	1,008.28
14:10:12	59.20	70.30	65.50	61.70	65.10	63.00	984.08
14:15:12	59.90	71.20	66.10	62.30	65.10	63.20	619.53
14:20:12	59.80	71.40	66.30	62.70	66.20	63.70	650.11
14:25:12	60.30	72.50	67.10	63.30	66.30	64.20	897.88
14:30:12	60.60	73.20	67.50	63.50	64.30	64.20	554.35
14:35:12	61.20	73.80	68.30	63.90	65.60	64.80	713.38
14:40:12	61.60	74.20	68.70	64.40	66.20	65.10	506.58
14:45:12	62.10	74.60	69.10	64.60	66.70	65.50	617.41
14:50:12	61.40	74.80	69.10	65.00	66.30	65.90	314.01
14:55:12	61.00	75.60	69.40	65.10	67.60	66.00	792.99
15:00:12	61.70	75.90	69.80	65.40	67.50	66.50	453.50
15:05:12	62.50	75.90	70.10	64.80	65.10	66.20	136.94
15:10:12	62.10	76.30	70.40	63.60	63.40	65.80	104.67
15:15:12	62.00	77.10	70.60	62.40	62.00	65.60	86.84
15:20:12	62.30	78.00	72.50	61.00	60.50	65.40	82.80
15:25:12	62.60	79.30	73.10	59.80	59.40	65.20	79.41

Table E.9 The data record of the solar-AHT on 15/10/2010 (Used hot water in tank).

Time	T1	T2	T3	T4	T5	T6	T7	T8
	('C)	('C)	('C)	('C)	('C)	('C)	('C)	('C)
15:36:55	77.9	65.5	78.1	67.8	26.5	29.4	80.9	86.6
15:37:55	77.9	65.6	78.1	67.5	26.5	29.4	80.8	86.5
15:38:55	77.9	65.7	78.1	67.7	26.4	29.3	80.7	86.5
15:39:55	77.8	65.7	78.1	67.5	26.3	29.3	80.5	86.3
15:40:55	77.8	65.7	78	67.7	26.3	29.2	80.3	86.2
15:41:55	77.9	65.8	78.1	67.8	26.3	29.1	80.2	86.1
15:42:55	77.9	65.8	78.1	67.6	26.2	29	80.1	86
15:43:55	77.9	65.8	78	67.4	26.2	29	79.7	85.9
15:44:55	77.7	65.8	77.9	67.2	26.1	28.9	79.6	85.7
15:45:55	77.8	65.9	78	67.1	26.1	28.9	79.5	85.5
15:46:55	77.8	66	78	67.2	26.2	29	79.3	85.3
15:47:55	77.8	66.1	78	67.5	26.1	28.9	79.2	85.2
15:48:55	77.8	66.1	78	66.5	26.1	29.1	79.1	85
15:52:55	77.6	65.6	77.9	66.1	26.2	29.1	78.6	84.5
15:53:55	77.5	65.6	77.8	66.4	26.2	29.1	78.6	84.7
15:54:55	77.6	65.6	77.8	66.6	26.2	29	78.5	84.6
15:55:55	77.5	65.6	77.8	66.5	26.2	29	78.3	84.6
15:56:55	77.5	65.7	77.8	66.7	26.1	29	78.1	84.5
15:57:55	77.5	65.7	77.8	66.8	26.2	29	78	84.5
15:58:55	77.4	65.8	77.7	66.6	26.2	29	77.8	84.4
15:59:55	77.3	65.8	77.6	66.7	26.1	29	77.7	84.4

Table E.9 The data record of the solar-AHT on 15/10/2010 (Used hot water in tank, Continued).

Time	T9	T10	T11	T12	T13	T14	T15	T16
	('C)	('C)	('C)	('C)	('C)	('C)	('C)	('C)
15:36:55	90.2	29.9	83.7	29.2	65.6	36.6	88.2	66.3
15:37:55	90.3	29.9	83.6	29.1	65.5	36.4	88.2	66.5
15:38:55	89.5	29.9	83.5	30.9	65.7	36.3	88.2	66.3
15:39:55	89.8	30	83.2	30	65.6	36.2	88	66.2
15:40:55	89.1	30.1	83.2	28.6	65.7	36	88	66.2
15:41:55	90	30.1	83.1	30.2	65.7	35.9	87.9	66.2
15:42:55	89.7	30.1	83	29.6	65.7	35.7	87.8	66
15:43:55	89.6	30.1	82.9	29.7	65.7	35.5	87.7	66.1
15:44:55	89.5	30.1	82.9	31.4	65.8	35.4	87.5	65.8
15:45:55	89.4	30.1	82.6	29.8	65.8	35.2	87.4	65.9
15:46:55	88.9	30.3	82.8	30.8	66.3	35.5	87.5	65.8
15:47:55	90.2	31	83	29.9	67.2	36.2	88	65.7
15:48:55	90.1	31.1	83	33.7	67.2	37.7	87.8	65.5
15:52:55	89	31.3	82.5	35.3	66.8	38.1	87.4	64.3
15:53:55	89.5	31.2	82.3	33.7	66.9	38	87.5	64.5
15:54:55	89.5	31.6	82.5	29.9	67.4	38.5	87.8	64.8
15:55:55	88.7	31.2	82.3	33.1	66.7	37.7	87.5	64.8
15:56:55	89.6	31.6	82.3	31.8	67.5	38.2	87.8	64.8
15:57:55	89.2	31.6	82.3	31.4	67.5	38.1	87.7	64.9
15:58:55	88.9	31.5	82.2	32.2	67.4	37.8	87.6	64.8
15:59:55	88.7	31.4	82.1	32.6	67.4	37.6	87.4	64.8

Table E.10 The data record of the solar-AHT on 15/10/2010 (Used hot water in tank, Continued).

Time	T17	T18	T19	T20	T21	T22	I_T
	('C)	('C)	('C)	('C)	('C)	('C)	(W/m^2)
15:36:55	62.80	78.10	72.00	56.90	56.60	65.00	35.24
15:37:55	62.90	78.10	71.90	56.90	56.40	65.00	35.03
15:38:55	62.80	78.00	71.90	56.60	56.20	65.00	35.46
15:39:55	62.90	78.00	71.80	56.50	56.00	65.00	35.88
15:40:55	63.00	77.90	71.80	56.20	55.80	65.00	36.94
15:41:55	63.10	77.90	71.80	56.00	55.50	65.00	38.00
15:42:55	63.00	77.70	71.70	55.70	55.30	65.00	39.07
15:43:55	63.10	77.70	71.80	55.60	55.10	65.00	40.76
15:44:55	62.70	77.40	71.40	55.10	54.70	64.80	42.25
15:45:55	62.60	77.30	71.40	55.10	54.60	64.80	43.74
15:46:55	62.90	77.30	71.50	54.80	54.40	64.90	45.01
15:47:55	62.90	77.30	71.40	54.70	54.20	64.90	46.71
15:48:55	63.00	77.00	71.20	54.60	54.00	64.90	47.77
15:52:55	62.50	76.60	71.00	53.70	53.30	64.80	52.65
15:53:55	62.50	76.70	71.10	53.60	53.00	64.80	54.78
15:54:55	62.80	76.80	71.10	53.40	53.00	64.80	56.48
15:55:55	62.70	76.60	71.10	53.10	52.60	64.70	58.39
15:56:55	62.80	76.70	71.00	52.90	52.50	64.70	60.30
15:57:55	62.80	76.70	71.00	52.80	52.30	64.70	62.21
15:58:55	62.90	76.60	71.10	52.60	52.10	64.70	63.91
15:59:55	62.80	76.60	71.00	52.40	51.90	64.70	65.82

Experimental Procedures and the Data Records of solar-CAHT

Figure E.2 shows the measuring positions of the sensors for the solar-CAHT with supplied heat from solar water heating system. The details of the instruments and the testing procedure are shown in Table E.11-E.15 and the details of the data records are shown in Table E.16-E.20.

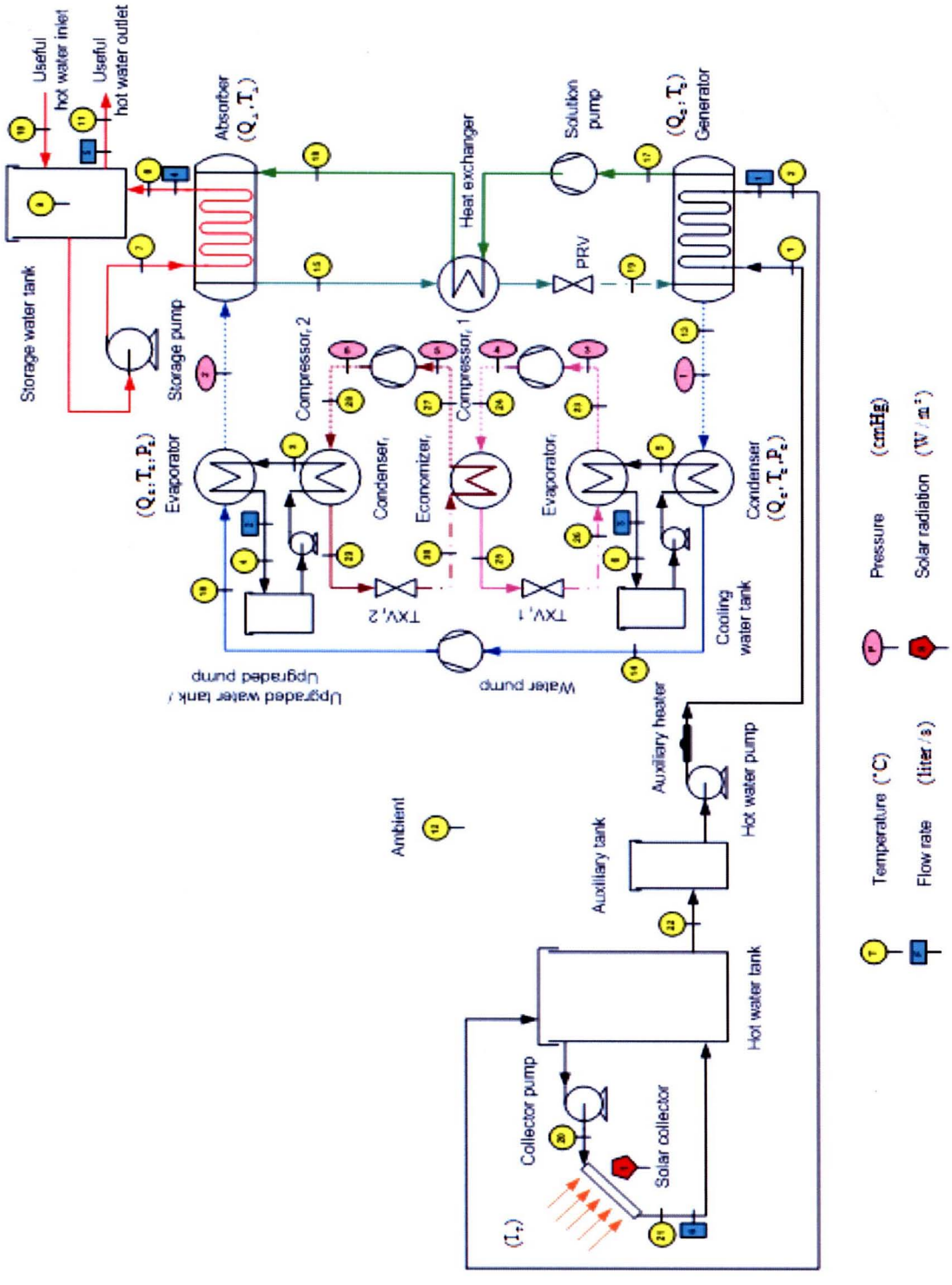


Figure E.2 Measuring positions of a solar-Compression/Absorption Heat Transformer (solar-CAHT) in the experiment.

Experimental Procedures

Table E.11 Descriptions of the temperature records of the solar-CAHT.

Temperature (°C)	Position	Frequency	Instrument
1. Hot water entering generator	Number 1		
2. Hot water leaving generator	Number 2		
3. Hot water entering evaporator	Number 3		
4. Hot water leaving evaporator	Number 4		
5. Cooling water entering condenser	Number 5		
6. Cooling water leaving condenser	Number 6		
7. Useful water entering absorber	Number 7		
8. Useful water leaving absorber	Number 8		
9. Useful water in storage tank	Number 9		
10. Useful water entering storage tank	Number 10		
11. Useful water leaving storage tank	Number 11		
12. Ambient temperature	Number 12		
13. Refrigerant leaving generator	Number 13	Record	1. Computer
14. Refrigerant leaving condenser	Number 14	continuously	2. Data logger
15. Refrigerant entering absorber	Number 15	every 5 min	3. Thermo
16. Refrigerant entering evaporator	Number 16	for 1.5 h.	couple
17. Strong solution leaving generator	Number 17		
18. Strong solution entering absorber	Number 18		
19. Weak solution entering generator	Number 19		
20. Hot water entering solar collectors	Number 20		
21. Hot water leaving solar collectors	Number 21		
22. Hot water leaving hot water tank	Number 22		
23. R-134A entering compressor$_r$1	Number 23		
24. R-134A entering economizer$_r$	Number 24		
25. R-134A entering PRV$_r$1	Number 25		
26. R-134A entering evaporator$_r$	Number 26		
27. R-123 entering compressor$_r$2	Number 27		
R-123 entering condenser$_r$	Number 28		

Table E.11 Descriptions of the temperature records of the solar-CAHT, Continued.

Temperature (°C)	Position	Frequency	Instrument
28. R-123 entering PRV_r2 29. R-123 entering $economizer_r$	Number 29 Number 30	Record continuously every 5 min for 1.5 h.	1. Computer 2. Data logger 3. Thermo couple

Table E.12 Descriptions of the pressure records.

Pressure (cmHg)	Position	Frequency	Instrument
1. Refrigerant entering condenser	Number 1	Record continuously every 5 min for 1 h.	Pressure gage
2. Refrigerant leaving evaporator	Number 2		
3. R-134A entering $compressor_r1$	Number 3		
4. R-134A leaving $compressor_r1$	Number 4		
5. R-123 entering $compressor_r2$	Number 5		
6. R-134A leaving $compressor_r2$	Number 6		

Table E.13 Descriptions of water flow rate records.

Flow rate (l/s)	Position	Frequency	Instrument
1. Water leaving generator	Number 1	Record continuously every day.	Flow meter
2. Water leaving evaporator	Number 2		
3. Water leaving condenser	Number 3		
4. Water leaving absorber	Number 4		
5. Water leaving storage tank	Number 5		
6. Water leaving solar collector	Number 6		

Table E.14 Descriptions of the electric power records of the AHT and the VCHP.

Parameters	Position	Frequency	Instrument
1. Power of the AHT (kW) 2. Power of the VCHP (kW)	Power supply of the AHT and the VCHP system	Record continuously every 5 min for 1 h.	Power logger

Data records

Table E.15 The electrical consumption and pressure of the AHT on 18/10/2010.

Time	$T_{HW,i}$ (°C)	$T_{CW,i}$ (°C)	$T_{UG,o}$ (°C)	P_H (cmHg)	P_L (cmHg)	W_1 (kW)	W_2 (kW)	W_3 (kW)	W_{AHT} (kW)
11:52:00	66.1	22.2	49.2	-66	-70	0.727	0.757	0.804	2.288
11:55:00	65.5	22.9	52.1	-65	-70	0.735	0.749	0.81	2.294
11:58:00	65	23.2	53.3	-65	-70	0.743	0.751	0.814	2.308
12:03:00	64.1	23.3	54.3	-65	-70	0.704	0.743	0.802	2.249
12:08:00	63.7	23.3	57.5	-65	-70	0.704	0.708	0.78	2.192
12:13:00	63.6	23.3	60.2	-65	-70	0.637	0.674	0.72	2.031
12:27:00	64.3	23.7	63.3	-63	-70	0.686	0.706	0.743	2.135
12:35:00	64.9	24.4	64.5	-62	-70	0.645	0.671	0.737	2.053
12:48:00	65.7	24.5	67.3	-60	-70	0.674	0.694	0.741	2.109
13:12:00	67.2	24.7	70.6	-59	-70	0.635	0.647	0.704	1.986
13:36:00	68.3	24.3	72.3	-58	-70	0.698	0.723	0.765	2.186
13:58:00	69.6	24.7	74.3	-56	-70	0.68	0.702	0.729	2.111
Average	65.7	23.7	-	-	-	0.689	0.71	0.762	2.162

Table E.16 The electrical consumption and pressure of the VCHP on 7/12/2010.

Time	$T_{UG,i}$ ('C)	$T_{CW,i}$ ('C)	$T_{UG,i}$-$T_{CW,i}$ (PSI)	$P_{H,R-134a}$ (PSI)	$P_{L,R-134a}$ (PSI)	$P_{H,R-123}$ (PSI)	$P_{L,R-123}$ (PSI)	W_{VCHP} (kW)
12:21:00	52.9	25.5	27.4	210	43	54	12	2.721
12:43:00	57	25	32	213	43	58	12	2.757
13:05:00	61.4	25.7	35.7	216	43	63	13	2.799
13:14:00	62.9	25.8	37.1	220	43	65	13	2.788
13:33:00	66.2	25.8	40.4	223	44	70	13	2.864
13:43:00	67.4	26.3	41.1	225	44	72	14	2.879
14:07:00	70.8	26	44.8	227	44	77	14	2.968
14:26:00	73.1	26.3	46.8	231	44	81	14	2.976
14:48:00	75.2	26.3	48.9	235	44	84	17	2.936
15:05:00	76.7	26.5	50.2	237	44	87	17	3.03
15:24:00	78.3	26.2	52.1	240	44	90	18	3.048
15:47:00	80.2	26.2	54	245	44	94	19	3.1
Average	-	26	-	-	-	-	-	2.906

Table E.17 The volume flow rate of the solar-CAHT.

Hot water leaving a set of solar collector

Bigger volume 20.00 gallon

75.71 liter

Times	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
7/12/2010	168	0.45	27.04	0.82	988.04	0.45
7/12/2010	169	0.45	26.88	0.82	988.04	0.44
7/12/2010	170	0.45	26.72	0.81	988.04	0.44
Average	169.00	0.45	26.88	0.82	988.04	0.44

Note : * At water temperature around 50 Celcius

Hot water leaving the AHT evaporator

Bigger volume 75.71 liter

Time	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
7/12/2010	187	0.4049	24.2914	0.7385	971.79	0.3934
7/12/2010	190	0.3985	23.9079	0.7269	971.79	0.3872
7/12/2010	189	0.4006	24.0344	0.7307	971.79	0.3893
Average	188.67	0.4013	24.0779	0.7320	971.7904	0.3900

Note : * at water temperature around 80 Celcius

Hot water leaving the AHT generator

Bigger volume 75.71 liter

Time	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
7/12/2010	208	0.3640	21.8389	0.6640	971.79	0.3537
7/12/2010	208	0.3640	21.8389	0.6640	971.79	0.3537
7/12/2010	208	0.3640	21.8389	0.6640	971.79	0.3537
Average	208.00	0.3640	21.8389	0.6640	971.7904	0.3537

Note : * at water temperature around 80 Celcius

Hot water leaving the AHT condenser

Bigger volume 75.71 liter

Time	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
7/12/2010	96	0.7886	47.3177	1.4386	997.05	0.7863
7/12/2010	96	0.7886	47.3177	1.4386	997.05	0.7863
7/12/2010	97	0.7805	46.8298	1.4237	997.05	0.7782
Average	96.33	0.7859	47.1550	1.4336	997.0476	0.7836

Note : * at water temperature around 40 Celcius

Hot water leaving the AHT absorber

Bigger volume 75.71 liter

Time	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
7/12/2010	195	0.3882	23.2948	0.7082	961.89	0.3735
7/12/2010	195	0.3882	23.2948	0.7082	961.89	0.3735
7/12/2010	195	0.3882	23.2948	0.7082	961.89	0.3735
Average	195.00	0.3882	23.2948	0.7082	961.8879	0.3735

Note : * at water temperature around 95 Celcius

Volume of upgraded water in storage tank

Glycol-Water (140/60) 200.00 liter

Hot water leaving the storage tank

Bigger volume 19.50 liter

Time	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/h)	(kg/m^3)	(kg/s)
7/12/2010	882	0.0221	1.3265	0.0403	961.89	0.0213

Note : * at water temperature around 95 Celcius

Hot water leaving the upgraded water tank (Loop of condenser$_r$ and tank)

Bigger volume 75.71 liter

Time	Record time	Volume flow rate			Density*	Mass flow rate
	(s)	(liter/s)	(liter/min)	(m^3/hr)	(kg/m^3)	(kg/s)
7/12/2553	95	0.7969	47.8157	1.4537	971.79	0.7744

Note : * at water temperature around 80 Celcius

Table E.18 The data record of the solar- CAHT on 7/12/2010 (Non-used hot water in tank).

Time	T1	T2	T3	T4	T5	T6	T7	T8
	('C)	('C)	('C)	('C)	('C)	('C)	('C)	('C)
14:00:12	74.50	62.50	74.60	61.90	27.20	30.10	67.40	74.00
14:05:12	75.20	63.00	75.30	63.30	27.00	29.90	68.80	75.40
14:10:12	75.70	62.60	75.80	63.40	27.30	29.80	70.90	76.40
14:15:12	75.90	62.90	76.10	64.70	27.30	29.80	73.30	78.30
14:20:12	76.30	62.80	76.50	64.40	27.20	30.20	74.20	78.80
14:25:12	76.90	63.20	77.00	65.80	27.40	30.20	75.80	80.20
14:30:12	77.10	63.30	77.30	66.90	27.20	30.10	77.10	81.30
14:35:12	77.60	63.60	77.70	68.50	27.20	30.20	77.90	81.80
14:40:12	78.20	63.90	78.30	67.10	27.00	29.70	79.20	82.50
14:45:12	78.30	64.30	78.50	69.70	27.00	29.70	80.20	83.20
14:50:12	78.40	63.50	78.60	67.00	27.20	30.30	80.60	83.60
14:55:12	78.40	63.40	78.60	68.50	27.40	30.40	81.50	84.80
15:00:12	78.80	64.10	79.00	68.30	27.50	30.50	81.90	85.10
15:05:12	78.60	64.80	78.90	70.80	26.80	29.50	82.60	85.00
15:10:12	78.40	64.40	78.50	67.50	26.70	29.70	83.30	85.50
15:15:12	78.20	64.50	78.40	68.50	26.60	29.70	83.40	86.50
15:20:12	78.10	64.60	78.30	65.00	26.50	30.10	83.50	86.20
15:25:12	78.00	64.80	78.10	68.20	26.90	30.00	84.60	87.50
15:30:12	77.90	65.00	78.10	68.40	26.80	29.90	84.70	87.80
15:35:12	77.90	65.20	78.10	68.50	26.70	29.80	84.80	88.00
15:40:12	78.00	65.30	78.10	68.50	26.80	29.80	84.80	88.20

Table E.18 The data record of the solar- CAHT on 7/12/2010 (Non-used hot water in tank, Continued).

Time	T9	T10	T11	T12	T13	T14	T15	T16
	('C)	('C)	('C)	('C)	('C)	('C)	('C)	('C)
14:00:12	74.50	41.90	41.10	34.00	62.00	32.20	77.10	58.80
14:05:12	77.20	42.90	41.00	33.00	62.30	32.30	78.30	60.20
14:10:12	78.60	43.90	41.10	34.60	61.80	36.50	79.20	60.90
14:15:12	80.10	45.00	40.70	34.70	62.20	36.20	80.60	62.10
14:20:12	81.80	46.60	40.80	34.30	62.20	37.50	80.90	62.00
14:25:12	82.80	47.30	40.50	35.10	62.70	37.00	82.30	63.50
14:30:12	84.20	47.10	38.20	32.00	63.20	36.50	83.10	64.30
14:35:12	85.30	46.90	38.00	34.50	63.60	36.00	83.50	64.50
14:40:12	85.90	47.20	37.20	32.80	64.20	35.60	84.10	65.30
14:45:12	86.80	47.10	37.90	32.10	64.70	35.20	84.70	65.00
14:50:12	87.10	48.90	37.20	32.70	64.00	35.70	84.80	65.10
14:55:12	87.90	49.50	38.10	33.70	63.70	35.50	86.30	66.30
15:00:12	89.00	49.70	38.60	34.50	64.50	35.30	86.40	66.20
15:05:12	89.30	49.50	35.00	31.70	65.20	35.00	86.10	65.50
15:10:12	89.50	50.30	32.70	32.10	64.70	34.60	86.60	66.00
15:15:12	90.20	50.90	32.00	32.00	64.50	34.40	87.90	67.20
15:20:12	91.20	50.10	31.40	30.00	65.00	35.50	87.00	64.70
15:25:12	91.50	51.50	30.90	30.20	65.20	35.00	88.80	66.70
15:30:12	91.50	50.90	31.00	29.80	65.40	34.90	89.10	66.80
15:35:12	91.60	50.80	30.70	29.80	65.30	34.90	89.20	67.10
15:40:12	91.80	51.60	30.70	29.50	65.40	34.90	89.30	67.30

Table E.18 The data record of the solar- CAHT on 7/12/2010 (Non-used hot water in tank).

Time	T17	T18	T19	T20	T21	T22	I_T
	('C)	('C)	('C)	('C)	('C)	('C)	(W/m^2)
14:00:12	59.50	69.20	65.20	60.50	64.40	61.90	1,025.69
14:05:12	59.70	69.80	65.60	61.20	64.90	62.70	1,008.28
14:10:12	59.20	70.30	65.50	61.70	65.10	63.00	984.08
14:15:12	59.90	71.20	66.10	62.30	65.10	63.20	619.53
14:20:12	59.80	71.40	66.30	62.70	66.20	63.70	650.11
14:25:12	60.30	72.50	67.10	63.30	66.30	64.20	897.88
14:30:12	60.60	73.20	67.50	63.50	64.30	64.20	554.35
14:35:12	61.20	73.80	68.30	63.90	65.60	64.80	713.38
14:40:12	61.60	74.20	68.70	64.40	66.20	65.10	506.58
14:45:12	62.10	74.60	69.10	64.60	66.70	65.50	617.41
14:50:12	61.40	74.80	69.10	65.00	66.30	65.90	314.01
14:55:12	61.00	75.60	69.40	65.10	67.60	66.00	792.99
15:00:12	61.70	75.90	69.80	65.40	67.50	66.50	453.50
15:05:12	62.50	75.90	70.10	64.80	65.10	66.20	136.94
15:10:12	62.10	76.30	70.40	63.60	63.40	65.80	104.67
15:15:12	62.00	77.10	70.60	62.40	62.00	65.60	86.84
15:20:12	62.30	78.00	72.50	61.00	60.50	65.40	82.80
15:25:12	62.60	79.30	73.10	59.80	59.40	65.20	79.41
15:30:12	62.60	78.80	72.50	59.50	59.00	65.20	77.07
15:35:12	62.60	79.00	72.50	59.30	58.80	65.20	73.25
15:40:12	62.80	79.10	72.60	59.10	58.60	65.20	68.15

Table E.18 The data record of the solar- CAHT on 7/12/2010 (Non-used hot water in tank).

Time	T1r ('C)	T2r ('C)	T3r ('C)	T4r ('C)	T5r ('C)	T6r ('C)	T7r ('C)	T8r ('C)
14:00:12	25.90	89.20	57.50	10.50	82.50	114.70	69.50	45.70
14:05:12	25.70	88.80	57.40	10.10	82.20	114.60	69.90	46.00
14:10:12	25.80	89.10	57.60	10.40	82.50	115.40	69.80	46.00
14:15:12	25.80	88.80	57.60	10.30	82.30	114.90	69.90	46.10
14:20:12	25.70	89.40	57.60	10.20	82.60	114.90	69.80	46.40
14:25:12	26.00	89.20	57.80	10.40	83.10	115.10	70.00	46.20
14:30:12	26.20	89.70	57.80	10.50	82.60	114.80	69.60	46.30
14:35:12	26.30	89.70	58.10	10.60	83.20	115.60	70.00	46.60
14:40:12	26.20	89.70	57.80	10.50	83.10	115.60	70.10	46.50
14:45:12	26.50	90.10	58.20	10.60	83.30	115.70	70.40	46.60
14:50:12	26.50	90.00	58.20	10.80	83.40	115.60	70.30	46.50
14:55:12	26.20	90.10	58.20	10.70	83.40	115.70	70.30	46.50
15:00:12	26.50	89.90	58.20	10.60	83.40	115.50	69.90	46.50
15:05:12	26.00	89.70	57.90	10.40	83.20	115.00	70.30	46.60
15:10:12	26.10	90.10	58.20	10.80	83.20	115.30	70.70	46.50
15:15:12	25.70	89.20	58.10	10.50	82.30	114.80	70.20	46.40
15:20:12	26.20	89.60	58.10	10.70	83.20	115.10	70.10	46.50
15:25:12	26.30	90.10	58.20	10.80	83.30	115.90	70.40	46.40
15:30:12	26.30	89.60	58.00	10.60	83.00	115.20	69.80	46.50
15:35:12	26.50	90.10	58.20	10.70	83.10	115.40	70.20	46.50
15:40:12	26.50	90.10	58.10	10.60	83.20	115.80	70.10	46.60

Table E.19 The data record of the solar- CAHT on 7/12/2010 (Used hot water in tank).

Time	T1	T2	T3	T4	T5	T6	T7	T8
	('C)	('C)	('C)	('C)	('C)	('C)	('C)	('C)
15:45:55	77.9	65.70	78.10	67.70	26.40	29.30	80.70	86.50
15:46:55	77.8	65.70	78.10	67.50	26.30	29.30	80.50	86.30
15:47:55	77.8	65.70	78.00	67.70	26.30	29.20	80.30	86.20
15:48:55	77.9	65.80	78.10	67.80	26.30	29.10	80.20	86.10
15:49:55	77.90	65.80	78.10	67.60	26.20	29.00	80.10	86.00
15:50:55	77.90	65.80	78.00	67.40	26.20	29.00	79.70	85.90
15:51:55	77.70	65.80	77.90	67.20	26.10	28.90	79.60	85.70
15:52:55	77.80	65.90	78.00	67.10	26.10	28.90	79.50	85.50
15:53:55	77.80	66.00	78.00	67.20	26.20	29.00	79.30	85.30
15:54:55	77.80	66.10	78.00	67.50	26.10	28.90	79.20	85.20
15:55:55	77.80	66.10	78.00	66.50	26.10	29.10	79.10	85.00
15:56:55	77.60	65.60	77.90	66.10	26.20	29.10	78.60	84.50
15:57:55	77.50	65.60	77.80	66.40	26.20	29.10	78.60	84.70
15:58:55	77.60	65.60	77.80	66.60	26.20	29.00	78.50	84.60
15:59:55	77.50	65.60	77.80	66.50	26.20	29.00	78.30	84.60
16:00:55	77.50	65.70	77.80	66.70	26.10	29.00	78.10	84.50
16:01:55	77.50	65.70	77.80	66.80	26.20	29.00	78.00	84.50
16:02:55	77.40	65.80	77.70	66.60	26.20	29.00	77.80	84.40
16:03:55	77.30	65.80	77.60	66.70	26.10	29.00	77.70	84.40
16:04:55	77.20	65.80	77.50	66.40	26.10	28.90	77.70	84.20
16:05:55	77.4	65.50	77.70	66.00	25.90	28.80	76.80	83.60

Table E.19 The data record of the solar- CAHT on 7/12/2010 (Used hot water in tank, Continued).

Time	T9	T10	T11	T12	T13	T14	T15	T16
	('C)	('C)	('C)	('C)	('C)	('C)	('C)	('C)
15:45:55	89.50	29.90	83.50	30.90	65.70	36.30	88.20	66.30
15:46:55	89.80	30.00	83.20	30.00	65.60	36.20	88.00	66.20
15:47:55	89.10	30.10	83.20	28.60	65.70	36.00	88.00	66.20
15:48:55	90.00	30.10	83.10	30.20	65.70	35.90	87.90	66.20
15:49:55	89.70	30.10	83.00	29.60	65.70	35.70	87.80	66.00
15:50:55	89.60	30.10	82.90	29.70	65.70	35.50	87.70	66.10
15:51:55	89.50	30.10	82.90	31.40	65.80	35.40	87.50	65.80
15:52:55	89.40	30.10	82.60	29.80	65.80	35.20	87.40	65.90
15:53:55	88.90	30.30	82.80	30.80	66.30	35.50	87.50	65.80
15:54:55	90.20	31.00	83.00	29.90	67.20	36.20	88.00	65.70
15:55:55	90.10	31.10	83.00	33.70	67.20	37.70	87.80	65.50
15:56:55	89.00	31.30	82.50	35.30	66.80	38.10	87.40	64.30
15:57:55	89.50	31.20	82.30	33.70	66.90	38.00	87.50	64.50
15:58:55	89.50	31.60	82.50	29.90	67.40	38.50	87.80	64.80
15:59:55	88.70	31.20	82.30	33.10	66.70	37.70	87.50	64.80
16:00:55	89.60	31.60	82.30	31.80	67.50	38.20	87.80	64.80
16:01:55	89.20	31.60	82.30	31.40	67.50	38.10	87.70	64.90
16:02:55	88.90	31.50	82.20	32.20	67.40	37.80	87.60	64.80
16:03:55	88.70	31.40	82.10	32.60	67.40	37.60	87.40	64.80
16:04:55	89.50	40.60	79.10	32.20	67.30	37.50	87.30	64.80
16:05:55	86.40	30.00	79.30	28.10	66.50	35.70	85.80	63.90

Table E.19 The data record of the solar-CAHT on 7/12/2010 (Used hot water in tank, Continued).

Time	T17	T18	T19	T20	T21	T22	I_T
	('C)	('C)	('C)	('C)	('C)	('C)	(W/m^2)
15:45:55	62.80	78.00	71.90	56.60	56.20	65.00	35.46
15:46:55	62.90	78.00	71.80	56.50	56.00	65.00	35.88
15:47:55	63.00	77.90	71.80	56.20	55.80	65.00	36.94
15:48:55	63.10	77.90	71.80	56.00	55.50	65.00	38.00
15:49:55	63.00	77.70	71.70	55.70	55.30	65.00	39.07
15:50:55	63.10	77.70	71.80	55.60	55.10	65.00	40.76
15:51:55	62.70	77.40	71.40	55.10	54.70	64.80	42.25
15:52:55	62.60	77.30	71.40	55.10	54.60	64.80	43.74
15:53:55	62.90	77.30	71.50	54.80	54.40	64.90	45.01
15:54:55	62.90	77.30	71.40	54.70	54.20	64.90	46.71
15:55:55	63.00	77.00	71.20	54.60	54.00	64.90	47.77
15:56:55	62.50	76.60	71.00	53.70	53.30	64.80	52.65
15:57:55	62.50	76.70	71.10	53.60	53.00	64.80	54.78
15:58:55	62.80	76.80	71.10	53.40	53.00	64.80	56.48
15:59:55	62.70	76.60	71.10	53.10	52.60	64.70	58.39
16:00:55	62.80	76.70	71.00	52.90	52.50	64.70	60.30
16:01:55	62.80	76.70	71.00	52.80	52.30	64.70	62.21
16:02:55	62.90	76.60	71.10	52.60	52.10	64.70	63.91
16:03:55	62.80	76.60	71.00	52.40	51.90	64.70	65.82
16:04:55	62.80	76.50	71.00	52.20	51.70	64.60	67.73
16:05:55	62.20	75.80	70.40	47.80	46.80	64.40	80.47

Table E.19 The data record of the solar-CAHT on 7/12/2010 (Used hot water in tank, Continued).

Time	T1r	T2r	T3r	T4r	T5r	T6r	T7r	T8r
	('C)	('C)	('C)	('C)	('C)	('C)	('C)	('C)
15:45:55	29.30	90.40	57.80	11.20	84.50	114.60	65.20	45.40
15:46:55	28.00	90.50	57.60	11.00	83.80	114.70	65.20	45.20
15:47:55	27.20	90.30	57.40	11.00	84.00	114.70	65.50	45.20
15:48:55	26.20	89.00	57.10	10.50	82.50	114.00	65.30	44.80
15:49:55	25.80	89.00	56.80	10.50	82.80	114.20	65.90	45.00
15:50:55	25.70	88.60	56.60	10.40	82.30	113.80	66.20	44.90
15:51:55	25.30	88.40	56.30	10.00	81.90	113.60	65.80	44.90
15:52:55	24.90	88.00	56.20	9.90	80.90	113.80	65.20	44.80
15:53:55	24.70	87.70	56.10	10.00	80.80	113.30	66.10	44.50
15:54:55	24.40	87.40	55.90	9.80	80.50	113.10	66.00	44.60
15:55:55	24.10	87.20	55.80	9.70	79.90	113.00	65.40	44.60
15:56:55	26.50	87.70	56.10	10.20	80.10	112.20	65.30	44.70
15:57:55	26.60	87.50	55.90	10.00	79.70	111.80	65.40	44.60
15:58:55	27.50	88.40	56.30	10.40	80.40	112.50	64.70	44.80
15:59:55	27.80	88.50	56.50	10.60	80.70	111.80	65.40	44.80
16:00:55	27.80	88.80	56.60	10.70	81.40	112.30	65.30	44.70
16:01:55	28.00	88.90	56.60	10.50	81.10	112.70	65.00	44.70
16:02:55	27.40	89.00	56.50	10.50	81.50	112.50	65.20	44.60
16:03:55	26.50	88.50	56.20	10.20	81.40	113.20	65.30	44.70
16:04:55	25.00	87.60	55.80	9.80	80.50	112.40	65.40	44.80
16:05:55	25.80	87.60	55.90	10.20	80.30	112.20	65.00	44.30

APPENDIX F The Calculation Results of the Data Records

The calculation results of the solar-AHT

Table F.1 The calculation results of the solar-AHT from data recorder on 15/10/2010 (Non-used water in tank).

Time	$\rho_{Gly\text{-}Water}$	$Cp_{Gly\text{-}Water}$	Q_{ST}	$TG_{HW,bulk}$	$\Delta T_{HW,G}$	$Cp_{HW,G}$	$\rho_{HW,G}$
	(kg/m³)	(kJ/kg-K)	(kW)	('C)	('C)	(kJ/kg-K)	(kg/m³)
13:45:12	1073.31	3.26	15.15	66.2	10.6	4.19	979.86
13:50:12	1072.51	3.28	11.9	67.1	11	4.19	979.36
13:55:12	1072.11	3.28	8.96	68.1	11.6	4.19	978.81
14:00:12	1071.77	3.29	7.57	68.5	12	4.19	978.58
14:05:12	1071.29	3.3	7.3	69.1	12.2	4.19	978.24
14:10:12	1071.03	3.31	6.54	69.15	13.1	4.19	978.22
14:15:12	1070.75	3.31	6.07	69.4	13	4.19	978.07
14:20:12	1070.43	3.32	5.79	69.55	13.5	4.19	977.99
14:25:12	1070.24	3.32	5.38	70.05	13.7	4.19	977.71
14:30:12	1069.97	3.33	5.16	70.2	13.8	4.19	977.62
14:35:12	1069.76	3.33	4.92	70.6	14	4.19	977.39
14:40:12	1069.64	3.34	4.61	71.05	14.3	4.19	977.13
14:45:12	1069.47	3.34	4.41	71.3	14	4.19	976.99
14:50:12	1069.41	3.34	4.13	70.95	14.9	4.19	977.19
14:55:12	1069.25	3.34	3.98	70.9	15	4.19	977.22
15:00:12	1069.03	3.35	3.89	71.45	14.7	4.19	976.9
15:05:12	1068.97	3.35	3.7	71.7	13.8	4.19	976.76
15:10:12	1068.93	3.35	3.51	71.4	14	4.19	976.93
15:15:12	1068.79	3.35	3.41	71.35	13.7	4.19	976.96
15:20:12	1068.59	3.36	3.36	71.35	13.5	4.19	976.96
15:25:12	1068.52	3.36	3.23	71.4	13.2	4.19	976.93

Table F.1 The calculation results of the solar-AHT from data recorder on 15/10/2010 (Non-used water in tank, Continued).

Time	Q_G	$TE_{HW,bulk}$	$\Delta T_{HW,E}$	$Cp_{HW,E}$	$\rho_{HW,E}$	Q_E
	(kW)	(°C)	(°C)	(kJ/kg-K)	(kg/m³)	(kW)
13:45:12	10.24	64.05	15.3	4.19	981.03	12.73
13:50:12	10.62	65.7	14.4	4.19	980.14	11.98
13:55:12	11.2	67.1	14.2	4.19	979.36	11.8
14:00:12	11.58	68.25	12.7	4.19	978.72	10.55
14:05:12	11.77	69.3	12	4.19	978.13	9.96
14:10:12	12.64	69.6	12.4	4.19	977.96	10.29
14:15:12	12.54	70.4	11.4	4.19	977.51	9.46
14:20:12	13.02	70.45	12.1	4.19	977.48	10.04
14:25:12	13.21	71.4	11.2	4.19	976.93	9.29
14:30:12	13.31	72.1	10.4	4.19	976.52	8.62
14:35:12	13.5	73.1	9.2	4.19	975.94	7.63
14:40:12	13.78	72.7	11.2	4.19	976.17	9.29
14:45:12	13.49	74.1	8.8	4.19	975.35	7.29
14:50:12	14.36	72.8	11.6	4.19	976.12	9.62
14:55:12	14.46	73.55	10.1	4.19	975.67	8.37
15:00:12	14.17	73.65	10.7	4.19	975.62	8.87
15:05:12	13.3	74.85	8.1	4.19	974.9	6.71
15:10:12	13.49	73	11	4.19	976	9.12
15:15:12	13.2	73.45	9.9	4.19	975.73	8.21
15:20:12	13.01	71.65	13.3	4.19	976.79	11.03
15:25:12	12.72	73.15	9.9	4.19	975.91	8.21

Table F.1 The calculation results of the solar-AHT from data recorder on 15/10/2010 (Non-used water in tank, Continued).

Time	$TC_{CW,bulk}$	$\Delta T_{CW,C}$	$Cp_{CW,C}$	$\rho_{HW,C}$	Q_C	$TA_{UG,bulk}$
	('C)	('C)	(kJ/kg-K)	(kg/m^3)	(kW)	('C)
13:45:12	26.65	1.1	4.18	996.57	6.94	63.45
13:50:12	27.7	1.4	4.18	996.28	8.83	64.6
13:55:12	28.2	1.6	4.18	996.14	10.09	67.45
14:00:12	28.65	2.9	4.18	996.01	18.28	70.7
14:05:12	28.45	2.9	4.18	996.06	18.28	72.1
14:10:12	28.55	2.5	4.18	996.03	15.76	73.65
14:15:12	28.55	2.5	4.18	996.03	15.76	75.8
14:20:12	28.7	3	4.18	995.99	18.91	76.5
14:25:12	28.8	2.8	4.18	995.96	17.65	78
14:30:12	28.65	2.9	4.18	996.01	18.28	79.2
14:35:12	28.7	3	4.18	995.99	18.91	79.85
14:40:12	28.35	2.7	4.18	996.09	17.02	80.85
14:45:12	28.35	2.7	4.18	996.09	17.02	81.7
14:50:12	28.75	3.1	4.18	995.98	19.54	82.1
14:55:12	28.9	3	4.18	995.93	18.91	83.15
15:00:12	29	3	4.18	995.9	18.91	83.5
15:05:12	28.15	2.7	4.18	996.15	17.03	83.8
15:10:12	28.2	3	4.18	996.14	18.92	84.4
15:15:12	28.15	3.1	4.18	996.15	19.55	84.95
15:20:12	28.3	3.6	4.18	996.11	22.7	84.85
15:25:12	28.45	3.1	4.18	996.06	19.55	86.05

Table F.1 The calculation results of the solar-AHT from data recorder on 15/10/2010 (Non-used water in tank, Continued).

Time	$\Delta T_{UG,A}$	$Cp_{UG,A}$	$\rho_{UG,A}$	Q_A	HR_{UG}	$EER_{solar\text{-}AHT}$
	('C)	(kJ/kg-K)	(kg/m³)	(kW)	(-)	(-)
13:45:12	8.3	3.25	1073.65	11.24	0.49	5.33
13:50:12	9.8	3.25	1073.46	13.29	0.59	6.3
13:55:12	7.7	3.26	1072.99	10.47	0.46	4.97
14:00:12	6.6	3.28	1072.44	9	0.41	4.27
14:05:12	6.6	3.28	1072.2	9.02	0.41	4.28
14:10:12	5.5	3.29	1071.92	7.53	0.33	3.57
14:15:12	5	3.3	1071.54	6.86	0.31	3.25
14:20:12	4.6	3.3	1071.41	6.31	0.27	2.99
14:25:12	4.4	3.31	1071.14	6.05	0.27	2.87
14:30:12	4.2	3.31	1070.92	5.78	0.26	2.74
14:35:12	3.9	3.31	1070.8	5.37	0.25	2.55
14:40:12	3.3	3.32	1070.61	4.55	0.2	2.16
14:45:12	3	3.32	1070.45	4.14	0.2	1.96
14:50:12	3	3.32	1070.37	4.14	0.17	1.96
14:55:12	3.3	3.33	1070.17	4.56	0.2	2.16
15:00:12	3.2	3.33	1070.11	4.42	0.19	2.1
15:05:12	2.4	3.33	1070.05	3.32	0.17	1.57
15:10:12	2.2	3.33	1069.93	3.04	0.13	1.44
15:15:12	3.1	3.33	1069.83	4.29	0.2	2.03
15:20:12	2.7	3.33	1069.85	3.74	0.16	1.77
15:25:12	2.9	3.34	1069.61	4.02	0.19	1.91

Table F.1 The calculation results of the AHT from data recorder on 15/10/2010 (Non-used water in tank, Continued).

Time	P_{Low}		P_{High}		X_{max}	X_{min}	h_1
	(kPa)	(PSI)	(kPa)	(PSI)	(%LiBr)	(%LiBr)	(kJ/kg)
13:45:12	4.82	0.7	14.87	2.16	52.97	44.97	2610.05
13:50:12	4.93	0.72	17.01	2.47	53.16	44.43	2611.44
13:55:12	5.07	0.74	18.43	2.67	53.07	44.47	2612.14
14:00:12	5.07	0.74	19.76	2.87	53.12	44.7	2612.31
14:05:12	5.1	0.74	21.09	3.06	53.22	44.51	2612.83
14:10:12	6.44	0.93	21.78	3.16	50.33	44.59	2611.96
14:15:12	6.33	0.92	23	3.34	50.75	44.65	2612.66
14:20:12	6.79	0.99	22.9	3.32	49.91	44.9	2612.66
14:25:12	6.61	0.96	24.5	3.55	50.52	44.76	2613.53
14:30:12	6.44	0.93	25.4	3.68	51.12	44.72	2614.39
14:35:12	6.26	0.91	25.63	3.72	51.66	44.83	2615.08
14:40:12	6.13	0.89	26.56	3.85	52.24	44.67	2616.12
14:45:12	5.99	0.87	26.21	3.8	52.75	45.23	2616.99
14:50:12	6.16	0.89	26.32	3.82	52.07	45.22	2615.78
14:55:12	6.09	0.88	27.76	4.03	52.02	45.33	2615.26
15:00:12	6.03	0.87	27.64	4.01	52.58	45.46	2616.64
15:05:12	5.93	0.86	26.79	3.89	53.14	45.73	2617.85
15:10:12	5.8	0.84	27.4	3.97	53.11	45.71	2616.99
15:15:12	5.73	0.83	28.88	4.19	53.13	45.7	2616.64
15:20:12	6.09	0.88	25.86	3.75	52.73	46.77	2617.5
15:25:12	5.93	0.86	28.25	4.1	53.14	46.54	2617.85

Table F.1 The calculation results of the AHT from data recorder on 15/10/2010 (Non-used water in tank, Continued).

Time	h_2	m'_{ref}	m'_5	m'_8	ρ_2	v_2	ρ_5
	(kJ/kg)	(kg/s)	(kg/s)	(kg/s)	(kg/m^3)	(m^3/kg)	(kg/m^3)
13:45:12	131.17	0.0028	0.0157	0.0185	995.21	0.001	1143.99
13:50:12	132.84	0.0036	0.0181	0.0217	995.08	0.001	1143.5
13:55:12	134.93	0.0041	0.0211	0.0251	994.92	0.001	1143.32
14:00:12	134.93	0.0074	0.0392	0.0466	994.92	0.001	1143.25
14:05:12	135.35	0.0074	0.0377	0.0451	994.89	0.001	1143.06
14:10:12	152.9	0.0064	0.0498	0.0562	993.47	0.001	1143.92
14:15:12	151.65	0.0064	0.0469	0.0533	993.57	0.001	1143.69
14:20:12	157.08	0.0077	0.069	0.0767	993.11	0.001	1143.72
14:25:12	154.99	0.0072	0.0558	0.063	993.29	0.001	1143.44
14:30:12	152.9	0.0074	0.0519	0.0593	993.47	0.001	1143.11
14:35:12	150.81	0.0077	0.0504	0.0581	993.64	0.001	1142.81
14:40:12	149.14	0.0069	0.0407	0.0476	993.78	0.001	1142.36
14:45:12	147.47	0.0069	0.0415	0.0484	993.92	0.001	1141.94
14:50:12	149.56	0.0079	0.0523	0.0602	993.75	0.001	1142.51
14:55:12	148.72	0.0077	0.052	0.0596	993.82	0.001	1142.68
15:00:12	147.89	0.0077	0.0489	0.0566	993.89	0.001	1142.1
15:05:12	146.63	0.0069	0.0425	0.0494	993.99	0.001	1141.54
15:10:12	144.96	0.0077	0.0473	0.0549	994.13	0.001	1141.82
15:15:12	144.13	0.0079	0.0486	0.0565	994.2	0.001	1141.92
15:20:12	148.72	0.0092	0.0722	0.0813	993.82	0.001	1141.78
15:25:12	146.63	0.0079	0.0558	0.0637	993.99	0.001	1141.54

Table F.1 The calculation results of the AHT from data recorder on 15/10/2010 (Non-used water in tank, Continued).

Time	v_5	W_P	W_{SP}	COP_{AHT}	$(T_{A,i}-T_E)/(T_{G,i}-T_C)$
	(m^3/kg)	(W)	(W)	(-)	(-)
13:45:12	0.0009	0.00035	0.00173	0.49	0.16
13:50:12	0.0009	0.00054	0.00239	0.59	0.10
13:55:12	0.0009	0.00068	0.00307	0.46	0.15
14:00:12	0.0009	0.00136	0.00629	0.41	0.20
14:05:12	0.0009	0.00148	0.00659	0.41	0.20
14:10:12	0.0009	0.00124	0.00835	0.33	0.26
14:15:12	0.0009	0.00134	0.00854	0.31	0.28
14:20:12	0.0009	0.00156	0.01215	0.27	0.31
14:25:12	0.0009	0.00162	0.01091	0.27	0.31
14:30:12	0.0009	0.00177	0.01076	0.26	0.32
14:35:12	0.0009	0.00187	0.01067	0.25	0.32
14:40:12	0.0009	0.00177	0.00910	0.20	0.33
14:45:12	0.0009	0.00175	0.00917	0.20	0.35
14:50:12	0.0009	0.00201	0.01154	0.17	0.36
14:55:12	0.0009	0.00209	0.01231	0.20	0.35
15:00:12	0.0009	0.00208	0.01157	0.19	0.36
15:05:12	0.0009	0.00181	0.00972	0.17	0.39
15:10:12	0.0009	0.00208	0.01118	0.13	0.39
15:15:12	0.0009	0.00230	0.01232	0.20	0.37
15:20:12	0.0009	0.00229	0.01561	0.16	0.44
15:25:12	0.0009	0.00222	0.01364	0.19	0.42

Table F.2 The calculation results of the AHT from data recorder on 15/10/2010 (Used water in tank).

Time	$\rho_{UF,bulk}$	$Cp_{UF,bulk}$	Q_{ST}	$TG_{HW,bulk}$	$\Delta T_{HW,G}$	$Cp_{HW,G}$
	(kg/m³)	(kJ/kg-K)	(kW)	('C)	('C)	(kJ/kg-K)
15:36:55	984.77	4.18	4.19	71.7	12.4	4.19
15:37:55	984.8	4.18	4.18	71.75	12.3	4.19
15:38:55	984.82	4.18	4.18	71.8	12.2	4.19
15:39:55	984.87	4.18	4.15	71.75	12.1	4.19
15:40:55	984.85	4.18	4.14	71.75	12.1	4.19
15:41:55	984.87	4.18	4.13	71.85	12.1	4.19
15:42:55	984.9	4.18	4.12	71.85	12.1	4.19
15:43:55	984.92	4.18	4.11	71.85	12.1	4.19
15:44:55	984.92	4.18	4.11	71.75	11.9	4.19
15:45:55	985	4.18	4.09	71.85	11.9	4.19
15:46:55	984.9	4.18	4.09	71.9	11.8	4.19
15:47:55	984.68	4.18	4.05	71.95	11.7	4.19
15:48:55	984.65	4.18	4.04	71.95	11.7	4.19
15:52:55	984.73	4.18	3.99	71.6	12	4.19
15:53:55	984.8	4.18	3.98	71.55	11.9	4.19
15:54:55	984.65	4.18	3.97	71.6	12	4.19
15:55:55	984.8	4.18	3.98	71.55	11.9	4.19
15:56:55	984.7	4.18	3.95	71.6	11.8	4.19
15:57:55	984.7	4.18	3.95	71.6	11.8	4.19
15:58:55	984.75	4.18	3.95	71.6	11.6	4.19
15:59:55	984.8	4.18	3.95	71.55	11.5	4.19

Table F.2 The calculation results of the AHT from data recorder on 15/10/2010 (Used water in tank).

Time	$\rho_{HW,G}$	Q_G	$TE_{HW,bulk}$	$\Delta T_{HW,E}$	$Cp_{HW,E}$	$\rho_{HW,E}$	Q_E
	(kg/m³)	(kW)	(°C)	(°C)	(kJ/kg-K)	(kg/m³)	(kW)
15:36:55	976.76	11.95	72.95	10.3	4.19	976.03	8.54
15:37:55	976.73	11.85	72.8	10.6	4.19	976.12	8.79
15:38:55	976.7	11.76	72.9	10.4	4.19	976.06	8.62
15:39:55	976.73	11.66	72.8	10.6	4.19	976.12	8.79
15:40:55	976.73	11.66	72.85	10.3	4.19	976.09	8.54
15:41:55	976.67	11.66	72.95	10.3	4.19	976.03	8.54
15:42:55	976.67	11.66	72.85	10.5	4.19	976.09	8.7
15:43:55	976.67	11.66	72.7	10.6	4.19	976.17	8.79
15:44:55	976.73	11.47	72.55	10.7	4.19	976.26	8.87
15:45:55	976.67	11.47	72.55	10.9	4.19	976.26	9.04
15:46:55	976.64	11.37	72.6	10.8	4.19	976.23	8.95
15:47:55	976.61	11.27	72.75	10.5	4.19	976.14	8.71
15:48:55	976.61	11.27	72.25	11.5	4.19	976.44	9.54
15:52:55	976.81	11.56	72	11.8	4.19	976.58	9.79
15:53:55	976.84	11.47	72.1	11.4	4.19	976.52	9.45
15:54:55	976.81	11.56	72.2	11.2	4.19	976.47	9.29
15:55:55	976.84	11.47	72.15	11.3	4.19	976.49	9.37
15:56:55	976.81	11.37	72.25	11.1	4.19	976.44	9.2
15:57:55	976.81	11.37	72.3	11	4.19	976.41	9.12
15:58:55	976.81	11.18	72.15	11.1	4.19	976.49	9.21
15:59:55	976.84	11.08	72.15	10.9	4.19	976.49	9.04

Table F.2 The calculation results of the AHT from data recorder on 15/10/2010 (Used water in tank).

Time	$T_{CW,bulk,C}$	$\Delta T_{CW,C}$	$Cp_{CW,C}$	$\rho_{HW,C}$	Q_C	$T_{UG,bulk,A}$
	('C)	('C)	(kJ/kg-K)	(kg/m³)	(kW)	('C)
15:36:55	27.95	2.9	4.18	996.21	15.24	83.75
15:37:55	27.95	2.9	4.18	996.21	15.24	83.65
15:38:55	27.85	2.9	4.18	996.23	15.24	83.6
15:39:55	27.8	3	4.18	996.25	15.77	83.4
15:40:55	27.75	2.9	4.18	996.26	15.24	83.25
15:41:55	27.7	2.8	4.18	996.28	14.72	83.15
15:42:55	27.6	2.8	4.18	996.31	14.72	83.05
15:43:55	27.6	2.8	4.18	996.31	14.72	82.8
15:44:55	27.5	2.8	4.18	996.33	14.72	82.65
15:45:55	27.5	2.8	4.18	996.33	14.72	82.5
15:46:55	27.6	2.8	4.18	996.31	14.72	82.3
15:47:55	27.5	2.8	4.18	996.33	14.72	82.2
15:48:55	27.6	3	4.18	996.31	15.77	82.05
15:52:55	27.65	2.9	4.18	996.29	15.24	81.55
15:53:55	27.65	2.9	4.18	996.29	15.24	81.65
15:54:55	27.6	2.8	4.18	996.31	14.72	81.55
15:55:55	27.6	2.8	4.18	996.31	14.72	81.45
15:56:55	27.55	2.9	4.18	996.32	15.24	81.3
15:57:55	27.6	2.8	4.18	996.31	14.72	81.25
15:58:55	27.6	2.8	4.18	996.31	14.72	81.1
15:59:55	27.55	2.9	4.18	996.32	15.24	81.05

Table F.2 The calculation results of the AHT from data recorder on 15/10/2010 (Used water in tank).

Time	$\Delta T_{UG,A}$	$Cp_{UG,A}$	$\rho_{UG,G}$	Q_A	HR_{UG}	HR_{ST}	EER_{AHT}
	('C)	(kJ/kg-K)	(kg/m^3)	(kW)	(-)	(-)	(-)
15:36:55	5.7	3.33	1070.06	7.88	0.38	0.17	3.74
15:37:55	5.7	3.33	1070.08	7.88	0.38	0.16	3.74
15:38:55	5.8	3.33	1070.09	8.02	0.39	0.16	3.8
15:39:55	5.8	3.33	1070.13	8.02	0.39	0.16	3.8
15:40:55	5.9	3.33	1070.16	8.15	0.4	0.17	3.87
15:41:55	5.9	3.33	1070.17	8.15	0.4	0.16	3.87
15:42:55	5.9	3.32	1070.19	8.15	0.4	0.16	3.87
15:43:55	6.2	3.32	1070.24	8.56	0.42	0.16	4.06
15:44:55	6.1	3.32	1070.27	8.42	0.41	0.16	3.99
15:45:55	6	3.32	1070.3	8.28	0.4	0.16	3.93
15:46:55	6	3.32	1070.34	8.28	0.41	0.16	3.93
15:47:55	6	3.32	1070.36	8.28	0.41	0.17	3.93
15:48:55	5.9	3.32	1070.38	8.14	0.39	0.15	3.86
15:52:55	5.9	3.32	1070.48	8.14	0.38	0.14	3.86
15:53:55	6.1	3.32	1070.46	8.42	0.4	0.14	3.99
15:54:55	6.1	3.32	1070.48	8.41	0.4	0.16	3.99
15:55:55	6.3	3.32	1070.5	8.69	0.42	0.15	4.12
15:56:55	6.4	3.32	1070.53	8.83	0.43	0.15	4.19
15:57:55	6.5	3.32	1070.54	8.96	0.44	0.15	4.25
15:58:55	6.6	3.32	1070.56	9.1	0.45	0.15	4.32
15:59:55	6.7	3.32	1070.57	9.24	0.46	0.15	4.38

Table F.2 The calculation results of the AHT from data recorder on 15/10/2010 (Used water in tank).

Time	P_{Low}		P_{High}		X_{max}	X_{min}	h_1
	(kPa)	(PSI)	(kPa)	(PSI)	(%LiBr)	(%LiBr)	(kJ/kg)
15:36:55	6.47	0.94	27.76	4.03	52.38	46.45	2618.54
15:37:55	6.4	0.93	28.01	4.06	52.45	46.32	2618.37
15:38:55	6.37	0.92	27.76	4.03	52.62	46.45	2618.71
15:39:55	6.33	0.92	27.64	4.01	52.63	46.4	2618.54
15:40:55	6.26	0.91	27.64	4.01	52.8	46.4	2618.71
15:41:55	6.23	0.9	27.64	4.01	52.86	46.34	2618.71
15:42:55	6.16	0.89	27.4	3.97	52.98	46.41	2618.71
15:43:55	6.09	0.88	27.52	3.99	53.11	46.29	2618.71
15:44:55	6.06	0.88	27.15	3.94	53.22	46.36	2618.88
15:45:55	5.99	0.87	27.27	3.96	53.34	46.24	2618.88
15:46:55	6.09	0.88	27.15	3.94	53.42	46.36	2619.75
15:47:55	6.33	0.92	27.03	3.92	53.48	46.71	2621.3
15:48:55	6.87	1	26.79	3.89	52.58	46.73	2621.3
15:52:55	7.02	1.02	25.4	3.68	52.12	47.26	2620.61
15:53:55	6.98	1.01	25.63	3.72	52.23	47.19	2620.78
15:54:55	7.17	1.04	25.97	3.77	52.2	47.17	2621.64
15:55:55	6.87	1	25.97	3.77	52.31	47	2620.43
15:56:55	7.06	1.02	25.97	3.77	52.44	47.17	2621.81
15:57:55	7.02	1.02	26.09	3.78	52.5	47.05	2621.81
15:58:55	6.91	1	25.97	3.77	52.62	47.06	2621.64
15:59:55	6.83	0.99	25.97	3.77	52.75	46.94	2621.64

Table F.2 The calculation results of the AHT from data recorder on 15/10/2010 (Used water in tank).

Time	h_2	m'_{ref}	m'_5	m'_8	ρ_2	v_2	ρ_5
	(kJ/kg)	(kg/s)	(kg/s)	(kg/s)	(kg/m^3)	(m^3/kg)	(kg/m^3)
15:36:55	153.32	0.0062	0.0484	0.0546	993.43	0.001	1141.56
15:37:55	152.49	0.0062	0.0467	0.0529	993.5	0.001	1141.6
15:38:55	152.07	0.0062	0.0465	0.0527	993.54	0.001	1141.44
15:39:55	151.65	0.0064	0.0476	0.054	993.57	0.001	1141.49
15:40:55	150.81	0.0062	0.0448	0.0509	993.64	0.001	1141.38
15:41:55	150.4	0.006	0.0424	0.0483	993.68	0.001	1141.36
15:42:55	149.56	0.006	0.0421	0.0481	993.75	0.001	1141.32
15:43:55	148.72	0.006	0.0404	0.0464	993.82	0.001	1141.28
15:44:55	148.31	0.006	0.0403	0.0462	993.85	0.001	1141.18
15:45:55	147.47	0.006	0.0388	0.0447	993.92	0.001	1141.13
15:46:55	148.72	0.006	0.0391	0.0451	993.82	0.001	1140.83
15:47:55	151.65	0.006	0.0411	0.0471	993.57	0.001	1140.32
15:48:55	157.92	0.0064	0.0511	0.0575	993.03	0.001	1140.64
15:52:55	159.59	0.0062	0.0602	0.0664	992.89	0.001	1140.98
15:53:55	159.17	0.0062	0.058	0.0642	992.92	0.001	1140.9
15:54:55	161.26	0.006	0.0561	0.0621	992.74	0.001	1140.63
15:55:55	157.92	0.006	0.0529	0.0589	993.03	0.001	1140.99
15:56:55	160.01	0.0062	0.0554	0.0616	992.85	0.001	1140.51
15:57:55	159.59	0.006	0.0516	0.0576	992.89	0.001	1140.49
15:58:55	158.34	0.006	0.0506	0.0565	993	0.001	1140.51
15:59:55	157.5	0.0062	0.05	0.0562	993.07	0.001	1140.47

Table F.2 The calculation results of the AHT from data recorder on 15/10/2010 (Used water in tank).

Time	v_5	W_P	W_{SP}	COP_{AHT}	$(T_{A,i}-T_E)/(T_{G,i}-T_C)$
	(m^3/kg)	(W)	(W)	(-)	(-)
15:36:55	0.0009	0.00166	0.01129	0.38	0.35
15:37:55	0.0009	0.00168	0.01105	0.38	0.34
15:38:55	0.0009	0.00166	0.01090	0.39	0.35
15:39:55	0.0009	0.00171	0.01111	0.39	0.34
15:40:55	0.0009	0.00166	0.01048	0.40	0.34
15:41:55	0.0009	0.00161	0.00994	0.40	0.33
15:42:55	0.0009	0.00159	0.00979	0.40	0.33
15:43:55	0.0009	0.00161	0.00949	0.42	0.32
15:44:55	0.0009	0.00158	0.00930	0.41	0.33
15:45:55	0.0009	0.00159	0.00904	0.40	0.32
15:46:55	0.0009	0.00158	0.00902	0.41	0.32
15:47:55	0.0009	0.00155	0.00933	0.41	0.32
15:48:55	0.0009	0.00161	0.01117	0.39	0.34
15:52:55	0.0009	0.00143	0.01213	0.38	0.36
15:53:55	0.0009	0.00145	0.01184	0.40	0.36
15:54:55	0.0009	0.00142	0.01156	0.40	0.35
15:55:55	0.0009	0.00144	0.01107	0.42	0.34
15:56:55	0.0009	0.00147	0.01149	0.43	0.34
15:57:55	0.0009	0.00143	0.01079	0.44	0.33
15:58:55	0.0009	0.00143	0.01057	0.45	0.33
15:59:55	0.0009	0.00149	0.01048	0.46	0.32

The calculation results of the solar-CAHT

Table F.3 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Non-used water in tank).

Time	$\rho_{Gly\text{-}Water}$ (kg/m³)	$Cp_{Gly\text{-}Water}$ (kJ/kg-K)	Q_{ST} (kW)	$TG_{HW,bulk}$ ('C)	$\Delta T_{HW,G}$ ('C)	$Cp_{HW,G}$ (kJ/kg-K)	$\rho_{HW,G}$ (kg/m³)
14:00:12	1071.77	3.29	7.57	68.50	12.00	4.19	978.58
14:05:12	1071.29	3.30	7.30	69.10	12.20	4.19	978.24
14:10:12	1071.03	3.31	6.54	69.15	13.10	4.19	978.22
14:15:12	1070.75	3.31	6.07	69.40	13.00	4.19	978.07
14:20:12	1070.43	3.32	5.79	69.55	13.50	4.19	977.99
14:25:12	1070.24	3.32	5.38	70.05	13.70	4.19	977.71
14:30:12	1069.97	3.33	5.16	70.20	13.80	4.19	977.62
14:35:12	1069.76	3.33	4.92	70.60	14.00	4.19	977.39
14:40:12	1069.64	3.34	4.61	71.05	14.30	4.19	977.13
14:45:12	1069.47	3.34	4.41	71.30	14.00	4.19	976.99
14:50:12	1069.41	3.34	4.13	70.95	14.90	4.19	977.19
14:55:12	1069.25	3.34	3.98	70.90	15.00	4.19	977.22
15:00:12	1069.03	3.35	3.89	71.45	14.70	4.19	976.90
15:05:12	1068.97	3.35	3.70	71.70	13.80	4.19	976.76
15:10:12	1068.93	3.35	3.51	71.40	14.00	4.19	976.93
15:15:12	1068.79	3.35	3.41	71.35	13.70	4.19	976.96
15:20:12	1068.59	3.36	3.36	71.35	13.50	4.19	976.96
15:25:12	1068.52	3.36	3.23	71.40	13.20	4.19	976.93
15:30:12	1068.52	3.36	3.20	71.45	12.90	4.19	976.90
15:35:12	1068.50	3.36	3.18	71.55	12.70	4.19	976.84
15:40:12	1068.46	3.36	3.17	71.65	12.70	4.19	976.79

Table F.3 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Non-used water in tank, Continued).

Time	Q_G	$TE_{HW,bulk}$	$\Delta T_{HW,E}$	$Cp_{HW,E}$	$\rho_{HW,E}$	Q_E
	(kW)	('C)	('C)	(kJ/kg-K)	(kg/m³)	(kW)
14:00:12	11.58	68.25	12.70	4.19	978.72	10.55
14:05:12	11.77	69.30	12.00	4.19	978.13	9.96
14:10:12	12.64	69.60	12.40	4.19	977.96	10.29
14:15:12	12.54	70.40	11.40	4.19	977.51	9.46
14:20:12	13.02	70.45	12.10	4.19	977.48	10.04
14:25:12	13.21	71.40	11.20	4.19	976.93	9.29
14:30:12	13.31	72.10	10.40	4.19	976.52	8.62
14:35:12	13.50	73.10	9.20	4.19	975.94	7.63
14:40:12	13.78	72.70	11.20	4.19	976.17	9.29
14:45:12	13.49	74.10	8.80	4.19	975.35	7.29
14:50:12	14.36	72.80	11.60	4.19	976.12	9.62
14:55:12	14.46	73.55	10.10	4.19	975.67	8.37
15:00:12	14.17	73.65	10.70	4.19	975.62	8.87
15:05:12	13.30	74.85	8.10	4.19	974.90	6.71
15:10:12	13.49	73.00	11.00	4.19	976.00	9.12
15:15:12	13.20	73.45	9.90	4.19	975.73	8.21
15:20:12	13.01	71.65	13.30	4.19	976.79	11.03
15:25:12	12.72	73.15	9.90	4.19	975.91	8.21
15:30:12	12.43	73.25	9.70	4.19	975.85	8.04
15:35:12	12.24	73.30	9.60	4.19	975.82	7.96
15:40:12	12.24	73.30	9.60	4.19	975.82	7.96

Table F.3 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Non-used water in tank, Continued).

Time	$TC_{CW,bulk}$	$\Delta T_{CW,C}$	$Cp_{CW,C}$	$\rho_{HW,C}$	Q_C	$TA_{UG,bulk}$
	('C)	('C)	(kJ/kg-K)	(kg/m^3)	(kW)	('C)
14:00:12	28.65	2.90	4.18	996.01	18.28	70.70
14:05:12	28.45	2.90	4.18	996.06	18.28	72.10
14:10:12	28.55	2.50	4.18	996.03	15.76	73.65
14:15:12	28.55	2.50	4.18	996.03	15.76	75.80
14:20:12	28.70	3.00	4.18	995.99	18.91	76.50
14:25:12	28.80	2.80	4.18	995.96	17.65	78.00
14:30:12	28.65	2.90	4.18	996.01	18.28	79.20
14:35:12	28.70	3.00	4.18	995.99	18.91	79.85
14:40:12	28.35	2.70	4.18	996.09	17.02	80.85
14:45:12	28.35	2.70	4.18	996.09	17.02	81.70
14:50:12	28.75	3.10	4.18	995.98	19.54	82.10
14:55:12	28.90	3.00	4.18	995.93	18.91	83.15
15:00:12	29.00	3.00	4.18	995.90	18.91	83.50
15:05:12	28.15	2.70	4.18	996.15	17.03	83.80
15:10:12	28.20	3.00	4.18	996.14	18.92	84.40
15:15:12	28.15	3.10	4.18	996.15	19.55	84.95
15:20:12	28.30	3.60	4.18	996.11	22.70	84.85
15:25:12	28.45	3.10	4.18	996.06	19.55	86.05
15:30:12	28.35	3.10	4.18	996.09	19.55	86.25
15:35:12	28.25	3.10	4.18	996.12	19.55	86.40
15:40:12	28.30	3.00	4.18	996.11	18.92	86.50

Table F.3 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Non-used water in tank, Continued).

Time	$\Delta T_{UG,A}$	$Cp_{UG,A}$	$\rho_{UG,A}$	Q_A	HR_{UG}	$EER_{solar\text{-}CAHT}$
	(°C)	(kJ/kg-K)	(kg/m³)	(kW)	(-)	(-)
14:00:12	6.60	3.28	1072.44	9.00	0.41	4.27
14:05:12	6.60	3.28	1072.20	9.02	0.41	4.28
14:10:12	5.50	3.29	1071.92	7.53	0.33	3.57
14:15:12	5.00	3.30	1071.54	6.86	0.31	3.25
14:20:12	4.60	3.30	1071.41	6.31	0.27	2.99
14:25:12	4.40	3.31	1071.14	6.05	0.27	2.87
14:30:12	4.20	3.31	1070.92	5.78	0.26	2.74
14:35:12	3.90	3.31	1070.80	5.37	0.25	2.55
14:40:12	3.30	3.32	1070.61	4.55	0.20	2.16
14:45:12	3.00	3.32	1070.45	4.14	0.20	1.96
14:50:12	3.00	3.32	1070.37	4.14	0.17	1.96
14:55:12	3.30	3.33	1070.17	4.56	0.20	2.16
15:00:12	3.20	3.33	1070.11	4.42	0.19	2.10
15:05:12	2.40	3.33	1070.05	3.32	0.17	1.57
15:10:12	2.20	3.33	1069.93	3.04	0.13	1.44
15:15:12	3.10	3.33	1069.83	4.29	0.20	2.03
15:20:12	2.70	3.33	1069.85	3.74	0.16	1.77
15:25:12	2.90	3.34	1069.61	4.02	0.19	1.91
15:30:12	3.10	3.34	1069.57	4.30	0.21	2.04
15:35:12	3.20	3.34	1069.54	4.44	0.22	2.10
15:40:12	3.40	3.34	1069.52	4.71	0.23	2.24

Table F.3 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Non-used water in tank, Continued).

Time	P_{Low}		P_{High}		X_{max}	X_{min}	h_1
	(kPa)	(PSI)	(kPa)	(PSI)	(%LiBr)	(%LiBr)	(kJ/kg)
14:00:12	5.07	0.74	19.76	2.87	53.12	44.7	2575.48
14:05:12	5.10	0.74	21.09	3.06	53.22	44.51	2575.30
14:10:12	6.44	0.93	21.78	3.16	50.33	44.59	2575.48
14:15:12	6.33	0.92	23.00	3.34	50.75	44.65	2574.76
14:20:12	6.79	0.99	22.90	3.32	49.91	44.9	2574.94
14:25:12	6.61	0.96	24.50	3.55	50.52	44.76	2574.40
14:30:12	6.44	0.93	25.40	3.68	51.12	44.72	2570.29
14:35:12	6.26	0.91	25.63	3.72	51.66	44.83	2569.93
14:40:12	6.13	0.89	26.56	3.85	52.24	44.67	2568.50
14:45:12	5.99	0.87	26.21	3.80	52.75	45.23	2569.75
14:50:12	6.16	0.89	26.32	3.82	52.07	45.22	2568.50
14:55:12	6.09	0.88	27.76	4.03	52.02	45.33	2570.11
15:00:12	6.03	0.87	27.64	4.01	52.58	45.46	2571.01
15:05:12	5.93	0.86	26.79	3.89	53.14	45.73	2564.55
15:10:12	5.80	0.84	27.40	3.97	53.11	45.71	2560.41
15:15:12	5.73	0.83	28.88	4.19	53.13	45.7	2559.15
15:20:12	6.09	0.88	25.86	3.75	52.73	46.77	2558.07
15:25:12	5.93	0.86	28.25	4.10	53.14	46.54	2557.17
15:30:12	5.89	0.85	28.38	4.12	53.31	46.65	2557.35
15:35:12	5.89	0.85	28.76	4.17	53.25	46.52	2556.81
15:40:12	5.89	0.85	29.01	4.21	53.31	46.45	2556.81

Table F.3 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Non-used water in tank, Continued).

Time	h_2	m'_{ref}	m'_5	m'_8	ρ_2	v_2	ρ_5
	(kJ/kg)	(kg/s)	(kg/s)	(kg/s)	(kg/m^3)	(m^3/kg)	(kg/m^3)
14:00:12	142.45	0.0017	0.0091	0.0108	994.33	0.0010	1153.48
14:05:12	138.27	0.0017	0.0088	0.0105	994.66	0.0010	1153.49
14:10:12	144.96	0.0017	0.0134	0.0151	994.13	0.0010	1154.04
14:15:12	145.38	0.0017	0.0126	0.0143	994.09	0.0010	1154.20
14:20:12	143.71	0.0017	0.0154	0.0171	994.23	0.0010	1154.18
14:25:12	147.05	0.0017	0.0134	0.0151	993.96	0.0010	1154.30
14:30:12	134.09	0.0017	0.0120	0.0137	994.99	0.0010	1155.25
14:35:12	144.54	0.0017	0.0113	0.0130	994.16	0.0010	1155.25
14:40:12	137.44	0.0017	0.0101	0.0119	994.73	0.0010	1155.46
14:45:12	134.51	0.0017	0.0103	0.0120	994.95	0.0010	1155.01
14:50:12	137.02	0.0017	0.0113	0.0131	994.76	0.0010	1155.50
14:55:12	141.20	0.0017	0.0117	0.0134	994.43	0.0010	1155.13
15:00:12	144.54	0.0017	0.0110	0.0127	994.16	0.0010	1154.76
15:05:12	132.84	0.0017	0.0106	0.0123	995.08	0.0010	1156.10
15:10:12	134.51	0.0017	0.0106	0.0124	994.95	0.0010	1157.06
15:15:12	134.09	0.0017	0.0106	0.0123	994.99	0.0010	1157.33
15:20:12	125.73	0.0017	0.0135	0.0152	995.61	0.0010	1157.71
15:25:12	126.57	0.0017	0.0121	0.0138	995.55	0.0010	1157.77
15:30:12	124.90	0.0017	0.0120	0.0138	995.67	0.0010	1157.66
15:35:12	124.90	0.0017	0.0119	0.0136	995.67	0.0010	1157.81
15:40:12	123.64	0.0017	0.0116	0.0134	995.76	0.0010	1157.78

Table F.3 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Non-used water in tank, Continued).

Time	v_5	W_P	W_{SP}	COP_{CAHT}	$(T_{A,i}-T_E)/(T_{G,i}-T_C)$
	(m^3/kg)	(W)	(W)	(-)	(-)
14:00:12	0.0009	0.00015	0.00013	0.41	0.20
14:05:12	0.0009	0.00016	0.00014	0.41	0.20
14:10:12	0.0009	0.00015	0.00013	0.33	0.26
14:15:12	0.0009	0.00017	0.00014	0.31	0.28
14:20:12	0.0009	0.00016	0.00014	0.27	0.31
14:25:12	0.0009	0.00018	0.00015	0.27	0.31
14:30:12	0.0009	0.00019	0.00016	0.26	0.32
14:35:12	0.0009	0.00019	0.00017	0.25	0.32
14:40:12	0.0009	0.00021	0.00018	0.20	0.33
14:45:12	0.0009	0.00020	0.00017	0.20	0.35
14:50:12	0.0009	0.00020	0.00017	0.17	0.36
14:55:12	0.0009	0.00022	0.00019	0.20	0.35
15:00:12	0.0009	0.00022	0.00019	0.19	0.36
15:05:12	0.0009	0.00021	0.00018	0.17	0.39
15:10:12	0.0009	0.00022	0.00019	0.13	0.39
15:15:12	0.0009	0.00023	0.00020	0.20	0.37
15:20:12	0.0009	0.00020	0.00017	0.16	0.44
15:25:12	0.0009	0.00022	0.00019	0.19	0.42
15:30:12	0.0009	0.00023	0.00019	0.21	0.42
15:35:12	0.0009	0.00023	0.00020	0.22	0.41
15:40:12	0.0009	0.00023	0.00020	0.23	0.41

Table F.3 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Non-used water in tank, Continued).

Time	$T_{UG,o}$-$T_{CW,o}$	$T_{bulk,CW}$	ΔT_{CW}	Cp_{CW}	ρ_{CW}	Q_{CW}
	('C)	('C)	('C)	(kJ/kg-'C)	(kg/m^3)	(kW)
14:00:12	45.20	24.15	1.70	4.1820	997.22	5.57
14:05:12	45.50	24.40	1.60	4.1819	997.16	5.24
14:10:12	45.60	24.20	1.60	4.1819	997.21	5.24
14:15:12	45.60	24.55	1.70	4.1818	997.12	5.57
14:20:12	45.80	24.45	1.70	4.1818	997.14	5.57
14:25:12	45.70	24.45	1.70	4.1818	997.14	5.57
14:30:12	45.40	24.90	1.60	4.1816	997.03	5.24
14:35:12	45.00	25.25	1.50	4.1815	996.94	4.91
14:40:12	45.20	25.15	1.30	4.1815	996.96	4.26
14:45:12	45.10	25.10	1.60	4.1816	996.98	5.24
14:50:12	45.20	25.00	1.60	4.1816	997.00	5.24
14:55:12	45.10	25.10	1.60	4.1816	996.98	5.24
15:00:12	45.30	25.00	1.60	4.1816	997.00	5.24
15:05:12	45.80	24.70	1.60	4.1817	997.08	5.24
15:10:12	46.00	24.55	1.50	4.1818	997.12	4.92
15:15:12	46.00	24.45	1.30	4.1818	997.14	4.26
15:20:12	45.50	24.70	1.60	4.1817	997.08	5.24
15:25:12	45.30	24.85	1.50	4.1817	997.04	4.92
15:30:12	45.30	25.00	1.40	4.1816	997.00	4.59
15:35:12	45.20	25.00	1.60	4.1816	997.00	5.24
15:40:12	45.20	25.10	1.60	4.1816	996.98	5.24

Table F.3 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Non-used water in tank, Continued).

Time	$T_{bulk,UG}$	ΔT_{UG}	Cp_{UG}	ρ_{UG}	Q_{UG}	$Cp_{UG,Tank}$
	('C)	('C)	(kJ/kg-'C)	(kg/m^3)	(kW)	(kJ/kg-'C)
14:00:12	72.50	4.60	4.1917	976.29	7.55	4.1903
14:05:12	73.00	4.60	4.1920	976.00	7.55	4.1906
14:10:12	72.95	4.70	4.1920	976.03	7.72	4.1906
14:15:12	73.30	4.60	4.1922	975.82	7.55	4.1908
14:20:12	73.50	4.80	4.1924	975.70	7.88	4.1909
14:25:12	73.25	4.50	4.1922	975.85	7.39	4.1908
14:30:12	73.30	4.40	4.1922	975.82	7.22	4.1909
14:35:12	73.30	4.60	4.1922	975.82	7.55	4.1908
14:40:12	73.25	4.50	4.1922	975.85	7.39	4.1908
14:45:12	73.30	4.60	4.1922	975.82	7.55	4.1908
14:50:12	73.35	4.70	4.1923	975.79	7.72	4.1908
14:55:12	73.35	4.70	4.1923	975.79	7.72	4.1908
15:00:12	73.40	4.60	4.1923	975.76	7.55	4.1909
15:05:12	73.60	4.60	4.1924	975.65	7.55	4.1910
15:10:12	73.60	4.60	4.1924	975.65	7.55	4.1910
15:15:12	73.45	4.70	4.1923	975.73	7.72	4.1909
15:20:12	73.35	4.70	4.1923	975.79	7.72	4.1908
15:25:12	73.25	4.70	4.1922	975.85	7.72	4.1908
15:30:12	73.30	4.60	4.1922	975.82	7.55	4.1908
15:35:12	73.35	4.70	4.1923	975.79	7.72	4.1908
15:40:12	73.40	4.60	4.1923	975.76	7.55	4.1909

Table F.3 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Non-used water in tank, Continued).

Time	$\rho_{UG,Tank}$	$Q_{UG,Tank}$	$T_{UG,o}$-$T_{CW,o}$	W_{Comp}	EER_{VCHP}
	(kJ/kg-'C)	(kW)	('C)	(kW)	(-)
14:00:12	974.93	0	45.20	2.96	2.56
14:05:12	974.64	1.36	45.50	2.96	2.55
14:10:12	974.64	0.54	45.60	2.96	2.61
14:15:12	974.46	0.73	45.60	2.96	2.55
14:20:12	974.28	0.61	45.80	2.96	2.66
14:25:12	974.52	0.44	45.70	2.96	2.50
14:30:12	974.52	0.41	45.40	2.96	2.44
14:35:12	974.46	0.31	45.00	2.95	2.56
14:40:12	974.52	0.30	45.20	2.96	2.50
14:45:12	974.46	0.29	45.10	2.95	2.56
14:50:12	974.40	0.29	45.20	2.96	2.61
14:55:12	974.40	0.28	45.10	2.95	2.61
15:00:12	974.40	0.31	45.30	2.96	2.55
15:05:12	974.28	0.35	45.80	2.96	2.55
15:10:12	974.28	0.34	46.00	2.96	2.55
15:15:12	974.34	0.27	46.00	2.96	2.60
15:20:12	974.40	0.23	45.50	2.96	2.61
15:25:12	974.46	0.19	45.30	2.96	2.61
15:30:12	974.46	0.22	45.30	2.96	2.55
15:35:12	974.40	0.21	45.20	2.96	2.61
15:40:12	974.40	0.24	45.20	2.96	2.56

Table F.4 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Used water in tank).

Time	$\rho_{UF,bulk}$	$Cp_{UF,bulk}$	Q_{ST}	$TG_{HW,bulk}$	$\Delta T_{HW,G}$	$Cp_{HW,G}$
	(kg/m³)	(kJ/kg-K)	(kW)	('C)	('C)	(kJ/kg-K)
15:45:55	1068.93	3.35	3.28	71.80	12.20	4.19
15:46:55	1068.87	3.35	3.32	71.75	12.10	4.19
15:47:55	1069.01	3.35	3.40	71.75	12.10	4.19
15:48:55	1068.83	3.35	3.30	71.85	12.10	4.19
15:49:55	1068.89	3.35	3.33	71.85	12.10	4.19
15:50:55	1068.91	3.35	3.32	71.85	12.10	4.19
15:51:55	1068.93	3.35	3.21	71.75	11.90	4.19
15:52:55	1068.95	3.35	3.29	71.85	11.90	4.19
15:53:55	1069.05	3.35	3.24	71.90	11.80	4.19
15:54:55	1068.79	3.35	3.32	71.95	11.70	4.19
15:55:55	1068.81	3.35	3.08	71.95	11.70	4.19
15:56:55	1069.03	3.35	2.94	71.60	12.00	4.19
15:57:55	1068.93	3.35	3.03	71.55	11.90	4.19
15:58:55	1068.93	3.35	3.28	71.60	12.00	4.19
15:59:55	1069.09	3.35	3.07	71.55	11.90	4.19
16:00:55	1068.91	3.35	3.15	71.60	11.80	4.19
16:01:55	1068.99	3.35	3.17	71.60	11.80	4.19
16:02:55	1069.05	3.35	3.12	71.60	11.60	4.19
16:03:55	1069.09	3.35	3.09	71.55	11.50	4.19
16:04:55	1068.93	3.35	2.93	71.50	11.40	4.19
16:05:55	1069.54	3.34	3.77	71.45	11.90	4.19

Table F.4 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Used water in tank, Continued).

Time	$\rho_{HW,G}$	Q_G	$TE_{HW,bulk}$	$\Delta T_{HW,E}$	$Cp_{HW,E}$	$\rho_{HW,E}$	Q_E
	(kg/m³)	(kW)	('C)	('C)	(kJ/kg-K)	(kg/m³)	(kW)
15:45:55	976.70	11.76	72.90	10.40	4.19	976.06	8.62
15:46:55	976.73	11.66	72.80	10.60	4.19	976.12	8.79
15:47:55	976.73	11.66	72.85	10.30	4.19	976.09	8.54
15:48:55	976.67	11.66	72.95	10.30	4.19	976.03	8.54
15:49:55	976.67	11.66	72.85	10.50	4.19	976.09	8.70
15:50:55	976.67	11.66	72.70	10.60	4.19	976.17	8.79
15:51:55	976.73	11.47	72.55	10.70	4.19	976.26	8.87
15:52:55	976.67	11.47	72.55	10.90	4.19	976.26	9.04
15:53:55	976.64	11.37	72.60	10.80	4.19	976.23	8.95
15:54:55	976.61	11.27	72.75	10.50	4.19	976.14	8.71
15:55:55	976.61	11.27	72.25	11.50	4.19	976.44	9.54
15:56:55	976.81	11.56	72.00	11.80	4.19	976.58	9.79
15:57:55	976.84	11.47	72.10	11.40	4.19	976.52	9.45
15:58:55	976.81	11.56	72.20	11.20	4.19	976.47	9.29
15:59:55	976.84	11.47	72.15	11.30	4.19	976.49	9.37
16:00:55	976.81	11.37	72.25	11.10	4.19	976.44	9.20
16:01:55	976.81	11.37	72.30	11.00	4.19	976.41	9.12
16:02:55	976.81	11.18	72.15	11.10	4.19	976.49	9.21
16:03:55	976.84	11.08	72.15	10.90	4.19	976.49	9.04
16:04:55	976.87	10.99	71.95	11.10	4.19	976.61	9.21
16:05:55	976.90	11.47	71.85	11.70	4.19	976.67	9.70

Table F.4 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Used water in tank, Continued).

Time	$T_{CW,bulk,C}$	$\Delta T_{CW,C}$	$Cp_{CW,C}$	$\rho_{HW,C}$	Q_C	$T_{UG,bulk,A}$
	('C)	('C)	(kJ/kg-K)	(kg/m³)	(kW)	('C)
15:45:55	27.85	2.90	4.18	996.23	15.24	83.60
15:46:55	27.80	3.00	4.18	996.25	15.77	83.40
15:47:55	27.75	2.90	4.18	996.26	15.24	83.25
15:48:55	27.70	2.80	4.18	996.28	14.72	83.15
15:49:55	27.60	2.80	4.18	996.31	14.72	83.05
15:50:55	27.60	2.80	4.18	996.31	14.72	82.80
15:51:55	27.50	2.80	4.18	996.33	14.72	82.65
15:52:55	27.50	2.80	4.18	996.33	14.72	82.50
15:53:55	27.60	2.80	4.18	996.31	14.72	82.30
15:54:55	27.50	2.80	4.18	996.33	14.72	82.20
15:55:55	27.60	3.00	4.18	996.31	15.77	82.05
15:56:55	27.65	2.90	4.18	996.29	15.24	81.55
15:57:55	27.65	2.90	4.18	996.29	15.24	81.65
15:58:55	27.60	2.80	4.18	996.31	14.72	81.55
15:59:55	27.60	2.80	4.18	996.31	14.72	81.45
16:00:55	27.55	2.90	4.18	996.32	15.24	81.30
16:01:55	27.60	2.80	4.18	996.31	14.72	81.25
16:02:55	27.60	2.80	4.18	996.31	14.72	81.10
16:03:55	27.55	2.90	4.18	996.32	15.24	81.05
16:04:55	27.50	2.80	4.18	996.33	14.72	80.95
16:05:55	27.35	2.90	4.18	996.38	15.24	80.20

Table F.4 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Used water in tank, Continued).

Time	$\Delta T_{UG,A}$ ('C)	$Cp_{UG,A}$ (kJ/kg-K)	$\rho_{UG,G}$ (kg/m³)	Q_A (kW)	HR_{UG} (-)	HR_{ST} (-)	EER_{CAHT} (-)
15:45:55	5.80	3.33	1070.09	8.02	0.39	0.16	3.80
15:46:55	5.80	3.33	1070.13	8.02	0.39	0.16	3.80
15:47:55	5.90	3.33	1070.16	8.15	0.40	0.17	3.87
15:48:55	5.90	3.33	1070.17	8.15	0.40	0.16	3.87
15:49:55	5.90	3.32	1070.19	8.15	0.40	0.16	3.87
15:50:55	6.20	3.32	1070.24	8.56	0.42	0.16	4.06
15:51:55	6.10	3.32	1070.27	8.42	0.41	0.16	3.99
15:52:55	6.00	3.32	1070.30	8.28	0.40	0.16	3.93
15:53:55	6.00	3.32	1070.34	8.28	0.41	0.16	3.93
15:54:55	6.00	3.32	1070.36	8.28	0.41	0.17	3.93
15:55:55	5.90	3.32	1070.38	8.14	0.39	0.15	3.86
15:56:55	5.90	3.32	1070.48	8.14	0.38	0.14	3.86
15:57:55	6.10	3.32	1070.46	8.42	0.40	0.14	3.99
15:58:55	6.10	3.32	1070.48	8.41	0.40	0.16	3.99
15:59:55	6.30	3.32	1070.50	8.69	0.42	0.15	4.12
16:00:55	6.40	3.32	1070.53	8.83	0.43	0.15	4.19
16:01:55	6.50	3.32	1070.54	8.96	0.44	0.15	4.25
16:02:55	6.60	3.32	1070.56	9.10	0.45	0.15	4.32
16:03:55	6.70	3.32	1070.57	9.24	0.46	0.15	4.38
16:04:55	6.50	3.32	1070.59	8.96	0.44	0.14	4.25
16:05:55	6.80	3.31	1070.73	9.37	0.44	0.18	4.44

Table F.4 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Used water in tank, Continued).

Time	P_{Low}		P_{High}		X_{max}	X_{min}	h_1
	(kPa)	(PSI)	(kPa)	(PSI)	(%LiBr)	(%LiBr)	(kJ/kg)
15:45:55	6.37	0.92	27.76	4.03	52.62	46.45	2648.85
15:46:55	6.33	0.92	27.64	4.01	52.63	46.4	2648.35
15:47:55	6.26	0.91	27.64	4.01	52.8	46.4	2648.35
15:48:55	6.23	0.90	27.64	4.01	52.86	46.34	2648.18
15:49:55	6.16	0.89	27.40	3.97	52.98	46.41	2648.02
15:50:55	6.09	0.88	27.52	3.99	53.11	46.29	2647.85
15:51:55	6.06	0.88	27.15	3.94	53.22	46.36	2647.85
15:52:55	5.99	0.87	27.27	3.96	53.34	46.24	2647.35
15:53:55	6.09	0.88	27.15	3.94	53.42	46.36	2647.68
15:54:55	6.33	0.92	27.03	3.92	53.48	46.71	2648.02
15:55:55	6.87	1.00	26.79	3.89	52.58	46.73	2648.02
15:56:55	7.02	1.02	25.40	3.68	52.12	47.26	2647.19
15:57:55	6.98	1.01	25.63	3.72	52.23	47.19	2646.85
15:58:55	7.17	1.04	25.97	3.77	52.2	47.17	2647.19
15:59:55	6.87	1.00	25.97	3.77	52.31	47	2646.85
16:00:55	7.06	1.02	25.97	3.77	52.44	47.17	2646.85
16:01:55	7.02	1.02	26.09	3.78	52.5	47.05	2646.85
16:02:55	6.91	1.00	25.97	3.77	52.62	47.06	2646.69
16:03:55	6.83	0.99	25.97	3.77	52.75	46.94	2646.52
16:04:55	6.79	0.99	25.97	3.77	52.75	46.88	2641.51
16:05:55	6.16	0.89	24.95	3.62	53.41	46.59	2641.84

Table F.4 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Used water in tank, Continued).

Time	h_2	m'_{ref}	m'_5	m'_8	ρ_2	v_2	ρ_5
	(kJ/kg)	(kg/s)	(kg/s)	(kg/s)	(kg/m^3)	(m^3/kg)	(kg/m^3)
15:45:55	129.50	0.0017	0.0125	0.0142	995.33	0.0010	1131.26
15:46:55	125.73	0.0017	0.0123	0.0140	995.61	0.0010	1131.44
15:47:55	119.88	0.0017	0.0120	0.0136	996.02	0.0010	1131.39
15:48:55	126.57	0.0017	0.0118	0.0134	995.55	0.0010	1131.43
15:49:55	124.06	0.0017	0.0117	0.0134	995.73	0.0010	1131.45
15:50:55	124.48	0.0017	0.0112	0.0129	995.70	0.0010	1131.46
15:51:55	131.59	0.0017	0.0112	0.0129	995.18	0.0010	1131.42
15:52:55	124.90	0.0017	0.0108	0.0125	995.67	0.0010	1131.55
15:53:55	129.08	0.0017	0.0109	0.0126	995.36	0.0010	1131.40
15:54:55	125.32	0.0017	0.0114	0.0131	995.64	0.0010	1131.26
15:55:55	141.20	0.0017	0.0133	0.0150	994.43	0.0010	1131.58
15:56:55	147.89	0.0017	0.0163	0.0179	993.89	0.0010	1132.00
15:57:55	141.20	0.0017	0.0156	0.0173	994.43	0.0010	1132.09
15:58:55	125.32	0.0017	0.0155	0.0172	995.64	0.0010	1131.98
15:59:55	138.69	0.0017	0.0148	0.0164	994.63	0.0010	1132.07
16:00:55	133.26	0.0017	0.0149	0.0166	995.05	0.0010	1132.04
16:01:55	131.59	0.0017	0.0143	0.0160	995.18	0.0010	1132.02
16:02:55	134.93	0.0017	0.0141	0.0158	994.92	0.0010	1132.04
16:03:55	136.60	0.0017	0.0135	0.0151	994.79	0.0010	1132.06
16:04:55	134.93	0.0017	0.0133	0.0150	994.92	0.0010	1133.83
16:05:55	117.79	0.0017	0.0113	0.0130	996.16	0.0010	1133.48

Table F.4 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Used water in tank, Continued).

Time	v_5	W_P	W_{SP}	COP_{AHT}	$(T_{A,i}-T_E)/(T_{G,i}-T_C)$
	(m^3/kg)	(W)	(W)	(-)	(-)
15:45:55	0.0009	0.00021	0.00019	0.47	0.35
15:46:55	0.0009	0.00021	0.00019	0.48	0.34
15:47:55	0.0009	0.00021	0.00019	0.49	0.34
15:48:55	0.0009	0.00022	0.00019	0.49	0.33
15:49:55	0.0009	0.00021	0.00019	0.49	0.33
15:50:55	0.0009	0.00022	0.00019	0.51	0.32
15:51:55	0.0009	0.00021	0.00019	0.51	0.33
15:52:55	0.0009	0.00021	0.00019	0.50	0.32
15:53:55	0.0009	0.00021	0.00019	0.50	0.32
15:54:55	0.0009	0.00021	0.00018	0.50	0.32
15:55:55	0.0009	0.00020	0.00018	0.50	0.34
15:56:55	0.0009	0.00018	0.00016	0.49	0.36
15:57:55	0.0009	0.00019	0.00016	0.51	0.36
15:58:55	0.0009	0.00019	0.00017	0.50	0.35
15:59:55	0.0009	0.00019	0.00017	0.52	0.34
16:00:55	0.0009	0.00019	0.00017	0.53	0.34
16:01:55	0.0009	0.00019	0.00017	0.54	0.33
16:02:55	0.0009	0.00019	0.00017	0.56	0.33
16:03:55	0.0009	0.00019	0.00017	0.57	0.32
16:04:55	0.0009	0.00019	0.00017	0.56	0.32
16:05:55	0.0009	0.00019	0.00017	0.56	0.31

Table F.4 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Used water in tank, Continued).

Time	$T_{UG,o}$-$T_{CW,o}$	$T_{bulk,CW}$	ΔT_{CW}	Cp_{CW}	ρ_{CW}	Q_{CW}
	('C)	('C)	('C)	(kJ/kg-'C)	(kg/m^3)	(kW)
15:45:55	37.50	27.95	1.50	4.1806	996.21	4.91
15:46:55	38.70	26.80	1.40	4.1809	996.53	4.58
15:47:55	39.90	25.65	1.30	4.1813	996.83	4.26
15:48:55	40.60	24.90	1.40	4.1816	997.03	4.59
15:49:55	40.90	24.50	1.60	4.1818	997.13	5.24
15:50:55	41.50	24.00	1.40	4.1820	997.25	4.59
15:51:55	41.90	23.70	1.60	4.1822	997.33	5.24
15:52:55	42.30	23.20	1.40	4.1824	997.45	4.59
15:53:55	42.60	22.85	1.50	4.1826	997.53	4.92
15:54:55	42.80	22.70	1.40	4.1827	997.57	4.59
15:55:55	42.90	22.55	1.30	4.1828	997.60	4.26
15:56:55	40.20	25.10	1.40	4.1816	996.98	4.59
15:57:55	39.70	25.35	1.30	4.1815	996.91	4.26
15:58:55	39.10	26.05	1.50	4.1812	996.73	4.91
15:59:55	38.60	26.35	1.30	4.1811	996.65	4.26
16:00:55	38.30	26.60	1.40	4.1810	996.58	4.58
16:01:55	38.40	26.55	1.30	4.1810	996.59	4.26
16:02:55	39.10	25.70	1.40	4.1813	996.82	4.59
16:03:55	39.80	25.00	1.60	4.1816	997.00	5.24
16:04:55	41.50	23.60	1.40	4.1822	997.35	4.59
16:05:55	41.00	24.20	1.20	4.1819	997.21	3.93

Table F.4 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Used water in tank, Continued).

Time	$T_{bulk,UG}$	ΔT_{UG}	Cp_{UG}	ρ_{UG}	Q_{SP}	$T_{UG,o}$-$T_{CW,o}$
	('C)	('C)	(kJ/kg-'C)	(kg/m^3)	(kW)	('C)
15:45:55	46.65	36.90	4.1807	989.47	6.99	37.50
15:46:55	46.90	36.60	4.1808	989.37	6.93	38.70
15:47:55	46.50	37.20	4.1807	989.54	7.04	39.90
15:48:55	46.60	36.60	4.1807	989.49	6.93	40.60
15:49:55	46.95	36.70	4.1808	989.34	6.95	40.90
15:50:55	46.75	36.70	4.1807	989.43	6.95	41.50
15:51:55	46.90	36.80	4.1808	989.37	6.97	41.90
15:52:55	46.60	36.80	4.1807	989.49	6.97	42.30
15:53:55	46.55	37.10	4.1807	989.52	7.03	42.60
15:54:55	46.35	37.70	4.1806	989.60	7.14	42.80
15:55:55	46.20	38.00	4.1806	989.67	7.20	42.90
15:56:55	46.15	37.90	4.1806	989.69	7.18	40.20
15:57:55	46.00	37.60	4.1806	989.75	7.12	39.70
15:58:55	46.10	37.60	4.1806	989.71	7.12	39.10
15:59:55	46.05	37.10	4.1806	989.73	7.03	38.60
16:00:55	46.10	37.00	4.1806	989.71	7.01	38.30
16:01:55	46.10	37.00	4.1806	989.71	7.01	38.40
16:02:55	46.20	36.60	4.1806	989.67	6.93	39.10
16:03:55	46.35	36.70	4.1806	989.60	6.95	39.80
16:04:55	46.50	36.60	4.1807	989.54	6.93	41.50
16:05:55	46.60	37.20	4.1807	989.49	7.04	41.00

Table F.4 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Used water in tank, Continued).

Time	W_{Comp}	COP_{VCHP}	$T_{bulk,UG}$	ΔT_{UG}	Cp_{UG}
	(kW)	(-)	('C)	('C)	(kJ/kg-'C)
15:45:55	2.87	2.43	67.60	2.80	4.1889
15:46:55	2.89	2.40	67.60	2.80	4.1889
15:47:55	2.90	2.43	67.60	2.80	4.1889
15:48:55	2.91	2.38	67.55	2.70	4.1888
15:49:55	2.91	2.39	67.65	2.90	4.1889
15:50:55	2.92	2.38	67.60	2.80	4.1889
15:51:55	2.92	2.39	67.75	2.70	4.1889
15:52:55	2.92	2.38	67.55	2.70	4.1888
15:53:55	2.93	2.40	67.55	2.70	4.1888
15:54:55	2.93	2.44	67.55	2.70	4.1888
15:55:55	2.93	2.46	67.55	2.90	4.1888
15:56:55	2.90	2.47	67.40	2.80	4.1888
15:57:55	2.90	2.46	67.15	2.90	4.1886
15:58:55	2.89	2.46	67.30	2.80	4.1887
15:59:55	2.89	2.43	67.00	2.80	4.1885
16:00:55	2.88	2.43	66.90	2.60	4.1885
16:01:55	2.88	2.43	66.90	2.60	4.1885
16:02:55	2.89	2.40	66.90	2.80	4.1885
16:03:55	2.90	2.40	67.00	2.80	4.1885
16:04:55	2.92	2.38	67.05	2.50	4.1886
16:05:55	2.91	2.42	67.20	2.80	4.1886

Table F.4 The calculation results of the solar-CAHT from data recorder on 7/12/2010 (Used water in tank, Continued).

Time	ρ_{UG}	Q_{UG}	EER_{VCHP}
	(kg/m^3)	(kW)	(-)
15:45:55	979.09	9.15	3.18
15:46:55	979.09	9.15	3.17
15:47:55	979.09	9.15	3.16
15:48:55	979.11	8.82	3.04
15:49:55	979.06	9.48	3.26
15:50:55	979.09	9.15	3.14
15:51:55	979.00	8.82	3.02
15:52:55	979.11	8.82	3.02
15:53:55	979.11	8.82	3.01
15:54:55	979.11	8.82	3.01
15:55:55	979.11	9.48	3.23
15:56:55	979.20	9.15	3.15
15:57:55	979.34	9.48	3.27
15:58:55	979.25	9.15	3.17
15:59:55	979.42	9.15	3.17
16:00:55	979.48	8.50	2.95
16:01:55	979.48	8.50	2.95
16:02:55	979.48	9.15	3.17
16:03:55	979.42	9.15	3.16
16:04:55	979.39	8.17	2.80
16:05:55	979.31	9.15	3.14

APPENDIX G The Calculation of the Exergy Costing

The calculation results of the solar-AHT on April day

Investment cost (Cs)

= Cost of the absorption machine + Cost of solar collector + Cost of hot water tank

= (200,000 Baht/unit) + (35 units x 19,000 Baht/unit) + (10,000 Baht/unit)

= 200,000 Baht + 665,000 Baht + 10,000 Baht

= 875,000 Baht

Cost of electrical power of operating time at 300 d/y and 8 h/d (AFC)

= The electrical power in Chapter 4 kW x Operating time x Cost of the electrical power

= (2.11 kW) x (300 d/y) x (8 h/d) x 2.98 (Baht/kW.h)

= 15,091 Baht

Salvage cost (SV, 10% of investment cost, Baht)

= 875,000 Baht x 10%

= 87,500 Baht

Annual maintenance cost of the system (AMC, 5% of investment cost, Baht)

= 875,000 Baht x 5%

= 43,750 Baht

Annual discount rate on loans (i)

= 6.45%

Operation life of the system in consideration (N, year)

= 10 years

Capital recovery factor ($CRF = \frac{i(1+i)^N}{(1+i)^N - 1}$)

$$= \frac{0.0645(1+0.0645)^{10}}{(1+0.0645)^{10} - 1}$$

= 0.1388

Sinking fund factor ($SFF = \frac{i}{(1+i)^N - 1}$)

$$= \frac{0.0645}{(1+0.0645)^{10} - 1}$$

$$= \quad 0.0743$$

Annual cost ($AC = C_S(CRF) + AFC + AMC - SV(SFF)$, Baht/y)

$$= \quad 875{,}000 \times 0.1388 + 15{,}091 + 43{,}750 - 87{,}500 \times 0.0743$$

$$= \quad 173{,}773 \text{ Baht/y}$$

Exergy of the AHT absorber (Ex_A, From simulation in Chapter 5)

$$= \quad 1.20 \text{ kW}$$

Exergy costing of the solar-AHT

$$= \quad AC \text{ (Baht.y)} / Ex_A \text{ (kW)}$$

$$= \quad \frac{173{,}773}{1.20} \text{ Baht/kW.y}$$

$$= \quad 144{,}382 \text{ Baht/ kW.y}$$

The calculation results of the solar-CAHT on April day

Investment cost (Cs)

= Cost of the absorption machine
+ Cost of the absorption machine
+Cost of solar collector
+ Cost of hot water tank

= (200,000 Baht/unit) + (150,000 Baht/unit)
+ (18 units x 19,000 Baht/unit) + (10,000 Baht/unit)

= 200,000 Baht + 150,000 Baht + 342,000 Baht
+ 10,000 Baht

= 702,000 Baht

Cost of electrical power of operating time at 300 d/y and 8 h/d (AFC)

= The electrical power in Chapter 4 kW x Operating time
x Cost of the electrical power

= (2.11 + 3.02 kW) x (300 d/y) x (8 h/d) x 2.98
(Baht/kW.h)

= 36,690 Baht

Salvage cost (SV, 10% of investment cost, Baht)

= 702,000 Baht x 10%

= 70,200 Baht

Annual maintenance cost of the system (AMC, 5% of investment cost, Baht)

= 702,000 Baht x 5%

= 35,100 Baht

Annual discount rate on loans (i)

= 6.45%

Operation life of the system in consideration (N, year)

= 10 years

Capital recovery factor ($CRF = \frac{i(1+i)^N}{(1+i)^N - 1}$)

$$= \frac{0.0645(1+0.0645)^{10}}{(1+0.0645)^{10} - 1}$$

= 0.1388

Sinking fund factor ($SFF = \frac{i}{(1+i)^N - 1}$)

$$= \frac{0.0645}{(1+0.0645)^{10} - 1}$$

$$= 0.0743$$

Annual cost ($AC = C_S(CRF) + AFC + AMC - SV(SFF)$, Baht/y)

$$=$$ 702,000 x 0.1388 + 36,690 + 35,100 - 70,200 x 0.0743

$$=$$ 163,998 Baht/y

Exergy of the AHT absorber (Ex_A, From simulation in Chapter 5)

$$=$$ 1.72 kW

Exergy costing of the solar-CAHT

$$=$$ AC (Baht.y) / Ex_A (kW)

$$= \frac{163,998}{1.72}$$ Baht/kW.y

$$=$$ 95,264 Baht/ kW.y

APPENDIX H Publications

1. Improvement of an Absorption Heat Transformer Combined with Propane Vapor Compression Heat Pump in Industrial Process, International Conference on Green & Sustainable Innovation 2th, Le Meridien Chiang Rai Resort, Chiang Rai, Thailand, 2-4 December 2009.
2. Improvement of an Absorption Heat Transformer Performance for Upgrading Low Temperature Heat by Coupling with a Vapor Compression Heat Pump, Chiang Mai University Journal of Natural Sciences, Volume 10 No.2, 2011.
3. Upgrading of Low Temperature Solar Heat for Medium Temperature Applications by a Solar-Absorption Heat Transformer Assisting with a Vapor Compression Heat Pump, International Symposium on Low Carbon & Renewable Energy Technology 2010, Lotte Hotel, Jeju, Korea, 15-18 November 2010.
4. Experimental Study and a Simplified Model of a 10 kW_{th} Solar-Absorption Heat Transformer, Heat and Mass Transfer in Thermal Equipments 10th, Chiang Mai Grand View Hotel, Chiang Mai, Thailand, 10-11 March 2011.

Improvement of an Absorption Heat Transformer Combined with Propane Vapor Compression Heat Pump in Industrial Process

ICGSI
International Conference on Green and Sustainable Innovation

"Sufficiency and Sustainability through Life Cycle Thinking"

December 2nd – 4th, 2009, Chiang Rai, Thailand

Department of Mechanical Engineering, Chiang Mai University, Chiang Mai, Thailand 50200

Tel: +66-53-944146 Fax: +66-53-944145, E-mail: ICGSI2009@eng.cmu.ac.th, http://icgsi.eng.cmu.ac.th

September 21, 2009.

Dear Author(s),

On behalf of the ICGSI 2009 Organizing Committee, we would like to thank you for submitting an abstract for the International Conference on Green and Sustainable Innovation: ICGSI-2009. We are pleased to confirm that your abstract entitled

"Improvement of an absorption heat transformer combined with propane vapor compression heat pump in industrial process"
written by Nattaporn Chaiyat and Tanongkiat Kiatsiriroat

has been accepted for oral presentation at the conference. Therefore, we kindly invite you to submit your full paper by October 26, 2009 as MS Word 2003/XP and MS Word 2007 via the conference e-mail: icgsi2009@eng.cmu.ac.th. The instruction for submitting your full paper and the manuscript template are available either in the attached files or on our website: http://icgsi.eng.cmu.ac.th

Note that the registration is a prerequisite as soon as possible for final scheduling. Since there are many programs at the same time as ICGSI 2009, Chiang Rai will be hosting a big number of visitors. Therefore, early booking of hotel accommodation is strongly recommended. Please check our website for more information.

We are looking forward to receiving your full paper. If there is any question, please do not hesitate to contact us.

Your sincerely,

Professor Dr. Nobutaka Ito

Co-Chairman of the Organizing Committee
ICGSI 2009
Tel: (66)(53) 944146 ext. 431
Fax: (66)(53) 944145
Email: icgsi2009@eng.cmu.ac.th
Address:
ICGSI2009 Secretariat,
Department of Mechanical Engineering
Chiang Mai University, Chiang Mai, Thailand, 50200

Improvement of an Absorption Heat Transformer Performance for Upgrading Low Temperature Heat by Coupling with a Vapor Compression Heat Pump

Chiang Mai University Journal of Natural sciences
Office of the University, Chiang Mai University, Chiang Mai 50200, Thailand.

Phone: 66-53-94-2676-7 Fax: 66-53-94-3600
E-mail: cmujour@chiangmai.ac.th
Website: http://cmuj.chiangmai.ac.th,
or http://www.rac.oop.cmu.ac.th

Ref: No.6392(11)/ 583

September 9th , 2010

Professor Dr. Tanongkiat Kiatsiriroat
Department of Mechanical Engineering
Faculty of Engineering
Chiang Mai University
Chiang Mai 50200

Dear Professor Dr. Tanongkiat Kiatsiriroat:

Thank you for the manuscript entitled **"Improvement of an Absorption Heat Transformer Performance for Upgrading Low Temperature Heat by Coupling with a Vapor Compression Heat Pump"**, which you submitted for possible publication in the Chiang Mai University Journal of Natural Sciences.

I am pleased to inform you that the Editorial Committee has now agreed to accept your revised manuscript for publication.

Thank you for choosing the CMU journal of Natural Sciences as your preferred medium for publication.

Yours sincerely,

Chuckree Senthong

Professor Chuckree Senthong, Ph.D.
Editor-in-Chief
Tel: 053 94 2676
Fax: 053 94 3600
E-mail: cmujour@chiangmai.ac.th
http://cmuj.chiangmai.ac.th

CHIANG MAI UNIVERSITY JOURNAL OF NATURAL SCIENCES

Upgrading of Low Temperature Solar Heat for Medium Temperature Applications by a Solar-Absorption Heat Transformer Assisting with a Vapor Compression Heat Pump

O-ST-002

ISLCT2010, 15-18 November 2010, Jeju, Korea

UPGRADING OF LOW TEMPERATURE SOLAR HEAT FOR MEDIUM TEMPERATURE APPLICATIONS BY A SOLAR-ABSORPTION HEAT TRANSFORMER ASSISTING WITH A VAPOR COMPRESSION HEAT PUMP

Nattaporn Chaiyat and Tanongkiat Kiatsiriroat*

Department of Mechanical Engineering, Chiang Mai University, Chiang Mai, 50200, Thailand

* Corresponding author:tanongkiat_k@yahoo.com

In tropical area, even solar radiation level is rather high but diffuse solar radiation component is also very significant thus only solar flat-pate solar collector could be competitive with conventional energy for heat generation with a temperature not over 70℃. For higher temperature applications, a technique to boost-up the temperature is needed.

This paper presents simulation results of a H_2O-LiBr absorption heat transformer (AHT) having a R123 vapor compression heat pump (VCHP) recovering heat at the AHT condenser which is transferred to the AHT evaporator. The heat capacity at the AHT absorber is 10 kW.The unit is used to upgrade heat from a solar hot water heater of which the heat is supplied by a set of flat-plate solar collectors in parallel connection each having an area of $2m^2$ with $F_R(\tau\alpha)$ and $F_R U_L$of 0.802 and $10.37W/m^2 \cdot K$, respectively. The weather data of Chiang Mai, Thailand are the input information for the calculation.

The AHT could be operated when the hot water temperature from the solar water heating system is over 70 ℃. For the AHT with VCHP assisted, the number of the solar collectors is around 30 units which is about 50% of that without the VCHP. Moreover, the COP of the modified AHT is about 0.8 compared with 0.5 of the conventional AHT when the AHT absorber temperature is between 80-120℃. The total cost of the modified unit is also cheaper than the conventional one.

Keywords: Heat transformer, Absorption heat pump, Flat plate solar collector, Simulation

Experimental Study and a Simplified Model of a 10 kW_{th} Solar-Absorption Heat Transformer

Experimental Study and a Simplified Model of a 10 kW_{th} Solar-Absorption Heat Transformer

Nattaporn Chaiyat

Tanongkiat Kiatsiriroat

Department of Mechanical Engineering,
Chiang Mai University,
Chiang Mai, Thailand

Experimental study of a 10 kW_{th} single-stage LiBr-water absorption heat transformer (AHT) to boost up low temperature heat from a solar hot water system having a set of flat-plate solar collectors was carried out. The solar heat could be upgraded for generating hot water up to 100 °C which was around 20 °C higher than that of the input heat. The COP_{AHT} and EER_{AHT} of the AHT were around 0.42 and 4.1, respectively. A simplified model to predict the system performances such as the COP_{AHT} and EER_{AHT} was also developed and the results agreed well with those from the experiments.

Introduction

In general, heat will transfer from a high temperature heat source to a lower temperature heat sink and if we want to reverse the heat direction, a heat driven machine is needed.

Absorption heat transformer (AHT) is one method for upgrading low temperature heat to a higher temperature level. Low temperature heat is absorbed at the AHT generator and the AHT evaporator and then the heat is delivered at the AHT absorber at a higher temperature, while the AHT condenser rejects heat at a lower temperature. Theoretical and experimental studies of the AHT have been reported by various literatures. Rivera et al [1] presented a single-stage and advanced AHT operating with water-LiBr and water-Carrol™ mixtures to increase the temperature of the useful heat produced by solar pond. The results showed that the single-stage and the double AHT increased solar pond's temperature until 50 °C at COP about 0.48 and 100 °C at COP about 0.33, respectively. Xuehu et al. [2] reported the test results of the first industrial-scale water-LiBr AHT in China to recover waste heat released from an organic vapor at 98 °C in a synthetic rubber plant. The recovered heat was used to heat hot water from 95 °C to 110 °C. The AHT system was operating with a heat rate of 5,000 kW with a mean COP of 0.47. The payback was approximately 2 years. Sotsil Silva Sotelo et al. [3] presented an AHT cycle operating with water-Carrol™ mixture which had a higher solubility than aqueous Lithium Bromide mixture. It could be found that the coefficient of performance was higher and less crystallization risk was obtained compared with the water-Lithium Bromide solution.

The main objective of this work was to study thermal performance of a10 kW_{th} single-stage LiBr-water absorption heat transformer (AHT) to boost up low temperature heat from a solar hot water system supplying heat from a set of flat-plate solar collectors. A simplified model to predict the system performances such as the COP_{AHT} and EER_{AHT} was also developed.

Solar-Absorption Heat Transformer

Fig. 1 shows a schematic sketch of a solar-absorption heat transformer (Solar-AHT). Solar heat from a solar hot water system is supplied to the generator and evaporator at a medium temperature (around 60-80 °C) and rejected heat at a lower temperature (around 35-45 °C) at the condenser. A higher temperature heat (around 80-110 °C) is obtained at the absorber.

At the generator, a binary liquid mixture consisting of a volatile component (absorbate) and a less volatile component (absorbent) is heated at a medium temperature. Part of the absorbate boils at a low pressure (P_C) and a generator temperature (T_G) at state 1. The vapor condenses in the condenser at a condenser temperature (T_C) to be liquid at state

CURRICULUM VITAE

Name – Surname	Nattaporn Chaiyat	
Date of Birth	25 April 1979	
Educations	1. Master Degree:	M.ENG Energy Engineering
	Department:	Energy Engineering Program, Faculty of Engineering, Chiang Mai University.
	Academic Year:	2007
	2. Bachelor Degree :	B.ENG Electrical Engineering
	Department:	Electrical Engineering Program, Faculty of Engineering, Chiang Mai University.
	Academic Year:	2002