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## APPENDICES

### Appendix A Location and description of each stream for design case and actual case.

#### A-1 Location and description of each stream for design case.

**Table A1** Location of streams at unit 100 for design case

HEX	STREAM
100-E2/2A	H1:C2
100-E1	H2:C2
100-E6	H3:C3
100-E4	H6:C5
100-EA3	H1:AIR
100-EA1	H29:AIR
100-EA2	H2:AIR
100-E9	H3:CW
100-E7	H4:CW
100-E10	H5:RE
100-EA4	H7:AIR
100-EA5	H6:AIR
100-E12AB	H6:CW
100-E3-3A	C1:HP
100-E11	C4:LP
100-E5	C6:LP

**Table A2** Location of streams at unit 110 for design case

HEX	STREAM
110-E1A-D	H8:C9
110-EA1	H8:AIR
110-E2/2A	C7:HP

**Table A3** Location of streams at unit 150 for design case

HEX	STREAM
150-E1A-H	H9:C10
150-H1	C10:HEATER
150-E2AB	H12:C11
150-EA3	H12:AIR
150-EA1	H10:AIR
150-EA2	H11:AIR
150-H2	C12:HEATER

**Table A4** Location of streams at unit 200 for design case

HEX	STREAM
200-E2	H13:C13
200-E6A-B	H20:C15
200-EA1	H14:AIR
200-E12	H16:CW
200-E13	H16:RE
200-EA2	H28:AIR
200-E3	H17:CW
200-EA3	H15:AIR
200-E4AB	H18:CW
200-E5	H19:CW
200-E7A/B	H21:CW
200-E15	H22:RE
200-E14	C14:MP
200-H5	C16:HEATER

**Table A5** Location of streams at unit 250 for design case

HEX	STREAM
250-EA4	H27:AIR
250-EA3	H26:AIR
250-EA2	H25:AIR
250-EA1	H24:AIR
250-E3	H23:CW
250-E1	C17:MP
250-H2	C20:HEATER
250-H1	C19:HEATER
250-H3	C21:HEATER
250-H4	C22:HEATER
250-E2	C18:MP

**Table A6** Description of hot streams for design case

stream	Unit	Description
H1	100	Bottom from naphtha splitter column, Condensate residue to storage
H2	100	Top from naphtha splitter column(100-V3), Feed to Naphtah splitter receiver
H3	100	Bottom from DeC2 (100-V7), To LPG storage or LPG treating
H4	100	Top from DeC2 (100-V7), Feed to deethanizer receiver
H5	100	Deethanizer off gas chiller
H6	100	Bottoms from DeC4, Light Naphtha to storage
H7	100	100-EA4
H8	110	Product from hydrolysis reactor, Feed to degasing drum (110-V2)
H9	150	Bottom from Reactor, Feed to 150-EA1 R1
H10	150	150-EA1
H11	150	150-EA2
H12	150	Bottom from stripper, Stripper Bottoms to platforming unit
H13	200	200-E2
H14	200	200-EA1
H15	200	200-EA3
H16	200	Product from recycle comp., Feed to recycle gas
H17	200	To 200-V2
H18	200	To 200-V3
H19	200	From 200-C2A/B/C, Feed to 200-V5
H20	200	Reformate from feed prep. Unit
H21	200	Feed to DeC4 condenser, Feed to 200-V8
H22	200	200-E15
H23	250	Feed to top of 250-V8
H24	250	250-EA1
H25	250	250-EA2
H26	250	250-EA3
H27	250	250-EA4
H28	200	200-EA2
H29	100	100-EA1

**Table A7** Description of cold streams for design case

stream	Unit	Description
C1	100	Feed to DeC5 reboiler, Feed to DeC5 bottom
C2	100	Full range condensate from storage, Feed to DeC5
C3	100	Overhead liq. From CCR, Feed to DeC2 (100V7)
C4	100	Deethanizer off gas
C5	100	FRC, Feed to DeC4
C6	100	Feed to debutanizer reboiler, Feed to DeC4 bottom
C7	110	H2 rich gas from CCR
C9	110	From water settling drum, To 110-E2
C10	150	Bottom of 150-V1, Feed to reactor
C11	150	Bottom from separator, Feed to stripper
C12	150	150-H2
C13	200	FRC, Feed to Recator
C14	200	Imported Reformate from feed prep. Unit
C15	200	bottom from 200-V27
C16	200	200-H5
C17	250	Recycle gas from platforming
C18	250	Booster gas from coalescer
C19	250	250-H1
C20	250	250-H2
C21	250	250-H3
C22	250	250-H4

**A-2 Location and description of each stream fro actual case.**

**Table A8** Location of streams at unit 100 for actual case

HEX no.	HEX	STREAM
1	100-E1	H2:C2
2	100-E2/2A	H1:C2
3	100-E3/3A	HP:C1
4	100-E4	H6:C5
5	100-E5	LP:C6
6	100-E6	H3:C3
7	100-E7	H4:CW
8	100-E9	H3:CW
9	100-E10	H5:RE
10	100-E11	LP:C4
11	100-E12AB	H6:CW
12	100-EA1	H29:AIR
13	100-EA2	H2:AIR
14	100-EA3	H1:AIR
15	100-EA4	H7:AIR
16	100-EA5	H6:AIR

**Table A9** Location of streams at unit 110 for actual case

HEX no.	HEX	STREAM
17	110-E1A-D	H8:C9
18	110-E2	HP:C8
19	110-E2A	HP:C7
20	110-EA1	H9:AIR

**Table A10** Location of streams at unit 150 for actual case

HEX no.	HEX	STREAM
21	150-E1A-H	H9:C10
22	150-E2AB	H12:C11
23	150-EA1	H10:AIR
24	150-EA2	H11:AIR
25	150-EA3	H12:AIR
26	150-H1	HEATER:C10
27	150-H2	HEATER:C12

**Table A11** Location of streams at unit 200 for actual case

HEX no.	HEX	STREAM
28	200-E2	H13:C13
29	200-E3	H17:CW
30	200-E4AB	H18:CW
31	200-E5	H19:CW
32	200-E6AB	H20:C15
33	200-E7AB	H21:CW
34	200-E12	H16:CW
35	200-E13	H16:RE
36	200-E14	MP:C14
37	200-E15	H22:RE
38	200-EA1	H14:AIR
39	200-EA2	H28:AIR
40	200-EA3	H15:AIR
41	200-H5	HEATER:C16

**Table A12** Description of hot streams for actual case

stream	Unit	Description
H1	100	Bottom from naphtha splitter column, Condensate residue to storage
H2	100	Top from naphtha splitter column(100-V3), Feed to Naphtah splitter receiver
H3	100	Bottom from DeC2 (100-V7), To LPG storage or LPG treating
H4	100	Top from DeC2 (100-V7), Feed to deethanizer receiver
H5	100	Deethanizer off gas chiller
H6	100	Bottoms from DeC4, Light Naphtha to storage
H7	100	100-EA4
H8	110	Product from hydrolysis reactor, Feed to degasing drum (110-V2)
H9	150	Bottom from Reactor, Feed to 150-EA1 R1
H10	150	150-EA1
H11	150	150-EA2
H12	150	Bottom from stripper, Stripper Bottoms to platforming unit
H13	200	200-E2
H14	200	200-EA1
H15	200	200-EA3
H16	200	Product from recycle comp., Feed to recycle gas
H17	200	To 200-V2
H18	200	To 200-V3
H19	200	From 200-C2A/B/C, Feed to 200-V5
H20	200	Reformate from feed prep. Unit
H21	200	Feed to DeC4 condenser, Feed to 200-V8
H22	200	200-E15
H28	200	200-EA2
H29	100	100-EA1



**Table A13** Description of cold streams for actual case

stream	Unit	Description
C1	100	Feed to DeC5 reboiler, Feed to DeC5 bottom
C2	100	Full range condensate from storage, Feed to DeC5
C3	100	Overhead liq. From CCR, Feed to DeC2 (100V7)
C4	100	Deethanizer off gas
C5	100	FRC, Feed to DeC4
C6	100	Feed to debutanizer reboiler, Feed to DeC4 bottom
C7	110	H2 rich gas from CCR
C8	110	H2 rich gas from CCR
C9	110	From water settling drum, To 110-E2
C10	150	Bottom of 150-V1, Feed to reactor
C11	150	Bottom from separator, Feed to stripper
C12	150	150-H2
C13	200	FRC, Feed to Recator
C14	200	Imported Reformate from feed prep. Unit
C15	200	bottom from 200-V27
C16	200	200-H5

**Appendix B Problem table algorithm for various  $\Delta T_{\min}$  for design case.**

DT units -5																													
Time	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H20	H21	H22	H23	H24	H25	H26	H27	H28	
mCp (hW/C)	47.105	132.558	16.761	2.806	25.385	31.061	169.200	110.312			18.668	127.876	0.179		29.707	4.749			4.222	98.212	18.019	0.598	76.000	3.125	0.611	0.438	10.857	18.200	
Inlet heat (hW/C)	611.600		10.593	2.667	613.075			170.954	111.667	791.088				275.654	30.571	6.676	121.453	101.738	4.286		98.212	2.719							
379.5																													
372.5																													
341.5																													
321.5																													
314.5																													
484.5																													
479.5																													10.857
474.5																													10.857
454.5																													0.438
422.5																													0.438
341.5																													0.438
340.5																													0.438
318.1										110.312																			0.438
302.5										110.312																			0.438
292.5										110.312																			0.438
291.484										110.312																			0.438
291.372										110.312																			0.438
274.172										110.312																			0.438
265.982										170.954																			0.438
236.5										170.954																			0.438
232.5	47.105									170.954																			0.438
230.5	47.105									170.954																			0.438
224.5	47.105									170.954																			0.438
222.5	47.105									170.954																			0.438
219.5	47.105									170.954																			0.438
217.5	47.105									170.954																			0.438
216.215	47.105									169.200	170.954																		0.438
214.2	47.105									169.200	170.954																		0.438
209.2	47.105									169.200	170.954																		0.438
203.5	47.105									169.200	170.954																		0.438
194.823	47.105									169.200	170.954										90.212								0.438
191.2	47.105									169.200	170.954										90.212								0.438
190.5	47.105									169.200	170.954										90.212								0.438
187.7	47.105									169.200	170.954										90.212								0.438
177.4	47.105									169.200	170.954										90.212								0.438
164.5	47.105									169.200	170.954										90.212								0.438
159.5	47.105									169.200	170.954										90.212								0.438
156.6	47.105									169.200	170.954										90.212								0.438
151.5	47.105									169.200	170.954										90.212								0.438
146.5	47.105									169.200	170.954										90.212								0.438
145.5	47.105	411.600								169.200	170.954										90.212								0.438
132.5	47.105	411.600								169.200	170.954										90.212								0.438
130.4	47.105	411.600								169.200	170.954										90.212								0.438
128.5	47.105	411.600								169.200	170.954										90.212								0.438
120.5	47.105	411.600								169.200											90.212								0.438
118.508	47.105	411.600								169.200											90.212								0.438
118.5	47.105	411.600								169.200											90.212								0.438
114.3	47.105	411.600								169.200											90.212								0.438
113.5	47.105	411.600								169.200											90.212								0.438
109.3	47.105	411.600								169.200											90.212								0.438
108.523	47.105	411.600								169.200											90.212								0.438
106.5	47.105	132.558								169.200											90.212								0.438
104.5	47.105	132.558	16.761							169.200											90.212								0.438
100.5	47.105	16.761								169.200											90.212								0.438
100.7	47.105	16.761								169.200											90.212								0.438
94.5	47.105	16.761								169.200											90.212								0.438
91.768	47.105	16.761								169.200											90.212								0.438
88.5	47.105	16.761								169.200											90.212								0.438
80.5	47.105	16.761								169.200											90.212								0.438
78.5	47.105	16.761								169.200											90.212								0.438
66.891	47.105	16.761								169.200											90.212								0.438
66.162	47.105	16.761								169.200											90.212								0.438
63.5	47.105	16.761								169.200											90.212								0.438
64.23	47.105	16.761								169.200											90.212								0.438
63.5	47.105	16.761								169.200											90.212								0.438
62.202	47.105	16.761								169.200											90.212								0.438
61.5	47.105	16.761								169.200											90.212								0.438
61.067	47.105	16.761	2.806							169.200											90.212								0.438
59.21	47.105	16.761	2.806							169.200											90.212								0.438
18.387	47.105	16.761	2.806							169.200											90.212								0.438
57.5	47.105	16.761	10.593							169.200											90.212								0.438
57.04	47.105	16.761	10.593							169.200											90.212								0.438
54.5	47.105	16.761	10.593																										

H29	C1	C2	C3	C4	C5	C6	C7	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	MCp,im	Qpw	Qou	Rzu		
72 698	121 113	173 143	15 429	0 232	35 833	158 752	232 056	159 144	103 799			0 302	17 500	83 433	101 704	88 108	0 721	0 210	10 753	0 391	0 402	kW/C	kW	kW	kW		
454 858	1829 517					2755 387					825 000				501 580							0 000	0 000	0 000	30506 919		
																						0 391	2 740	2 740	10304 179		
																						0 794	24 605	-27 346	10479 574		
																			0 210			1 004	20 076	-47 422	10459 498		
																						0 825	5 776	-53 197	10453 722		
																				0 310			-10 032	-300 962	247 765	10734 684	
																				0 210	10 753		-0 701	3 506	244 258	10731 178	
																				0 210	10 753		11 518	57 792	186 466	10695 386	
																				0 210	10 753		11 130	222 409	-35 943	10470 977	
																				0 210			0 387	12 388	-48 331	10458 589	
																						0 391	0 402	0 177	14 340	-62 471	10444 249
									103 799													0 391	0 402	103 976	103 976	-166 647	10340 273
									103 799													0 391	0 402	-6 336	141 932	-24 714	10482 203
									103 799		0 302											0 391	0 402	-6 034	-94 138	69 424	10376 343
									103 799		0 302											0 391	0 402	-6 034	-60 345	139 769	10636 688
									499 122		0 302											0 391	0 402	-6 646	-6 752	136 521	10643 440
									499 122		0 302											0 391	0 402	188 678	43 532	92 989	10399 908
									499 122		0 302											0 391	0 402	188 678	66 83 258	-6572 269	23 914 650
									499 122		0 302											0 391	0 402	328 036	26 66 614	9278 883	21228 036
									103 799		0 302											0 391	0 402	-47 288	1983 799	7295 105	23211 815
									103 799		0 302											0 391	0 402	-114 393	-437 372	-4827 512	23 666 387
									103 799	825 000	0 302											0 391	0 402	710 607	1421 214	4828 746	22248 173
									103 799	825 000	0 302											0 391	0 402	1212 187	7273 120	-15531 866	14975 053
									103 799		0 302			501 580								0 391	0 402	187 187	774 373	-16306 239	14300 680
									232 056	103 799	0 302			501 580								0 391	0 402	619 243	1817 729	-18143 968	12342 951
									232 056	103 799	0 302			501 580								0 391	0 402	491 367	982 734	-19146 702	11360 217
									232 056	103 799	0 302			501 580								0 391	0 402	322 167	413 984	-19560 687	10946 233
									232 056	103 799	0 302			101 704								0 391	0 402	-77 709	-116 583	-19404 104	11102 816
									232 056	103 799	0 302											0 391	0 402	-179 411	897 064	-18507 040	11999 880
									232 056	103 799	0 302											0 391	0 402	-269 622	-1536 804	-16970 176	13336 743
									232 056	103 799	0 302											0 391	0 402	1559 892	13516 743	-20566 919	0 800
									232 056	103 799	0 302											0 391	0 402	148 512	-537 912	-29949 007	337 913
									232 056	159 144	103 799	0 302										0 391	0 402	10 632	7 442	-29976 449	536 470
									232 056	159 144	103 799	0 302										0 391	0 402	-110 481	-386 684	-29589 766	917 154
									159 144	103 799	0 302											0 391	0 402	-342 537	-3288 359	-26301 407	4205 512
									159 144	103 799	0 302											0 391	0 402	-342 539	-4416 426	-21884 981	8621 939
									159 144	103 799	0 302			17 500								0 391	0 402	-324 835	-1624 293	-20260 688	10746 233
									159 144	103 799	95 370	0 302	17 500									0 391	0 402	248 156	-719 452	-19541 036	10965 884
									159 144	103 799	95 370	0 302	17 500	83 433								0 391	0 402	-164 723	-840 086	-18700 949	11805 970
									159 144	103 799	95 370	0 302	17 500	83 433								0 391	0 402	-73 894	-379 470	-18321 479	12185 440
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	-687 494	-17633 986	12872 934	
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	-514 251	-6686 359	-10947 426	19359 497
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	517 476	1036 499	9860 727	20646 197
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	545 183	1039 648	8823 079	216 875 840
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	394 428	3155 429	-3665 450	24841 269
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	2360 928	-10368 479	20 138 241	
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	235 677	-1 885	-10366 793	20 140 126
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	-506 399	-2125 600	-4241 193	23265 726
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	-506 397	-405 118	-8726 075	22670 844
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	531 782	-2233 483	-5602 592	24904 327
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	-536 530	-416 884	-1815 708	23321 211
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	57 489	-116 301	-5069 408	25437 512
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	53 626	107 253	-176 660	23330 299
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	186 183	670 265	-5846 925	24659 954
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	376 397	55 279	-1502 205	24604 713
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	6 743	4 608	1966 813	24600 107
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	71 955	196 583	-5710 231	24796 688
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	-454 115	-1484 047	-4236 184	26280 735
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	-471 615	-3772 917	-453 267	30053 453
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	-456 186	-912 372	459 101	10966 025
									159 144	103 799	95 370	0 302	17 500	83 433			88 108	0 721				0 391	0 402	-4879 875	5338 981	35845 900	
									159 144	103 799	95 370	0 302	17 500														





DT mda - 20																													
Tot	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H20	H21	H22	H23	H24	H25	H26	H27	H28	
mCp (L W/C)	47 105	132 558	16 761	2 806	25 385	31 061	169 200	110 312	18 668	127 876	0 179			275 654	30 571	6 676	121 453	101 738	4 222	98 212	18 019	0 598	76 000	3 125	0 611	0 438	10 857	18 200	
latent heat (L W/C)	611 600	10 593	2 667		611 075			170 954	111 667	791 088											98 212	2 719							
547																													
549																													
514																													
507														0.179															
492														0.179															10 857
473														0.179															10 857
467														0.179															
463														0.179															0 438
430														0.179															0 438
349														0.179															0 438
333														0.179															0 438
325 4										110 312				0.179															0 438
310										110 312				0.179															0 438
298 984										110 312				0.179															0 438
298 872										110 312				0.179															0 438
285										110 312				0.179															0 438
273 482										110 312				0.179															0 611 0 438
266 673										110 312				0.179															0 611 0 438
240										170 954				0.179															0 611 0 438
238										170 954				0.179															0 611 0 438
232										170 954				0.179															0 611 0 438
230										170 954				0.179															0 611 0 438
229										170 954				0.179															0 611 0 438
223 715	47 105									170 954				0.179															0 611 0 438
221 7	47 105									170 954				0.179															0 611 0 438
212	47 105									170 954				0.179															0 611 0 438
211	47 105									170 954				0.179															0 611 0 438
210	47 105									170 954				0.179															0 611 0 438
203 323	47 105									169 200	170 954			127 876	0 179														0 611 0 438
201	47 105									169 200	170 954			127 876	0 179														0 611 0 438
198 7	47 105									169 200	170 954			127 876	0 179						90 212								0 611 0 438
198	47 105									169 200	170 954			127 876	0 179						90 212								0 611 0 438
194 5	47 105									169 200	170 954			127 876	0 179						90 212								0 611 0 438
173	47 105									169 200	170 954			127 876	0 179						90 212								0 611 0 438
169 9	47 105									169 200	170 954			127 876	0 179						90 212								0 611 0 438
167	47 105									169 200	170 954			127 876							90 212								0 611 0 438
164	47 105									169 200	170 954			127 876							90 212								0 611 0 438
159	47 105									169 200	170 954			127 876							90 212								0 611 0 438
153	47 105									169 200	170 954			127 876							90 212								0 611 0 438
152	47 105									169 200	170 954			127 876							90 212								0 611 0 438
139	47 105									169 200	170 954			18 668	127 876						90 212								0 611 0 438
128	47 105	611 600								169 200	170 954			18 668	127 876						90 212								0 611 0 438
126 008	47 105	611 600								169 200	170 954			18 668	127 876						90 212								0 611 0 438
126	47 105	611 600								169 200	170 954			18 668	127 876						90 212								0 611 0 438
125	47 105	611 600								169 200	170 954			18 668	127 876						90 212								0 611 0 438
122 9	47 105	611 600								169 200	170 954			18 668	127 876						90 212								0 611 0 438
121 8	47 105	611 600								169 200	170 954			18 668	127 876						90 212								0 611 0 438
121	47 105	611 600								169 200	170 954			18 668	127 876						29 707								0 611 0 438
111	47 105	611 600								169 200	170 954			18 668	127 876						29 707								0 611 0 438
106	47 105	611 600								169 200	170 954			18 668	127 876						29 707								0 611 0 438
101 021	47 105	611 600								169 200	170 954			111 667	18 668	127 876					29 707								0 611 0 438
101 023	47 105	611 600								169 200	170 954			111 667	18 668	127 876					29 707								0 611 0 438
99	47 105	132 558								169 200	170 954			111 667	18 668	127 876					29 707	4 749							0 611 0 438
97	47 105	132 558	16 761							169 200	170 954			111 667	18 668	127 876					29 707	4 749							0 611 0 438
96	47 105	16 761								169 200	170 954			111 667	18 668	127 876					29 707	4 749							0 611 0 438
93 4	47 105	16 761								169 200	170 954			111 667	18 668	127 876					29 707	4 749							0 611 0 438
93 2	47 105	16 761								169 200	170 954			111 667	18 668	127 876					29 707	4 749							0 611 0 438
88	47 105	16 761								169 200	170 954			111 667	18 668	127 876					275 654	29 707	4 749						0 611 0 438
87	47 105	16 761								169 200	170 954			111 667	18 668	127 876					275 654	29 707	4 749						0 611 0 438
86	47 105	16 761								169 200	170 954			111 667	18 668	127 876					275 654	29 707	4 749						0 611 0 438
84 368	47 105	16 761								169 200	170 954			111 667	18 668	127 876					275 654	29 707	4 749						0 611 0 438
77	47 105	16 761								169 200	170 954			111 667	18 668	127 876					275 654	29 707	4 749						0 611 0 438
62	47 105	16 761								169 200	170 954			111 667	18 668	127 876					275 654	29 707	4 749						0 611 0 438
59 391	47 105	16 761								169 200	170 954			111 667	18 668	127 876					275 654	29 707	4 749						0 611 0 438
59	47 105	16 761								169 200	170 954			111 667	18 668	127 876					275 654	29 707	4 749						0 611 0 438
58 662																													

1129	C1	C2	C3	C4	C5	C6	C7	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	MCP,mm k/W	Qm k/W	Qma k/W	Rma k/W
72 698	123 113	173 143	15 429	0 222	35 833	158 752	232 036	159 144	103 799			0 302	17 500	83 433	101 704	88 108	0 721	0 210	10 733	0 391	0 402	0 000	0 000	0 000	39549 645
454 858	1820 517					2755 387			499 122	95 370	823 000				501 380							0 391	3 740	-2 740	39346 704
																						0 391	2 740	-2 740	39346 704
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																						0 391	2 740	-2 740	39346 704
																						0 391	2 740	-2 740	39346 704





H29	C1	C2	C3	C4	C5	C6	C7	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	MC <sub>part</sub>	Q <sub>net</sub>	Q <sub>net</sub>		
72 698	121 113	173 143	15 429	0 222	35 833	158 752	232 056	159 144	103 799			0.302	17 500	83 433	101 704	88 108	0 721	0 210	10 733	0 391	0 402	kW/C	kW	kW		
454 858	1829 517					2755 387			499 122	85 370	825 000				501 580							0 000	0 000	0 000		
																						0.391	2 740	-2 740		
																						0.391	24 605	-27 346		
																						0.210	1 004	45 171	-72 517	
																						0.210	0 825	5 776	-78 292	
																						0.210	-10 032	-50 160	-28 132	
																						0.210	0 701	21 038	-48 170	
																						0.210	0 825	4 125	-53 296	
																						0.210	0 387	10 452	-63 748	
																						0.391	0 177	14 340	-78 088	
									103 799													0.391	0 402	103 976	2433 035	2511 123
									103 799			0.302										0.391	0 402	104 278	271 122	2782 244
									103 799			0.302										0.391	0 402	-6 034	-78 448	-2703 706
									103 799			0.302										0.391	0 402	-6 034	-66 476	-2637 320
									499 122			0.302										0.391	0 402	389 289	43 600	-2680 920
									499 122			0.302										0.391	0 402	389 289	9293 111	-11974 031
									499 122			0.302										0.391	0 402	388 678	590 013	-12564 064
									103 799			0.302										0.391	0 402	-6 646	-111 717	12452 327
									103 799			0.302										0.391	0 402	-67 288	-1121 822	-11330 505
									103 799			0.302										0.391	0 402	757 712	1515 424	-12845 930
									825 000			0.302										0.391	0 402	1259 292	7555 751	-20401 681
									825 000			0.302			501 580							0.391	0 402	434 292	868 584	-21270 265
												0.302		501 580								0.391	0 402	666 348	4187 999	-25458 264
							232 056		103 799			0.302			501 580							0.391	0 402	266 473	536 943	25995 206
							232 056		103 799			0.302			101 704							0.391	0 402	164 769	444 875	-26440 082
							232 056		103 799			0.302										0.391	0 402	117 663	941 306	-27381 188
							232 056		103 799			0.302										0.391	0 402	1947 181	16897 633	-44279 021
							232 056		103 799			0.302										0.391	0 402	238 776	76 886	-44355 906
	121 113						232 056		103 799			0.302										0.391	0 402	110 900	221 800	-44577 706
	121 113						232 056		103 799			0.302										0.391	0 402	-58 300	-75 790	-44501 916
	121 113						232 056		103 799			0.302										0.391	0 402	100 844	70 591	-44572 507
	121 113						232 056	159 144	103 799			0.302										0.391	0 402	-20 269	-70 940	-44501 567
							159 144		103 799			0.302										0.391	0 402	-252 325	-706 510	-43765 057
							159 144		103 799			0.302										0.391	0 402	-342 537	-6747 986	-37047 071
							159 144		103 799			0.302	17 500									0.391	0 402	-325 037	-1625 187	-15421 884
							159 144		103 799	95 370		0.302	17 500									0.391	0 402	-229 667	-666 034	-34755 850
							159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-146 234	-614 183	-34141 667
							159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-146 055	-131 450	-34010 217
							159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-57 226	-343 359	-33666 858
							159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	115 916	1275 080	-34941 918
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	97 249	1264 235	-36296 174
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-514 351	-514 351	-35691 823
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	2241 016	4464 143	-40155 966
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-355 599	-2 845	-40153 121
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-514 351	-2160 273	-37992 848
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-514 652	3499 637	-34493 211
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-517 777	-1087 333	-33405 879
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-547 485	-1040 221	-32365 657
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-394 730	3947 304	-28418 354
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-506 397	-2531 985	-25886 368
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-549 282	-2306 983	-25779 385
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-584 030	-430 882	-23148 504
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	-74 989	-151 703	-22997 200
	173 143						159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	16 126	16 126	-32033 127
	173 143	15 429					159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	51 555	51 555	-23084 882
	173 143	15 429					159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	184 113	184 113	-23268 995
	173 143	15 429			35 833		159 144		103 799	95 370		0.302	17 500	83 433								0.391	0 402	219 947	571 861	-23840 856
	173 143	15 429			35 833		159 144		103 799																	



H39	C1	C3	C4	C5	C6	C7	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	MCp,ref	Qm	Qm	Qm	Rm
72.698	121.113	173.143	15.429	0.222	35.833	158.752	232.056	159.144	103.799	0.302	17.500	83.433	101.704	88.108	0.721	0.210	10.733	0.391	0.402		kW/C	kW	kW	kW	
454.858	1829.517					2755.387			499.122	95.370	825.000			501.580							0.000	0.000	0.000	48918.463	
																					0.391	2.740	-2.740	49915.723	
																					0.391	0.794	24.405	-37.946	48891.118
																					0.210	1.004	15.209	-82.555	48823.909
																					0.210	0.825	1.650	-84.205	48834.258
																					0.210	11.558	37.792	-141.997	48776.466
																					0.210	0.701	17.532	-159.529	48758.935
																					0.210	-10.032	-100.321	-59.208	48859.255
																					0.210	0.825	4.125	-63.334	48855.130
																					0.210	0.825	6.581	-69.915	48848.549
																					0.210	0.177	14.340	-84.255	48834.309
																					0.391	0.402	2433.025	-2517.289	46401.174
								103.799													0.391	104.278	1313.898	-1821.187	45087.276
								103.799	0.302												0.391	-6.014	-18.103	-3813.084	45105.380
								103.799	0.302												0.391	-6.014	-66.476	-3746.608	45171.856
								499.122	0.302												0.391	389.289	43.600	-3790.208	45128.255
								499.122	0.302												0.391	389.289	9884.022	-13674.260	35244.202
								103.799	0.302												0.391	-6.014	-51.185	-13623.075	35299.388
								103.799	0.302												0.391	-6.444	-121.805	-13501.270	35417.193
								103.799	0.302												0.391	-67.388	-448.944	-13052.326	35866.137
								103.799	825.000	0.302											0.391	757.712	1515.424	-14567.751	34350.713
								103.799	825.000	0.302				501.580							0.391	1259.292	7555.751	-22133.502	26794.961
								103.799		0.302				501.580							0.391	434.292	868.184	-22992.086	25926.378
								232.056		0.302				501.580							0.391	666.348	4187.999	-3710.085	21738.379
								232.056		0.302				101.704							0.391	266.473	536.943	-27717.027	21201.456
								103.799		0.302											0.391	160.769	1763.023	-39480.051	19418.413
								232.056		0.302											0.391	1994.284	3988.272	-13468.422	15449.841
								232.056		0.302											0.391	1847.181	13003.272	-46471.894	2446.569
								232.056		0.302											0.391	238.776	864.847	-47336.741	1581.723
								232.056	159.144	0.302											0.391	397.928	278.544	-47615.285	1303.179
								232.056	159.144	0.302											0.391	646.807	968.876	-48384.111	134.353
								159.144	103.799	0.302											0.391	44.751	111.878	-48693.989	322.475
								159.144	103.799	0.302											0.391	-81.135	-166.250	-48939.929	388.725
								159.144	103.799	0.302											0.391	252.325	-2094.297	-46445.441	2482.022
								159.144	103.799	0.302											0.391	-342.517	3332.417	-411.12829	5805.635
								159.144	103.799	0.302	17.500										0.391	-325.037	-1625.187	-41487.642	7430.821
								159.144	103.799	95.370	0.302	17.500									0.391	129.667	-666.034	-40821.608	8096.856
								159.144	103.799	95.370	0.302	17.500	83.433								0.391	146.234	-745.794	-40075.814	8847.649
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	-57.405	-344.431	-39731.383	9187.080
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	113.778	358.987	-40900.162	8878.284
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	159.816	2074.903	-43165.075	7533.390
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	97.249	388.995	-42514.069	6364.393
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	2852.615	5682.450	-48236.518	681.945
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	256.061	2.048	-48238.566	679.897
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	97.249	408.445	-48647.012	271.452
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	96.947	371.452	-48918.463	0.000
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	514.622	-7205.135	-41731.329	7205.135
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	-81.135	-166.250	-48939.929	8878.725
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	547.485	-1040.221	-39583.775	9333.489
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	384.700	-1973.652	-37612.123	11306.341
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	-412.250	-2061.152	-35510.971	13367.493
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	522.897	-1571.691	-33979.279	14939.184
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	-508.448	-1016.937	-32962.343	15956.121
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	498.020	-2091.483	-30870.639	18047.804
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	502.748	-390.651	-30663.841	18754.423
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	-23.727	-48.000	-30432.008	18486.455
								159.144	103.799	95.370	0.302	17.500	83.433		88.108	0.721					0.391	407.338	-174.776	-30606.785	18311.679
								159.144	103.799	95.370	0.302														

**Appendix C Hot and cold composite curves calculation fro minimum area at various  $\Delta T_{\min}$  for design and actual case.**

**C-1 Hot and cold composite curves calculation for minimum area at various  $\Delta T_{\min}$  for design case.**

**Table C1** Hot composite curve calculation for minimum area at various  $\Delta T_{min}$  for design case

Interval	Temp Interval mCp (kW/C)	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H20	H21	H22	H23	H24	H25	H26	H27	H28	H29	Th C	SumMCP,h kW/C	Qint,h kW	cumQh kW
0		47.11	132.56	16.76	2.81	10.59	2.67	25.38	31.06	169.20	110.31	18.67	127.88	0.18	275.65	30.57	6.68	121.45	101.74	4.29	90.21	18.02	0.60	76.00	3.13	0.61	0.44	10.86	18.20	72.70				
1	8	23															6.68						2.72							8	0.00	0.00	0.00	
2	23	37.323				2.67											6.68						2.72							17.323	12.06	172.76	113.68	
3	37.323	37.78			2.67												6.68						0.60							37.78	9.94	4.54	318.22	
4	37.78	37.91			2.67												6.68		101.74	4.29										37.91	115.37	15.00	333.22	
5	37.91	38			2.67												6.68	121.45	101.74	4.29										38	236.82	21.31	354.53	
6	38	38.3	16.76				25.38										6.68	121.45	101.74	4.29				76.00							38.3	352.30	105.69	460.22
7	38.3	40	16.76				25.38										6.68	121.45	101.74	4.29		98.21		76.00						40	450.51	765.87	1226.09	
8	40	44.584	16.76	10.59			25.38										6.68	121.45	101.74	4.29		98.21								44.584	385.10	1765.31	2991.40	
9	44.584	46.86	16.76	10.59			25.38										6.68	121.45	101.74	4.29		98.21								46.86	385.04	876.35	3867.75	
10	46.86	47	16.76	10.59			25.38										6.68		101.74	4.29		98.21								47	263.59	36.90	3904.65	
11	47	48.53	16.76	10.59			25.38	613.08									6.68		101.74	4.29		98.21								48.53	876.66	1341.29	5245.94	
12	48.53	49	16.76	10.59			25.38	613.08							275.65		6.68		101.74	4.29		98.21								49	1152.32	541.59	5787.53	
13	49	50	47.11				25.38	613.08			111.67						6.68		101.74	4.29		98.21								50	1311.09	1311.09	7098.62	
14	50	51	449	47.11			25.38	613.08			111.67	791.09					6.68		101.74	4.29		98.21								51	449	2102.18	3046.05	10144.67
15	51	449	52	47.11			25.38	613.08			111.67	18.67					6.68		101.74	4.29		98.21								52	1329.76	732.70	10877.37	
16	52	53	925	47.11			25.38	613.08			111.67	18.67					6.68		101.74	4.29		98.21								53	925	1402.45	2699.72	13577.09
17	53	925	55	47.11			25.38	31.06			111.67	18.67					6.68		101.74	4.29		98.21								55	820.44	881.97	14459.06	
18	55	56	47.11				25.38	31.06			111.67	18.67					6.68		101.74	4.29		98.21								56	854.14	854.14	15313.20	
19	56	56	11	47.11			25.38				111.67	18.67					6.68		101.74	4.29		98.21								57	823.07	90.54	15403.74	
20	56	11	56	19	47.11		25.38				111.67	18.67					6.68		101.74	4.29		98.21								58	823.07	90.54	15403.74	
21	56	19	59	54	47.11		25.38				111.67	18.67					6.68		101.74	4.29		98.21								59	823.07	90.54	15403.74	
22	59	54	60	47.11			25.38				111.67	18.67					6.68		101.74	4.29		98.21								60	832.22	382.82	18663.70	
23	60	60	887	47.11			25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								60	887	1001.42	888.26	19551.96
24	60	887	61	71	47.11		25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								61	71	993.63	817.76	20369.72
25	61	71	63	567	47.11		25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								63	567	992.77	1843.58	22213.30
26	63	567	64	47.11			25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								64	47.11	990.84	429.04	22642.33
27	64	65	202	47.11			25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								65	202	988.04	1187.62	23829.96
28	65	202	66	47.11			25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								66	47.11	907.84	724.46	24554.42
29	66	66	75	47.11			25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								66	75	908.89	681.67	25236.09
30	66	75	68	662	47.11		25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								68	662	890.87	1703.35	26939.44
31	68	662	69	391	47.11		25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								69	391	1273.03	928.04	27867.48
32	69	391	94	268	47.11		25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								94	268	1176.13	29258.50	57125.98
33	94	268	97	47.11			25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								97	47.11	793.97	2169.12	59295.10
34	97	103	2	47.11			25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								103	2	721.27	4471.86	63766.96
35	103	2	103	4	47.11		25.38		169.20		-111.67	18.67					6.68		101.74	4.29		98.21								103	4	445.61	89.12	63856.08
36	103	4	107	47.11			25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								107	4	535.83	1928.98	65785.06
37	107	109	109	47.11	132.56	16.76	25.38		169.20		111.67	18.67					6.68		101.74	4.29		98.21								109	668.39	1336.77	67121.83	
38	109	111	023	47.11	132.56		25.38		169.20		111.67	18.67	127.88				6.68		101.74	4.29		98.21								111	023	779.50	1576.93	68698.76
39	111	023	111	8	47.11	611.60	25.38		169.20		111.67	18.67	127.88				6.68		101.74	4.29		98.21								111	8	1258.54	977.89	69676.65
40	111	8	116	47.11	611.60		25.38		169.20		111.67	18.67	127.88				6.68		101.74	4.29		98.21								116	47.11	1253.79	5265.93	74942.58
41	116	121	131	47.11	611.60		25.38		169.20		111.67	18.67	127.88				6.68		101.74	4.29		98.21								121	131	1228.41	6142.04	81084.62
42	121	131	132	9	47.11	611.60	25.38		169.20		111.67	18.67	127.88				6.68		101.74	4.29		98.21								131	131	1116.74	11167.42	92252.05
43	131	132	9	47.11	611.60		25.38		169.20	170.95	111.67	18.67	127.88				6.68		101.74	4.29														

**Table C2** Cold composite calculation for minimum area at various  $\Delta T_{min}$  for design case

Temp Interval		C1	C2	C3	C4	C5	C6	C7	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	Tc	SumMCp,c	Qint,c	cumQc	cumQc	cumQc	cumQc	cumQc	cumQc
Interval i	mCp (kW/C)	121.11	173.14	15.43	0.22	35.83	158.75	232.06	159.14	103.80			0.30	17.50	83.43	101.70	88.11	0.72	0.21	10.73	0.39	0.40	C	kW/C	kW	kW	kW	kW	kW	kW	kW
	latent heat (kW/C)	1829.52					2755.39			499.12	95.37	825.00				501.58															
	h (kW/m2C)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80									
0																							24	0.00	0.00	47712.21	50751.35	56741.33	61788.92	66123.75	74.36
1	24	36.8			0.22																		36.8	0.22	2.84	47715.05	50754.20	56744.17	61791.77	66126.60	77.21
2	36.8	37			0.22			159.14															37	159.37	31.87	47746.93	50786.07	56776.05	61823.64	66158.47	109.08
3	37	38			0.22			159.14							83.43								38	242.80	242.80	47989.72	51028.87	57018.85	62066.44	66401.27	351.88
4	38	42	173.14		0.22			159.14							83.43		88.11	0.72			0.39	0.40	42	505.56	2022.26	50011.98	53051.13	59041.10	64088.70	68423.53	2374.14
5	42	43	173.14					159.14							83.43		88.11	0.72			0.39	0.40	43	505.34	505.34	50517.33	53556.47	59546.45	64594.04	68928.87	2879.48
6	43	49	173.14	15.43				159.14							83.43		88.11	0.72			0.39	0.40	49	520.77	3124.63	53641.95	56681.10	62671.07	67718.67	72053.50	6004.11
7	49	52	173.14	15.43				159.14			95.37				83.43		88.11	0.72			0.39	0.40	52	616.14	1848.42	55490.38	58529.52	64519.50	69567.09	73901.92	7852.53
8	52	63	173.14	15.43	35.83			159.14			95.37				83.43		88.11	0.72			0.39	0.40	63	651.97	7171.72	62662.10	65701.25	71691.22	76738.82	81073.64	15024.25
9	63	76	173.14	15.43	35.83			159.14	103.80	95.37					83.43		88.11	0.72			0.39	0.40	76	755.77	9825.06	72487.16	75526.30	81516.28	86563.87	90898.70	24849.31
10	76	78	173.14	15.43				159.14	103.80	95.37					83.43		88.11	0.72			0.39	0.40	78	719.94	1439.88	73927.04	76966.18	82956.16	88003.75	92338.58	26289.19
11	78	86	173.14					159.14	103.80	95.37					83.43		88.11	0.72			0.39	0.40	86	704.51	5636.09	79563.13	82602.28	88592.25	93639.85	97974.67	31925.28
12	86	111.8	173.14					159.14	103.80	95.37			17.50	83.43			88.11	0.72			0.39	0.40	111.8	722.01	18627.90	98191.03	101230.18	107220.15	112267.75	116602.58	50553.19
13	111.8	116	173.14					159.14	103.80	95.37			0.30	17.50	83.43		88.11	0.72			0.39	0.40	116	722.31	3033.72	101224.75	104263.90	110253.87	115301.47	119636.29	53586.90
14	116	116.008	173.14				158.75		159.14	103.80	95.37		0.30	17.50	83.43		88.11	0.72			0.39	0.40	116.008	881.07	7.05	101231.80	104270.94	110260.92	115308.51	119643.34	53593.95
15	116.008	118	173.14				2755.39		159.14	103.80	95.37		0.30	17.50	83.43		88.11	0.72			0.39	0.40	118	3477.70	6927.58	108159.38	111198.52	117188.50	122236.09	126570.92	60521.53
16	118	143	173.14						159.14	103.80	95.37		0.30	17.50	83.43		88.11	0.72			0.39	0.40	143	722.31	18057.84	126217.21	129256.36	135246.33	140293.93	144628.76	78579.36
17	143	149							159.14	103.80	95.37		0.30	17.50	83.43		88.11	0.72			0.39	0.40	149	549.17	3295.02	129512.23	132551.38	138541.36	143588.95	147923.58	81874.39
18	149	154.1							159.14	103.80	95.37		0.30	17.50	83.43		88.11	0.72			0.39	0.40	154.1	460.34	2347.74	131859.98	134899.13	140889.10	145936.69	150271.52	84222.13
19	154.1	157							159.14	103.80	95.37		0.30	17.50							0.39	0.40	157	376.91	1093.04	132953.01	135992.16	141982.13	147029.73	151364.56	85315.17
20	157	162							159.14	103.80			0.30	17.50							0.39	0.40	162	281.54	1407.69	134360.71	137399.85	143389.83	148437.42	152772.25	86722.86
21	162	184.5							159.14	103.80			0.30								0.39	0.40	184.5	264.04	5940.86	140301.57	143340.72	149330.69	154378.29	158713.11	92663.72
22	184.5	188						232.06	159.14	103.80			0.30								0.39	0.40	188	496.09	1736.33	142037.90	145077.05	151067.02	156114.62	160449.45	94400.05
23	188	188.7	121.11					232.06	159.14	103.80			0.30								0.39	0.40	188.7	617.21	432.05	142469.95	145509.09	151499.07	156546.66	160881.49	94832.10
24	188.7	192.322	121.11					232.06		103.80			0.30								0.39	0.40	192.322	458.06	1659.11	144129.05	147168.20	153158.17	158205.77	162540.60	96491.21
25	192.322	201	1829.52					232.06		103.80			0.30								0.39	0.40	201	2166.47	18800.61	162929.66	165968.81	171958.78	177006.38	181341.20	115291.81
26	201	211.7						232.06		103.80			0.30								0.39	0.40	211.7	336.95	3605.37	166535.03	169574.18	175564.15	180611.75	184946.58	118897.18
27	211.7	213.715						232.06		103.80			0.30			101.70					0.39	0.40	213.715	438.65	883.89	167418.92	170458.07	176448.04	181495.64	185830.46	119781.07
28	213.715	220						232.06		103.80			0.30			501.58					0.39	0.40	220	838.53	5270.16	172689.08	175728.23	181718.20	186765.80	191100.63	125051.24
29	220	222							103.80				0.30			501.58					0.39	0.40	222	606.47	1212.95	173902.03	176941.18	182931.15	187978.75	192313.58	126264.18
30	222	228							103.80			825.00	0.30			501.58					0.39	0.40	228	1431.47	8588.84	182490.88	185530.02	191520.00	196567.59	200902.42	134853.03
31	228	230							103.80			825.00	0.30								0.39	0.40	230	929.89	1859.79	184350.66	187389.81	193379.78	198427.38	202762.21	136712.82
32	230	263.482							103.80				0.30								0.39	0.40	263.482	104.89	3512.07	187862.73	190901.88	196891.85	201939.45	206274.28	140224.89
33	263.482	288.872							499.12				0.30								0.39	0.40	288.872	500.22	12700.53	200563.27	203602.41	209592.39	214639.98	218974.81	152925.42
34	288.872	288.984							499.12				0.30								0.39	0.40	288.984	500.22	56.02	200619.29	203658.44	209648.41	214696.01	219030.84	152981.44
35	288.984	300							103.80				0.30								0.39	0.40	300	104.89	1155.52	201774.81	204813.95	210803.93	215851.52	220186.35	154136.96
36	300	315.6							103.80				0.30								0.39	0.40	315.6	104.89	1636.35	203411.16	206450.30	212440.28	217487.87	221822.70	155773.31
37	315.6	339							103.80				0.30								0.39	0.40	339	104.59	2447.46	205858.62	208897.77	214887.74	219935.34	224270.16	158220.77
38	339	420											0.30								0.39	0.40	420	0.79	64.29	205922.91	208962.06	214952.03	219999.63	224334.46	158285.07
39	420	452											0.30								0.39	0.40	452	1.00	32.12	205955.03	208994.18	214984.15	220031.75	224366.58	158317.19
40	452	482											0.21	10.73							0.39	0.40	482	11.74	352.11	206307.15	209346.30	215336.27	220383.86	224718.69	158669.30
41	482	539											0.30								0.39	0.40	539	1.00	57.22	206364.36	209403.51	215393.49	220441.08	224775.91	158726.52
42	539	570											0.30								0.39	0.40	570	0.79	24.61	206388.97	209428.12	215418.09	220465.69	224800.51	158751.12
43	570	577											0.30								0.39		577	0.39	2.74	206391.71	209430.86	215420.83	220468.43	224803.25	158753.86

**Table C3** Calculation of Target area at  $\Delta T_{\min}=5^{\circ}\text{C}$  for design case

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m2	Sum(MCp,c/c) m2	Sum(Q/h) m2C	LMTDi C	A m2
0	47715.05	1176.13	0.22	86.27	36.80	980.11	0.19	0.00	0.00	0.00
1	47746.93	1176.13	159.37	86.29	37.00	980.11	132.81	53.12	49.38	1.08
2	47989.72	1176.13	242.80	86.50	38.00	980.11	202.33	404.67	48.90	8.28
3	50011.98	1176.13	505.56	88.22	42.00	980.11	421.30	3370.43	47.35	71.18
4	50517.33	1176.13	505.34	88.65	43.00	980.11	421.12	842.24	45.93	18.34
5	53641.95	1176.13	520.77	91.31	49.00	980.11	433.98	5207.71	43.96	118.48
6	55490.38	1176.13	616.14	92.88	52.00	980.11	513.45	3080.71	41.59	74.08
7	57125.98	1176.13	651.97	94.27	54.51	980.11	543.31	2726.00	40.32	67.62
8	59295.10	793.97	651.97	97.00	57.84	661.64	543.31	3615.20	39.46	91.61
9	62662.10	721.27	651.97	101.67	63.00	601.06	543.31	5611.68	38.92	144.20
10	63766.96	721.27	755.77	103.20	64.46	601.06	629.81	1841.43	38.70	47.58
11	63856.08	445.61	755.77	103.40	64.58	371.35	629.81	148.54	38.78	3.83
12	65785.06	535.83	755.77	107.00	67.13	446.52	629.81	3214.96	39.34	81.72
13	67121.83	668.39	755.77	109.00	68.90	556.99	629.81	2227.95	39.98	55.72
14	68698.76	779.50	755.77	111.02	70.99	649.58	629.81	2628.22	40.07	65.59
15	69676.65	1258.54	755.77	111.80	72.28	1048.79	629.81	1629.81	39.78	40.97
16	72487.16	1253.79	755.77	114.04	76.00	1044.83	629.81	4684.18	38.78	120.80
17	73927.04	1253.79	719.94	115.19	78.00	1044.83	599.95	2399.80	37.61	63.80
18	74942.58	1253.79	704.51	116.00	79.44	1253.79	704.51	2031.09	36.87	55.08
19	79563.13	1228.41	704.51	119.76	86.00	1228.41	704.51	9241.10	35.14	262.97
20	81084.62	1228.41	722.01	121.00	88.11	1228.41	722.01	3042.99	33.33	91.31
21	92252.05	1116.74	722.01	131.00	103.57	1116.74	722.01	22334.84	30.08	742.60
22	94664.09	1269.50	722.01	132.90	106.92	1269.50	722.01	4824.09	26.70	180.69
23	97267.65	1239.79	722.01	135.00	110.52	1239.79	722.01	5207.11	25.22	206.43
24	98191.03	1236.66	722.01	135.75	111.80	1236.66	722.01	1846.77	24.21	76.28
25	101224.75	1236.66	722.31	138.20	116.00	1236.66	722.31	6067.43	23.06	263.09
26	101231.80	1236.66	881.07	138.21	116.01	1236.66	881.07	14.10	22.20	0.64
27	108159.38	1236.66	3477.70	143.81	118.00	1236.66	3477.70	13855.16	23.96	578.33
28	114580.95	1236.66	722.31	149.00	126.89	1236.66	722.31	12843.14	23.91	537.12
29	122706.79	625.06	722.31	162.00	138.14	625.06	722.31	16251.68	22.97	707.40
30	126217.21	606.40	722.31	167.79	143.00	606.40	722.31	7020.85	24.32	288.67
31	129512.23	606.40	549.17	173.22	149.00	606.40	549.17	6590.05	24.50	268.93
32	131859.98	606.40	460.34	177.09	154.10	606.40	460.34	4695.49	23.60	198.93
33	132953.01	606.40	376.91	178.90	157.00	606.40	376.91	2186.07	22.44	97.41
34	133561.29	606.40	281.54	179.90	160.68	606.40	281.54	1644.82	20.53	80.12
35	134360.71	606.58	281.54	181.22	162.00	606.58	281.54	1170.56	19.22	60.91
36	140301.57	606.58	264.04	191.01	184.50	606.58	264.04	11881.73	11.74	1012.00
37	142037.90	606.58	496.09	193.87	188.00	606.58	496.09	3472.66	6.19	561.21
38	142469.95	606.58	617.21	194.59	188.70	606.58	617.21	864.09	5.88	146.94
39	144129.05	606.58	458.06	197.32	192.32	606.58	458.06	3318.21	5.43	610.94
40	152850.40	606.58	2166.47	211.70	196.35	606.58	2166.47	17442.70	9.23	1890.17
41	157136.22	516.36	2166.47	220.00	198.33	516.36	2166.47	8571.63	18.33	467.58
42	157830.55	347.16	2166.47	222.00	198.65	347.16	2166.47	1388.65	22.50	61.71
43	161558.43	219.29	2166.47	239.00	200.37	219.29	2166.47	7455.77	30.36	245.62
44	162929.66	172.18	2166.47	246.96	201.00	172.18	2166.47	2742.46	42.19	65.00
45	166535.03	172.18	336.95	267.90	211.70	172.18	336.95	7210.74	50.91	141.63
46	167418.92	172.18	438.65	273.04	213.72	172.18	438.65	1767.78	57.75	30.61
47	168044.88	172.18	838.53	276.67	214.46	172.18	838.53	1251.91	60.75	20.61
48	170089.18	111.54	838.53	295.00	216.90	111.54	838.53	4088.62	69.85	58.53
49	172689.08	110.93	838.53	318.44	220.00	110.93	838.53	5199.80	87.88	59.17
50	173902.03	110.93	606.47	329.37	222.00	110.93	606.47	2425.90	102.84	23.59
51	175413.77	110.93	1431.47	343.00	223.06	110.93	1431.47	3023.47	113.54	26.63
52	175496.40	0.62	1431.47	477.00	223.11	0.62	1431.47	165.27	178.62	0.93
53	175497.30	0.18	1431.47	482.00	223.11	0.18	1431.47	1.79	256.38	0.01
54	175883.55	11.04	1431.47	517.00	223.38	11.04	1431.47	772.51	275.89	2.80
55	175884.80	0.18	1431.47	524.00	223.39	0.18	1431.47	2.50	297.10	0.01
	182490.88		1431.47		228.00				<b>Total Area</b>	<b>11197.47</b>



**Table C4** Calculation of Target area at  $\Delta T_{\min}=10^{\circ}\text{C}$  for design case

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m2	Sum(MCp,c/c) m2	Sum(Q/h) m2C	LMTDi C	A m2
0	50751.35	1176.13	0.00	88.85	24.00	1176.13	0.00	0.00	0.00	0.00
1	50754.20	1176.13	0.22	88.85	36.80	1176.13	0.22	5.69	58.21	0.10
2	50786.07	1176.13	159.37	88.88	37.00	1176.13	159.37	63.75	51.96	1.23
3	51028.87	1176.13	242.80	89.08	38.00	1176.13	242.80	485.60	51.48	9.43
4	53051.13	1176.13	505.56	90.80	42.00	1176.13	505.56	4044.52	49.93	81.00
5	53556.47	1176.13	505.34	91.23	43.00	1176.13	505.34	1010.69	48.52	20.83
6	56681.10	1176.13	520.77	93.89	49.00	1176.13	520.77	6249.25	46.54	134.27
7	57125.98	1176.13	616.14	94.27	49.72	1176.13	616.14	889.76	44.72	19.90
8	58529.52	793.97	616.14	96.04	52.00	793.97	616.14	2807.09	44.29	63.38
9	59295.10	793.97	651.97	97.00	53.17	793.97	651.97	1531.14	43.93	34.85
10	63766.96	721.27	651.97	103.20	60.03	721.27	651.97	8943.73	43.50	205.62
11	63856.08	445.61	651.97	103.40	60.17	445.61	651.97	178.25	43.20	4.13
12	65701.25	535.83	651.97	106.84	63.00	535.83	651.97	3690.33	43.54	84.76
13	65785.06	535.83	755.77	107.00	63.11	535.83	755.77	167.62	43.87	3.82
14	67121.83	668.39	755.77	109.00	64.88	668.39	755.77	2673.54	44.00	60.76
15	68698.76	779.50	755.77	111.02	66.97	779.50	755.77	3153.86	44.09	71.53
16	69676.65	1258.54	755.77	111.80	68.26	1258.54	755.77	1955.77	43.80	44.65
17	74942.58	1253.79	755.77	116.00	75.23	1253.79	755.77	10531.86	42.14	249.92
18	75526.30	1228.41	755.77	116.48	76.00	1228.41	755.77	1167.45	40.62	28.74
19	76966.18	1228.41	719.94	117.65	78.00	1228.41	719.94	2879.76	40.06	71.89
20	81084.62	1228.41	704.51	121.00	83.85	1228.41	704.51	8236.88	38.39	214.57
21	82602.28	1116.74	704.51	122.36	86.00	1116.74	704.51	3035.31	36.76	82.58
22	92252.05	1116.74	722.01	131.00	99.37	1116.74	722.01	19299.54	33.94	568.60
23	94664.09	1269.50	722.01	132.90	102.71	1269.50	722.01	4824.09	30.91	156.07
24	97267.65	1239.79	722.01	135.00	106.31	1239.79	722.01	5207.11	29.43	176.90
25	101230.18	1236.66	722.01	138.20	111.80	1236.66	722.01	7925.07	27.53	287.87
26	104263.90	1236.66	722.31	140.66	116.00	1236.66	722.31	6067.43	25.52	237.74
27	104270.94	1236.66	881.07	140.66	116.01	1236.66	881.07	14.10	24.66	0.57
28	111198.52	1236.66	3477.70	146.26	118.00	1236.66	3477.70	13855.16	26.42	524.44
29	114580.95	1236.66	722.31	149.00	122.68	1236.66	722.31	6764.85	27.28	247.98
30	122706.79	625.06	722.31	162.00	133.93	625.06	722.31	16251.68	27.18	597.86
31	129256.36	606.40	722.31	172.80	143.00	606.40	722.31	13099.15	28.93	452.86
32	132551.38	606.40	549.17	178.23	149.00	606.40	549.17	6590.05	29.52	223.26
33	133561.29	606.40	460.34	179.90	151.19	606.40	460.34	2019.82	28.97	69.72
34	134899.13	606.58	460.34	182.11	154.10	606.58	460.34	2675.66	28.35	94.36
35	135992.16	606.58	376.91	183.91	157.00	606.58	376.91	2186.07	27.45	79.63
36	137399.85	606.58	281.54	186.23	162.00	606.58	281.54	2815.38	25.54	110.22
37	143340.72	606.58	264.04	196.02	184.50	606.58	264.04	11881.73	17.10	695.02
38	145077.05	606.58	496.09	198.88	188.00	606.58	496.09	3472.66	11.20	310.04
39	145509.09	606.58	617.21	199.60	188.70	606.58	617.21	864.09	10.89	79.34
40	147168.20	606.58	458.06	202.33	192.32	606.58	458.06	3318.21	10.45	317.61
41	152850.40	606.58	2166.47	211.70	194.94	606.58	2166.47	11364.41	13.09	867.88
42	157136.22	516.36	2166.47	220.00	196.92	516.36	2166.47	8571.63	19.75	434.06
43	157830.55	347.16	2166.47	222.00	197.24	347.16	2166.47	1388.65	23.91	58.09
44	161558.43	219.29	2166.47	239.00	198.96	219.29	2166.47	7455.77	31.79	234.56
45	165968.81	172.18	2166.47	264.61	201.00	172.18	2166.47	8820.75	50.92	173.23
46	168044.88	172.18	336.95	276.67	207.16	172.18	336.95	4152.14	66.52	62.42
47	169574.18	111.54	336.95	290.38	211.70	111.54	336.95	3058.61	74.00	41.33
48	170089.18	111.54	438.65	295.00	212.87	111.54	438.65	1030.01	80.39	12.81
49	170458.07	110.93	438.65	298.33	213.72	110.93	438.65	737.77	83.36	8.85
50	175413.77	110.93	838.53	343.00	219.62	110.93	838.53	9911.40	102.78	96.44
51	175496.40	0.62	838.53	477.00	219.72	0.62	838.53	165.27	182.20	0.91
52	175497.30	0.18	838.53	482.00	219.72	0.18	838.53	1.79	259.77	0.01
53	175728.23	11.04	838.53	502.93	220.00	11.04	838.53	461.87	272.47	1.70
54	175883.55	11.04	606.47	517.00	220.26	11.04	606.47	310.64	289.78	1.07
55	175884.80	0.18	606.47	524.00	220.26	0.18	606.47	2.50	300.23	0.01
	176941.18		606.47		222.00				<b>Total Area</b>	<b>8711.43</b>

**Table C5** Calculation of Target area at  $\Delta T_{\min}=20^{\circ}\text{C}$  for design case

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m2	Sum(MCp,c/c) m2	Sum(Q/h) m2C	LMTDi C	A m2
0	56741.33	1176.13	0.00	93.94	24.00	1176.13	0.00	0.00	0.00	0.00
1	56744.17	1176.13	0.22	93.94	36.80	1176.13	0.22	5.69	63.33	0.09
2	56776.05	1176.13	159.37	93.97	37.00	1176.13	159.37	63.75	57.06	1.12
3	57018.85	1176.13	242.80	94.18	38.00	1176.13	242.80	485.60	56.57	8.58
4	57125.98	1176.13	505.56	94.27	38.21	1176.13	505.56	214.26	56.12	3.82
5	59041.10	793.97	505.56	96.68	42.00	793.97	505.56	3830.25	55.37	69.18
6	59295.10	793.97	505.34	97.00	42.50	793.97	505.34	507.98	54.59	9.31
7	59546.45	721.27	505.34	97.35	43.00	721.27	505.34	502.70	54.42	9.24
8	62671.07	721.27	520.77	101.68	49.00	721.27	520.77	6249.25	53.51	116.79
9	63766.96	721.27	616.14	103.20	50.78	721.27	616.14	2191.77	52.55	41.71
10	63856.08	445.61	616.14	103.40	50.92	445.61	616.14	178.25	52.45	3.40
11	64519.50	535.83	616.14	104.64	52.00	535.83	616.14	1326.83	52.56	25.25
12	65785.06	535.83	651.97	107.00	53.94	535.83	651.97	2531.12	52.85	47.89
13	67121.83	668.39	651.97	109.00	55.99	668.39	651.97	2673.54	53.03	50.41
14	68698.76	779.50	651.97	111.02	58.41	779.50	651.97	3153.86	52.81	59.72
15	69676.65	1258.54	651.97	111.80	59.91	1258.54	651.97	1955.77	52.25	37.43
16	71691.22	1253.79	651.97	113.41	63.00	1253.79	651.97	4029.15	51.14	78.78
17	74942.58	1253.79	755.77	116.00	67.30	1253.79	755.77	6502.72	49.55	131.24
18	81084.62	1228.41	755.77	121.00	75.43	1228.41	755.77	12284.09	47.12	260.71
19	81516.28	1116.74	755.77	121.39	76.00	1116.74	755.77	863.31	45.48	18.98
20	82956.16	1116.74	719.94	122.68	78.00	1116.74	719.94	2879.76	45.03	63.95
21	88592.25	1116.74	704.51	127.72	86.00	1116.74	704.51	11272.19	43.18	261.04
22	92252.05	1116.74	722.01	131.00	91.07	1116.74	722.01	7319.59	40.82	179.31
23	94664.09	1269.50	722.01	132.90	94.41	1269.50	722.01	4824.09	39.21	123.04
24	97267.65	1239.79	722.01	135.00	98.02	1239.79	722.01	5207.11	37.73	138.00
25	107220.15	1236.66	722.01	143.05	111.80	1236.66	722.01	19905.01	34.04	584.83
26	110253.87	1236.66	722.31	145.50	116.00	1236.66	722.31	6067.43	30.37	199.81
27	110260.92	1236.66	881.07	145.51	116.01	1236.66	881.07	14.10	29.50	0.48
28	114580.95	1236.66	3477.70	149.00	117.25	1236.66	3477.70	8640.06	30.61	282.26
29	117188.50	625.06	3477.70	153.17	118.00	625.06	3477.70	5215.10	33.43	155.99
30	122706.79	625.06	722.31	162.00	125.64	625.06	722.31	11036.58	35.76	308.61
31	133561.29	606.40	722.31	179.90	140.67	606.40	722.31	21709.02	37.78	574.64
32	135246.33	606.58	722.31	182.68	143.00	606.58	722.31	3370.08	39.45	85.42
33	138541.36	606.58	549.17	188.11	149.00	606.58	549.17	6590.05	39.39	167.29
34	140889.10	606.58	460.34	191.98	154.10	606.58	460.34	4695.49	38.49	121.99
35	141982.13	606.58	376.91	193.78	157.00	606.58	376.91	2186.07	37.33	58.56
36	143389.83	606.58	281.54	196.10	162.00	606.58	281.54	2815.38	35.43	79.47
37	149330.69	606.58	264.04	205.90	184.50	606.58	264.04	11881.73	27.26	435.89
38	151067.02	606.58	496.09	208.76	188.00	606.58	496.09	3472.66	21.08	164.76
39	151499.07	606.58	617.21	209.47	188.70	606.58	617.21	864.09	20.77	41.61
40	152850.40	606.58	458.06	211.70	191.65	606.58	458.06	2702.67	20.41	132.43
41	153158.17	516.36	458.06	212.30	192.32	516.36	458.06	615.54	20.01	30.76
42	157136.22	516.36	2166.47	220.00	194.16	516.36	2166.47	7956.10	22.78	349.23
43	157830.55	347.16	2166.47	222.00	194.48	347.16	2166.47	1388.65	26.67	52.06
44	161558.43	219.29	2166.47	239.00	196.20	219.29	2166.47	7455.77	34.60	215.48
45	168044.88	172.18	2166.47	276.67	199.19	172.18	2166.47	12972.89	58.43	222.01
46	170089.18	111.54	2166.47	295.00	200.14	111.54	2166.47	4088.62	85.88	47.61
47	171958.78	110.93	2166.47	311.85	201.00	110.93	2166.47	3739.19	102.65	36.43
48	175413.77	110.93	336.95	343.00	211.25	110.93	336.95	6909.97	121.00	57.11
49	175496.40	0.62	336.95	477.00	211.50	0.62	336.95	165.27	190.88	0.87
50	175497.30	0.18	336.95	482.00	211.50	0.18	336.95	1.79	267.99	0.01
51	175564.15	11.04	336.95	488.06	211.70	11.04	336.95	133.71	273.42	0.49
52	175883.55	11.04	438.65	517.00	212.43	11.04	438.65	638.80	290.24	2.20
53	175884.80	0.18	438.65	524.00	212.43	0.18	438.65	2.50	308.06	0.01
	176448.04		438.65		213.72				<b>Total Area</b>	<b>6147.27</b>

**Table C6** Calculation of Target area at  $\Delta T_{\min}=30^{\circ}\text{C}$  for design case

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m2	Sum(MCp,c/c) m2	Sum(Q/h) m2C	LMTDi C	A m2
0	61788.92	721.27	0.00	100.46	24.00	721.27	0.00	0.00	0.00	0.00
1	61791.77	721.27	0.22	100.46	36.80	721.27	0.22	5.69	69.86	0.08
2	61823.64	721.27	159.37	100.51	37.00	721.27	159.37	63.75	63.58	1.00
3	62066.44	721.27	242.80	100.84	38.00	721.27	242.80	485.60	63.17	7.69
4	63766.96	721.27	505.56	103.20	41.36	721.27	505.56	3401.04	62.34	54.56
5	63856.08	445.61	505.56	103.40	41.54	445.61	505.56	178.25	61.85	2.88
6	64088.70	535.83	505.56	103.83	42.00	535.83	505.56	465.24	61.85	7.52
7	64594.04	535.83	505.34	104.78	43.00	535.83	505.34	1010.69	61.81	16.35
8	65785.06	535.83	520.77	107.00	45.29	535.83	520.77	2382.03	61.75	38.58
9	67121.83	668.39	520.77	109.00	47.85	668.39	520.77	2673.54	61.43	43.52
10	67718.67	779.50	520.77	109.77	49.00	779.50	520.77	1193.68	60.96	19.58
11	68698.76	779.50	616.14	111.02	50.59	779.50	616.14	1960.18	60.60	32.35
12	69567.09	1258.54	616.14	111.71	52.00	1258.54	616.14	1736.67	60.07	28.91
13	69676.65	1258.54	651.97	111.80	52.17	1258.54	651.97	219.11	59.67	3.67
14	74942.58	1253.79	651.97	116.00	60.24	1253.79	651.97	10531.86	57.67	182.62
15	76738.82	1228.41	651.97	117.46	63.00	1228.41	651.97	3592.47	55.11	65.19
16	81084.62	1228.41	755.77	121.00	68.75	1228.41	755.77	8691.61	53.35	162.92
17	86563.87	1116.74	755.77	125.91	76.00	1116.74	755.77	10958.50	51.07	214.58
18	88003.75	1116.74	719.94	127.20	78.00	1116.74	719.94	2879.76	49.55	58.12
19	92252.05	1116.74	704.51	131.00	84.03	1116.74	704.51	8496.58	48.07	176.74
20	93639.85	1269.50	704.51	132.09	86.00	1269.50	704.51	2775.60	46.53	59.65
21	94664.09	1269.50	722.01	132.90	87.42	1269.50	722.01	2048.48	45.79	44.74
22	97267.65	1239.79	722.01	135.00	91.02	1239.79	722.01	5207.11	44.72	116.43
23	112267.75	1236.66	722.01	147.13	111.80	1236.66	722.01	30000.20	39.49	759.60
24	114580.95	1236.66	722.31	149.00	115.00	1236.66	722.31	4626.39	34.66	133.48
25	115301.47	625.06	722.31	150.15	116.00	625.06	722.31	1441.04	34.08	42.29
26	115308.51	625.06	881.07	150.16	116.01	625.06	881.07	14.10	34.15	0.41
27	122236.09	625.06	3477.70	161.25	118.00	625.06	3477.70	13855.16	38.52	359.66
28	122706.79	625.06	722.31	162.00	118.65	625.06	722.31	941.39	43.30	21.74
29	133561.29	606.40	722.31	179.90	133.68	606.40	722.31	21709.02	44.77	484.91
30	140293.93	606.58	722.31	191.00	143.00	606.58	722.31	13465.27	47.10	285.86
31	143588.95	606.58	549.17	196.43	149.00	606.58	549.17	6590.05	47.71	138.11
32	145936.69	606.58	460.34	200.30	154.10	606.58	460.34	4695.49	46.81	100.30
33	147029.73	606.58	376.91	202.10	157.00	606.58	376.91	2186.07	45.65	47.89
34	148437.42	606.58	281.54	204.42	162.00	606.58	281.54	2815.38	43.75	64.35
35	152850.40	606.58	264.04	211.70	178.71	606.58	264.04	8825.96	37.51	235.31
36	154378.29	516.36	264.04	214.66	184.50	516.36	264.04	3055.76	31.55	96.85
37	156114.62	516.36	496.09	218.02	188.00	516.36	496.09	3472.66	30.09	115.41
38	156546.66	516.36	617.21	218.86	188.70	516.36	617.21	864.09	30.09	28.72
39	157136.22	516.36	458.06	220.00	189.99	516.36	458.06	1179.11	30.09	39.19
40	157830.55	347.16	458.06	222.00	191.50	347.16	458.06	1388.65	30.25	45.90
41	158205.77	219.29	458.06	223.71	192.32	219.29	458.06	750.44	30.94	24.25
42	161558.43	219.29	2166.47	239.00	193.87	219.29	2166.47	6705.33	37.84	177.18
43	168044.88	172.18	2166.47	276.67	196.86	172.18	2166.47	12972.89	60.83	213.26
44	170089.18	111.54	2166.47	295.00	197.81	111.54	2166.47	4088.62	88.22	46.35
45	175413.77	110.93	2166.47	343.00	200.26	110.93	2166.47	10649.17	118.51	89.86
46	175496.40	0.62	2166.47	477.00	200.30	0.62	2166.47	165.27	202.38	0.82
47	175497.30	0.18	2166.47	482.00	200.30	0.18	2166.47	1.79	279.19	0.01
48	175883.55	11.04	2166.47	517.00	200.48	11.04	2166.47	772.51	298.77	2.59
49	175884.80	0.18	2166.47	524.00	200.48	0.18	2166.47	2.50	320.01	0.01
	177006.38		2166.47		201.00				<b>Total Area</b>	<b>4891.98</b>

**Table C7** Calculation of Target area at  $\Delta T_{\min}=40^{\circ}\text{C}$  for design case

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m2	Sum(MCp,c/c) m2	Sum(Q/h) m2C	LMTDi C	A m2
0	66123.75	668.39	0.00	107.51	24.00	668.39	0.00	0.00	0.00	0.00
1	66126.60	668.39	0.22	107.51	36.80	668.39	0.22	5.69	76.93	0.07
2	66158.47	668.39	159.37	107.56	37.00	668.39	159.37	63.75	70.63	0.90
3	66401.27	668.39	242.80	107.92	38.00	668.39	242.80	485.60	70.24	6.91
4	67121.83	668.39	505.56	109.00	39.43	668.39	505.56	1441.12	69.75	20.66
5	68423.53	779.50	505.56	110.67	42.00	779.50	505.56	2603.39	69.12	37.66
6	68698.76	779.50	505.34	111.02	42.54	779.50	505.34	550.47	68.57	8.03
7	68928.87	1258.54	505.34	111.21	43.00	1258.54	505.34	460.22	68.34	6.73
8	69676.65	1258.54	520.77	111.80	44.44	1258.54	520.77	1495.56	67.78	22.06
9	72053.50	1253.79	520.77	113.70	49.00	1253.79	520.77	4753.70	66.02	72.00
10	73901.92	1253.79	616.14	115.17	52.00	1253.79	616.14	3696.85	63.93	57.83
11	74942.58	1253.79	651.97	116.00	53.60	1253.79	651.97	2081.32	62.79	33.15
12	81073.64	1228.41	651.97	120.99	63.00	1228.41	651.97	12262.13	60.17	203.79
13	81084.62	1228.41	755.77	121.00	63.01	1228.41	755.77	21.96	57.99	0.38
14	90898.70	1116.74	755.77	129.79	76.00	1116.74	755.77	19628.15	55.86	351.38
15	92252.05	1116.74	719.94	131.00	77.88	1116.74	719.94	2706.69	53.45	50.64
16	92338.58	1269.50	719.94	131.07	78.00	1269.50	719.94	173.07	53.09	3.26
17	94664.09	1269.50	704.51	132.90	81.30	1269.50	704.51	4651.02	52.33	88.88
18	97267.65	1239.79	704.51	135.00	85.00	1239.79	704.51	5207.11	50.80	102.51
19	97974.67	1236.66	704.51	135.57	86.00	1236.66	704.51	1414.06	49.79	28.40
20	114580.95	1236.66	722.01	149.00	109.00	1236.66	722.01	33212.54	44.61	744.43
21	116602.58	625.06	722.01	152.23	111.80	625.06	722.01	4043.26	40.22	100.54
22	119636.29	625.06	722.31	157.09	116.00	625.06	722.31	6067.43	40.76	148.86
23	119643.34	625.06	881.07	157.10	116.01	625.06	881.07	14.10	41.09	0.34
24	122706.79	625.06	3477.70	162.00	116.89	625.06	3477.70	6126.89	43.07	142.25
25	126570.92	606.40	3477.70	168.37	118.00	606.40	3477.70	7728.27	47.69	162.04
26	133561.29	606.40	722.31	179.90	127.68	606.40	722.31	13980.75	51.29	272.57
27	144628.76	606.58	722.31	198.15	143.00	606.58	722.31	22134.92	53.67	412.42
28	147923.78	606.58	549.17	203.58	149.00	606.58	549.17	6590.05	54.86	120.12
29	150271.52	606.58	460.34	207.45	154.10	606.58	460.34	4695.49	53.96	87.02
30	151364.56	606.58	376.91	209.25	157.00	606.58	376.91	2186.07	52.80	41.40
31	152772.25	606.58	281.54	211.57	162.00	606.58	281.54	2815.38	50.90	55.31
32	152850.40	606.58	264.04	211.70	162.30	606.58	264.04	156.31	49.49	3.16
33	157136.22	516.36	264.04	220.00	178.53	516.36	264.04	8571.63	45.32	189.13
34	157830.55	347.16	264.04	222.00	181.16	347.16	264.04	1388.65	41.16	33.74
35	158713.11	219.29	264.04	226.02	184.50	219.29	264.04	1765.13	41.18	42.86
36	160449.45	219.29	496.09	233.94	188.00	219.29	496.09	3472.66	43.70	79.47
37	160881.49	219.29	617.21	235.91	188.70	219.29	617.21	864.09	46.57	18.55
38	161558.43	219.29	458.06	239.00	190.18	219.29	458.06	1353.88	48.01	28.20
39	162540.60	172.18	458.06	244.70	192.32	172.18	458.06	1964.33	50.58	38.84
40	168044.88	172.18	2166.47	276.67	194.86	172.18	2166.47	11008.56	66.01	166.78
41	170089.18	111.54	2166.47	295.00	195.81	111.54	2166.47	4088.62	90.22	45.32
42	175413.77	110.93	2166.47	343.00	198.26	110.93	2166.47	10649.17	120.53	88.35
43	175496.40	0.62	2166.47	477.00	198.30	0.62	2166.47	165.27	204.45	0.81
44	175497.30	0.18	2166.47	482.00	198.30	0.18	2166.47	1.79	281.19	0.01
45	175883.55	11.04	2166.47	517.00	198.48	11.04	2166.47	772.51	300.77	2.57
46	175884.80	0.18	2166.47	524.00	198.48	0.18	2166.47	2.50	322.01	0.01
	181341.20		2166.47		201.00				<b>Total Area</b>	<b>4120.34</b>

**Table C8** Calculation of Target area at  $\Delta T_{\min}=50.92^{\circ}\text{C}$  for design case  
corresponding to the usage utility in the existing plant)

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m2	Sum(MCp,c/c) m2	Sum(Q/h) m2C	LMTDi C	A m2
0	78926.90	1228.41	0.00	119.24	24.00	1228.41	0.00	0.00	0.00	0.00
1	78929.74	1228.41	0.22	119.25	36.80	1228.41	0.22	5.69	88.69	0.06
2	78961.62	1228.41	159.37	119.27	37.00	1228.41	159.37	63.75	82.36	0.77
3	79204.42	1228.41	242.80	119.47	38.00	1228.41	242.80	485.60	81.87	5.93
4	81084.62	1228.41	505.56	121.00	41.72	1228.41	505.56	3760.41	80.37	46.79
5	81226.68	1116.74	505.56	121.13	42.00	1116.74	505.56	284.10	79.20	3.59
6	81732.02	1116.74	505.34	121.58	43.00	1116.74	505.34	1010.69	78.85	12.82
7	84856.65	1116.74	520.77	124.38	49.00	1116.74	520.77	6249.25	76.97	81.19
8	86705.07	1116.74	616.14	126.03	52.00	1116.74	616.14	3696.85	74.70	49.49
9	92252.05	1116.74	651.97	131.00	60.51	1116.74	651.97	11093.95	72.25	153.55
10	93876.79	1269.50	651.97	132.28	63.00	1269.50	651.97	3249.49	69.88	46.50
11	94664.09	1269.50	755.77	132.90	64.04	1269.50	755.77	1574.59	69.07	22.80
12	97267.65	1239.79	755.77	135.00	67.49	1239.79	755.77	5207.11	68.18	76.37
13	103701.85	1236.66	755.77	140.20	76.00	1236.66	755.77	12868.41	65.84	195.44
14	105141.73	1236.66	719.94	141.37	78.00	1236.66	719.94	2879.76	63.78	45.15
15	110777.82	1236.66	704.51	145.92	86.00	1236.66	704.51	11272.19	61.63	182.90
16	114580.95	1236.66	722.01	149.00	91.27	1236.66	722.01	7606.24	58.82	129.31
17	122706.79	625.06	722.01	162.00	102.52	625.06	722.01	16251.68	58.60	277.33
18	129405.72	606.40	722.01	173.05	111.80	606.40	722.01	13397.88	60.36	221.97
19	132439.44	606.40	722.31	178.05	116.00	606.40	722.31	6067.43	61.65	98.42
20	132446.49	606.40	881.07	178.06	116.01	606.40	881.07	14.10	62.05	0.23
21	133561.29	606.40	3477.70	179.90	116.33	606.40	3477.70	2229.61	62.81	35.50
22	139374.07	606.58	3477.70	189.48	118.00	606.58	3477.70	11625.55	67.45	172.36
23	152850.40	606.58	722.31	211.70	136.66	606.58	722.31	26952.67	73.25	367.96
24	157136.22	516.36	722.31	220.00	142.59	516.36	722.31	8571.63	76.22	112.46
25	157431.90	347.16	722.31	220.85	143.00	347.16	722.31	591.37	77.63	7.62
26	157830.55	347.16	549.17	222.00	143.73	347.16	549.17	797.29	78.06	10.21
27	160726.93	219.29	549.17	235.21	149.00	219.29	549.17	5792.76	82.18	70.49
28	161558.43	219.29	460.34	239.00	150.81	219.29	460.34	1663.01	87.20	19.07
29	163074.67	172.18	460.34	247.81	154.10	172.18	460.34	3032.48	90.92	33.35
30	164167.71	172.18	376.91	254.15	157.00	172.18	376.91	2186.07	95.42	22.91
31	165575.40	172.18	281.54	262.33	162.00	172.18	281.54	2815.38	98.73	28.52
32	168044.88	172.18	264.04	276.67	171.35	172.18	264.04	4938.96	102.80	48.04
33	170089.18	111.54	264.04	295.00	179.10	111.54	264.04	4088.62	110.53	36.99
34	171516.26	110.93	264.04	307.86	184.50	110.93	264.04	2854.16	119.60	23.86
35	173252.59	110.93	496.09	323.52	188.00	110.93	496.09	3472.66	129.35	26.85
36	173684.64	110.93	617.21	327.41	188.70	110.93	617.21	864.09	137.11	6.30
37	175343.74	110.93	458.06	342.37	192.32	110.93	458.06	3318.21	144.31	22.99
38	175413.77	110.93	2166.47	343.00	192.35	110.93	2166.47	140.04	150.35	0.93
39	175496.40	0.62	2166.47	477.00	192.39	0.62	2166.47	165.27	210.57	0.78
40	175497.30	0.18	2166.47	482.00	192.39	0.18	2166.47	1.79	287.10	0.01
41	175883.55	11.04	2166.47	517.00	192.57	11.04	2166.47	772.51	306.69	2.52
42	175884.80	0.18	2166.47	524.00	192.57	0.18	2166.47	2.50	327.92	0.01
	194144.35		2166.47		201.00				<b>Total Area</b>	<b>2700.35</b>

**C-2 Hot and cold composite curves calculation for minimum area at various  $\Delta T_{\min}$  for actual case.**

Table C9 Hot composite curve calculation for minimum area at various  $\Delta T_{min}$  for actual case

Interval i	Temp Interval mCp (kW/C)	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H20	H21	H22	H28	H29	Th C	SumMCP,h kW/C	Qint,h kW	cumQh kW		
	latent heat (kW/C)	47.66	129.01	18.04																											
	h (kW/m2C)		627.60		10.59	2.67		613.08		170.95	111.67	791.09			275.65	30.57	6.68	121.45	101.74	4.29		98.21	2.72	115.11	454.86						
0																										9.710	0.00	0.00	0.00		
1	9.710	19.197														6.68											19.197	6.68	63.33	63.33	
2	19.197	19.475				2.67										6.68											19.475	9.34	2.60	65.93	
3	19.475	31.047				2.67										6.68							2.72				31.047	12.06	139.57	205.51	
4	31.047	32.527				2.67	20.11									6.68							2.72				32.527	32.17	47.61	253.11	
5	32.527	35.611				2.67	20.11									6.68					4.29		2.72				35.611	36.45	112.42	365.54	
6	35.611	36.712	18.04			2.67	20.11									6.68					4.29		2.72				36.712	54.49	60.00	425.54	
7	36.712	36.718	18.04			2.67	20.11									6.68	121.45				4.29		2.72				36.718	175.94	1.03	426.57	
8	36.718	36.955	18.04			2.67	20.11									6.68	121.45	101.74	4.29		4.29		2.72				36.955	277.68	65.87	492.44	
9	36.955	37.323	18.04	10.59		20.11										6.68	121.45	101.74	4.29		4.29		2.72				37.323	285.61	105.01	597.45	
10	37.323	38.545	18.04	10.59		20.11										6.68	121.45	101.74	4.29		4.29		2.72				38.545	283.66	346.56	944.00	
11	38.545	39.780	18.04	10.59		20.11										6.68	121.45	101.74	4.29		4.29		0.77				39.780	282.89	349.58	1293.58	
12	39.780	43.712	18.04	10.59		20.11										6.68	121.45	101.74	4.29		4.29		98.21				43.712	381.10	1498.40	2791.98	
13	43.712	44.584	18.04	10.59		20.11										6.68					3.79		98.21					44.584	259.65	226.34	3018.32
14	44.584	45.852	18.04	10.59		20.11										6.68					3.79		98.21					45.852	259.15	328.57	3346.90
15	45.852	46.018	18.04	10.59		20.11	613.08									6.68					3.79		98.21					46.018	872.22	144.48	3491.38
16	46.018	49.639	18.04	10.59		20.11	613.08								275.65	6.68					3.79		98.21					49.639	1147.88	4156.67	7648.05
17	49.639	51.007	18.04	10.59		20.11	613.08					791.09			275.65	6.68					3.79		98.21					51.007	1938.96	2652.19	10300.24
18	51.007	51.449	18.04	10.59		20.11	613.08					791.09			275.65	6.68					3.79		98.21					51.449	2050.63	907.25	11207.49
19	51.449	51.693	18.04	10.59		20.11	613.08					791.09			275.65	6.68					3.79		98.21					51.693	1284.19	313.51	11521.00
20	51.693	53.925	18.04	10.59		20.11	613.08					791.09			275.65	6.68					3.79		98.21			73.41		53.925	1357.61	3030.00	14551.00
21	53.925	54.492	18.04	10.59		20.11	31.84					791.09			275.65	6.68					3.79		98.21			73.41		54.492	776.37	440.46	14991.47
22	54.492	54.718	18.04	10.59		20.11	31.84					791.09			275.65	30.57	6.68				3.79		98.21			73.41		54.718	806.95	182.19	15173.66
23	54.718	55.082	18.04	10.59		20.11	31.84					791.09			275.65	30.57	6.68				3.79		98.21			73.41		55.082	705.21	256.36	15430.01
24	55.082	55.136	18.04			20.11	31.84					791.09			275.65	30.57	6.68				3.79		98.21			73.41		55.136	694.61	37.91	15467.92
25	55.136	57.508	18.04			20.11						791.09			275.65	30.57	6.68				3.79		98.21			73.41		57.508	662.77	1571.63	17039.55
26	57.508	57.698	18.04	47.66		20.11						791.09			275.65	30.57	6.68				3.79		98.21			73.41		57.698	710.43	135.23	17174.78
27	57.698	60.002	18.04	47.66		20.11						791.09			275.65	30.57	6.68				3.79		98.21	115.11		73.41		60.002	825.54	1902.08	19076.86
28	60.002	61.710	18.04	47.66		20.11		76.43				791.09			275.65	30.57	6.68				3.79		98.21	115.11		73.41		61.710	901.97	1540.66	20617.52
29	61.710	62.133	18.04	47.66		20.11		76.43				791.09			275.65	26.64	6.68				3.79		98.21	115.11		73.41		62.133	898.04	380.15	20997.67
30	62.133	63.137	18.04	47.66		20.11		76.43				791.09		0.09	275.65	26.64	6.68				3.79		98.21	115.11		73.41		63.137	898.12	901.73	21899.40
31	63.137	63.378	18.04	47.66		20.11		76.43				791.09		100.88	0.09	275.65	26.64	6.68			3.79		98.21	115.11		73.41		63.378	999.01	240.87	22140.28
32	63.378	63.567	18.04	47.66		20.11		76.43				791.09		100.88	0.09	275.65	26.64	6.68			3.79		98.21	115.11		73.41		63.567	900.79	169.85	22310.12
33	63.567	67.305	18.04	47.66		20.11		76.43				791.09		100.88	0.09	275.65	26.64	3.75			3.79		98.21	115.11		73.41		67.305	897.87	3356.07	25666.19
34	67.305	68.662	18.04	47.66		20.11		76.43				791.09		100.88	0.09	275.65	26.64	3.75			3.79		98.21	115.11		73.41		68.662	894.08	1213.42	26879.61
35	68.662	69.391	18.04	47.66		20.11		76.43				791.09		100.88	0.09	275.65	26.64	3.75			3.79		98.21	115.11	454.86		69.391	1275.52	929.86	27809.46	
36	69.391	80.534	18.04	47.66		20.11		76.43				791.09		100.88	0.09	275.65	26.64	3.75			3.79		98.21	16.32	454.86		80.534	1176.74	13112.17	40921.64	
37	80.534	95.028	18.04	47.66		20.11		76.43				791.09		100.88	0.09	275.65	26.64	3.75			3.79		98.21	16.32			95.028	721.88	10463.32	51384.95	
38	95.028	95.209	18.04	47.66		20.11		76.43				791.09		100.88	0.09	26.64	3.75				3.79		98.21	16.32			95.209	446.23	80.67	51465.62	
39	95.209	107.837	18.04	47.66	129.01	20.11		76.43				791.09		100.88	0.09	26.64	3.75				3.79		98.21	16.32			107.837	575.23	7264.06	58729.67	
40	107.837	110.168	18.04	47.66	129.01	20.11		76.43				791.09		100.88	0.09	26.64	3.75				3.79		98.21	16.32			110.168	557.20	1298.68	60028.36	
41	110.168	111.023	18.04	47.66	129.01	20.11		76.43				791.09		100.88	0.09	26.64	3.75				3.79		98.21	16.32			111.023	537.09	459.27	60487.63	
42	111.023	112.826	18.04	47.66	627.60	20.11		76.43				791.09		100.88	0.09	26.64	3.75				3.79		98.21	16.32			112.826	1035.68	1866.92	62354.55	
43	112.826	118.902	18.04	47.66	627.60	20.11		76.43				791.09		100.88	0.09	26.64	3.75				3.79		98.21	16.32			118.902	1031.93	6270.03	68624.58	
44	118.902	130.280	18.04	47.66	627.60	20.11		76.43				791.09		100.88	0.09	26.64	3.75				3.79		98.21	16.32			130.280	1128.99	12846.03	81470.61	
45	130.280	132.821	18.04	47.66	627.60	20.11		76.43				791.09		100.88	0.09	26.64	3.75				3.79		98.21	16.32			132.821	1102.35	2801.02	84271.63	
46	132.821	133.448	18.04	47.66	627.60	20.11		76.43	170.95			791.09		100.88	0.09	26.64	3.75				3.79		98.21	16.32			133.448	1161.63	727.90	84999.53	
47	133.448	138.810	18.04	47.66	627.60	20.11		76.43	170.95			791.09		100.88	0.09	26.64	3.75				3.79		98.21	16.32			138.810	534.04	2863.74	87863.27	
48	138.810	153.505	18.04	47.66	627.60	20.11		76.43	170.95			791.09		100.88	0.09	26.64	3.75				3.79		98.21	16.32			153.505				

**Table C10** Cold composite calculation for minimum area at any  $\Delta T_{min}$  for actual case

Interval i	Temp Interval mCp (kW/C)	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	Tc C	SumMCP,c kW/C	Qint,c kW	DTmin =5	DTmin =10	DTmin =20	DTmin =30	DTmin =40	DTmin =51 034	
																					cumQc kW	cumQc kW	cumQc kW	cumQc kW	cumQc kW	cumQc kW	
	latent heat (kW/C)	1829.52									499.12	90.84					501.58										
	h (kW/m2C)																										
0																		19.197	0.00	0.00	51975.80	54059.10	57659.50	60083.80	62270.80	66656.00	
1	19.197	29.343			0.30													29.343	0.30	3.07	51978.87	54062.17	57662.57	60086.87	62273.87	66659.07	
2	29.343	35.000	159.69		0.30													35.000	159.99	905.13	52884.00	54967.30	58567.70	60992.00	63179.00	67584.20	
3	35.000	36.985	159.69		0.30													36.985	189.75	376.55	53280.55	55343.85	58944.25	61368.55	63555.55	67940.75	
4	36.985	42.974	159.69		0.30													42.974	260.90	1562.62	54823.17	56906.47	60506.87	62931.17	65118.17	69503.37	
5	42.974	51.284	159.69	15.59	0.30													51.284	276.49	2297.82	57120.99	59204.29	62804.69	65228.99	67415.99	71801.19	
6	51.284	52.125	159.69	15.59	0.30							90.84						52.125	367.33	308.76	57429.75	59513.05	63113.45	65537.75	67724.75	72109.95	
7	52.125	60.002	159.69	15.59	0.30	31.80						90.84						60.002	399.13	3143.91	60573.66	62656.96	66257.36	68681.66	70868.66	75253.86	
8	60.002	71.143	159.69	15.59	0.30	31.80			103.75			90.84						71.143	502.88	5602.50	66176.16	68259.46	71859.86	74284.16	76471.16	80856.36	
9	71.143	71.778	159.69	15.59	0.30				103.75			90.84						71.778	471.08	299.44	66475.60	68558.90	72159.30	74583.60	76770.60	81155.80	
10	71.778	75.175	159.69		0.30				103.75			90.84						75.175	455.48	1547.05	68022.65	70105.95	73706.35	76130.65	78317.65	82702.85	
11	75.175	81.757	159.69						103.75			90.84						81.757	455.18	2996.15	71018.79	73102.09	76702.49	79128.79	81313.79	85898.99	
12	81.757	81.865	159.69									90.84						81.865	351.43	37.95	71056.74	73140.04	76740.44	79164.74	81351.74	85736.94	
13	81.865	97.892	159.69									108.02	90.84					97.892	459.46	7383.58	78420.32	80503.62	84104.02	86528.32	88715.32	93100.52	
14	97.892	108.184	159.69									103.05	108.02	90.84				108.184	562.51	5789.10	84209.43	86292.73	89893.13	92317.43	94504.43	98889.63	
15	108.184	110.168	199.20									103.05	108.02	90.84				110.168	602.01	1194.55	85403.97	87487.27	91087.67	93511.97	95698.97	100084.17	
16	110.168	112.826	199.20				139.83					103.05	108.02	90.84				112.826	741.84	1971.60	87375.57	89458.87	93059.27	95483.57	97670.57	102055.77	
17	112.826	113.168	199.20				139.83					103.05	108.02	90.84	0.61	29.75	71.15	113.168	742.45	254.13	87629.70	89713.00	93313.40	95737.70	97924.70	102309.90	
18	113.168	116.008	199.20									103.05	108.02	90.84	0.61	29.75	71.15	116.008	602.62	1711.50	89341.20	91424.50	95024.90	97449.20	99636.20	104021.40	
19	116.008	127.322	199.20									103.05	108.02	90.84	0.61	29.75	71.15	127.322	602.62	6817.97	96159.17	98242.47	101842.87	104267.17	108454.17	110839.37	
20	127.322	131.399	199.20									103.05	108.02	90.84	0.61	71.15		131.399	572.87	2335.61	98494.79	100578.09	104178.49	106602.79	108789.79	113174.99	
21	131.399	157.289										103.05	108.02	90.84	0.61	71.15		157.289	373.67	9674.45	108169.23	110252.53	113852.93	116277.23	118484.23	122849.43	
22	157.289	157.542						99.30				108.02	90.84	0.61	71.15			157.542	369.93	93.55	108262.79	110346.09	113946.49	116370.79	118557.79	122942.99	
23	157.542	160.705						99.30				108.02	90.84	0.61				160.705	298.77	944.93	109207.72	111291.02	114891.42	117315.72	119502.72	123887.92	
24	160.705	176.999						99.30				108.02		0.61				176.999	207.93	3388.17	112595.89	114679.19	118279.59	120703.89	122890.89	127276.09	
25	176.999	184.949						99.30				108.02						184.949	207.33	1648.16	114244.05	116327.35	119927.75	122352.05	124539.05	128924.25	
26	184.949	192.001	114.24					99.30				108.02						192.001	321.57	2267.87	116511.92	118595.22	122195.62	124619.92	126806.92	131192.12	
27	192.001	192.322	114.24									108.02						192.322	222.26	71.27	116583.19	118666.49	122266.89	124691.19	126878.19	131263.39	
28	192.322	198.949	1829.52									108.02						198.949	1937.54	12839.72	129422.91	131506.21	135106.61	137530.91	139717.91	144103.11	
29	198.949	206.704										108.02						206.704	108.02	837.77	130260.68	132343.98	135944.38	138368.68	140555.68	144940.88	
30	206.704	207.288										108.02	207.03					207.288	315.05	183.78	130444.46	132527.76	136128.16	138552.46	140739.46	145124.66	
31	207.288	213.158										108.02	207.03					213.158	420.54	2468.88	132913.34	134996.64	138597.04	141021.34	143208.34	147593.54	
32	213.158	213.715										108.02						213.715	213.51	118.84	133032.18	135115.48	138715.88	141140.18	143327.18	147712.38	
33	213.715	222.000										108.02						222.000	609.80	5050.56	138082.74	140166.04	143766.44	146180.74	148377.74	152762.94	
34	222.000	230.547										108.02						230.547	609.80	5210.54	143293.28	145376.58	148976.98	151401.28	153588.28	157973.48	
35	230.547	263.482										108.02						263.482	108.02	3557.69	146850.98	148934.28	152534.68	154958.98	157145.98	161531.18	
36	263.482	288.984										499.12						288.984	499.12	12728.62	159579.60	161662.90	165263.30	167687.60	169874.60	174259.80	
37	288.984	324.809										108.02						324.809	108.02	3869.92	163449.51	165532.81	169133.21	171557.51	173744.51	178129.71	



**Table C11** Calculation of Target area at  $\Delta T_{\min}=5^{\circ}\text{C}$  for actual case

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m2	Sum(MCp,c/h) m2	Sum(Q/h) m2C	LMTDi C	A m2
0	51975.80	575.23	0.00	96.10	19.20	575.23	0.00	0.00	0.00	0.00
1	51978.87	575.23	0.30	96.10	29.34	575.23	0.30	6.14	71.71	0.09
2	52884.00	575.23	159.99	97.67	35.00	575.23	159.99	1810.26	64.70	27.98
3	53260.55	575.23	189.75	98.33	36.98	575.23	189.75	753.10	62.01	12.15
4	54823.17	575.23	260.90	101.05	42.97	575.23	260.90	3125.24	59.69	52.35
5	57120.99	575.23	276.49	105.04	51.28	575.23	276.49	4595.64	55.89	82.23
6	57429.75	575.23	367.33	105.58	52.12	575.23	367.33	617.51	53.60	11.52
7	58729.67	575.23	399.13	107.84	55.38	575.23	399.13	2599.85	52.95	49.10
8	60028.36	557.20	399.13	110.17	58.64	557.20	399.13	2597.37	51.99	49.96
9	60487.63	537.09	399.13	111.02	59.79	537.09	399.13	918.55	51.38	17.88
10	60573.66	1035.68	399.13	111.11	60.00	1035.68	399.13	172.06	51.17	3.36
11	62354.55	1035.68	502.88	112.83	63.54	1035.68	502.88	3561.78	50.19	70.97
12	66176.16	1031.93	502.88	116.53	71.14	1031.93	502.88	7643.22	47.31	161.56
13	66475.60	1031.93	471.08	116.82	71.78	1031.93	471.08	598.88	45.21	13.25
14	68022.65	1031.93	455.48	118.32	75.17	1031.93	455.48	3094.10	44.09	70.18
15	68624.58	1031.93	455.18	118.90	76.50	1031.93	455.18	1203.87	42.77	28.15
16	71018.79	1128.99	455.18	121.02	81.76	1128.99	455.18	4788.43	40.81	117.32
17	71056.74	1128.99	351.43	121.06	81.87	1128.99	351.43	75.90	39.23	1.93
18	78420.32	1128.99	459.46	127.58	97.89	1128.99	459.46	14727.16	34.22	430.38
19	81470.61	1128.99	562.51	130.28	103.31	1128.99	562.51	6100.57	28.30	215.54
20	84209.43	1102.35	562.51	132.76	108.18	1102.35	562.51	5477.64	25.75	212.68
21	84271.63	1102.35	602.01	132.82	108.29	1102.35	602.01	124.41	24.56	5.07
22	84999.53	1161.63	602.01	133.45	109.50	1161.63	602.01	1455.80	24.24	60.05
23	85403.97	534.04	602.01	134.20	110.17	534.04	602.01	808.89	23.99	33.71
24	87375.57	534.04	741.84	137.90	112.83	534.04	741.84	3943.19	24.55	160.62
25	87629.70	534.04	742.45	138.37	113.17	534.04	742.45	508.25	25.14	20.22
26	87863.27	534.04	602.62	138.81	113.56	534.04	602.62	467.14	25.23	18.52
27	89341.20	517.72	602.62	141.66	116.01	517.72	602.62	2955.86	25.46	116.12
28	95471.04	517.72	602.62	153.50	126.18	517.72	602.62	12259.69	26.48	462.94
29	96159.17	493.07	602.62	154.90	127.32	493.07	602.62	1376.26	27.45	50.13
30	98494.79	493.07	572.87	159.64	131.40	493.07	572.87	4671.23	27.91	167.38
31	108169.23	493.07	373.67	179.26	157.29	493.07	373.67	19348.89	24.97	774.80
32	108262.79	493.07	369.93	179.45	157.54	493.07	369.93	187.11	21.94	8.53
33	109207.72	493.07	298.77	181.36	160.70	493.07	298.77	1889.86	21.28	88.82
34	112595.89	493.07	207.93	188.24	177.00	493.07	207.93	6776.34	15.47	437.95
35	113897.62	493.07	207.33	190.88	183.28	493.07	207.33	2603.45	9.30	279.97
36	114244.05	416.64	207.33	191.71	184.95	416.64	207.33	692.86	7.17	96.63
37	116511.92	416.64	321.57	197.15	192.00	416.64	321.57	4535.74	5.92	766.48
38	116583.19	416.64	222.26	197.32	192.32	416.64	222.26	142.55	5.07	28.09
39	120492.31	416.64	1937.54	206.70	194.34	416.64	1937.54	7818.24	8.13	961.18
40	120676.50	315.76	1937.54	207.29	194.43	315.76	1937.54	368.39	12.61	29.22
41	128154.09	218.70	1937.54	241.48	198.29	218.70	1937.54	14955.17	25.03	597.54
42	129422.91	171.04	1937.54	248.90	198.95	171.04	1937.54	2537.64	46.48	54.59
43	130260.68	171.04	108.02	253.79	206.70	171.04	108.02	1675.54	48.50	34.54
44	130444.46	171.04	315.05	254.87	207.29	171.04	315.05	367.56	47.34	7.77
45	132913.34	171.04	420.54	269.30	213.16	171.04	420.54	4937.75	51.75	95.42
46	133032.18	171.04	213.51	270.00	213.72	171.04	213.51	237.69	56.21	4.23
47	134173.69	171.04	609.60	276.67	215.59	171.04	609.60	2283.01	58.65	38.93
48	136791.72	56.55	609.60	322.97	219.88	56.55	609.60	5236.06	80.26	65.24
49	136808.04	0.09	609.60	510.93	219.91	0.09	609.60	32.65	181.08	0.18
	138082.74		609.60		222.00		609.60		<b>Total Area</b>	<b>7093.46</b>

**Table C12** Calculation of Target area at  $\Delta T_{\min}=10^{\circ}\text{C}$  for actual case

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m2	Sum(MCp,c/h) m2	Sum(Q/h) m2C	LMTDi C	A m2
0	54059.10	575.23	0.00	99.72	19.20	575.23	0.00	0.00	0.00	0.00
1	54062.17	575.23	0.30	99.72	29.34	575.23	0.30	6.14	75.34	0.08
2	54967.30	575.23	159.99	101.30	35.00	575.23	159.99	1810.26	68.32	26.50
3	55343.85	575.23	189.75	101.95	36.98	575.23	189.75	753.10	65.63	11.48
4	56906.47	575.23	260.90	104.67	42.97	575.23	260.90	3125.24	63.32	49.36
5	58729.67	575.23	276.49	107.84	49.57	575.23	276.49	3646.40	59.97	60.81
6	59204.29	557.20	276.49	108.69	51.28	557.20	276.49	949.23	57.84	16.41
7	59513.05	557.20	367.33	109.24	52.12	557.20	367.33	617.51	57.26	10.78
8	60028.36	557.20	399.13	110.17	53.42	557.20	399.13	1030.62	56.93	18.10
9	60487.63	537.09	399.13	111.02	54.57	537.09	399.13	918.55	56.60	16.23
10	62354.55	1035.68	399.13	112.83	59.24	1035.68	399.13	3733.84	55.01	67.88
11	62656.96	1031.93	399.13	113.12	60.00	1031.93	399.13	604.82	53.35	11.34
12	68259.46	1031.93	502.88	118.55	71.14	1031.93	502.88	11204.99	50.21	223.18
13	68558.90	1031.93	471.08	118.84	71.78	1031.93	471.08	598.88	47.23	12.68
14	68624.58	1031.93	455.48	118.90	71.92	1031.93	455.48	131.36	47.02	2.79
15	70105.95	1128.99	455.48	120.21	75.17	1128.99	455.48	2962.73	46.00	64.40
16	73102.09	1128.99	455.18	122.87	81.76	1128.99	455.18	5992.29	43.04	139.21
17	73140.04	1128.99	351.43	122.90	81.87	1128.99	351.43	75.90	41.07	1.85
18	80503.62	1128.99	459.46	129.42	97.89	1128.99	459.46	14727.16	36.08	408.23
19	81470.61	1128.99	562.51	130.28	99.61	1128.99	562.51	1933.97	31.10	62.19
20	84271.63	1102.35	562.51	132.82	104.59	1102.35	562.51	5602.05	29.43	190.33
21	84999.53	1161.63	562.51	133.45	105.88	1161.63	562.51	1455.80	27.90	52.19
22	86292.73	534.04	562.51	135.87	108.18	534.04	562.51	2586.39	27.62	93.63
23	87487.27	534.04	602.01	138.11	110.17	534.04	602.01	2389.09	27.81	85.90
24	87863.27	534.04	741.84	138.81	110.67	534.04	741.84	751.99	28.04	26.82
25	89458.87	517.72	741.84	141.89	112.83	517.72	741.84	3191.20	28.60	111.59
26	89713.00	517.72	742.45	142.38	113.17	517.72	742.45	508.25	29.14	17.44
27	91424.50	517.72	602.62	145.69	116.01	517.72	602.62	3423.00	29.45	116.24
28	95471.04	517.72	602.62	153.50	122.72	517.72	602.62	8093.09	30.23	267.74
29	98242.47	493.07	602.62	159.13	127.32	493.07	602.62	5542.86	31.29	177.14
30	100578.09	493.07	572.87	163.86	131.40	493.07	572.87	4671.23	32.13	145.37
31	110252.53	493.07	373.67	183.48	157.29	493.07	373.67	19348.89	29.22	662.25
32	110346.09	493.07	369.93	183.67	157.54	493.07	369.93	187.11	26.16	7.15
33	111291.02	493.07	298.77	185.59	160.70	493.07	298.77	1889.86	25.50	74.10
34	113897.62	493.07	207.93	190.88	173.24	493.07	207.93	5213.19	21.05	247.63
35	114679.19	416.64	207.93	192.75	177.00	416.64	207.93	1563.15	16.68	93.73
36	116327.35	416.64	207.33	196.71	184.95	416.64	207.33	3296.32	13.66	241.34
37	118595.22	416.64	321.57	202.15	192.00	416.64	321.57	4535.74	10.93	414.81
38	118666.49	416.64	222.26	202.32	192.32	416.64	222.26	142.55	10.07	14.15
39	120492.31	416.64	1937.54	206.70	193.26	416.64	1937.54	3651.64	11.64	313.84
40	120676.50	315.76	1937.54	207.29	193.36	315.76	1937.54	368.39	13.68	26.92
41	128154.09	218.70	1937.54	241.48	197.22	218.70	1937.54	14955.17	26.23	570.06
42	131506.21	171.04	1937.54	261.08	198.95	171.04	1937.54	6704.24	52.69	127.24
43	132343.98	171.04	108.02	265.97	206.70	171.04	108.02	1675.54	60.69	27.61
44	132527.76	171.04	315.05	267.05	207.29	171.04	315.05	367.56	59.52	6.18
45	134173.69	171.04	420.54	276.67	211.20	171.04	420.54	3291.85	62.57	52.61
46	134996.64	56.55	420.54	291.23	213.16	56.55	420.54	1645.91	71.58	22.99
47	135115.48	56.55	213.51	293.33	213.72	56.55	213.51	237.69	78.84	3.01
48	136791.72	56.55	609.60	322.97	216.46	56.55	609.60	3352.47	92.41	36.28
49	136808.04	0.09	609.60	510.93	216.49	0.09	609.60	32.65	184.81	0.18
	140166.04		609.60		222.00		609.60		<b>Total Area</b>	<b>5429.98</b>

**Table C13** Calculation of Target area at  $\Delta T_{\min}=20^{\circ}\text{C}$  for actual case

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m2	Sum(MCp,c/h) m2	Sum(Q/h) m2C	LMTDi C	A m2
0	57659.50	575.23	0.00	105.98	19.20	575.23	0.00	0.00	0.00	0.00
1	57662.57	575.23	0.30	105.98	29.34	575.23	0.30	6.14	81.60	0.08
2	58567.70	575.23	159.99	107.56	35.00	575.23	159.99	1810.26	74.58	24.27
3	58729.67	575.23	189.75	107.84	35.85	575.23	189.75	323.95	72.27	4.48
4	58944.25	557.20	189.75	108.22	36.98	557.20	189.75	429.16	71.61	5.99
5	60028.36	557.20	260.90	110.17	41.14	557.20	260.90	2168.21	70.13	30.92
6	60487.63	537.09	260.90	111.02	42.90	537.09	260.90	918.55	68.57	13.39
7	60506.87	1035.68	260.90	111.04	42.97	1035.68	260.90	38.48	68.10	0.57
8	62354.55	1035.68	276.49	112.83	49.66	1035.68	276.49	3695.36	65.59	56.34
9	62804.69	1031.93	276.49	113.26	51.28	1031.93	276.49	900.28	62.57	14.39
10	63113.45	1031.93	367.33	113.56	52.12	1031.93	367.33	617.51	61.71	10.01
11	66257.36	1031.93	399.13	116.61	60.00	1031.93	399.13	6287.83	58.99	106.60
12	68624.58	1031.93	502.88	118.90	68.01	1031.93	502.88	6393.11	53.70	119.05
13	71859.86	1128.99	502.88	121.77	71.14	1128.99	502.88	4811.89	50.76	94.80
14	72159.30	1128.99	471.08	122.03	71.78	1128.99	471.08	598.88	50.44	11.87
15	73706.35	1128.99	455.48	123.40	75.17	1128.99	455.48	3094.10	49.23	62.84
16	76702.49	1128.99	455.18	126.06	81.76	1128.99	455.18	5992.29	46.24	129.60
17	76740.44	1128.99	351.43	126.09	81.87	1128.99	351.43	75.90	44.26	1.71
18	81470.61	1128.99	459.46	130.28	92.16	1128.99	459.46	9460.33	41.10	230.20
19	84104.02	1102.35	459.46	132.67	97.89	1102.35	459.46	5266.83	36.42	144.60
20	84271.63	1102.35	562.51	132.82	98.19	1102.35	562.51	335.22	34.70	9.66
21	84999.53	1161.63	562.51	133.45	99.48	1161.63	562.51	1455.80	34.30	42.45
22	87863.27	534.04	562.51	138.81	104.58	534.04	562.51	5727.48	34.10	167.97
23	89893.13	517.72	562.51	142.73	108.18	517.72	562.51	4059.72	34.39	118.05
24	91087.67	517.72	602.01	145.04	110.17	517.72	602.01	2389.09	34.71	68.83
25	93059.27	517.72	741.84	148.85	112.83	517.72	741.84	3943.19	35.44	111.26
26	93313.40	517.72	742.45	149.34	113.17	517.72	742.45	508.25	36.09	14.08
27	95024.90	517.72	602.62	152.64	116.01	517.72	602.62	3423.00	36.40	94.03
28	95471.04	517.72	602.62	153.50	116.75	517.72	602.62	892.29	36.70	24.32
29	101842.87	493.07	602.62	166.43	127.32	493.07	602.62	12743.66	37.92	336.08
30	104178.49	493.07	572.87	171.16	131.40	493.07	572.87	4671.23	39.43	118.45
31	113852.93	493.07	373.67	190.79	157.29	493.07	373.67	19348.89	36.54	529.51
32	113897.62	493.07	369.93	190.88	157.41	493.07	369.93	89.36	33.48	2.67
33	113946.49	416.64	369.93	190.99	157.54	416.64	369.93	97.74	33.46	2.92
34	114891.42	416.64	298.77	193.26	160.70	416.64	298.77	1889.86	33.00	57.27
35	118279.59	416.64	207.93	201.39	177.00	416.64	207.93	6776.34	28.28	239.62
36	119927.75	416.64	207.33	205.35	184.95	416.64	207.33	3296.32	22.34	147.57
37	120492.31	416.64	321.57	206.70	186.70	416.64	321.57	1129.13	20.20	55.90
38	120676.50	315.76	321.57	207.29	187.28	315.76	321.57	368.39	20.01	18.41
39	122195.62	218.70	321.57	214.23	192.00	218.70	321.57	3038.23	21.10	143.98
40	122266.89	218.70	222.26	214.56	192.32	218.70	222.26	142.55	22.23	6.41
41	128154.09	218.70	1937.54	241.48	195.36	218.70	1937.54	11774.40	32.74	359.65
42	134173.69	171.04	1937.54	276.67	198.47	171.04	1937.54	12039.19	60.76	198.16
43	135106.61	56.55	1937.54	293.17	198.95	56.55	1937.54	1865.85	85.96	21.70
44	135944.38	56.55	108.02	307.99	206.70	56.55	108.02	1675.54	97.71	17.15
45	136128.16	56.55	315.05	311.24	207.29	56.55	315.05	367.56	102.61	3.58
46	136791.72	56.55	420.54	322.97	208.87	56.55	420.54	1327.11	108.95	12.18
47	136808.04	0.09	420.54	510.93	208.90	0.09	420.54	32.65	193.06	0.17
	138597.04		420.54		213.16		420.54		<b>Total Area</b>	<b>3983.74</b>

**Table C14** Calculation of Target area at  $\Delta T_{\min}=30^{\circ}\text{C}$  for actual case

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m <sup>2</sup>	Sum(MCp,c/h) m <sup>2</sup>	Sum(Q/h) m <sup>2</sup> C	LMTDi C	A m <sup>2</sup>
0	60083.80	537.09	0.00	110.27	19.20	537.09	0.00	0.00	0.00	0.00
1	60086.87	537.09	0.30	110.28	29.34	537.09	0.30	6.14	85.90	0.07
2	60487.63	537.09	159.99	111.02	31.85	537.09	159.99	801.52	80.05	10.01
3	60992.00	1035.68	159.99	111.51	35.00	1035.68	159.99	1008.74	77.84	12.96
4	61368.55	1035.68	189.75	111.87	36.98	1035.68	189.75	753.10	75.70	9.95
5	62354.55	1035.68	260.90	112.83	40.76	1035.68	260.90	1972.00	73.47	26.84
6	62931.17	1031.93	260.90	113.38	42.97	1031.93	260.90	1153.24	71.23	16.19
7	65228.99	1031.93	276.49	115.61	51.28	1031.93	276.49	4595.64	67.32	68.26
8	65537.75	1031.93	367.33	115.91	52.12	1031.93	367.33	617.51	64.06	9.64
9	68624.58	1031.93	399.13	118.90	59.86	1031.93	399.13	6173.66	61.38	100.58
10	68681.66	1128.99	399.13	118.95	60.00	1128.99	399.13	114.17	59.00	1.94
11	74284.16	1128.99	502.88	123.91	71.14	1128.99	502.88	11204.99	55.80	200.79
12	74583.60	1128.99	471.08	124.18	71.78	1128.99	471.08	598.88	52.59	11.39
13	76130.65	1128.99	455.48	125.55	75.17	1128.99	455.48	3094.10	51.38	60.22
14	79126.79	1128.99	455.18	128.20	81.76	1128.99	455.18	5992.29	48.38	123.85
15	79164.74	1128.99	351.43	128.24	81.87	1128.99	351.43	75.90	46.41	1.64
16	81470.61	1128.99	459.46	130.28	86.88	1128.99	459.46	4611.73	44.87	102.78
17	84271.63	1102.35	459.46	132.82	92.98	1102.35	459.46	5602.05	41.59	134.69
18	84999.53	1161.63	459.46	133.45	94.56	1161.63	459.46	1455.80	39.36	36.99
19	86528.32	534.04	459.46	136.31	97.89	534.04	459.46	3057.58	38.65	79.11
20	87863.27	534.04	562.51	138.81	100.27	534.04	562.51	2669.89	38.48	69.38
21	92317.43	517.72	562.51	147.41	108.18	517.72	562.51	8908.32	38.89	229.09
22	93511.97	517.72	602.01	149.72	110.17	517.72	602.01	2389.09	39.39	60.65
23	95471.04	517.72	741.84	153.50	112.81	517.72	741.84	3918.14	40.12	97.66
24	95483.57	493.07	741.84	153.53	112.83	493.07	741.84	25.05	40.70	0.62
25	95737.70	493.07	742.45	154.05	113.17	493.07	742.45	508.25	40.79	12.46
26	97449.20	493.07	602.62	157.52	116.01	493.07	602.62	3423.00	41.19	83.10
27	104267.17	493.07	602.62	171.34	127.32	493.07	602.62	13635.95	42.75	318.95
28	106602.79	493.07	572.87	176.08	131.40	493.07	572.87	4671.23	44.35	105.32
29	113897.62	493.07	373.67	190.88	150.92	493.07	373.67	14589.66	42.27	345.12
30	116277.23	416.64	373.67	196.59	157.29	416.64	373.67	4759.24	39.63	120.10
31	116370.79	416.64	369.93	196.81	157.54	416.64	369.93	187.11	39.28	4.76
32	117315.72	416.64	298.77	199.08	160.70	416.64	298.77	1889.86	38.82	48.68
33	120492.31	416.64	207.93	206.70	175.98	416.64	207.93	6353.18	34.41	184.65
34	120676.50	315.76	207.93	207.29	176.87	315.76	207.93	368.39	30.57	12.05
35	120703.89	218.70	207.93	207.41	177.00	218.70	207.93	54.77	30.42	1.80
36	122352.05	218.70	207.33	214.95	184.95	218.70	207.33	3296.32	30.21	109.13
37	124619.92	218.70	321.57	225.32	192.00	218.70	321.57	4535.74	31.63	143.40
38	124691.19	218.70	222.26	225.64	192.32	218.70	222.26	142.55	33.32	4.28
39	128154.09	218.70	1937.54	241.48	194.11	218.70	1937.54	6925.80	39.93	173.43
40	134173.69	171.04	1937.54	276.67	197.22	171.04	1937.54	12039.19	62.04	194.07
41	136791.72	56.55	1937.54	322.97	198.57	56.55	1937.54	5236.06	100.26	52.23
42	136808.04	0.09	1937.54	510.93	198.58	0.09	1937.54	32.65	204.16	0.16
	137530.91		1937.54		198.95		1937.54		<b>Total Area</b>	<b>3378.96</b>

**Table C15** Calculation of Target area at  $\Delta T_{\min}=40^{\circ}\text{C}$  for actual case

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m2	Sum(MCp,c/h) m2	Sum(Q/h) m2C	LMTDi C	A m2
0	62270.80	1035.68	0.00	112.74	19.20	1035.68	0.00	0.00	0.00	0.00
1	62273.87	1035.68	0.30	112.75	29.34	1035.68	0.30	6.14	88.38	0.07
2	62354.55	1035.68	159.99	112.83	29.85	1035.68	159.99	161.36	83.19	1.94
3	63179.00	1031.93	159.99	113.62	35.00	1031.93	159.99	1648.90	80.78	20.41
4	63555.55	1031.93	189.75	113.99	36.98	1031.93	189.75	753.10	77.81	9.68
5	65118.17	1031.93	260.90	115.50	42.97	1031.93	260.90	3125.24	74.75	41.81
6	67415.99	1031.93	276.49	117.73	51.28	1031.93	276.49	4595.64	69.44	66.18
7	67724.75	1031.93	367.33	118.03	52.12	1031.93	367.33	617.51	66.17	9.33
8	68624.58	1031.93	399.13	118.90	54.38	1031.93	399.13	1799.66	65.21	27.60
9	70868.66	1128.99	399.13	120.89	60.00	1128.99	399.13	4488.17	62.69	71.60
10	76471.16	1128.99	502.88	125.85	71.14	1128.99	502.88	11204.99	57.74	194.05
11	76770.60	1128.99	471.08	126.12	71.78	1128.99	471.08	598.88	54.52	10.98
12	78317.65	1128.99	455.48	127.49	75.17	1128.99	455.48	3094.10	53.32	58.03
13	81313.79	1128.99	455.18	130.14	81.76	1128.99	455.18	5992.29	50.32	119.08
14	81351.74	1128.99	351.43	130.17	81.87	1128.99	351.43	75.90	48.35	1.57
15	81470.61	1128.99	459.46	130.28	82.12	1128.99	459.46	237.73	48.23	4.93
16	84271.63	1102.35	459.46	132.82	88.22	1102.35	459.46	5602.05	46.36	120.85
17	84999.53	1161.63	459.46	133.45	89.80	1161.63	459.46	1455.80	44.12	33.00
18	87863.27	534.04	459.46	138.81	96.04	534.04	459.46	5727.48	43.21	132.56
19	88715.32	517.72	459.46	140.46	97.89	517.72	459.46	1704.11	42.67	39.94
20	94504.43	517.72	562.51	151.64	108.18	517.72	562.51	11578.21	43.01	269.21
21	95471.04	517.72	602.01	153.50	109.79	517.72	602.01	1933.23	43.58	44.36
22	95698.97	493.07	602.01	153.97	110.17	493.07	602.01	455.86	43.76	10.42
23	97670.57	493.07	741.84	157.97	112.83	493.07	741.84	3943.19	44.47	88.68
24	97924.70	493.07	742.45	158.48	113.17	493.07	742.45	508.25	45.23	11.24
25	99636.20	493.07	602.62	161.95	116.01	493.07	602.62	3423.00	45.63	75.02
26	106454.17	493.07	602.62	175.78	127.32	493.07	602.62	13635.95	47.19	288.96
27	108789.79	493.07	572.87	180.52	131.40	493.07	572.87	4671.23	48.79	95.75
28	113897.62	493.07	373.67	190.88	145.07	493.07	373.67	10215.66	47.44	215.32
29	118464.23	416.64	373.67	201.84	157.29	416.64	373.67	9133.24	45.17	202.18
30	118557.79	416.64	369.93	202.06	157.54	416.64	369.93	187.11	44.53	4.20
31	119502.72	416.64	298.77	204.33	160.70	416.64	298.77	1889.86	44.07	42.88
32	120492.31	416.64	207.93	206.70	160.70	416.64	207.93	989.59	44.80	22.09
33	120676.50	315.76	207.93	207.29	160.70	315.76	207.93	184.19	46.29	3.98
34	122890.89	218.70	207.93	217.41	177.00	218.70	207.93	5602.56	43.43	129.02
35	124539.05	218.70	207.33	224.95	184.95	218.70	207.33	3296.32	40.21	81.99
36	126806.92	218.70	321.57	235.32	192.00	218.70	321.57	4535.74	41.64	108.94
37	126878.19	218.70	222.26	235.64	192.32	218.70	222.26	142.55	43.32	3.29
38	128154.09	218.70	1937.54	241.48	192.98	218.70	1937.54	2551.80	45.86	55.64
39	134173.69	171.04	1937.54	276.67	196.09	171.04	1937.54	12039.19	63.19	190.53
40	136791.72	56.55	1937.54	322.97	197.44	56.55	1937.54	5236.06	101.40	51.64
41	136808.04	0.09	1937.54	510.93	197.45	0.09	1937.54	32.65	205.37	0.16
	139717.91		1937.54		198.95		1937.54		<b>Total Area</b>	<b>2959.07</b>

**Table C16** Calculation of Target area at  $\Delta T_{\min}=51.034^{\circ}\text{C}$  for actual case  
(corresponding to the usage utility in the existing plant)

i	CumQi kW	SumMCp,h kW/C	SumMCp,c kW/C	Thi C	Tci C	Sum(MCp,h/h) m2	Sum(MCp,c/h) m2	Sum(Q/h) m2C	LMTDi C	A m2
0	66656.00	1031.93	0.00	116.99	19.20	1031.93	0.00	0.00	0.00	0.00
1	66659.07	1031.93	0.30	117.00	29.34	1031.93	0.30	6.14	92.63	0.07
2	67564.20	1031.93	159.99	117.87	35.00	1031.93	159.99	1810.26	85.24	21.24
3	67940.75	1031.93	189.75	118.24	36.98	1031.93	189.75	753.10	82.06	9.18
4	68624.58	1031.93	260.90	118.90	39.61	1031.93	260.90	1367.65	80.27	17.04
5	69503.37	1128.99	260.90	119.68	42.97	1128.99	260.90	1757.59	77.99	22.53
6	71801.19	1128.99	276.49	121.72	51.28	1128.99	276.49	4595.64	73.52	62.51
7	72109.95	1128.99	367.33	121.99	52.12	1128.99	367.33	617.51	70.15	8.80
8	75253.86	1128.99	399.13	124.77	60.00	1128.99	399.13	6287.83	67.29	93.45
9	80856.36	1128.99	502.88	129.74	71.14	1128.99	502.88	11204.99	61.63	181.81
10	81155.80	1128.99	471.08	130.00	71.78	1128.99	471.08	598.88	58.41	10.25
11	81470.61	1128.99	455.48	130.28	72.47	1128.99	455.48	629.62	58.02	10.85
12	82702.85	1102.35	455.48	131.40	75.17	1102.35	455.48	2464.48	57.01	43.23
13	84271.63	1102.35	455.18	132.82	78.62	1102.35	455.18	3137.57	55.21	56.83
14	84999.53	1161.63	455.18	133.45	80.22	1161.63	455.18	1455.80	53.71	27.10
15	85698.99	534.04	455.18	134.76	81.76	534.04	455.18	1398.93	53.11	26.34
16	85736.94	534.04	351.43	134.83	81.87	534.04	351.43	75.90	52.98	1.43
17	87863.27	534.04	459.46	138.81	86.49	534.04	459.46	4252.65	52.64	80.79
18	93100.52	517.72	459.46	148.93	97.89	517.72	459.46	10474.51	51.67	202.71
19	95471.04	517.72	562.51	153.50	102.11	517.72	562.51	4741.04	51.22	92.57
20	98889.63	493.07	562.51	160.44	108.18	493.07	562.51	6837.17	51.83	131.93
21	100084.17	493.07	602.01	162.86	110.17	493.07	602.01	2389.09	52.47	45.53
22	102055.77	493.07	741.84	166.86	112.83	493.07	741.84	3943.19	53.36	73.90
23	102309.90	493.07	742.45	167.37	113.17	493.07	742.45	508.25	54.12	9.39
24	104021.40	493.07	602.62	170.85	116.01	493.07	602.62	3423.00	54.52	62.78
25	110839.37	493.07	602.62	184.67	127.32	493.07	602.62	13635.95	56.09	243.13
26	113174.99	493.07	572.87	189.41	131.40	493.07	572.87	4671.23	57.68	80.98
27	113897.62	493.07	373.67	190.88	133.33	493.07	373.67	1445.26	57.78	25.01
28	120492.31	416.64	373.67	206.70	150.98	416.64	373.67	13189.39	56.63	232.91
29	120676.50	315.76	373.67	207.29	151.47	315.76	373.67	368.39	55.77	6.61
30	122849.43	218.70	373.67	217.22	157.29	218.70	373.67	4345.86	57.85	75.12
31	122942.99	218.70	369.93	217.65	157.54	218.70	369.93	187.11	60.02	3.12
32	123887.92	218.70	298.77	221.97	160.70	218.70	298.77	1889.86	60.69	31.14
33	127276.09	218.70	207.93	237.46	177.00	218.70	207.93	6776.34	60.86	111.33
34	128154.09	218.70	207.33	241.48	181.23	218.70	207.33	1756.00	60.35	29.10
35	128924.25	171.04	207.33	245.98	184.95	171.04	207.33	1540.31	60.64	25.40
36	131192.12	171.04	321.57	259.24	192.00	171.04	321.57	4535.74	64.09	70.78
37	131263.39	171.04	222.26	259.66	192.32	171.04	222.26	142.55	67.29	2.12
38	134173.69	171.04	1937.54	276.67	193.82	171.04	1937.54	5820.58	74.82	77.79
39	136791.72	56.55	1937.54	322.97	195.18	56.55	1937.54	5236.06	103.70	50.49
40	136808.04	0.09	1937.54	510.93	195.18	0.09	1937.54	32.65	207.79	0.16
	144103.11		1937.54		198.95		1937.54		<b>Total Area</b>	<b>2357.45</b>

**Appendix D Problem table algorithm with multiple utility level for design and actual case.**

**C-1 Problem table algorithm with multiple utility level at various  $\Delta T_{\min}$  for design case.**

**Table D1** Problem table algorithm with multiple utility level at  $\Delta T_{min}=5^{\circ}C$  for design case

Temperature Interval C	Enthalpy kW	Surplus kW	Cascade kW	
579 50	30506 919			
579 50	572 50	30504 179	-2 740	50.902 power
572 50	541 50	30479 574	-24 605	26 296
541 50	521 50	30459 498	-20 076	6 220
521 50	514 50	30453 722	-5 776	0 445
514 50	484 50	30754 684	300 962	301 407
484 50	479 50	30751 178	-3 506	297 900
479 50	474 50	30693 386	-57 792	240 108
474 50	454 50	30470 977	-222 409	17 699
454 50	422 50	30458 589	-12 388	5 311
422 50	392 50	11275 648	-5 311	0 000
392 50	341 50	19168 601	-9 029	30444 249 HP steam
341 50	340 50	30340 273	-103 976	30340 273
340 50	318 10	30482 205	141 932	30482 205
318 10	302 50	30576 343	94 138	30576 343
302 50	292 50	30636 688	60 345	30636 688
292 50	291 48	30643 440	6 752	30643 440
291 48	291 37	30599 908	-43 532	30599 908
291 37	274 17	23914 650	-6685 258	23914 650
274 17	265 98	21228 036	-2686 614	21228 036
265 98	236 50	23211 815	1983 779	23211 815
236 50	232 50	23669 387	457 572	23669 387
232 50	230 50	22248 173	-1421 214	22248 173
230 50	224 50	14975 053	-7273 120	14975 053
224 50	222 50	14200 680	-774 373	14200 680
222 50	219 50	12342 951	-1857 729	12342 951
219 50	217 50	11360 217	-982 734	11360 217
217 50	216 22	10946 233	-411 984	10946 233
216 22	214 20	11102 816	156 583	11102 816
214 20	209 20	11999 880	897 064	11999 880
209 20	203 50	13536 743	1536 864	13536 743
203 50	194 82	0 000	-13536 743	0 000
194 82	191 20	537 912	537 912	537 912
191 20	190 50	530 470	-7 442	530 470
190 50	187 00	917 154	386 684	917 154
187 00	177 40	4205 512	3288 359	4205 512
177 40	164 50	8621 939	4416 426	8621 939
164 50	159 50	10246 232	1624 293	10246 232
159 50	156 60	10965 884	719 652	10965 884
156 60	151 50	11805 970	840 086	11805 970
151 50	146 50	12185 440	379 470	12185 440
146 50	145 50	12872 934	687 494	12872 934
145 50	132 50	19559 493	6686 559	19559 493
132 50	130 40	20646 192	1086 699	20646 192
130 40	128 50	21685 840	1039 648	21685 840
128 50	120 50	24841 269	3155 429	24841 269
120 50	118 51	20138 241	-4703 028	20138 241
118 51	118 50	20140 126	1 885	20140 126
118 50	114 30	22265 726	2125 600	22265 726
114 30	113 50	22670 844	405 118	22670 844
113 50	109 30	24904 327	2233 483	24904 327
109 30	108 52	25321 211	416 884	25321 211
108 52	106 50	25437 512	116 301	25437 512
106 50	104 50	25330 259	-107 253	25330 259
104 50	100 90	24659 994	-670 265	24659 994
100 90	100 70	24604 715	-55 279	24604 715
100 70	94 50	24600 107	-4 608	24600 107
94 50	91 77	24796 688	196 582	24796 688
91 77	88 50	26280 735	1484 047	26280 735
88 50	80 50	30053 653	3772 917	30053 653
80 50	78 50	30966 025	912 372	30966 025
78 50	66 89	35845 900	4879 875	35845 900
66 89	66 16	36322 983	377 083	36322 983
66 16	65 50	36312 420	89 437	36312 420
65 50	64 25	36611 045	298 625	36611 045
64 25	63 50	36803 735	192 689	36803 735
63 50	62 70	37007 918	204 184	37007 918
62 70	61 50	37411 866	403 948	37411 866
61 50	61 07	37558 596	146 730	37558 596
61 07	59 21	38191 455	632 859	38191 455
59 21	58 39	38472 641	281 186	38472 641
58 39	57 50	38782 601	309 960	38782 601
57 50	57 04	38865 514	82 914	38865 514
57 04	54 50	39334 066	468 551	39334 066
54 50	53 69	39512 510	178 445	39512 510
53 69	53 61	39538 274	25 763	39538 274
53 61	53 50	39561 036	22 763	39561 036
53 50	52 50	39799 030	237 994	39799 030
52 50	51 50	40003 329	204 298	40003 329
51 50	51 43	40025 804	22 475	40025 804
51 43	49 50	41723 043	1697 239	41723 043
49 50	48 95	42168 793	445 750	42168 793
48 95	47 50	44460 249	2291 455	44460 249
47 50	46 50	45250 566	790 317	45250 566
46 50	46 03	45547 392	296 826	45547 392
46 03	45 50	45736 014	188 622	45736 014
45 50	44 50	46107 333	371 320	46107 333
44 50	44 36	46073 456	-33 877	46073 456
44 36	42 08	45799 140	-274 316	45799 140
42 08	40 50	45608 329	-190 811	45608 329
40 50	39 50	45750 633	142 304	45750 633
39 50	39 30	45795 780	45 147	45795 780
39 30	38 50	30661 585	307 905	46303 685 air
38 50	37 50	25826 981	384 881	384 881
37 50	35 80	47254 054	765 489	1150 370
35 80	35 50	47359 677	105 623	1255 992
35 50	35 41	47380 971	21 294	1277 286
35 41	35 28	47395 939	14 969	1292 255
35 28	34 82	47400 380	4 441	1296 696
34 82	34 50	1843 344	3 824	1300 520 cooling water
34 50	26 50	45655 574	94 713	94 713
26 50	20 50	47571 286	72 368	167 082
20 50	5 50	47712 207	140 921	308 003 Re



**Table D2** Problem table algorithm with multiple utility level at  $\Delta T_{min}=10^{\circ}\text{C}$  for design case

Temperature Interval C	Enthalpy kW	Surplus kW	Cascade kW	
582.00	582.00	33539.798		
582.00	575.00	33537.058	-2.740	54.870 power
575.00	544.00	33512.453	-24.605	30.265
544.00	519.00	33487.358	-25.095	5.170
519.00	512.00	33481.582	-5.776	-0.606
512.00	487.00	33732.384	250.802	250.196
487.00	477.00	33725.371	-7.013	243.183
477.00	472.00	33667.579	-57.792	185.391
472.00	457.00	33500.722	-166.807	18.584
457.00	425.00	33488.384	-12.388	6.196
425.00	390.00	14464.093	-6.196	0.000
390.00	344.00	19009.951	-8.144	33474.044 HP steam
344.00	338.00	32850.189	-623.855	32850.189
338.00	320.60	32960.440	110.251	32960.440
320.60	305.00	33054.578	94.138	33054.578
305.00	293.98	33121.054	66.476	33121.054
293.98	293.87	33077.454	-43.600	33077.454
293.87	290.00	33570.126	-1507.328	33570.126
290.00	271.67	24444.439	-7123.687	24444.439
271.67	268.48	23400.005	-1046.434	23400.005
268.48	235.00	25652.935	2252.930	25652.935
235.00	234.00	24895.222	-757.712	24895.222
234.00	233.00	24184.616	-710.607	24184.616
233.00	227.00	16911.496	-7273.120	16911.496
227.00	225.00	16137.122	-774.373	16137.122
225.00	218.72	12245.180	-3891.942	12245.180
218.72	217.00	11868.965	-376.215	11868.965
217.00	216.70	11841.517	-27.447	11841.517
216.70	215.00	11858.879	17.362	11858.879
215.00	206.70	13348.006	1489.126	13348.006
206.70	206.00	13536.743	188.738	13536.743
206.00	197.32	0.000	-13536.743	0.000
197.32	193.70	537.912	537.912	537.912
193.70	193.00	530.470	-7.442	530.470
193.00	189.50	917.154	386.684	917.154
189.50	174.90	5918.199	5001.045	5918.199
174.90	167.00	8622.832	2704.633	8622.832
167.00	162.00	10247.125	1624.293	10247.125
162.00	159.10	10912.641	665.516	10912.641
159.10	157.00	11219.358	306.716	11219.358
157.00	154.00	11713.526	494.168	11713.526
154.00	148.00	12168.890	455.364	12168.890
148.00	144.00	11779.895	-388.995	11779.895
144.00	130.00	18980.805	7200.910	18980.805
130.00	127.90	20067.504	1086.699	20067.504
127.90	126.00	21107.152	1039.648	21107.152
126.00	123.00	22290.437	1183.286	22290.437
123.00	121.01	17587.409	-4703.028	17587.409
121.01	121.00	17589.295	1.885	17589.295
121.00	116.80	19245.895	1656.600	19245.895
116.80	116.00	19561.679	315.784	19561.679
116.00	111.00	22093.665	2531.985	22093.665
111.00	106.80	24327.148	2233.483	24327.148
106.80	106.02	24744.032	416.884	24744.032
106.02	104.00	24860.332	116.301	24860.332
104.00	102.00	24753.080	-107.253	24753.080
102.00	98.40	24082.815	-670.265	24082.815
98.40	98.20	24027.535	-55.279	24027.535
98.20	92.00	24022.927	-4.608	24022.927
92.00	91.00	24094.883	71.955	24094.883
91.00	89.27	24249.819	154.936	24249.819
89.27	83.00	27212.168	2962.349	27212.168
83.00	81.00	28124.540	912.372	28124.540
81.00	68.00	33589.126	5464.586	33589.126
68.00	64.39	35480.789	1891.663	35480.789
64.39	61.66	35933.541	452.752	35933.541
61.66	61.75	36390.318	456.777	36390.318
61.75	61.00	36583.008	192.689	36583.008
61.00	60.20	36787.191	204.184	36787.191
60.20	59.00	37191.139	403.948	37191.139
59.00	58.57	37337.870	146.730	37337.870
58.57	57.00	37871.807	534.028	37871.807
57.00	56.71	37981.120	109.223	37981.120
56.71	55.89	38291.797	310.677	38291.797
55.89	55.00	38633.540	341.744	38633.540
55.00	54.54	38732.937	99.397	38732.937
54.54	54.00	38851.901	118.963	38851.901
54.00	51.19	39738.941	887.040	39738.941
51.19	51.11	39772.334	33.393	39772.334
51.11	51.00	39805.587	33.253	39805.587
51.00	50.00	40138.952	333.365	40138.952
50.00	48.93	40461.095	322.144	40461.095
48.93	48.00	41276.652	815.557	41276.652
48.00	47.00	42173.763	897.111	42173.763
47.00	46.45	42627.892	454.129	42627.892
46.45	45.00	44941.382	2313.489	44941.382
45.00	44.00	45746.905	805.523	45746.905
44.00	43.53	46050.878	303.973	46050.878
43.53	43.00	46247.559	196.682	46247.559
43.00	42.00	46881.422	633.863	46881.422
42.00	41.86	46896.013	14.591	46896.013
41.86	41.80	46909.553	13.540	46909.553
41.80	41.00	47242.710	333.157	47242.710
41.00	39.58	40519.597	544.901	40519.597
39.58	37.00	387690.774	994.532	387690.774
37.00	35.00	21608.465	769.762	21608.465
35.00	33.31	50292.090	765.489	50292.090
33.31	33.00	50387.713	95.623	50387.713
33.00	32.91	50419.007	21.294	50419.007
32.91	32.71	50433.975	14.969	50433.975
32.71	32.32	50438.416	4.441	50438.416
32.32	29.00	50477.758	39.342	50477.758
29.00	18.00	50610.434	132.675	50610.434
18.00	3.00	50751.355	140.921	50751.355

power

HP steam

air

cooling water

Re

**Table D3** Problem table algorithm with multiple utility level at  $\Delta T_{min}=20^{\circ}C$  for design case

Temperature Interval C	Enthalpy kW	Surplus kW	Cascade kW	
587.00	587.00	39549.445		
587.00	580.00	39546.704	-2.740	62.807 power
580.00	549.00	39522.099	-24.605	38.202
549.00	514.00	39486.966	-35.133	3.069
514.00	507.00	39481.190	-5.776	-2.707
507.00	492.00	39631.671	150.481	147.774
492.00	472.00	39617.646	-14.025	133.749
472.00	467.00	39559.854	-57.792	75.957
467.00	462.00	39504.252	-55.602	20.355
462.00	430.00	39491.864	-12.388	7.967
430.00	385.00	21931.958	-7.967	0.000
385.00	349.00	17545.566	-6.373	39477.524 HP steam
349.00	333.00	37813.910	-1663.613	37813.910
333.00	325.60	37860.798	46.888	37860.798
325.60	310.00	37954.937	94.138	37954.937
310.00	298.98	38021.413	66.476	38021.413
298.98	298.87	37977.812	-43.600	37977.812
298.87	285.00	32577.593	-5400.219	32577.593
285.00	273.48	28100.802	-4476.791	28100.802
273.48	266.67	28146.060	45.258	28146.060
266.67	240.00	29940.760	1794.700	29940.760
240.00	238.00	28425.336	-1515.424	28425.336
238.00	232.00	20869.584	-7555.751	20869.584
232.00	230.00	20001.000	-868.584	20001.000
230.00	229.00	19334.652	-666.348	19334.652
229.00	223.72	16061.953	-3272.699	16061.953
223.72	221.70	15619.927	-442.025	15619.927
221.70	212.00	14478.593	-1141.334	14478.593
212.00	211.00	14488.806	10.213	14488.806
211.00	210.00	12669.502	-1819.304	12669.502
210.00	202.32	0.000	-12669.502	0.000
202.32	201.70	36.263	36.263	36.263
201.70	198.70	481.800	445.537	481.800
198.70	198.00	474.358	-7.442	474.358
198.00	194.50	861.042	386.684	861.042
194.50	172.00	8568.132	7707.091	8568.132
172.00	169.90	9250.711	682.578	9250.711
169.90	167.00	10192.801	942.090	10192.801
167.00	164.10	10858.317	665.516	10858.317
164.10	159.00	11603.199	744.882	11603.199
159.00	153.00	11946.557	343.359	11946.557
153.00	152.00	11830.641	-115.916	11830.641
152.00	139.00	10566.406	-1264.235	10566.406
139.00	128.00	16224.264	5657.858	16224.264
128.00	126.01	11760.120	-4464.143	11760.120
126.01	126.00	11762.965	2.845	11762.965
126.00	125.00	12277.316	514.351	12277.316
125.00	122.90	13364.015	1086.699	13364.015
122.90	121.80	13965.916	601.901	13965.916
121.80	121.00	14403.904	437.988	14403.904
121.00	111.00	18351.208	3947.304	18351.208
111.00	106.00	20883.194	2531.985	20883.194
106.00	101.80	23116.677	2233.483	23116.677
101.80	101.02	23533.561	416.884	23533.561
101.02	99.00	23649.861	116.301	23649.861
99.00	97.00	23542.609	-107.253	23542.609
97.00	96.00	23356.424	-186.185	23356.424
96.00	93.40	22917.844	-438.580	22917.844
93.40	93.20	22866.064	-51.779	22866.064
93.20	88.00	22953.200	87.135	22953.200
88.00	87.00	22954.528	1.328	22954.528
87.00	86.00	23028.554	74.027	23028.554
86.00	84.27	23094.705	66.151	23094.705
84.27	73.00	27831.240	4736.535	27831.240
73.00	62.00	33596.908	5765.667	33596.908
62.00	59.39	35057.908	1461.001	35057.908
59.39	59.00	35314.753	256.845	35314.753
59.00	58.66	35569.018	254.265	35569.018
58.66	56.75	36278.569	709.550	36278.569
56.75	56.00	36569.661	291.092	36569.661
56.00	55.20	36878.545	308.884	36878.545
55.20	54.00	37440.200	561.655	37440.200
54.00	53.57	37643.741	203.542	37643.741
53.57	53.00	37911.365	267.624	37911.365
53.00	52.00	38398.794	487.428	38398.794
52.00	51.71	38540.083	141.290	38540.083
51.71	50.89	38941.765	401.682	38941.765
50.89	50.00	39381.590	439.825	39381.590
50.00	49.54	39531.853	150.262	39531.853
49.54	48.00	40041.406	509.554	40041.406
48.00	47.00	40635.051	593.644	40635.051
47.00	46.80	40753.780	118.729	40753.780
46.80	46.19	41263.875	510.095	41263.875
46.19	46.11	41338.911	75.037	41338.911
46.11	46.00	41429.425	90.514	41429.425 air
46.00	45.00	42283.339	853.914	853.914
45.00	43.93	43165.072	881.734	1735.647
43.93	42.00	45864.368	2699.296	4434.943 cooling water
42.00	41.45	46598.166	733.797	733.797
41.45	40.00	49643.896	3045.731	3779.528
40.00	39.00	50954.762	1310.866	5090.394
39.00	38.53	51496.246	541.484	5631.878
38.53	37.00	52837.199	1340.953	6972.831
37.00	36.86	52874.070	36.871	7009.702
36.86	34.58	53750.059	875.989	7885.691
34.58	34.00	53974.829	224.770	8110.461
34.00	30.00	55515.242	1540.412	9650.874
30.00	28.30	56281.108	765.866	10416.740
28.30	28.00	56386.798	105.689	10522.429
28.00	27.91	56408.111	21.314	10543.743
27.91	27.78	56423.109	14.998	10558.741
27.78	27.32	56427.652	4.543	10563.283
27.32	13.00	56600.407	172.755	10736.039
13.00	-2.00	56741.328	140.921	10876.960 Re

**Table D4** Problem table algorithm with multiple utility level at  $\Delta T_{min}=30^{\circ}\text{C}$  for design case

Temperature Interval C	Enthalpy kW	Surplus kW	Cascade kW	
592.00	44577.706			
592.00	585.00	44574.966	-2.740	70.745 power
585.00	554.00	44550.361	-24.605	46.139
554.00	509.00	44505.189	-45.171	0.968
509.00	502.00	44499.414	-5.776	-4.807
502.00	497.00	44549.574	50.160	45.353
497.00	467.00	44528.536	-21.038	24.315
467.00	462.00	44524.411	-4.125	20.189
462.00	435.00	44513.958	-10.452	9.737
435.00	380.00	30215.790	-9.737	0.000
380.00	354.00	14283.828	-4.603	44499.618 HP steam
354.00	330.60	42066.584	-2433.035	42066.584
330.60	328.00	41795.462	-271.122	41795.462
328.00	315.00	41873.910	78.448	41873.910
315.00	303.98	41940.386	66.476	41940.386
303.98	303.87	41896.786	-43.600	41896.786
303.87	280.00	32603.675	-9293.111	32603.675
280.00	278.48	32013.662	-590.013	32013.662
278.48	261.67	32125.379	111.717	32125.379
261.67	245.00	33247.201	1121.822	33247.201
245.00	243.00	31731.776	-1515.424	31731.776
243.00	237.00	24176.025	-7555.751	24176.025
237.00	235.00	23307.441	-868.584	23307.441
235.00	228.72	19119.442	-4187.999	19119.442
228.72	226.70	18582.500	-536.943	18582.500
226.70	224.00	18137.625	-444.875	18137.625
224.00	216.00	17196.318	-941.306	17196.318
216.00	207.32	298.686	-16897.633	298.686
207.32	207.00	221.800	-76.886	221.800
207.00	205.00	0.000	-221.800	0.000
205.00	203.70	75.790	75.790	75.790
203.70	203.00	5.199	-70.591	5.199
203.00	199.50	76.140	70.940	76.140
199.50	196.70	782.650	706.510	782.650
196.70	177.00	7530.636	6747.986	7530.636
177.00	172.00	9155.822	1625.187	9155.822
172.00	169.10	9821.857	666.034	9821.857
169.10	164.90	10436.039	614.183	10436.039
164.90	164.00	10567.489	131.450	10567.489
164.00	158.00	10910.848	343.359	10910.848
158.00	147.00	9635.768	-1275.080	9635.768
147.00	134.00	8371.533	-1264.235	8371.533
134.00	133.00	8885.883	514.351	8885.883
133.00	131.01	4421.740	-4464.143	4421.740
131.01	131.00	4424.585	2.845	4424.585
131.00	126.80	6584.858	2160.273	6584.858
126.80	120.00	10084.495	3499.637	10084.495
120.00	117.90	11171.828	1087.333	11171.828
117.90	116.00	12212.049	1040.221	12212.049
116.00	106.00	16159.353	3947.304	16159.353
106.00	101.00	18691.338	2531.985	18691.338
101.00	96.80	20998.321	2306.983	20998.321
96.80	96.02	21428.803	430.482	21428.803
96.02	94.00	21580.506	151.703	21580.506
94.00	93.00	21544.379	-36.126	21544.379
93.00	92.00	21492.824	-51.555	21492.824
92.00	91.00	21308.711	-184.113	21308.711
91.00	88.40	20736.850	-571.861	20736.850
88.40	88.20	20674.818	-62.032	20674.818
88.20	82.00	20460.887	-213.932	20460.887
82.00	79.27	20567.963	107.076	20567.963
79.27	78.00	21103.506	535.543	21103.506
78.00	67.00	26869.173	5765.667	26869.173
67.00	64.00	28549.128	1679.955	28549.128
64.00	58.00	32481.260	3932.132	32481.260
58.00	57.00	33152.043	670.784	33152.043
57.00	54.39	34901.539	1749.495	34901.539
54.39	53.66	35461.024	559.485	35461.024
53.66	53.00	35716.761	255.737	35716.761
53.00	52.00	36364.837	648.076	36364.837
52.00	51.80	36511.139	146.302	36511.139
51.80	51.75	36555.671	44.533	36555.671
51.75	51.00	37237.175	681.504	37237.175 air
51.00	50.20	37961.457	724.282	724.282
50.20	49.00	39148.812	1187.354	1911.637
49.00	48.57	39577.751	428.939	2340.576
48.57	47.00	34952.381	1555.324	3895.900 cooling water
47.00	46.71	6468.533	287.839	287.839
46.71	45.89	42238.492	817.578	1105.418
45.89	45.00	43126.557	888.064	1993.482
45.00	44.54	43509.276	382.720	2376.202
44.54	41.19	46310.619	2801.342	5177.544
41.19	41.11	46385.655	75.037	5252.581
41.11	41.00	46476.169	90.514	5343.094
41.00	40.00	47330.083	853.914	6197.008
40.00	39.00	48150.300	820.217	7017.225
39.00	38.93	48211.833	61.533	7078.758
38.93	37.00	50911.557	2699.724	9778.482
37.00	36.45	51644.252	732.695	10511.177
36.45	35.00	54690.305	3046.053	13557.230
35.00	34.00	56901.393	1311.088	14868.318
34.00	33.53	56542.981	541.589	15409.906
33.53	32.00	57884.274	1341.293	16751.199
32.00	31.86	57921.176	36.902	16788.101
31.86	29.58	58797.525	876.349	17664.450
29.58	25.00	60562.838	1765.313	19429.763
25.00	23.00	61328.704	765.866	20195.630
23.00	23.00	61434.394	105.689	20301.319
23.00	22.91	61455.707	21.314	20322.633
22.91	22.78	61470.705	14.998	20337.630
22.78	22.32	61475.248	4.543	20342.173
22.32	8.00	61648.003	172.755	20514.928
8.00	-7.00	61788.924	140.921	20655.850 Re

**Table D5** Problem table algorithm with multiple utility level at  $\Delta T_{min}=40^{\circ}C$  for design case

Temperature Interval C	Enthalpy kW	Surplus kW	Cascade kW
597.00	48666.00C		
597.00	590.00	48663.20C	-2.800
590.00	559.00	48638.60C	-24.600
559.00	504.00	48583.40C	-55.200
504.00	502.00	48581.70C	-1.700
502.00	497.00	48524.00C	-57.700
497.00	472.00	48506.40C	-17.600
472.00	462.00	48606.70C	100.300
462.00	457.00	48602.60C	-4.100
457.00	440.00	48596.00C	-6.600
440.00	375.00	38985.315	-11.475
375.00	359.00	9596.385	2.825
359.00	335.60	46162.70C	-2419.000
335.60	323.00	44856.40C	-1306.300
323.00	308.98	44949.40C	93.000
308.98	283.48	35021.70C	-9927.700
283.48	275.00	35072.90C	51.200
275.00	256.67	35194.70C	121.800
256.67	250.00	35643.70C	449.000
250.00	248.00	34128.20C	-1515.500
248.00	242.00	26572.50C	-7555.700
242.00	240.00	25703.90C	868.600
240.00	233.72	21515.90C	-4188.000
233.72	231.70	20979.00C	-536.900
231.70	221.00	19215.90C	-1763.100
221.00	219.00	15227.40C	-3988.500
219.00	212.32	2224.10C	-13003.300
212.32	208.70	1359.25C	864.850
208.70	208.00	1080.70C	-278.550
208.00	204.50	111.878	-968.822
204.50	202.00	0.00C	-111.878
202.00	200.00	166.25C	166.250
200.00	191.70	2260.55C	2094.300
191.70	182.00	5583.16C	3322.610
182.00	177.00	7208.34C	1625.180
177.00	174.10	7874.38C	666.040
174.10	169.00	8620.17C	745.790
169.00	163.00	8964.60C	344.430
163.00	159.90	8605.81C	-358.790
159.90	142.00	6530.90C	-2074.910
142.00	138.00	6141.91C	-388.990
138.00	136.01	5948.19C	-193.720
136.01	136.00	5946.14C	-2.050
136.00	131.80	5537.69C	-408.450
131.80	129.00	5266.24C	-271.450
129.00	115.00	12471.40C	7205.160
115.00	112.90	13558.70C	1087.300
112.90	111.00	14598.90C	1040.200
111.00	106.00	16572.60C	1973.700
106.00	101.00	18633.70C	2061.100
101.00	98.80	19786.30C	1152.600
98.80	98.00	20208.70C	422.400
98.00	96.00	21234.00C	1025.300
96.00	91.02	23733.20C	2499.200
91.02	89.00	23780.00C	46.800
89.00	87.00	23604.10C	-175.900
87.00	83.40	22810.10C	-794.000
83.40	83.20	22747.90C	-62.200
83.20	83.00	22740.90C	-7.000
83.00	77.00	23153.10C	412.200
77.00	74.27	23539.30C	386.200
74.27	72.00	24726.70C	1187.400
72.00	69.00	26404.90C	1678.200
69.00	63.00	30333.40C	3928.500
63.00	62.00	31003.60C	670.200
62.00	58.00	33683.40C	2679.80C
58.00	57.00	34616.20C	932.800
57.00	56.80	34819.40C	203.200
56.80	56.00	4699.927	940.240
56.00	52.00	23499.636	4701.201
52.00	49.39	15327.637	3066.359
49.39	48.66	44454.60C	927.400
48.66	46.75	46162.50C	1707.900
46.75	46.00	46845.90C	683.400
46.00	45.20	47572.30C	726.400
45.20	44.00	48762.70C	1190.400
44.00	43.57	49192.90C	430.200
43.57	41.71	51042.40C	1849.500
41.71	40.89	51862.80C	820.400
40.89	40.00	52753.80C	891.000
40.00	39.54	53138.10C	384.300
39.54	36.19	55950.90C	2813.800
36.19	36.11	56026.20C	75.300
36.11	36.00	56117.10C	90.900
36.00	35.00	56974.40C	857.300
35.00	33.93	57859.80C	885.400
33.93	32.00	59385.40C	1525.600
32.00	31.45	59780.30C	394.900
31.45	30.00	60791.70C	1011.400
30.00	29.00	61489.80C	698.100
29.00	28.53	61743.20C	253.400
28.53	27.00	62146.50C	403.300
27.00	26.86	62183.40C	36.900
26.86	24.58	63059.70C	876.300
24.58	20.00	64825.10C	1765.400
20.00	18.30	65590.90C	765.800
18.30	18.00	65696.60C	105.700
18.00	17.91	65717.90C	21.300
17.91	17.78	65732.90C	15.000
17.78	17.32	65737.50C	4.600
17.32	3.00	65871.30C	133.800
3.00	-12.00	65971.40C	100.100

power

HP steam

air

cooling water

Re

**C-2 Problem table algorithm with multiple utility level at various  $\Delta T_{min}$  for actual case.**

**Table D6 Problem table algorithm with multiple utility level at  $\Delta T_{min}=5^{\circ}C$  for actual case**

Temperature Interval C	Enthalpy kW	Surplus kW	Cascade kW
508.43	26641.500		
508.43	327.31	15.800	15.800
327.31	320.47	-738.100	25919.200
320.47	291.48	-1492.100	24427.100
291.48	274.17	-7661.900	16765.200
274.17	265.98	-2687.000	14078.200
265.98	238.98	1701.700	15779.900
238.98	233.05	656.500	16436.400
233.05	216.22	-6579.860	9856.540
216.22	215.66	2.890	9859.430
215.66	209.79	-1184.880	8674.550
209.79	209.20	-56.240	8618.310
209.20	204.79	488.840	9107.150
204.79	204.20	121.180	9228.330
204.20	201.45	850.370	10078.700
201.45	194.82	-10078.700	0.000
194.82	194.50	62.330	62.330
194.50	188.38	582.327	644.656
188.38	187.45	158.985	803.641
187.45	179.50	2271.559	3075.200
179.50	163.21	4646.070	7721.270
163.21	160.04	614.510	8335.780
160.04	159.79	8366.920	31.140
159.79	151.01	1048.820	9415.740
151.01	136.31	2116.760	11532.500
136.31	133.90	386.700	11919.200
133.90	130.95	-114.600	11804.600
130.95	130.32	369.100	12173.700
130.32	129.82	264.300	12438.000
129.82	127.78	1020.300	13458.300
127.78	116.40	5989.100	19447.400
116.40	115.67	315.000	19762.400
115.67	115.33	99.000	19861.400
115.33	112.67	771.000	20632.400
112.67	110.68	852.900	21485.300
110.68	110.33	168.000	21653.300
110.33	108.52	853.100	22506.400
108.52	107.67	-21.700	22484.700
107.67	105.34	-12.400	22472.300
105.34	100.39	63.000	22535.300
100.39	92.71	889.500	23424.800
92.71	92.53	-2.400	23422.400
92.53	84.37	2142.200	25564.600
84.37	84.26	40.000	25604.600
84.26	78.03	1659.800	27264.400
78.03	77.67	258.900	27523.300
77.67	74.28	2449.800	29973.100
74.28	73.64	448.500	30421.600
73.64	66.89	4549.800	34971.400
66.89	66.16	563.300	35534.700
66.16	64.80	530.900	36065.600
64.80	62.50	909.600	36975.200
62.50	61.07	715.700	37690.900
61.07	60.88	94.500	37785.400
60.88	60.64	144.700	37930.100
60.64	59.63	501.000	38431.100
59.63	59.21	211.200	38642.300
59.21	57.50	858.900	39501.200
57.50	55.20	982.500	40483.700
55.20	55.01	59.200	40542.900
55.01	54.63	100.900	40643.800
54.63	53.78	248.300	40892.100
53.78	52.64	443.500	41335.600
52.64	52.58	22.900	41358.500
52.58	52.22	155.800	41514.300
52.22	51.99	119.800	41634.100
51.99	51.43	283.500	41917.600
51.43	49.19	2413.000	44330.600
49.19	48.95	245.900	44576.500
48.95	48.51	784.900	45361.400
48.51	47.14	2274.100	47635.500
47.14	45.47	1450.700	49086.200
45.47	43.52	1735.200	50821.400
43.52	43.35	101.200	50922.600
43.35	42.08	-2.200	50920.400
42.08	41.21	-1.100	50919.300
41.21	39.48	207.700	51127.000
39.48	38.50	-25574.797	25552.203
38.50	37.50	402.295	402.295
37.50	37.28	25600.703	26002.997
37.28	36.04	151.900	26154.897
36.04	34.82	151.100	26305.997
34.82	34.50	-6263.636	20042.361
34.50	34.46	-39284.728	-39284.728
34.46	34.45	45595.764	6311.036
34.45	34.22	26.800	6337.836
34.22	34.21	0.100	6337.936
34.21	33.11	-116.200	6221.736
33.11	31.84	-156.700	6065.036
31.84	30.03	65.700	6130.736
30.03	28.55	47.100	6177.836
28.55	21.70	80.600	6258.436
21.70	16.98	56.900	6315.336
16.98	16.70	2.600	6317.936
16.70	7.21	63.300	6381.236

HP steam

air

cooling water

Re

**Table D7** Problem table algorithm with multiple utility level at  $\Delta T_{min}=10^{\circ}C$  for actual case

Temperature Interval C	Enthalpy kW	Surplus kW	Cascade kW
505 93	28724 800		
505 93	329 81	28740 000	15 200
329 81	317 97	27462 300	-1277 700
317 97	293 98	26227 500	-1234 800
293 98	271 67	16352 800	-9874 700
271 67	268 48	15306 200	-1046 600
268 48	236 48	17323 000	2016 800
236 48	235 55	17426 100	103 100
235 55	218 72	10846 200	-6579 900
218 72	218 16	10849 100	2 900
218 16	212 29	9664 240	-1184 860
212 29	211 70	9608 000	-56 240
211 70	203 95	10466 400	858 400
203 95	202 29	7610 790	-2855 610
202 29	201 70	6664 780	-946 010
201 70	197 32	0 000	-6664 780
197 32	197 00	62 330	62 330
197 00	189 95	732 790	670 461
189 95	185 88	1585 320	852 530
185 88	182 00	2693 070	1107 750
182 00	165 71	7339 140	4646 070
165 71	162 54	7953 650	614 510
162 54	162 29	7984 790	31 140
162 29	148 51	9630 600	1645 810
148 51	136 40	11374 400	1743 800
136 40	133 81	11231 600	-142 800
133 81	132 32	11173 900	-57 700
132 32	128 45	10908 200	-265 700
128 45	127 82	11258 700	350 500
127 82	125 28	12528 400	1269 700
125 28	118 17	16271 900	3743 500
118 17	117 83	16404 200	132 300
117 83	115 17	17433 100	1028 900
115 17	113 90	18100 400	667 300
113 90	113 18	18408 900	308 500
113 18	107 83	20924 000	2515 100
107 83	106 02	21777 100	853 100
106 02	105 17	21755 400	-21 700
105 17	102 89	21743 300	-12 100
102 89	102 84	21748 700	5 400
102 84	90 21	23210 700	1462 000
90 21	90 03	23708 300	-2 400
90 03	86 87	24038 400	830 100
86 87	86 76	24078 400	40 000
86 76	80 17	25833 900	1755 500
80 17	76 78	26738 700	904 800
76 78	76 14	26898 200	159 500
76 14	75 53	27031 500	133 300
75 53	65 00	34128 600	7097 100
65 00	64 39	34603 600	475 000
64 39	63 66	35242 500	638 900
63 66	62 30	35914 200	671 700
62 30	58 57	37778 400	1864 200
58 57	58 38	37873 000	94 600
58 38	58 14	38017 600	144 600
58 14	57 13	38518 600	501 000
57 13	57 13	38522 800	4 200
57 13	56 71	38743 000	220 200
56 71	56 28	38970 500	227 500
56 28	55 00	39772 800	802 300
55 00	52 70	41037 800	1265 000
52 70	52 51	41120 400	82 600
52 51	50 14	42036 400	916 000
50 14	50 08	42059 200	22 800
50 08	49 72	42215 000	155 800
49 72	49 49	42334 800	119 800
49 49	48 93	42618 400	283 600
48 93	47 97	43646 700	1028 300
47 97	46 69	45051 300	1404 600
46 69	46 45	45301 100	249 800
46 45	46 01	46092 800	791 700
46 01	44 64	48388 200	2295 400
44 64	41 98	50742 400	2354 200
41 98	41 02	51668 900	926 500
41 02	41 00	5500 069	-46168 831
41 00	40 85	46281 831	40781 762
40 85	40 00	51841 100	5559 269
40 00	39 58	51882 300	41 200
39 58	38 71	51969 200	86 900
38 71	37 00	23011 182	-28958 018
37 00	34 78	29827 318	6816 137
34 78	34 34	42892 300	23064 982
34 34	33 54	51117 800	225 500
33 54	32 32	53464 000	346 200
32 32	31 96	53568 900	104 900
31 96	31 95	53571 700	2 800
31 95	31 72	53634 800	63 100
31 72	31 71	53635 800	1 000
31 71	30 61	53695 500	59 700
30 61	27 53	53806 900	111 400
27 53	26 05	53854 100	47 200
26 05	24 20	53875 900	21 800
24 20	14 48	53993 100	117 200
14 48	14 20	53995 700	2 600
14 20	4 71	54059 100	63 400

HP steam

air

cooling water

Re

**Table D8** Problem table algorithm with multiple utility level at  $\Delta T_{min}=20^{\circ}C$  for actual case

Temperature Interval C	Enthalpy kW	Surplus kW	Cascade kW
	500.93	32325.200	
500.93	334.81	32339.700	14.500
334.81	312.97	29982.600	-2357.100
312.97	298.98	29262.600	-720.000
298.98	273.48	17976.000	-11286.600
273.48	266.67	17625.400	-350.600
266.67	240.55	19271.800	1646.400
240.55	231.48	15294.400	-3977.400
231.48	223.72	12259.700	-3034.700
223.72	223.16	12262.600	2.900
223.16	217.29	11077.700	-1184.900
217.29	216.70	11021.500	-56.200
216.70	208.95	11879.800	858.300
208.95	202.32	489.427	-11390.373
202.32	202.00	488.284	-1.143
202.00	197.29	3.392	-484.892
197.29	196.70	0.000	-3.392
196.70	194.95	166.873	166.873
194.95	187.00	1830.860	1663.987
187.00	180.88	3108.820	1277.960
180.88	170.71	6008.950	2900.130
170.71	167.54	6623.460	614.510
167.54	167.29	6654.600	31.140
167.29	143.51	9494.380	2839.780
143.51	141.40	9797.750	303.370
141.40	137.32	9572.890	-224.860
137.32	128.81	8850.200	-722.690
128.81	123.45	8482.450	-367.750
123.45	123.17	8639.040	156.590
123.17	122.83	8782.510	143.470
122.83	122.82	8784.450	1.940
122.82	120.28	9700.460	916.010
120.28	120.17	9743.860	43.400
120.17	118.18	10789.300	1045.440
118.18	108.90	16047.500	5258.200
108.90	107.89	16521.400	473.900
107.89	102.83	19421.500	2900.100
102.83	101.02	20460.400	1038.900
101.02	100.17	20526.800	66.400
100.17	97.84	20754.600	227.800
97.84	91.87	21446.000	691.400
91.87	91.76	21470.200	24.200
91.76	85.21	22256.300	786.100
85.21	85.17	22256.000	-0.300
85.17	85.03	22254.700	-1.300
85.03	81.78	23120.400	865.700
81.78	81.14	23279.900	159.500
81.14	70.53	25603.300	2323.400
70.53	70.00	25961.700	358.400
70.00	62.13	32086.800	6125.100
62.13	61.28	32767.200	680.400
61.28	59.39	34471.700	1704.500
59.39	58.66	35200.000	728.300
58.66	57.30	36038.200	838.200
57.30	53.57	38360.800	2322.600
53.57	53.38	38478.500	117.700
53.38	53.14	38652.700	174.200
53.14	52.97	38754.300	101.600
52.97	52.13	39289.900	535.600
52.13	51.71	39559.700	269.800
51.71	50.00	40654.700	1095.000
50.00	47.70	41955.700	1301.000
47.70	47.51	42041.200	85.500
47.51	46.98	42251.400	210.200
46.98	46.00	22970.974	-19280.426
46.00	45.14	20154.726	-2816.248
45.14	45.08	43153.200	22998.474
45.08	45.00	43195.300	42.100
45.00	44.72	43349.000	153.700
44.72	44.49	43495.100	146.100
44.49	43.93	43844.700	349.600
43.93	42.00	40121.230	-3723.470
42.00	41.69	6396.470	-33724.759
41.69	41.45	46792.100	40395.630
41.45	41.01	47628.500	836.400
41.01	39.64	50061.900	2433.400
39.64	39.34	50354.200	292.300
39.34	36.02	54170.200	3816.000
36.02	35.85	54314.600	144.400
35.85	34.58	34642.800	328.200
34.58	33.71	54868.900	226.100
33.71	29.78	56366.100	1487.200
29.78	29.20	56531.000	164.900
29.20	28.54	56715.500	184.500
28.54	27.32	57062.000	346.500
27.32	26.96	57167.000	105.000
26.96	26.95	57169.900	2.900
26.95	26.72	57233.000	63.100
26.72	26.71	57234.000	1.000
26.71	25.61	57294.000	60.000
25.61	22.53	57406.400	112.400
22.53	21.05	57454.000	47.600
21.05	9.48	57593.600	139.600
9.48	9.20	57596.200	2.600
9.20	-0.29	57659.500	63.300

HP steam

air

cooling water

Re

**Table D9** Problem table algorithm with multiple utility level at  $\Delta T_{\min}=30^{\circ}\text{C}$  for actual case

Temperature Interval C	Enthalpy kW	Surplus kW	Cascade kW
495.93	34749.500		
495.93	339.81	13.500	13.500
339.81	307.97	-3436.400	31326.600
307.97	303.98	-205.300	31121.300
303.98	278.48	-11286.600	19834.700
278.48	261.67	-865.300	18969.400
261.67	245.55	1016.200	19985.600
245.55	228.72	-7382.100	12603.500
228.72	228.16	-23.700	12579.800
228.16	226.48	-419.200	12160.600
226.48	222.29	-845.700	11314.900
222.29	221.70	-56.300	11258.600
221.70	213.95	858.400	12117.000
213.95	207.32	-11390.396	726.604
207.32	207.00	-1.142	725.462
207.00	199.95	0.000	0.000
199.95	192.29	87.157	87.157
192.29	192.00	31.265	118.422
192.00	191.70	31.807	150.229
191.70	175.88	3303.451	3453.680
175.88	175.71	48.800	3502.480
175.71	172.54	614.510	4116.990
172.54	172.29	31.140	4148.130
172.29	146.40	3091.240	7239.370
146.40	142.32	-325.360	6914.010
142.32	138.51	-418.160	6495.850
138.51	128.17	-877.660	5618.190
128.17	127.83	-76.920	5541.270
127.83	125.17	-595.660	4945.610
125.17	123.81	-114.460	4831.150
123.81	123.18	-42.560	4788.590
123.18	118.45	-134.810	4653.780
118.45	117.82	375.640	5029.420
117.82	115.28	1371.710	6401.130
115.28	112.89	1352.730	7753.860
112.89	103.90	6019.240	13773.100
103.90	97.83	3478.100	17251.200
97.83	96.87	553.500	17804.700
96.87	96.76	73.900	17878.600
96.76	96.02	426.300	18304.900
96.02	95.17	70.000	18374.900
95.17	92.84	237.800	18612.700
92.84	90.17	319.600	18932.300
90.17	86.78	406.700	19339.000
86.78	86.14	66.300	19405.300
86.14	80.21	429.300	19834.600
80.21	80.03	-10.200	19824.400
80.03	75.00	1100.800	20925.200
75.00	67.13	2346.700	23467.400
67.13	66.28	298.100	23765.500
66.28	65.53	334.300	24099.800
65.53	57.97	6805.800	30905.600
57.97	54.39	3281.300	34186.900
54.39	53.66	739.700	34926.600
53.66	52.30	859.300	35785.900
52.30	51.98	204.000	35989.900
51.98	51.00	-17438.338	18551.562
51.00	50.00	292.076	292.076
50.00	48.57	19608.962	19901.038
48.57	48.38	139.600	20040.638
48.38	48.14	202.300	20242.938
48.14	47.13	741.100	20984.038
47.13	47.00	-26987.167	-26987.167
47.00	46.71	14751.234	-12235.933
46.71	45.00	13815.733	1579.800
45.00	44.34	438.700	2018.500
44.34	42.70	1357.500	3376.000
42.70	42.51	135.100	3511.100
42.51	40.14	1571.000	5082.100
40.14	40.08	37.900	5120.000
40.08	39.72	256.200	5376.200
39.72	39.49	182.100	5558.300
39.49	38.93	440.300	5998.600
38.93	36.69	3029.300	9027.900
36.69	36.45	313.400	9341.300
36.45	36.01	907.100	10248.400
36.01	34.64	2651.900	12900.300
34.64	34.20	507.000	13407.300
34.20	31.02	3649.400	17056.700
31.02	30.85	144.500	17201.200
30.85	29.58	328.600	17529.800
29.58	28.71	226.300	17756.100
28.71	24.78	1498.400	19254.500
24.78	23.54	349.600	19604.100
23.54	22.32	346.500	19950.600
22.32	21.96	105.000	20055.600
21.96	21.95	2.900	20058.500
21.95	21.72	63.100	20121.600
21.72	21.71	1.000	20122.600
21.71	20.61	60.000	20182.600
20.61	17.53	112.400	20295.000
17.53	16.05	47.700	20342.700
16.05	4.48	139.500	20482.200
4.48	4.20	2.600	20484.800
4.20	-5.29	63.400	20548.200

HP steam

air

cooling water

Re



**Table D10** Problem table algorithm with multiple utility level at  $\Delta T_{min}=40^{\circ}C$  for actual case

Temperature Interval C	Enthalpy kW	Surplus kW	Cascade kW
490 93	36936 500		
490 93	344 81	36949 200	12 700
344 81	308 98	33082 400	-3866 800
308 98	302 97	30081 700	-3000 700
302 97	283 48	21456 300	-8625 400
283 48	256 67	20076 200	-1380 100
256 67	250 55	20462 200	386 000
250 55	233 72	13080 100	-7382 100
233 72	233 16	13056 500	-23 600
233 16	227 29	11591 800	-1464 700
227 29	226 70	11507 700	-84 100
226 70	221 48	11837 100	329 400
221 48	218 95	12117 000	279 900
218 95	212 32	726 604	-11390 396
212 32	212 00	725 462	-1 142
212 00	204 95	0 000	-725 462
204 95	197 00	90 437	90 437
197 00	187 29	195 020	104 583
187 29	186 70	257 916	62 896
186 70	180 71	1510 030	1252 114
180 71	177 54	1882 820	372 790
177 54	177 29	1894 630	11 810
177 29	170 88	2170 210	275 580
170 88	151 40	4495 720	2325 510
151 40	147 32	4170 360	-325 360
147 32	133 51	2656 670	-1513 690
133 51	133 17	2628 050	-28 620
133 17	132 83	2551 120	-76 930
132 83	130 17	1955 460	-595 660
130 17	128 18	1788 230	-167 230
128 18	118 81	1368 400	-419 830
118 81	117 89	1342 270	-26 130
117 89	113 45	1673 710	331 440
113 45	112 82	2113 970	440 260
112 82	110 28	3747 530	1633 560
110 28	101 87	9381 320	5633 790
101 87	101 76	9465 310	83 990
101 76	98 90	11389 400	1924 090
98 90	95 17	13518 800	2149 400
95 17	92 83	14892 800	1354 000
92 83	91 78	15500 600	607 800
91 78	91 14	15859 500	358 900
91 14	91 02	15923 300	63 800
91 02	90 17	15952 500	29 200
90 17	87 84	16079 100	126 600
87 84	80 00	16646 100	567 000
80 00	75 21	17490 100	844 000
75 21	75 03	17498 600	8 500
75 03	72 13	18435 700	937 100
72 13	71 28	18733 700	298 000
71 28	62 97	22435 100	3701 400
62 97	60 53	23559 900	1124 800
60 53	56 98	26810 500	3250 600
56 98	56 00	14272 249	-12538 251
56 00	55 00	14496 951	224 703
55 00	52 00	18437 565	3940 613
52 00	49 39	16034 535	-2403 029
49 39	49 34	34525 900	18491 365
49 34	48 66	35394 100	868 200
48 66	47 30	36607 100	1213 000
47 30	43 57	39962 000	3354 900
43 57	43 38	40131 800	169 800
43 38	43 14	40372 600	240 800
43 14	42 13	41274 000	901 400
42 13	41 71	41654 100	380 100
41 71	40 00	43194 200	1540 100
40 00	39 20	43858 500	664 300
39 20	37 70	45096 100	1237 600
37 70	37 51	45231 300	135 200
37 51	35 14	46802 900	1571 600
35 14	35 08	46840 800	37 900
35 08	34 72	47097 200	256 400
34 72	34 49	47279 400	182 200
34 49	33 93	47719 800	440 400
33 93	31 69	50749 800	3030 000
31 69	31 45	51063 300	313 500
31 45	31 01	51970 500	907 200
31 01	29 64	54622 800	2652 300
29 64	26 02	58779 400	4156 600
26 02	25 85	58923 800	144 400
25 85	24 58	59252 400	328 600
24 58	23 71	59478 800	226 400
23 71	19 78	60977 100	1498 300
19 78	18 54	61326 700	349 600
18 54	17 32	61673 200	346 500
17 32	16 96	61778 300	105 100
16 96	16 95	61781 100	2 800
16 95	16 72	61844 200	63 100
16 72	16 71	61845 300	1 100
16 71	15 61	61905 300	60 000
15 61	12 53	62017 700	112 400
12 53	11 05	62065 300	47 600
11 05	-0 53	62204 900	139 600
-0 53	-0 80	62207 500	2 600
-0 80	-10 29	62270 800	63 300

HP steam

air

cooling water

Re

**Appendix E Retrofit network cost report for actual case.**

**E-1 Retrofit network cost report for design option A.**

**Table E1** Cost of existing heat exchanger for design option A

HE no.	HE	U kW/m <sup>2</sup> oC	Old Area m <sup>2</sup>	New Area m <sup>2</sup>	Extra Area m <sup>2</sup>	Investment \$
1	100-E1	0.47	489.67	918.15	428.48	143700.64
2	100-E2/2A	0.52	194.11	118.01	-	-
4	100-E4	0.62	39.92	-	-	-
6	100-E6	0.56	29.55	-	-	-
17	110-E1A-D	0.30	2238.11	-	-	-
21	150-E1A-H	0.41	1258.17	-	-	-
22	150-E2AB	0.61	217.69	545.33	327.64	122157.36
28	200-E2	0.32	1.56	-	-	-
32	200-E6A-B	0.61	257.50	-	-	-
Total						265858.00

**Table E2** Cost of new heat exchanger for design option A

HE	Area m <sup>2</sup>	Investment \$
42	60.85	83156.45
43	54.98	79232.37
44	78.15	61211.87
Total		223600.70

Therefore the investment for extra area and new area is 489,458.70 \$

**Table E3** Utility savings for design option A

HE no.	HE	Old Q kW	New Q kW	Saved Q kW	Utility Type	annual cost \$/kWyr	Savings \$/yr
3	100-E3/3A	12966.200	11508.207	1457.993	HP	214.510	312753.681
5	100-E5	419.485	-	-	LP	200.000	-
7	100-E7	192.020	-	-	CW	21.040	-
8	100-E9	853.459	-	-	CW	21.040	-
9	100-E10	47.356	-	-	RE	0.000	-
10	100-E11	16.945	-	-	LP	200.000	-
11	100-E12AB	196.132	-	-	CW	21.040	-
12	100-EA1	6645.730	-	-	AIR	0.000	-
13	100-EA2	3523.390	1000.856	2522.534	AIR	0.000	0.000
14	100-EA3	4144.150	2306.940	1837.211	AIR	0.000	0.000
15	100-EA4	4987.980	-	-	AIR	0.000	-
16	100-EA5	789.921	-	-	AIR	0.000	-
18	110-E2	2257.050	0.000	2257.050	HP	214.510	484159.047
19	110-E2A	3447.060	-	-	HP	214.510	-
20	110-EA1	3881.440	-	-	AIR	0.000	-
23	150-EA1	9135.940	-	-	AIR	0.000	-
24	150-EA2	3947.750	-	-	AIR	0.000	-
25	150-EA3	4544.270	2415.346	2128.924	AIR	0.000	0.000
26	150-H1	9011.400	-	-	POWER	415.278	-
27	150-H2	1336.180	-	-	POWER	415.278	-
29	200-E3	850.168	-	-	CW	21.040	-
30	200-E4AB	1831.290	-	-	CW	21.040	-
31	200-E5	137.684	-	-	CW	21.040	-
33	200-E7AB	2317.610	-	-	CW	21.040	-
34	200-E12	398.094	-	-	CW	21.040	-
35	200-E13	146.007	-	-	RE	0.000	-
36	200-E14	2746.610	0.000	2746.610	MP	207.625	570265.649
37	200-E15	49.468	-	-	RE	0.000	-
38	200-EA1	13510.000	-	-	AIR	0.000	-
39	200-EA2	2478.920	-	-	AIR	0.000	-
40	200-EA3	2047.240	-	-	AIR	0.000	-
41	200-H5	9120.810	-	-	POWER	415.278	-
Total				12950.322	Total		1367178.377

Utility saving cost of design option A is 1,367,178.4 \$

## E-2 Retrofit network cost report for design option B.

**Table E4** Cost of existing heat exchanger for design option B

HE no.	HE	U kW/m <sup>2</sup> oC	Old Area m <sup>2</sup>	New Area m <sup>2</sup>	Extra Area m <sup>2</sup>	Investment \$
1	100-E1	0.47	489.67	918.15	428.48	143700.64
2	100-E2/2A	0.52	194.11	118.01	-	-
4	100-E4	0.62	39.92	-	-	-
6	100-E6	0.56	29.55	-	-	-
17	110-E1A-D	0.30	2238.11	-	-	-
21	150-E1A-H	0.41	1258.17	-	-	-
22	150-E2AB	0.61	217.69	545.33	327.64	122157.36
28	200-E2	0.32	1.56	-	-	-
32	200-E6A-B	0.61	257.50	-	-	-
Total						265858.00

**Table E5** Cost of new heat exchanger for design option B

HE	Area m <sup>2</sup>	Investment \$
42	60.85	83156.45
43	87.55	63891.53
44	177.34	151709.13
45	94.15	65739.19
Total		364496.31

Therefore the investment for extra area and new area is 630,354.3 \$

**Table E6** Utility savings for design option B

HE no.	HE	Old Q kW	New Q kW	Saved Q kW	Utility Type	annual cost \$/kWyr	Savings \$/yr
3	100-E3/3A	12966.200	11508.207	1457.993	HP	214.510	312753.681
5	100-E5	419.485	-	-	LP	200.000	-
7	100-E7	192.020	-	-	CW	21.040	-
8	100-E9	853.459	-	-	CW	21.040	-
9	100-E10	47.356	-	-	RE	0.000	-
10	100-E11	16.945	-	-	LP	200.000	-
11	100-E12AB	196.132	-	-	CW	21.040	-
12	100-EA1	6645.730	-	-	AIR	0.000	-
13	100-EA2	3523.390	1000.856	2522.534	AIR	0.000	0.000
14	100-EA3	4144.150	2616.294	1527.856	AIR	0.000	0.000
15	100-EA4	4987.980	-	-	AIR	0.000	-
16	100-EA5	789.921	-	-	AIR	0.000	-
18	110-E2	2257.050	0.000	2257.050	HP	214.510	484159.047
19	110-E2A	3447.060	1653.935	1793.125	HP	214.510	384642.720
20	110-EA1	3881.440	-	-	AIR	0.000	-
23	150-EA1	9135.940	6878.919	2257.021	AIR	0.000	0.000
24	150-EA2	3947.750	-	-	AIR	0.000	-
25	150-EA3	4544.270	2415.346	2128.924	AIR	0.000	0.000
26	150-H1	9011.400	-	-	POWER	415.278	-
27	150-H2	1336.180	-	-	POWER	415.278	-
29	200-E3	850.168	-	-	CW	21.040	-
30	200-E4AB	1831.290	-	-	CW	21.040	-
31	200-E5	137.684	-	-	CW	21.040	-
33	200-E7AB	2317.610	-	-	CW	21.040	-
34	200-E12	398.094	-	-	CW	21.040	-
35	200-E13	146.007	-	-	RE	0.000	-
36	200-E14	2746.610	0.000	2746.610	MP	207.625	570265.649
37	200-E15	49.468	-	-	RE	0.000	-
38	200-EA1	13510.000	-	-	AIR	0.000	-
39	200-EA2	2478.920	-	-	AIR	0.000	-
40	200-EA3	2047.240	-	-	AIR	0.000	-
41	200-H5	9120.810	-	-	POWER	415.278	-
Total				16691.114	Total		1751821.098

Utility saving cost of design option A is 1,751,821.1 \$

### E-3 Retrofit network cost report for design option C.

**Table E7** Cost of existing heat exchanger for design option C

HE no.	HE	U kW/m <sup>2</sup> oC	Old Area m <sup>2</sup>	New Area m <sup>2</sup>	Extra Area m <sup>2</sup>	Investment \$
1	100-E1	0.47	489.67	609.88	120.21	72810.12
2	100-E2/2A	0.52	194.11	-	-	-
4	100-E4	0.62	39.92	-	-	-
6	100-E6	0.56	29.55	-	-	-
17	110-E1A-D	0.30	2238.11	-	-	-
21	150-E1A-H	0.41	1258.17	-	-	-
22	150-E2AB	0.61	217.69	-	-	-
28	200-E2	0.32	1.56	-	-	-
32	200-E6A-B	0.61	257.50	-	-	-
Total						72810.12

**Table E8** Cost of new heat exchanger for design option C

HE	Area m <sup>2</sup>	Investment \$
42	118.01	118469.23
43	87.55	63891.53
44	264.49	108028.82
Total		290389.58

Therefore the investment for extra area and new area is 363,199.7\$

**Table E9** Utility savings for design option C

HE no.	HE	Old Q kW	New Q kW	Saved Q kW	Utility Type	annual cost \$/kWyr	Savings \$/yr
3	100-E3/3A	12966.20	11508.19	1458.01	HP	214.51	312757.93
5	100-E5	419.49	-	-	LP	200.00	-
7	100-E7	192.02	-	-	CW	21.04	-
8	100-E9	853.46	-	-	CW	21.04	-
9	100-E10	47.36	-	-	RE	0.00	-
10	100-E11	16.95	-	-	LP	200.00	-
11	100-E12AB	196.13	-	-	CW	21.04	-
12	100-EA1	6645.73	-	-	AIR	0.00	-
13	100-EA2	3523.39	2872.53	650.86	AIR	0.00	0.00
14	100-EA3	4144.15	3337.01	807.14	AIR	0.00	0.00
15	100-EA4	4987.98	-	-	AIR	0.00	-
16	100-EA5	789.92	-	-	AIR	0.00	-
18	110-E2	2257.05	0.00	2257.05	HP	214.51	484159.05
19	110-E2A	3447.06	-	-	HP	214.51	-
20	110-EA1	3881.44	-	-	AIR	0.00	-
23	150-EA1	9135.94	6878.92	2257.02	AIR	0.00	0.00
24	150-EA2	3947.75	1200.92	2746.83	AIR	0.00	0.00
25	150-EA3	4544.27	-	-	AIR	0.00	-
26	150-H1	9011.40	-	-	POWER	415.28	-
27	150-H2	1336.18	-	-	POWER	415.28	-
29	200-E3	850.17	-	-	CW	21.04	-
30	200-E4AB	1831.29	-	-	CW	21.04	-
31	200-E5	137.68	-	-	CW	21.04	-
33	200-E7AB	2317.61	-	-	CW	21.04	-
34	200-E12	398.09	-	-	CW	21.04	-
35	200-E13	146.01	-	-	RE	0.00	-
36	200-E14	2746.61	0.00	2746.61	MP	207.63	570265.65
37	200-E15	49.47	-	-	RE	0.00	-
38	200-EA1	13510.00	-	-	AIR	0.00	-
39	200-EA2	2478.92	-	-	AIR	0.00	-
40	200-EA3	2047.24	-	-	AIR	0.00	-
41	200-H5	9120.81	-	-	POWER	415.28	-
Total				12923.53	Total		1367182.62

Utility saving cost of design option A is 1,367,182.6 \$

#### E-4 Retrofit network cost report for design option D.

**Table E10** Cost of existing heat exchanger for design option D

HE no.	HE	U kW/m <sup>2</sup> oC	Old Area m <sup>2</sup>	New Area m <sup>2</sup>	Extra Area m <sup>2</sup>	Investment \$
1	100-E1	0.47	489.67	918.15	428.48	143700.64
2	100-E2/2A	0.52	194.11	107.73	-	-
4	100-E4	0.62	39.92	-	-	-
6	100-E6	0.56	29.55	-	-	-
17	110-E1A-D	0.30	2238.11	-	-	-
21	150-E1A-H	0.41	1258.17	-	-	-
22	150-E2AB	0.61	217.69	545.33	327.64	122157.36
28	200-E2	0.32	1.56	-	-	-
32	200-E6A-B	0.61	257.50	-	-	-
Total						265858.00

**Table E11** Cost of new heat exchanger for design option D

HE	Area m <sup>2</sup>	Investment \$
42	202.46	165105.22
43	60.40	55977.58
44	264.49	108028.82
45	60.85	83156.45
Total		412268.08

Therefore the investment for extra area and new area is 678,126.08 \$



**Table E12** Utility savings for design option D

HE no.	HE	Old Q kW	New Q kW	Saved Q kW	Utility Type	annual cost \$/kWyr	Savings \$/yr
3	100-E3/3A	12966.20	-	-	HP	214.51	-
5	100-E5	419.49	-	-	LP	200.00	-
7	100-E7	192.02	-	-	CW	21.04	-
8	100-E9	853.46	-	-	CW	21.04	-
9	100-E10	47.36	-	-	RE	0.00	-
10	100-E11	16.95	-	-	LP	200.00	-
11	100-E12AB	196.13	-	-	CW	21.04	-
12	100-EA1	6645.73	-	-	AIR	0.00	-
13	100-EA2	3523.39	1000.86	2522.53	AIR	0.00	0.00
14	100-EA3	4144.15	3105.85	1038.30	AIR	0.00	0.00
15	100-EA4	4987.98	-	-	AIR	0.00	-
16	100-EA5	789.92	-	-	AIR	0.00	-
18	110-E2	2257.05	0.00	2257.05	HP	214.51	484159.05
19	110-E2A	3447.06	1091.80	2355.26	HP	214.51	505226.66
20	110-EA1	3881.44	-	-	AIR	0.00	-
23	150-EA1	9135.94	-	-	AIR	0.00	-
24	150-EA2	3947.75	1200.92	2746.83	AIR	0.00	0.00
25	150-EA3	4544.27	2415.35	2128.92	AIR	0.00	0.00
26	150-H1	9011.40	-	-	POWER	415.28	-
27	150-H2	1336.18	285.76	1050.42	POWER	415.28	436214.66
29	200-E3	850.17	-	-	CW	21.04	-
30	200-E4AB	1831.29	-	-	CW	21.04	-
31	200-E5	137.68	-	-	CW	21.04	-
33	200-E7AB	2317.61	-	-	CW	21.04	-
34	200-E12	398.09	-	-	CW	21.04	-
35	200-E13	146.01	-	-	RE	0.00	-
36	200-E14	2746.61	0.00	2746.61	MP	207.63	570265.65
37	200-E15	49.47	-	-	RE	0.00	-
38	200-EA1	13510.00	-	-	AIR	0.00	-
39	200-EA2	2478.92	-	-	AIR	0.00	-
40	200-EA3	2047.24	-	-	AIR	0.00	-
41	200-H5	9120.81	-	-	POWER	415.28	-
Total				16845.93		Total	1995866.02

Utility saving cost of design option A is 1,995,866.02 \$

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