Appendix A
Software Installation and set-up

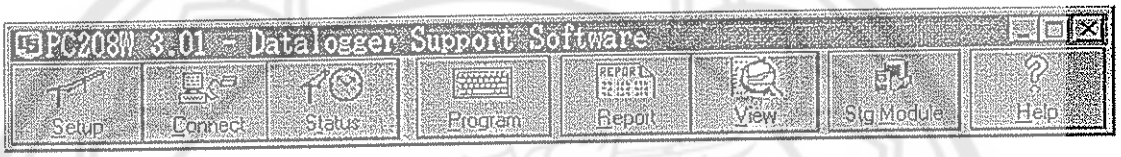
Appendix A: Software Installation and set-up

Install software

- Insert the PC208W disk in your computer floppy disk drive
- Select Add/Remove Programs from the Control Panel folder
- Click Install button
- Select setup.exe file
- Click Finish button to begin the installation

Running the program

- Click the "PC208W" icon from Start/Programs
- The following menu bar will be displayed



- Setup — For settings, only once after installation
- Connect — For monitoring collected data
- Program — For program elaboration
- View — To display collected data

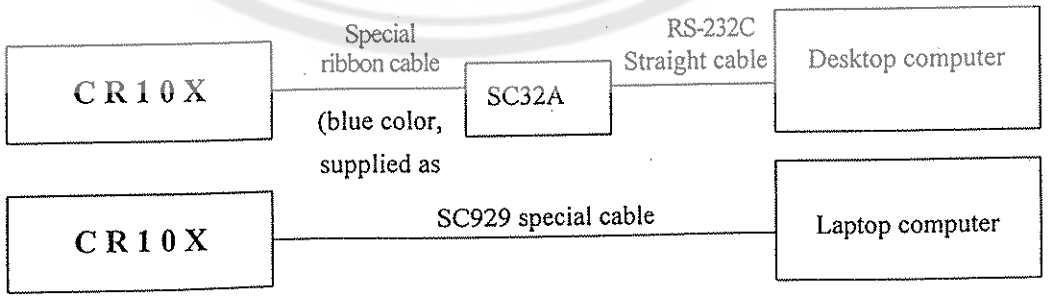
Connection between Data Logger and Computer

The PC208W software and CR10X Data Logger are designed for data communication using the standard RS-232C interface.

In case that a desktop computer is used, connect to the CR10X Data Logger through the SC32A interface using a RS-232C straight cable.

When the computer to be used is laptop type, connect it to the CR10X Data Logger using the SC929 special cable.

Communication parameters: 9600bps / 8bit / 1stop / parity none

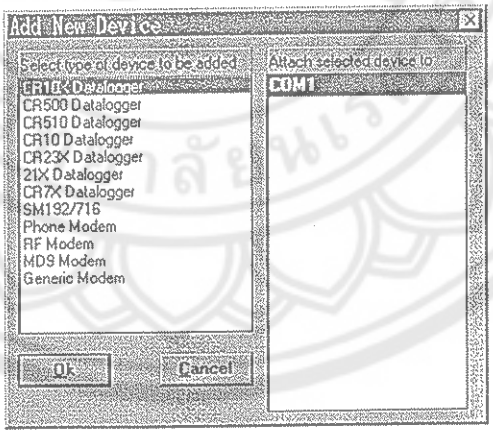


Set-up (setting communication parameters)

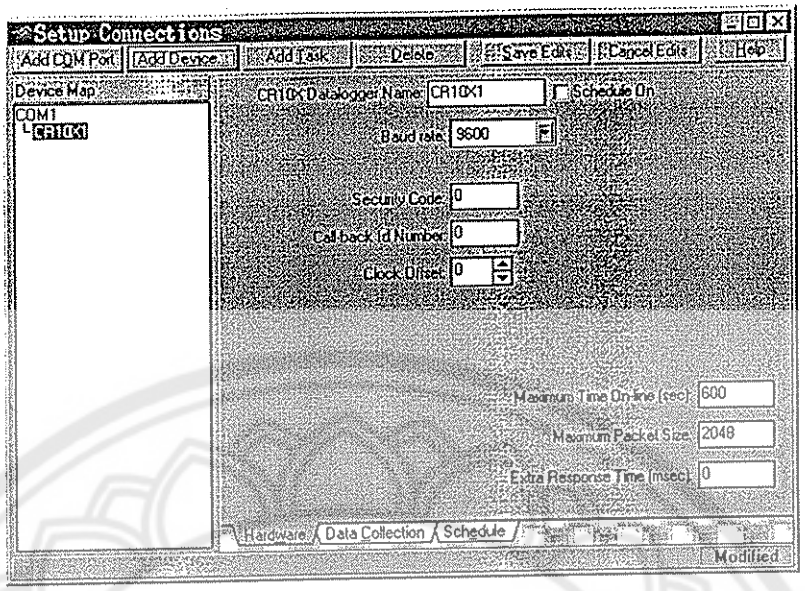
Click on Setup from the menu bar. This is to be done only once after installation.

The next menu window appears.

Several entry settings, such as selection of Com Port and model and name of Data Logger, can be done by using the buttons at the top part of the window. Only COM1 is set when the program is used for the first time.



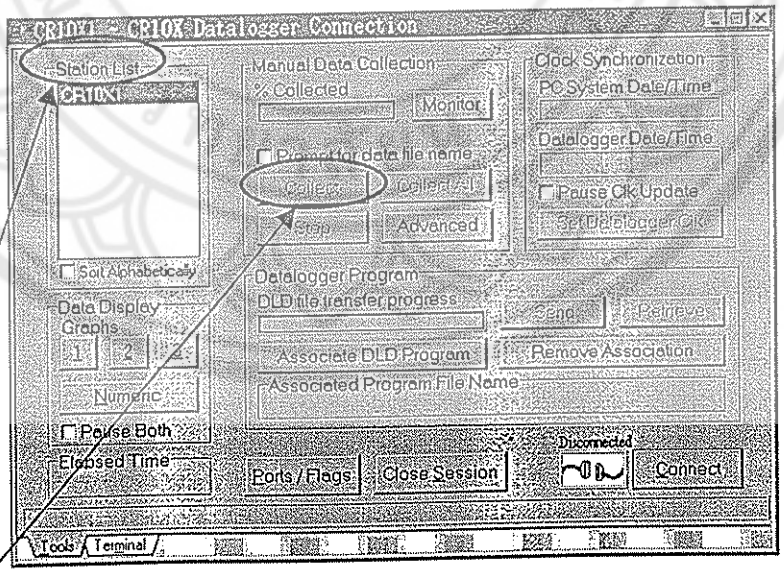
Click on Add Device to select the Data Logger to be used. Select COM1, which corresponds to the RS232 port used in most computers. Then click OK. Other parameters such as the Baud Rate can be left at the default value (9600).



The Data Logger name will be displayed. To change the name, place the cursor on it and type the new name. The Data Logger name will be the data name when data collection is done. After any change or input, select Save Edits to save them. Other parameters such as the Baud Rate can be left at the default value (9600).

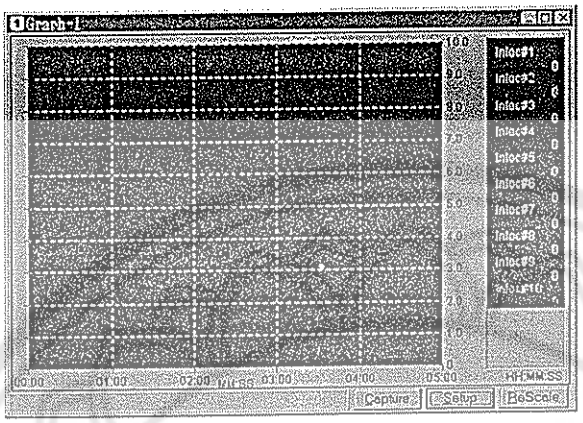
Data Collection, Monitoring and Graph Display

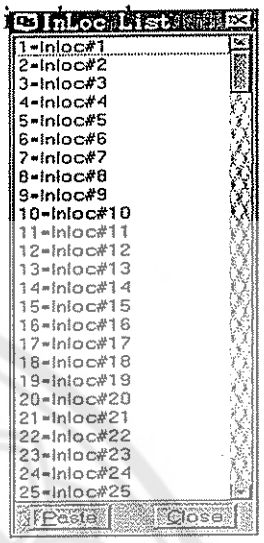
Select Connect from the menu bar. The next window appears.

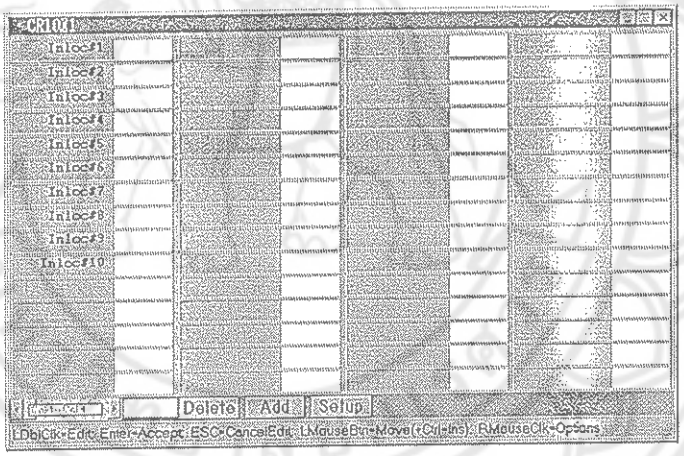


- Select from Station List the location to be connected for communication.
- Click Collect button to start data collection.

When Tools window is active, selected by the tab at the bottom part, the Data logger Date/Time box will show the current date and time. If not shown, verify that the Connect button at the bottom right part of the window







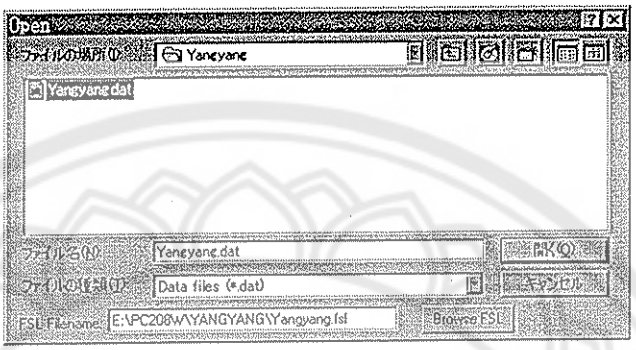
If Numeric is selected from Data logger Connection / Tools, the above window appears and data can be shown in numerical display. Numeric selection will allow monitoring data in a real time basis.

To display numerical data in this window click Add and then click on an empty row. Then select the data to be displayed from the list and then click Paste.

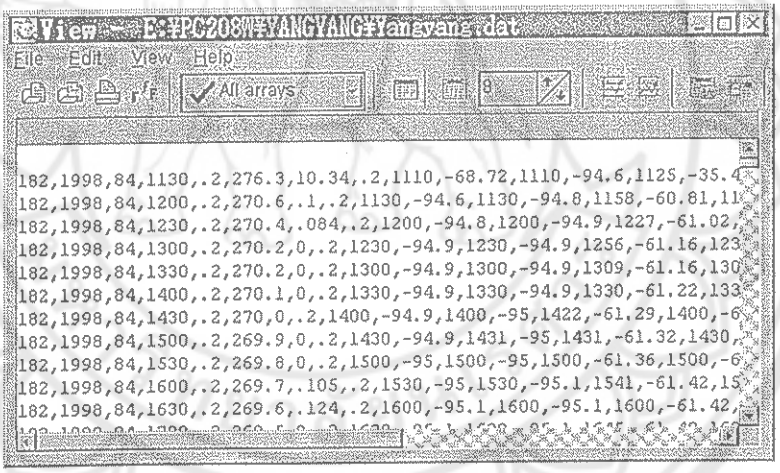
If graphs is selected from Data logger Connection / Tools, real-time graphs can be launched. This selection allows up to three graphs to be displayed simultaneously. Graph setting, such as data setting, top and bottom limits and time axis scaling, can be accessed by selecting Setup at the bottom of the graphs.

Displaying Collected Data

- Click View from the menu bar. The next file selection window appears.
- Select the file to be displayed from this window.



Data will be displayed as is shown in the following window. Data can not be edited.



Appendix B
Results and calculation from testing of solar water pumping system

Table 12 Results and calculation from testing of solar water pumping system at 20/3/2000

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
900	376.1	32.37	127.6	2.821	359.96	0.10	0.19	10.42	16.89	1.76
910	413.9	35.21	125.3	3.18	398.45	0.11	0.20	10.48	16.37	1.71
920	446.3	37.03	126.3	3.37	425.63	0.13	0.24	10.38	18.52	1.92
930	483	39.36	126.7	3.606	456.88	0.13	0.25	10.30	18.07	1.86
940	515.8	41.04	123.7	3.974	491.58	0.14	0.27	10.37	17.66	1.83
950	550.1	42.55	122.4	4.296	525.83	0.15	0.29	10.40	18.02	1.88
1000	585.8	43.75	122.5	4.597	563.13	0.16	0.31	10.46	17.74	1.86
1010	617.7	45.83	121.3	4.887	592.79	0.17	0.33	10.45	17.97	1.88
1020	645.8	48.1	119.9	5.121	614.01	0.19	0.36	10.35	18.93	1.96
1030	671.3	49.39	118.2	5.188	613.22	0.19	0.36	9.94	19.09	1.90
1040	694.1	50.27	117.9	5.131	604.94	0.19	0.36	9.49	19.52	1.85
1050	717	50.64	118.9	5.78	687.24	0.21	0.40	10.43	19.14	2.00
1100	742	51.39	116.9	5.693	665.51	0.21	0.40	9.76	19.64	1.92
1110	767	51.41	116	6.12	709.92	0.22	0.42	10.07	19.56	1.97
1120	790	50.4	117	6.494	759.80	0.24	0.45	10.47	19.33	2.02
1130	814	50.75	117.1	6.677	781.88	0.25	0.47	10.46	19.57	2.05
1140	825	52.54	116.3	6.751	785.14	0.25	0.48	10.36	19.91	2.06

Table 12 Results and calculation from testing of solar water pumping system at 20/3/2000 (con,d)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1150	834	54.07	113.6	6.623	752.37	0.24	0.46	9.82	19.84	1.95
1200	839	54.08	109.7	6.21	681.24	0.22	0.42	8.84	20.39	1.80
1210	838	55.09	113.1	6.912	781.75	0.25	0.48	10.15	20.15	2.05
1220	845	55.59	115.6	7.1	820.76	0.26	0.50	10.57	19.82	2.10
1230	849	56.73	115.5	7.12	822.36	0.26	0.49	10.54	19.42	2.05
1240	847	56.92	112.8	6.911	779.56	0.24	0.46	10.02	19.25	1.93
1250	851	56.04	114.3	7.18	820.67	0.25	0.48	10.50	19.02	2.00
1300	860	55.8	114.9	7.23	830.73	0.25	0.48	10.51	19.06	2.00
1310	852	55.75	115.4	7.17	827.42	0.26	0.49	10.57	19.18	2.03
1320	855	55.57	115.2	7.19	828.29	0.25	0.48	10.54	19.09	2.01
1330	833	57.03	114.2	6.999	799.29	0.24	0.46	10.44	18.79	1.96
1340	839	58.36	127.2	5.063	644.01	0.12	0.23	8.36	11.81	0.99
1350	830	60.52	142.7	5.02	716.35	0.13	0.25	9.39	11.49	1.08
1400	809	59.32	141.2	5.36	756.83	0.13	0.25	10.18	10.71	1.09
1410	798	58.01	144.2	5.78	833.48	0.13	0.25	11.37	9.67	1.10
1420	789	58.5	143.7	5.77	829.15	0.13	0.24	11.44	9.62	1.10

Table 12 Results and calculation from testing of solar water pumping system at 20/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1430	773	58.2	143.7	5.68	816.22	0.13	0.24	11.49	9.70	1.11
1440	748	57.26	144.3	3.677	530.59	0.13	0.24	7.72	14.75	1.14
1450	720	57.27	144.4	3.669	529.80	0.13	0.24	8.01	14.75	1.18
1500	659.7	56.37	142.9	4.201	600.32	0.14	0.26	9.91	13.97	1.38
1510	646	54.83	119.9	4.757	570.36	0.18	0.35	9.61	20.02	1.92
1520	617.8	53.41	117.1	5.272	617.35	0.20	0.38	10.88	20.18	2.19
1530	592.4	52.58	117.6	5.059	594.94	0.19	0.35	10.93	19.46	2.13
1540	553.3	52.01	117.7	4.721	555.66	0.17	0.33	10.93	19.35	2.11
1550	523.9	50.91	118.6	4.441	526.70	0.17	0.32	10.94	20.10	2.20
1600	499.4	48.26	120.1	4.17	500.82	0.16	0.30	10.92	19.37	2.11
1610	461.1	44.99	118.7	3.897	462.57	0.15	0.28	10.92	19.52	2.13
1620	403.8	43.46	117.7	3.436	404.42	0.13	0.24	10.90	19.81	2.16
1630	364.4	42.7	121.3	2.984	361.96	0.11	0.22	10.81	19.49	2.11
1640	333.4	42.05	123.2	2.686	330.92	0.10	0.20	10.80	19.54	2.11
1650	296.8	41.28	126.6	2.237	283.20	0.08	0.15	10.39	17.41	1.81
1700	253.5	40.19	126.1	1.921	242.24	0.05	0.10	10.40	13.71	1.43

Table 13 Results and calculation from testing of solar water pumping system at 21/3/2000

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
900	361.4	32.41	146	0.90	131.25	0.02	0.03	10.95	15.68	1.30
910	396.2	35.7	127.9	2.75	351.60	0.08	0.15	10.65	15.75	1.33
920	435.3	38.02	126.7	3.43	434.71	0.11	0.22	10.87	16.29	1.77
930	470	39.95	125.4	3.75	470.75	0.13	0.25	10.90	17.32	1.89
940	504.9	41.55	122.9	4.12	506.47	0.14	0.28	10.92	17.76	1.94
950	540.5	43.37	122.3	4.46	545.82	0.15	0.29	10.99	17.45	1.92
1000	569.3	45.09	133	4.80	638.40	0.09	0.32	12.21	17.50	1.10
1010	607	46.95	136.6	4.14	565.39	0.06	0.30	10.14	17.02	2.11
1020	639.2	47.68	119.2	5.37	639.51	0.20	0.38	10.89	19.44	2.12
1030	670.7	49.17	121.8	5.02	610.95	0.19	0.35	9.92	18.94	2.17
1040	694.3	51.76	114.5	5.12	586.58	0.17	0.33	9.20	18.24	2.36
1050	720	54.42	115.3	5.36	618.12	0.15	0.29	9.34	17.27	2.42
1100	739	55.57	115.7	5.00	578.85	0.16	0.31	10.52	17.29	2.47
1110	768	52.79	115.1	6.53	751.37	0.24	0.46	10.65	19.85	2.11
1120	786	52.71	115.3	6.68	770.20	0.24	0.46	10.67	19.63	2.09
1130	788	54.11	115.3	6.70	772.28	0.25	0.47	10.67	19.84	2.12
1140	814	54.14	115.2	6.90	795.23	0.25	0.48	10.63	19.81	2.11

Table 13 Results and calculation from testing of solar water pumping system at 21/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1150	822	54.44	114.9	6.97	800.39	0.26	0.49	10.60	20.12	2.13
1200	823	54.72	114.6	6.95	796.58	0.26	0.50	10.54	20.34	2.14
1210	814	54.93	114.2	6.87	784.67	0.25	0.48	10.49	19.94	2.09
1220	808	56.02	113.8	6.80	773.50	0.25	0.47	10.42	19.69	2.05
1230	830	54.63	115.6	6.97	805.39	0.25	0.48	10.56	19.35	2.04
1240	837	54.41	115.6	7.00	809.20	0.26	0.49	10.52	19.72	2.08
1250	829	54.57	115.3	6.92	797.99	0.26	0.50	10.48	20.30	2.13
1300	833	54.02	116.2	6.96	808.40	0.26	0.49	10.56	19.78	2.09
1310	822	54.8	115.5	6.89	795.91	0.25	0.48	10.54	19.56	2.06
1320	831	54.15	116	6.97	808.75	0.25	0.48	10.59	19.28	2.04
1330	849	54.51	117.2	7.08	829.78	0.25	0.48	10.64	18.85	2.01
1340	853	55.05	122.8	7.12	874.70	0.12	0.48	11.16	13.96	1.51
1350	836	56.64	133.1	7.02	934.50	0.15	0.28	12.17	12.89	1.21
1400	819	56.9	144	6.09	876.96	0.17	0.33	11.66	12.18	1.42
1410	798	55.91	145.8	6.00	874.95	0.17	0.33	11.93	12.36	1.48
1420	781	55.2	146.1	5.99	874.99	0.18	0.35	12.19	12.99	1.58

Table 14 Results and calculation from testing of solar water pumping system at 22/3/2000

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1430	755	54.74	146.1	5.87	857.75	0.17	0.33	12.37	12.49	1.54
1440	727	54.86	145.6	5.86	853.51	0.18	0.33	12.78	12.73	1.63
1450	699.5	55.36	144.9	5.70	826.51	0.18	0.34	12.86	13.28	1.71
1500	662.3	53.98	145.2	5.46	793.23	0.17	0.32	13.04	13.31	1.74
1510	633.4	53.07	142.6	5.30	755.78	0.17	0.32	12.99	13.89	1.80
1520	589.7	51.65	145.8	5.02	732.06	0.17	0.32	13.51	14.31	1.93
1530	557.8	51.72	144.8	5.33	771.93	0.17	0.31	12.06	13.27	2.00
1540	525.6	51.51	144.4	4.99	719.98	0.16	0.31	13.19	14.16	2.11
1550	479.6	49.92	144.7	4.98	720.61	0.16	0.31	13.65	14.05	2.30
1600	442.9	48.16	144.9	4.60	666.54	0.17	0.32	13.38	15.84	2.59
1610	406.6	47.39	131.9	4.23	557.94	0.16	0.31	13.93	18.07	2.70
1620	372.8	45.66	121.8	2.99	363.94	0.17	0.32	12.62	18.78	2.70
1630	323.6	44.15	122.2	2.47	301.35	0.17	0.32	12.13	18.82	2.83
1640	290.5	42.46	122.3	2.31	282.02	0.19	0.36	11.96	18.26	2.49
1650	257.5	41.21	123.2	2.02	248.86	0.17	0.32	11.56	18.92	2.14
1700	218.5	40.36	123.2	1.71	210.55	0.18	0.34	11.48	18.03	2.15

Table 14 Results and calculation from testing of solar water pumping system at 22/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency System (%)
900	200.1	32.87	147	3.38	497.01	0.19	0.35	10.03	16.30	1.30
910	231	33.4	130.6	3.49	455.92	0.18	0.35	10.98	16.92	2.35
920	382.5	34.95	126.8	3.16	401.20	0.16	0.31	11.42	16.46	2.91
930	426.1	37.57	124.3	3.56	442.88	0.16	0.30	11.31	16.40	2.54
940	532.8	40.84	124.2	4.35	539.65	0.14	0.27	11.02	16.63	1.83
950	638.4	42.3	123.9	5.29	655.31	0.19	0.37	11.17	18.44	2.06
1000	665.7	45.4	120.2	5.62	675.88	0.21	0.40	11.05	19.30	2.13
1010	699.3	47.38	118.3	5.96	705.07	0.22	0.41	10.97	19.15	2.10
1020	724	48.77	116.4	6.22	724.47	0.23	0.43	10.89	19.35	2.11
1030	756	48.92	116.9	6.46	755.29	0.24	0.45	10.87	19.69	2.14
1040	783	50.3	116.2	6.69	777.03	0.25	0.47	10.80	19.59	2.12
1050	802	50.84	116.5	6.83	795.35	0.26	0.49	10.79	20.15	2.17
1100	824	50.93	116.8	7.00	817.13	0.27	0.51	10.79	20.25	2.19
1110	841	51.53	116.4	7.14	831.10	0.27	0.51	10.76	20.23	2.18
1120	861	52.77	116.3	7.26	844.34	0.27	0.52	10.67	20.22	2.16
1130	882	53.48	116.3	7.40	860.62	0.28	0.54	10.62	20.36	2.16
1140	885	53.94	116.8	7.41	865.49	0.29	0.55	10.64	20.75	2.21

Table 14 Results and calculation from testing of solar water pumping system at 22/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency System (%)
1150	900	55.04	116	7.51	871.16	0.29	0.55	10.54	20.79	2.19
1200	914	55.16	115	7.61	875.15	0.30	0.57	10.42	21.25	2.22
1210	920	57.35	114.3	7.65	874.40	0.30	0.57	10.35	21.43	2.22
1220	931	59.07	112.8	7.76	875.33	0.31	0.58	10.23	21.77	2.23
1230	935	60.73	112.2	7.74	868.43	0.31	0.59	10.11	22.08	2.23
1240	939	60.34	112.9	7.78	878.36	0.31	0.59	10.18	21.95	2.24
1250	941	59.88	113.4	7.78	882.25	0.31	0.59	10.21	21.70	2.21
1300	936	59.52	113.4	7.74	877.72	0.31	0.58	10.21	21.62	2.21
1310	931	59.72	113.2	7.73	875.04	0.31	0.58	10.23	21.75	2.23
1320	917	59.75	113	7.65	864.45	0.30	0.57	10.26	21.49	2.20
1330	903	60.85	111.4	7.59	845.53	0.29	0.56	10.19	21.64	2.21
1340	903	61.51	115.4	6.70	773.18	0.26	0.49	9.32	20.79	1.94
1350	894	61.36	111.7	7.49	836.63	0.29	0.56	10.19	21.85	2.23
1400	879	62.51	110.5	7.40	817.70	0.29	0.55	10.13	21.86	2.21
1410	862	63.11	109.8	7.33	804.83	0.28	0.54	10.16	21.87	2.22
1420	844	60.95	112.7	7.05	794.54	0.28	0.53	10.25	21.99	2.25

Table 15 Results and calculation from testing of solar water pumping system at 23/3/2000

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency System (%)
1430	813	60.77	112.9	6.79	767.04	0.27	0.52	10.27	22.18	2.28
1440	791	59.5	112	6.74	755.10	0.26	0.50	10.39	21.70	2.26
1450	765	57.58	113.5	6.50	737.75	0.25	0.47	10.50	20.92	2.20
1500	739	57.2	115.2	6.19	712.51	0.23	0.44	10.49	20.40	2.14
1510	708	57	114.2	6.00	685.54	0.22	0.42	10.54	19.98	2.11
1520	675.4	56.69	112.8	5.84	658.64	0.21	0.40	10.61	19.90	2.11
1530	638.5	55.31	114.7	5.45	624.89	0.20	0.38	10.65	19.88	2.12
1540	604.1	53.1	117.2	5.11	598.31	0.19	0.37	10.78	20.06	2.16
1550	573.2	51.36	116.9	4.88	570.36	0.18	0.35	10.83	19.95	2.16
1600	538.9	50.17	117.5	4.58	537.80	0.17	0.33	10.86	19.87	2.16
1610	504.1	48.6	119.2	4.22	502.79	0.15	0.29	10.86	18.90	2.05
1620	470.3	47.63	120	3.91	469.44	0.14	0.27	10.86	18.55	2.02
1630	434.1	46.8	118.7	3.66	434.20	0.13	0.25	10.89	18.65	2.03
1640	392.5	45.8	119.8	3.27	391.27	0.11	0.21	10.85	17.90	1.94
1650	351.7	45.37	121.3	2.85	346.19	0.10	0.19	10.71	17.74	1.90
1700	308.2	44.6	123	2.41	296.68	0.08	0.15	10.48	16.85	1.77

Table 15 Results and calculation from testing of solar water pumping system at 23/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
900	410.7	36.34	126.5	3.35	423.90	0.07	0.13	11.23	9.68	1.09
910	452.6	37.35	126.4	3.70	467.81	0.08	0.15	11.25	10.38	1.17
920	466.2	38.68	123.2	3.93	484.05	0.09	0.17	11.30	11.23	1.27
930	517.4	40.16	122.4	4.38	536.60	0.11	0.20	11.29	12.49	1.41
940	566.1	41.56	122	4.81	587.31	0.13	0.25	11.29	14.19	1.60
950	562.4	41.64	122.3	4.75	581.29	0.14	0.26	11.25	14.53	1.63
1000	642.7	42.28	122.2	5.45	665.50	0.16	0.31	11.27	15.08	1.70
1010	703	44.5	119.9	5.99	718.56	0.18	0.35	11.13	15.95	1.78
1020	731	45.74	121.9	5.52	672.89	0.17	0.33	10.02	15.87	1.59
1030	740	46.85	149.9	5.60	839.44	0.18	0.33	12.35	13.02	1.61
1040	749	47.57	149.7	5.65	845.36	0.17	0.32	12.28	12.50	1.54
1050	736	47.13	149.1	5.53	824.67	0.17	0.32	12.20	12.79	1.56
1100	755	47.53	148.9	5.66	842.77	0.17	0.32	12.15	12.43	1.51
1110	850	49.5	148.8	5.78	860.06	0.17	0.32	11.01	12.06	1.33
1120	872	51.15	148.6	5.89	875.40	0.16	0.30	10.93	11.26	1.23
1130	885	51.38	148	5.90	873.35	0.18	0.34	10.74	12.80	1.37
1140	904	53.04	147.3	5.99	882.33	0.18	0.34	10.62	12.70	1.35

Table 15 Results and calculation from testing of solar water pumping system at 23/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1150	915	54.07	147	6.37	936.39	0.18	0.34	11.14	11.92	1.33
1200	924	54.57	146.6	6.38	934.58	0.18	0.33	11.01	11.68	1.29
1210	930	55.02	146.4	6.37	932.28	0.17	0.33	10.91	11.62	1.27
1220	932	55.07	146.7	6.78	994.63	0.17	0.32	11.62	10.60	1.23
1230	943	54.94	146.9	6.87	1009.50	0.18	0.35	11.65	11.29	1.32
1240	936	55.8	146	6.55	955.72	0.18	0.34	11.11	11.73	1.30
1250	927	55.44	147	6.50	956.09	0.19	0.36	11.23	12.20	1.37
1300	905	55.03	147.2	6.50	956.80	0.18	0.34	11.51	11.48	1.32
1310	883	55.5	146.2	6.49	948.69	0.17	0.32	11.69	11.13	1.30
1320	866	54.74	146.5	6.45	945.36	0.18	0.33	11.88	11.54	1.37
1330	843	55.27	145.8	6.50	947.70	0.17	0.33	12.24	11.40	1.40
1340	859	54.91	145.9	6.56	957.10	0.17	0.33	12.13	11.24	1.36
1350	835	55.13	145.7	6.45	939.91	0.17	0.32	12.25	11.22	1.37
1400	824	54.43	146.1	6.35	927.88	0.18	0.34	12.26	11.95	1.46
1410	818	54.57	145.2	6.30	914.76	0.17	0.33	12.17	11.71	1.43
1420	800	54.89	145	6.02	873.34	0.18	0.33	11.88	12.47	1.48

Table 16 Results and calculation from testing of solar water pumping system at 24/3/2000

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1430	768	55.5	144.5	6.00	867.00	0.17	0.33	12.29	12.36	1.52
1440	742	56.23	144.4	6.23	899.61	0.17	0.33	12.19	11.98	1.58
1450	712	55.59	144.4	6.15	888.64	0.17	0.33	12.58	12.17	1.65
1500	712	54.45	145.5	5.95	866.02	0.17	0.32	12.23	12.12	1.60
1510	587.3	54.36	143.2	5.20	744.64	0.17	0.31	12.08	13.83	1.91
1520	367.5	47.83	144	5.42	780.62	0.16	0.30	12.10	12.74	2.95
1530	417.2	46	146	4.58	668.68	0.16	0.30	12.44	14.87	2.59
1540	501.2	47.07	146.6	5.60	820.96	0.17	0.31	12.82	12.53	2.23
1550	538.2	48.87	146	5.24	764.46	0.17	0.32	12.46	13.48	2.08
1600	387.6	46.8	144.2	5.21	751.28	0.15	0.28	12.09	11.99	2.53
1610	309.3	43.53	144.4	4.26	614.86	0.14	0.27	12.63	14.37	3.11
1620	335.5	43.04	145.7	4.24	617.04	0.14	0.27	12.85	14.09	2.82
1630	387.6	43.74	146.5	4.24	621.01	0.16	0.30	12.49	16.00	2.79
1640	348.5	43.3	145.8	4.10	598.22	0.14	0.27	12.68	14.75	2.76
1650	284.1	42.39	144.4	4.02	580.92	0.14	0.27	12.61	14.95	3.33
1700	191.9	40.32	142	3.03	429.61	0.14	0.26	12.36	19.95	3.86

Table 16 Results and calculation from testing of solar water pumping system at 24/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
900	90.1	25.91	143.3	0.38	54.02	0	0	9.56	0	0
910	109.5	27.23	144.7	0.38	54.70	0	0	9.69	0	0
920	94.1	27.82	134.1	0.58	77.51	0.02	0.03	10.96	15.86	1.42
930	100.7	28.11	124.6	0.83	103.42	0.02	0.03	11.17	11.83	1.32
940	116.5	28.33	115	1.14	130.87	0.02	0.03	12.22	9.72	1.18
950	93	28.22	128.9	0.58	75.28	0.02	0.04	8.81	17.23	1.51
1000	118.1	28.61	117.5	1.03	121.38	0.02	0.04	11.18	12.54	1.40
1010	125.6	28.9	109.1	1.35	147.07	0.03	0.04	12.74	10.55	1.34
1020	125.2	29.16	109.2	1.35	147.20	0.03	0.04	12.77	10.58	1.35
1030	305.5	30.76	121.6	2.69	327.35	0.03	0.04	11.66	4.78	0.55
1040	301.9	34.74	126.4	2.53	319.79	0.04	0.08	11.53	8.28	0.95
1050	229.2	34.24	121.1	2.08	251.77	0.03	0.04	11.95	6.39	0.76
1100	267.9	34.07	126.9	2.28	288.70	0.03	0.06	11.73	6.98	0.81
1110	208.4	33.37	129	1.77	227.69	0.02	0.03	11.89	5.10	0.60
1120	149.6	31.8	128.9	1.29	166.28	0.02	0.04	12.09	8.97	1.08
1130	246.5	30.42	128.7	2.14	274.90	0.02	0.04	12.13	5.59	0.68
1140	414.5	33.54	127.6	3.47	443.03	0.08	0.14	11.63	10.75	1.25

Table 16 Results and calculation from testing of solar water pumping system at 24/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency Cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1150	524.3	38.23	123.2	4.44	546.64	0.13	0.25	11.34	15.23	1.72
1200	518.7	41.74	121.4	4.43	538.29	0.14	0.27	11.26	16.40	1.83
1210	683.4	46.34	118	5.86	691.72	0.20	0.38	11.01	18.33	2.02
1220	636.7	48.36	116.8	5.48	639.60	0.20	0.37	10.93	19.18	2.09
1230	592.7	47.24	118.5	5.05	598.54	0.19	0.35	10.99	19.23	2.11
1240	598.7	45.3	119.5	5.12	611.48	0.18	0.34	11.11	18.19	2.02
1250	448.2	43.73	118.7	3.87	458.89	0.12	0.23	11.14	16.48	1.83
1300	365.3	40.95	123.8	3.11	385.14	0.09	0.16	11.47	14.15	1.62
1310	418.1	41.19	121.8	3.58	435.80	0.11	0.20	11.34	15.26	1.73
1320	241.9	38.86	124.3	2.10	260.66	0.05	0.08	11.72	10.76	1.26
1330	326.8	37.51	126.1	2.77	349.68	0.07	0.13	11.64	12.32	1.43
1340	361.8	38.97	125.9	3.01	378.33	0.08	0.15	11.38	13.54	1.54
1350	326.9	39.7	123.5	2.78	343.82	0.07	0.14	11.44	13.47	1.54
1400	243.8	37.9	125.2	2.07	259.16	0.05	0.09	11.57	11.41	1.32
1410	245.4	36.21	126.1	2.12	267.84	0.04	0.08	11.88	10.36	1.23
1420	233.5	35.89	122.3	2.10	256.34	0.04	0.07	11.94	9.62	1.15

Table 17 Results and calculation from testing of solar water pumping system at 25/3/2000

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1430	168.4	34.55	122.3	1.57	191.77	0.02	0.03	12.39	5.21	0.64
1440	126.4	32.65	123.2	1.18	145.13	0.02	0.03	12.49	8.08	1.01
1450	97	31.2	128.8	0.62	80.37	0.02	0.03	9.01	12.19	1.10
1500	185.6	31.73	109.8	1.89	207.30	0.02	0.04	12.15	7.36	0.89
1510	169.9	32.07	109.8	1.73	190.39	0.02	0.03	12.19	5.11	0.62
1520	198.2	32.22	110	1.96	215.49	0.03	0.05	11.83	8.69	1.02
1530	195.7	32.39	109.7	1.93	211.61	0.03	0.05	11.77	7.92	0.93
1540	224.5	32.92	112.9	2.14	241.27	0.03	0.06	11.69	8.95	1.04
1550	344.8	34.82	127.8	2.89	369.60	0.06	0.11	11.66	9.94	1.16
1600	412.8	38.2	123	3.51	431.48	0.09	0.16	11.37	12.78	1.45
1610	187.7	35.53	124.5	1.62	201.32	0.02	0.03	11.67	5.473	0.63
1620	114.5	32.91	113.1	1.16	130.74	0.03	0.04	12.42	12.25	1.52
1630	87.6	31.72	130.4	0.53	69.37	0.03	0.05	8.620	24.88	2.14
1640	69.33	30.64	115.6	0.67	77.34	0.02	0.04	12.14	17.02	2.06
1650	54.63	29.69	117.4	0.59	69.38	0.02	0.04	13.82	21.12	2.92
1700	58.42	29.35	109.6	0.72	78.91	0.03	0.04	14.70	19.99	2.93

Table 17 Results and calculation from testing of solar water pumping system at 25/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
900	264.3	30.34	128.3	2.22	284.57	0.02	0.04	11.72	4.81	0.56
910	281.9	31.33	130.5	2.28	296.89	0.03	0.06	11.46	6.15	0.70
920	263.8	31.42	129.1	2.18	281.57	0.03	0.06	11.62	6.67	0.77
930	274.7	31.56	128.5	2.31	296.96	0.03	0.06	11.77	6.11	0.72
940	330.2	32.56	128.8	2.73	352.14	0.04	0.08	11.61	7.70	0.89
950	317.1	33.18	129.2	2.61	336.57	0.04	0.08	11.55	7.39	0.85
1000	397.7	34.36	128.2	3.27	419.21	0.06	0.12	11.47	9.21	1.06
1010	483.9	36.45	124.7	4.07	507.03	0.09	0.17	11.40	11.05	1.26
1020	470.3	39.05	123.1	3.99	490.92	0.09	0.17	11.36	11.06	1.26
1030	682.5	42.44	119.1	5.88	700.67	0.15	0.29	11.17	13.66	1.53
1040	854	46.18	118.4	7.26	859.58	0.20	0.38	10.96	14.58	1.60
1050	602	46.64	118.3	5.21	615.75	0.15	0.28	11.13	14.96	1.67
1100	819	46.6	118.5	6.99	828.79	0.20	0.39	11.01	15.24	1.68
1110	977	52.27	116.7	8.17	953.44	0.25	0.47	10.62	16.22	1.72
1120	967	53.47	116.2	8.10	941.22	0.26	0.49	10.59	16.88	1.79
1130	946	53.47	116.5	7.94	925.01	0.25	0.48	10.64	16.87	1.80
1140	979	52.72	117.4	8.19	961.51	0.26	0.49	10.69	16.69	1.78

Table 17 Results and calculation from testing of solar water pumping system at 25/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1150	921	53.75	117.3	7.66	898.52	0.24	0.46	10.62	16.60	1.76
1200	981	54.51	116.2	8.22	955.16	0.25	0.47	10.60	16.08	1.70
1210	981	56.96	115.6	8.15	942.14	0.24	0.46	10.45	15.98	1.67
1220	988	57.77	114.9	8.23	945.63	0.24	0.46	10.42	15.91	1.66
1230	984	57.49	115.5	8.14	940.17	0.24	0.46	10.40	16.00	1.66
1240	774	52.45	117.2	6.52	764.03	0.19	0.35	10.74	15.09	1.62
1250	1041	57.41	114.1	8.69	991.53	0.25	0.48	10.37	15.68	1.63
1300	1008	58.43	111.6	8.59	958.64	0.24	0.46	10.35	15.74	1.63
1310	1110	59.69	111.4	9.35	1041.59	0.26	0.49	10.21	15.52	1.59
1320	1033	58.92	121	6.50	786.02	0.19	0.35	10.28	14.77	1.22
1330	913	58.68	143.2	6.36	910.18	0.20	0.37	10.85	13.36	1.45
1340	839	57.8	143.1	6.40	915.84	0.02	0.39	11.88	14.05	0.16
1350	775	55.89	144.2	6.02	868.52	0.21	0.39	12.20	14.76	1.80
1400	866	57.67	143.7	6.00	862.20	0.21	0.41	10.84	15.38	1.67
1410	876	56.22	145.6	5.96	868.21	0.22	0.42	10.79	15.74	1.70
1420	860	57.09	144.1	5.86	843.99	0.22	0.42	10.68	16.17	1.73

Table 17 Results and calculation from testing of solar water pumping system at 25/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1430	668.5	56.17	143.1	5.87	840.57	0.20	0.38	10.68	14.88	2.04
1440	516.9	51.17	144.7	5.53	800.19	0.19	0.35	11.85	14.39	2.42
1450	698.3	50.75	147.4	5.23	771.49	0.18	0.35	12.03	14.82	1.78
1500	670.7	51.31	146.3	5.24	766.76	0.18	0.35	12.44	14.77	1.84
1510	719	54.14	144.9	5.24	758.70	0.19	0.37	11.49	15.88	1.82
1520	546.9	51.42	144.9	5.64	817.53	0.18	0.35	11.27	13.85	2.25
1530	596.6	48.76	147	5.03	738.68	0.19	0.36	13.48	15.72	2.12
1540	488.9	49.43	143.8	4.68	672.98	0.18	0.33	14.98	16.20	2.43
1550	596.8	47.33	148.3	5.23	775.76	0.17	0.33	14.15	13.81	1.95
1600	515.9	46.59	147.3	5.57	820.46	0.17	0.33	12.31	13.02	2.25
1610	504.8	45.23	147.7	5.03	743.23	0.17	0.32	12.02	14.22	2.28
1620	467.4	43.84	147.8	4.70	694.36	0.17	0.32	12.17	15.12	2.44
1630	435.1	42.2	148	4.30	636.40	0.17	0.32	12.92	16.46	2.62
1640	393.5	41.32	147.8	4.02	594.16	0.16	0.30	12.43	16.70	2.75
1650	354.2	39.93	147.8	3.68	543.90	0.16	0.30	12.71	17.97	3.00
1700	308.1	38.75	147.2	4.10	603.52	0.15	0.29	12.31	15.77	3.36

Table 18 Results and calculation from testing of solar water pumping system at 26/3/2000

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
900	466.7	41.06	122.5	3.88	475.42	0.17	0.32	11.09	22.21	2.46
910	505.7	43.13	121.6	4.24	515.58	0.13	0.24	11.10	15.48	1.72
920	542.8	45.52	120.1	4.60	551.98	0.15	0.28	11.07	16.64	1.84
930	581.7	47.6	119	4.95	588.57	0.18	0.34	11.01	18.63	2.05
940	614.3	49.91	117.9	5.24	617.44	0.19	0.35	10.94	18.79	2.06
950	651	50.15	117.5	5.59	656.83	0.19	0.36	10.98	17.90	1.97
1000	685.5	49.01	118.6	5.84	692.62	0.19	0.36	11.00	16.99	1.87
1010	718	51.04	115.7	6.18	715.49	0.19	0.37	10.85	16.87	1.83
1020	753	51.77	115.3	6.48	746.91	0.20	0.38	10.80	16.61	1.79
1030	783	52.74	114.9	6.71	770.63	0.20	0.39	10.71	16.50	1.77
1040	811	53.77	115.3	6.88	793.03	0.21	0.40	10.64	16.60	1.77
1050	836	55.68	115.3	7.02	809.41	0.22	0.41	10.54	16.53	1.74
1100	864	57.81	114.7	7.18	823.55	0.22	0.42	10.38	16.52	1.71
1110	885	59.13	114.1	7.32	835.21	0.22	0.43	10.27	16.72	1.72
1120	908	60.04	111.9	7.61	851.56	0.23	0.43	10.21	16.69	1.70
1130	925	61.8	112.1	7.67	859.81	0.23	0.44	10.12	16.90	1.71
1140	936	61.65	112.9	7.68	867.07	0.24	0.46	10.08	17.42	1.76

Table 18 Results and calculation from testing of solar water pumping system at 26/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1150	955	60.04	113.6	7.90	897.44	0.25	0.48	10.23	17.37	1.78
1200	964	59.44	114.9	7.90	907.71	0.25	0.48	10.25	17.30	1.77
1210	969	60.75	113.8	7.93	902.43	0.26	0.49	10.14	17.58	1.78
1220	972	60.78	114.3	7.94	907.54	0.25	0.48	10.16	17.31	1.76
1230	974	60.02	115	7.96	915.40	0.25	0.48	10.23	17.20	1.76
1240	973	60.71	114.8	7.97	914.96	0.25	0.48	10.24	17.10	1.75
1250	971	59.51	115.1	8.04	925.40	0.25	0.48	10.37	16.80	1.74
1300	979	58.97	115.6	8.06	931.74	0.25	0.47	10.36	16.52	1.71
1310	975	59.87	114.9	8.04	923.80	0.24	0.46	10.31	16.34	1.68
1320	972	61.11	118.5	6.90	818.12	0.20	0.39	9.16	15.52	1.42
1330	965	62.47	142.7	6.86	978.35	0.21	0.39	11.04	13.05	1.44
1340	956	62.12	143.4	6.59	944.43	0.20	0.39	10.75	13.46	1.45
1350	939	63.37	142.2	6.52	927.57	0.20	0.39	10.75	13.70	1.47
1400	932	61.39	143.8	6.21	893.57	0.21	0.39	10.44	14.44	1.51
1410	906	63.19	141.8	6.00	850.80	0.22	0.43	10.22	16.39	1.68
1420	887	62.44	142.3	5.96	848.68	0.22	0.41	10.41	15.78	1.64

Table 18 Results and calculation from testing of solar water pumping system at 26/3/2000 (con'd)

Time	Irradiant (W/m2)	Tcell (C)	V_Pump (V)	A_Pump (A)	Power (Watt)	Velocity (m/s)	Volume (m^3/10 min)	Efficiency cell (%)	Efficiency motor/pump (%)	Efficiency system (%)
1430	871	62.19	142.5	5.87	837.05	0.22	0.42	10.46	16.58	1.73
1440	848	62.89	141.7	5.38	762.06	0.22	0.42	9.78	18.04	1.76
1450	806	61.91	141.9	5.27	747.67	0.23	0.43	10.10	18.94	1.91
1500	755	61.44	141.5	5.38	760.70	0.24	0.45	10.97	19.23	2.11
1510	729	59.36	142.8	5.20	742.70	0.24	0.46	11.09	20.19	2.24
1520	722	57.73	143.8	5.00	719.00	0.25	0.47	10.84	21.16	2.29
1530	686.3	58.37	142.5	4.86	691.98	0.23	0.44	10.97	20.82	2.29
1540	638.4	57.15	142.1	4.37	621.55	0.24	0.46	10.60	24.08	2.55
1550	591.7	56.18	132.9	4.19	557.25	0.25	0.47	10.25	27.86	2.86
1600	564.9	53	117	4.09	478.76	0.22	0.42	9.23	28.47	2.63
1610	524.4	52.08	117.4	4.50	528.18	0.19	0.36	10.96	22.33	2.45
1620	493.6	50.84	118.5	4.16	493.08	0.17	0.32	10.87	21.54	2.34
1630	454.6	49.41	118.7	3.79	449.99	0.15	0.29	10.77	20.73	2.23
1640	409	48.63	117.9	3.42	403.34	0.13	0.24	10.73	19.57	2.10
1650	353.6	46.42	120.8	2.88	347.30	0.09	0.17	10.69	15.90	1.70
1700	300.4	45	122.6	2.39	292.65	0.06	0.12	10.60	13.38	1.42

Appendix C
Results and calculation from testing of PV module

Table 19 Results and calculation from testing of PV module
(Part 1: Temperature constant, Radiation variable)
G_T = 736 W/m^2, T = 38 °C

R	V (Volt)	I (Amp)	P (watt)
0	0.5	3	1.5
1	1	3	3
2	2	3	6
3	2.5	3	7.5
4	3	3	9
5	3.5	3	10.5
6	4	3	12
7	4.5	3	13.5
8	5	3	15
9	5.5	3	16.5
10	6	3	18
11	6.5	3	19.5
12	7	3	21
13	7.5	3	22.5
14	8	3	24
15	8.5	3	25.5
16	9	3	27
17	9.5	3	28.5
18	10.5	2.98	31.29
19	11	2.95	32.45
20	11.5	2.9	33.35
21	12	2.85	34.2
22	12.5	2.78	34.75
23	13	2.6	33.8
24	13.5	2.5	33.75
25	14	2.3	32.2
26	14.5	2.1	30.45
27	15	1.85	27.75

Table 19 Results and calculation from testing of PV module (Part 1: Temperature constant, Radiation variable) (con'd)

$G_T = 736$ W/m^2, T = 38 °C

R	V (Volt)	I (Amp)	P (watt)
28	15.5	1.6	24.8
29	16	1.25	20
30	16.5	0.85	14.025
31	17	0.5	8.5

$G_T = 630$ W/m^2, T = 38 °C

R	V (Volt)	I (Amp)	P (watt)
0	1	2.45	2.45
1	2	2.44	4.88
2	2.5	2.43	6.075
3	3	2.42	7.26
4	3.5	2.41	8.435
5	4	2.4	9.6
6	4.5	2.38	10.71
7	5	2.35	11.75
8	5.5	2.35	12.925
9	6	2.35	14.1
10	6.5	2.35	15.275
11	7	2.35	16.45
12	7.5	2.35	17.625
13	8	2.35	18.8
14	8.5	2.35	19.975
15	9	2.35	21.15
16	9.5	2.35	22.325
17	10	2.34	23.4
18	11	2.33	25.63
19	11.5	2.3	26.45

Table 19 Results and calculation from testing of PV module
(Part 1: Temperature constant, Radiation variable) (con'd)
G_T = 630 W/m^2, T = 38 °C

R	V (Volt)	I (Amp)	P (watt)
20	12	2.25	27
21	12.5	2.2	27.5
22	13	2.15	27.95
23	13.5	2	27
24	14	1.8	25.2
25	14.5	1.5	21.75
26	15	1.2	18
27	15.5	1	15.5
28	16	0.7	11.2
29	16.5	0.3	4.95
30	17	0.1	1.7

Table 20 Results and calculation from testing of PV module
(Part 2: Radiation constant, Temperature variable)

T = 35 °C

V (Volt)	I (Amp)	P (watt)
0.5	3.2	1.6
1	3.2	3.2
2.5	3.2	8
3	3.2	9.6
4	3.2	12.8
5	3.18	15.9
5.5	3.18	17.49
6	3.18	19.08
6.5	3.16	20.54
7	3.16	22.12
8	3.14	25.12
9	3.14	28.26
9.5	3.12	29.64
10	3.1	31
11	3.06	33.66
12	3	36
13	2.8	36.4
14	2.6	36.4
15	2.2	33
16	1.8	28.8
17	1.1	18.7
18	0.2	3.6

Table 20 Results and calculation from testing of PV module (Part 2: Radiation constant, Temperature variable) (con'd)
T = 40 °C

V (Volt)	I (Amp)	P (watt)
0.5	3.2	1.6
2	3.2	6.4
3	3.2	9.6
4	3.2	12.8
5	3.2	16
6	3.18	19.08
7	3.18	22.26
7.5	3.17	23.775
8	3.15	25.2
8.5	3.14	26.69
9	3.12	28.08
9.5	3.09	29.355
10	3.02	30.2
10.5	2.95	30.975
11	2.92	32.12
11.5	2.81	32.315
12	2.75	33
12.75	2.65	33.7875
13.25	2.5	33.125
13.75	2.3	31.625
14.25	2.05	29.2125
15	1.6	24
15.5	1.3	20.15
16	0.8	12.8
16.5	0.3	4.95

Table 20 Results and calculation from testing of PV module (Part 2: Radiation constant, Temperature variable) (con'd)
T = 45 °C

V (Volt)	I (Amp)	P (watt)
1	3.3	3.3
2	3.3	6.6
2.5	3.25	8.125
3	3.25	9.75
3.5	3.22	11.27
3.75	3.22	12.075
4	3.23	12.92
1.25	3.22	4.025
5	3.21	16.05
5.5	3.19	17.545
5.75	3.19	18.3425
6.5	3.18	20.67
7	3.17	22.19
7.5	3.15	23.625
8	3.12	24.96
9	3	27
10	2.85	28.5
11	2.6	28.6
12	2.4	28.8
12.5	2	25
13.5	1.5	20.25
14	0.85	11.9
15	0.2	3

Table 20 Results and calculation from testing of PV module (Part 2: Radiation constant, Temperature variable) (con'd)
T = 50 °C

V (Volt)	I (Amp)	P (watt)
0.5	3.35	1.675
0.75	3.35	2.5125
1	3.35	3.35
1.5	3.34	5.01
2	3.34	6.68
2.5	3.34	8.35
2.75	3.32	9.13
3	3.32	9.96
3.25	3.3	10.725
3.75	3.3	12.375
4	3.3	13.2
4.5	3.29	14.805
5	3.28	16.4
5.5	3.26	17.93
6	3.24	19.44
6.5	3.2	20.8
7	3.1	21.7
7.5	3.05	22.875
8	2.9	23.2
8.75	2.75	24.0625
9.5	2.5	23.75
10	2.3	23
10.5	2.05	21.525
11	1.75	19.25
11.75	1.25	14.6875
12.25	0.9	11.025
13	0.6	7.8
13.5	0.2	2.7

Table 20 Results and calculation from testing of PV module (Part 2: Radiation constant, Temperature variable) (con'd)
T = 55 °C

V (Volt)	I (Amp)	P (watt)
0.3	3.45	1.035
0.5	3.45	1.725
0.7	3.42	2.394
1	3.42	3.42
1.2	3.4	4.08
1.5	3.4	5.1
1.7	3.38	5.746
2	3.38	6.76
2.5	3.35	8.375
2.75	3.35	9.2125
3	3.33	9.99
3.5	3.32	11.62
4	3.31	13.24
4.5	3.31	14.895
5	3.29	16.45
5.5	3.27	17.985
6	3.25	19.5
6.5	3.2	20.8
7	3.14	21.98
7.5	3.05	22.875
7.75	2.9	22.475
8.25	2.75	22.6875
8.75	2.4	21
9.5	2.1	19.95
10	1.65	16.5
10.5	1.2	12.6
11	1	11

Table 20 Results and calculation from testing of PV module (Part 2: Radiation constant, Temperature variable) (con'd)

T = 60 °C

V (Volt)	I (Amp)	P (watt)
0.2	3.45	0.69
0.4	3.45	1.38
0.7	3.44	2.408
0.9	3.44	3.096
1.2	3.44	4.128
1.4	3.43	4.802
1.6	3.43	5.488
1.9	3.42	6.498
2.1	3.42	7.182
2.3	3.41	7.843
2.5	3.41	8.525
2.9	3.4	9.86
3.5	3.4	11.9
4	3.38	13.52
4.5	3.35	15.075
5	3.32	16.6
5.5	3.29	18.095
6	3.22	19.32
6.5	3.19	20.735
7	3	21
7.5	2.8	21
8	2.4	19.2
8.5	2.1	17.85
9	1.8	16.2
9.5	1.2	11.4
10	0.6	6
10.5	0.2	2.1

Table 21 Relation between the radiation and I_{SC} and V_{OC}

GT	Isc	Voc
650	3.3	17.5
600	3	17.5
570	2.8	17.5
530	2.5	17.5
500	2.2	16.8
460	2	16.2
420	1.6	13.5
380	1.4	11

Table 22 Relation between the temperature and I_{SC} and V_{OC}

T	Isc	Voc
30	3.25	19.5
35	3.25	18.3
40	3.35	16.7
45	3.4	15.5
50	3.4	14
55	3.5	12.5
60	3.5	11

NOMENCLATURE

Symbol	Descriptions	Unit
A_C	Area of solar cell	m^2
C_W	Unit water cost	Baht/m^3
d	Internal diameter of pipe	m
E_h	Hydraulic energy	J
g	Acceleration due to gravity	m/s^2
$G,(G_T)$	Global insolation over the PV generator plane	W/m^2
H_L	Friction head loss	m
H_t	The total head	m
I	Current	A
i	Interest rate	%
I_m	Maximum current	A
L	Length of the pipe	m
P_h	Hydraulic power	W
P_{MO}	Power of motor	W
P_{PV}	Power of PV	W
Q	Flow rater	m^3/s
R	Denotes the internal rate of return (IRR).	
r	Discount rate	%
V	Voltage	V
V_A	Annual water requirement	m^3
V_m	Maximum voltage	V
W_{pump}	Water pumped	liter
ρ	Density of water	Kg/m^3
η	Efficiency	(%)

Subscript

PV	PV array
M, MO.	Motor
H	Hydraulic
MP	Motor and pump
sys	System
LCC	Life Cycle Costing or
ALCC	Annual equivalent life cycle cost
EAC	Equivalent annual cost
FV	Future value
IRR	Internal rate of return
MPPT	Maximum Power Point Tracking
NPV	The net present value
PV	Present value
RAC	Recurrent annual cost