Technical report:

Validation of IDA Indoor Climate and Energy 4.0 build 4 with respect to ANSI/ASHRAE Standard 140-2004

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Contents

1 Introduction and overview

This report treats the validation of IDA Indoor Climate and Energy 4.0 build 4 (IDA ICE) with respect to the ANSI/ASHRAE Standard 140-2004 titled *Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs*.

The main reason for performing the tests is to ascertain that the computational models give reasonable values compared to other software programs. For some tests analytical solutions are also available.

2 Building Thermal Envelope and Fabric Load Test

2.1 Test Suite: ANSI/ASHRAE Standard 140-2004 Building Thermal envelope and fabric load tests

Section 5.2 of the ASHRAE standard describes a series of experiments which each tries to isolate a single factor in the building thermal envelope or fabric parameters.

The following tests were performed as described in the ASHRAE standard:

- Case 600 – Base Case
- Case610 – South Shading
- Case 620 – East/West Window Orientation
- Case 630 – East/West Shading
- Case 640 – Thermostat Setback
- Case 650 – Night Ventilation
- Case 900 – High Mass Base Case
- Case 910 – High Mass South Shading
- Case 920 – High Mass East/West Windows
- Case 930 – High Mass East/West Windows Shading
- Case 940 – High Mass Thermostat Setback
- Case 950 – High Mass Night Ventilation
- Case 960 – Sunspace
- Case 600FF
- Case 650FF
- Case 900FF
- Case 950FF

The cases with names ending in FF are free float cases (cases without either heater or cooler) based on the correspondingly numbered cases.

2.1.1 Case 600 –The Base Case

The basic test building is a rectangular 6 x 8 meters single zone with two south facing widows. The building is set up as an semi-adiabatic cell, with heavy insulating materials in all surfaces. For more information about the building materials, see Section 5.2.1 in the Standard 140-2004.

2.2 Modeler Report

2.2.1 Important parameters in IDA ICE and deviations from the problem formulations

The IDA ICE 4 objects Ideal Heater and Ideal Cooler were used to implement heating and cooling of the zone.

In order to get accurate results, the Tolerance parameter was set 100 times smaller than its default value. This lead to, in some cases, longer simulation times, but not to very different results (always less than 1 %), which validates the default choice as good in most cases.

The more detailed Climate zone model was used for all cases.

Minimum and maximum values have been obtained from the (one hour) table view of the corresponding signal. This value represents averages for whole hours of clock time, i.e. the standard 15 minute sliding averages have not been used for computation of extreme values.

2.2.2 Modeling difficulties

The night setback schedule in Case 640 was simulated by the default PI controller (with IDA ICE default settings k=0.3, Ti=300s). The combination of the sharp change in setpoint schedule and the unrealistically large powers of the heater and cooler made the system unstable when the schedule suddenly switched (as indeed a physical system with the same characteristics would be). This was resolved by slightly smoothing the schedule.

In IDA ICE 4, daylight savings time is implemented as default and not easy to disable, so the hourly schedules for the summer cases were modified by hand after the calculations were done.

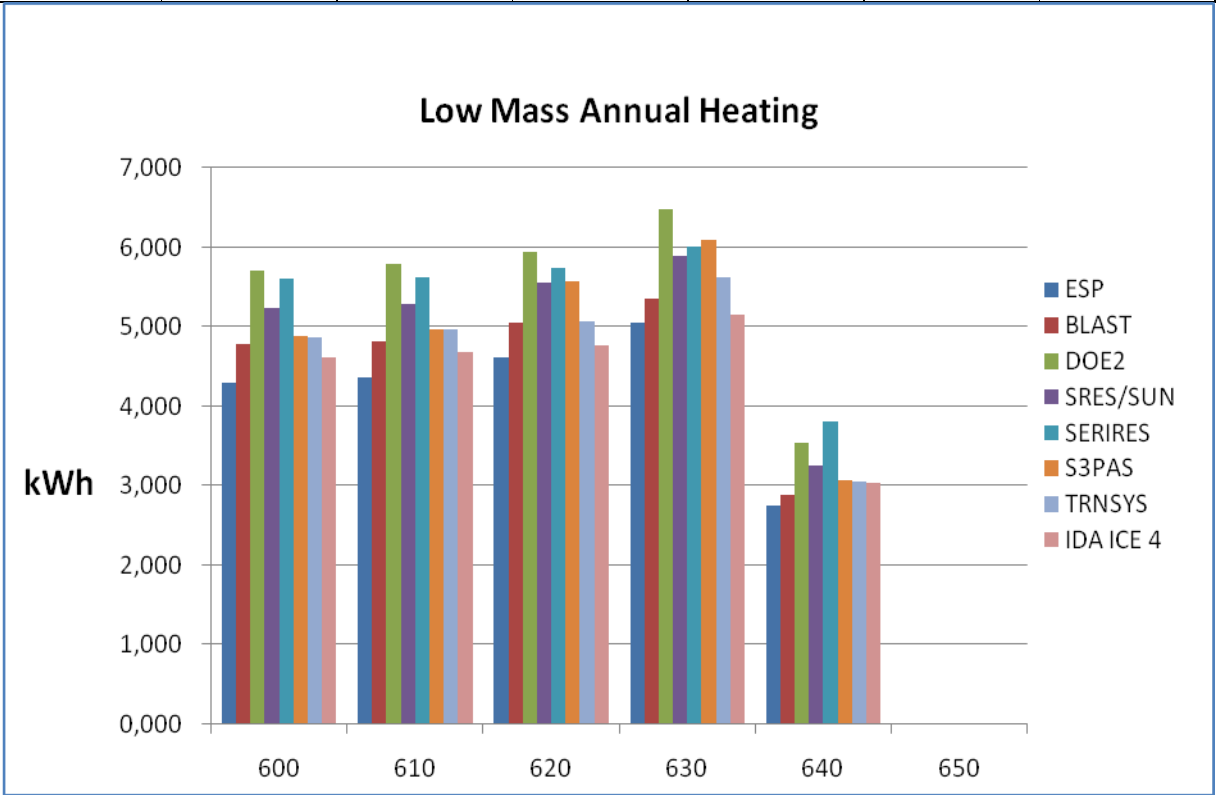
2.3 Results and Discussion

The results are presented in the tables and diagrams below:

Annual heating loads

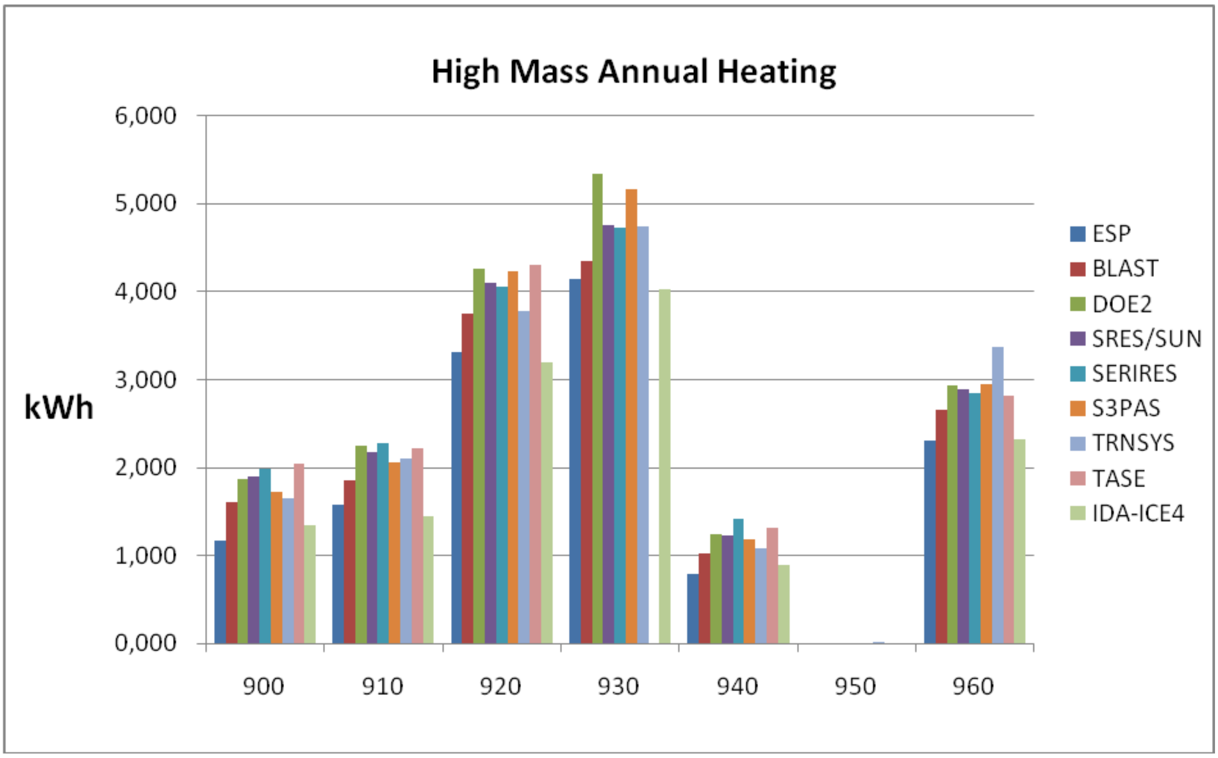
Lightweight cases (kWh)

Case	600	610	620	630	640	650
Min	4,296	4,355	4,613	5,050	2,751	0
Max	5,709	5,7866	5,944	6,469	3,803	0
IDA ICE 4	4,614	4,681	4,763	5,147	3,041	0



Heavyweight cases (kWh)

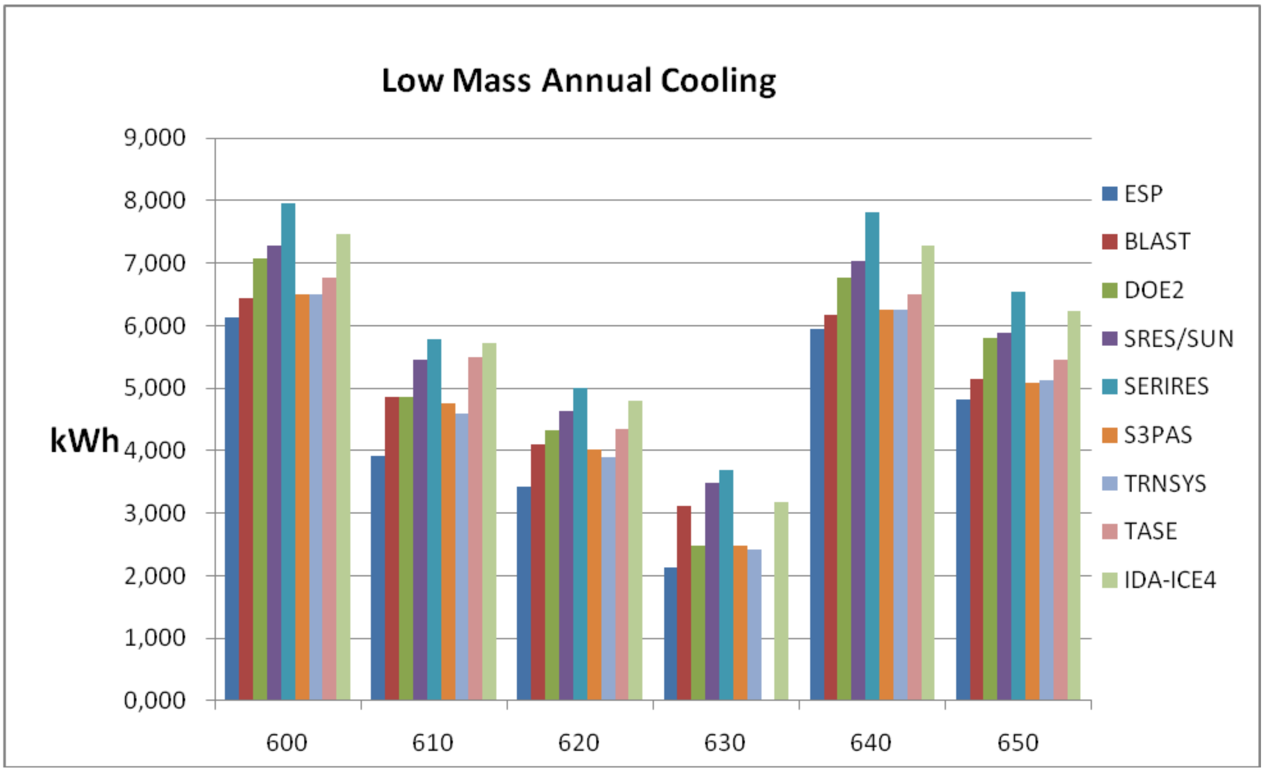
Case	900	910	920	930	940	950	960
Min	1,170	1,575	3,313	4,143	0,793	0	2,311
Max	2,041	2,282	4,300	5,335	1,411	0	3,373
IDA ICE4	1,348	1,447	3,195	4,031	0,9	0	2,315



Cooling loads

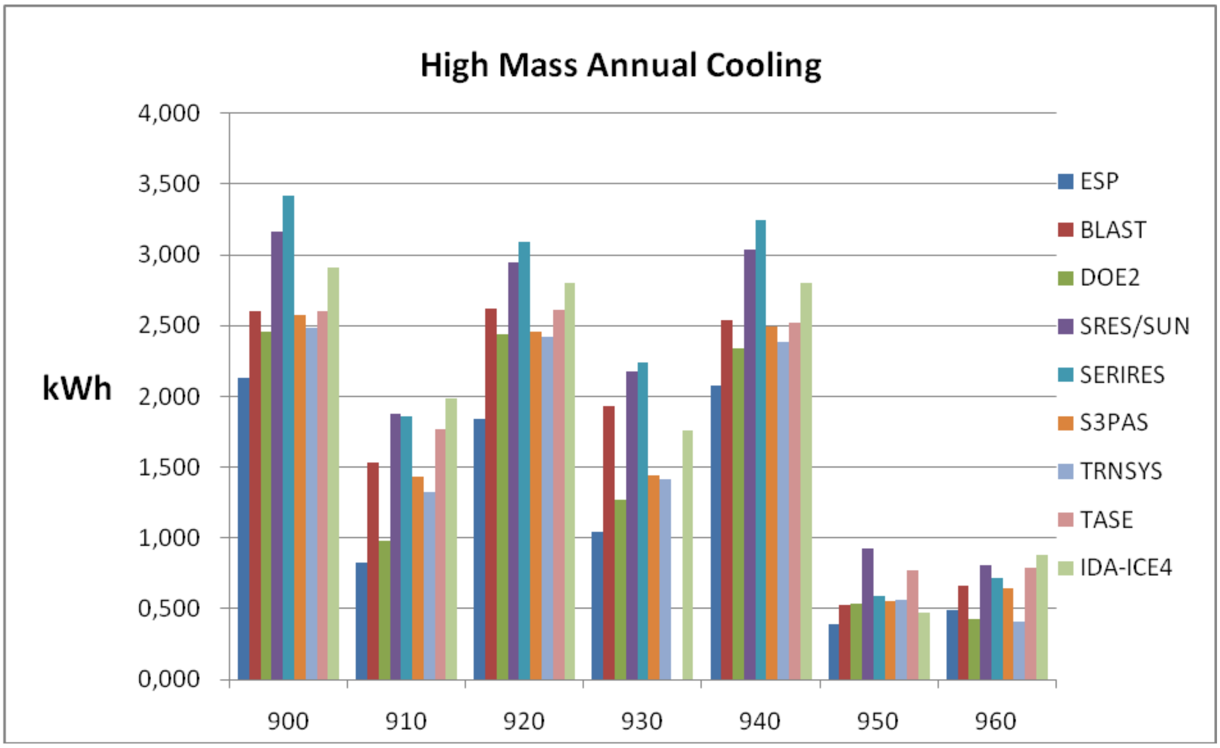
Lightweight cases (kWh)

Case	600	610	620	630	640	650
Min	6,137	3,915	3,417	2,129	5,952	4,816
Max	7,964	5,778	5,004	3,701	7,811	6,545
IDA ICE 4	7,467	5,729	4,799	3,175	7,280	6,235



Heavyweight cases (kWh)

Case	900	910	920	930	940	950	960
Min	2,132	0,821	1,840	1,039	2,079	0,387	0,411
Max	3,415	1,872	3,092	2,238	3,241	0,921	0,803
IDA ICE 4	2,906	1,987	2,803	1,758	2,804	0,476	0,877

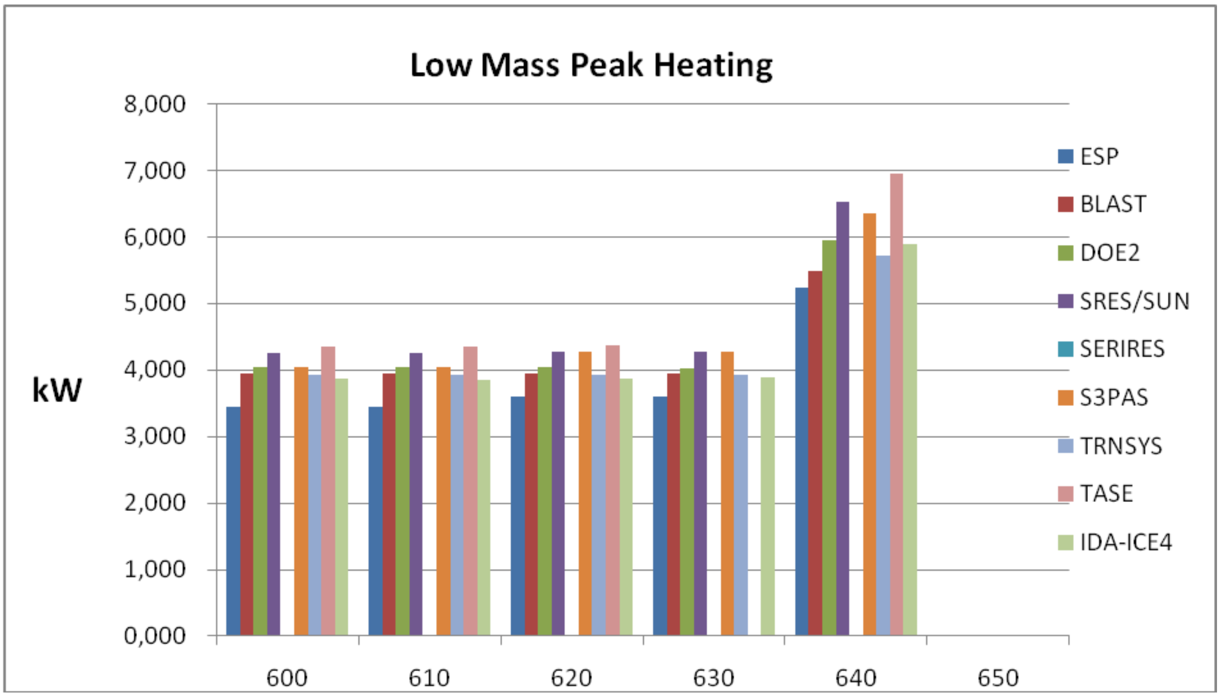


For cases 910 and 960, the cooling load is slightly larger than hitherto largest value, but not unreasonably so.

Peak Heating loads

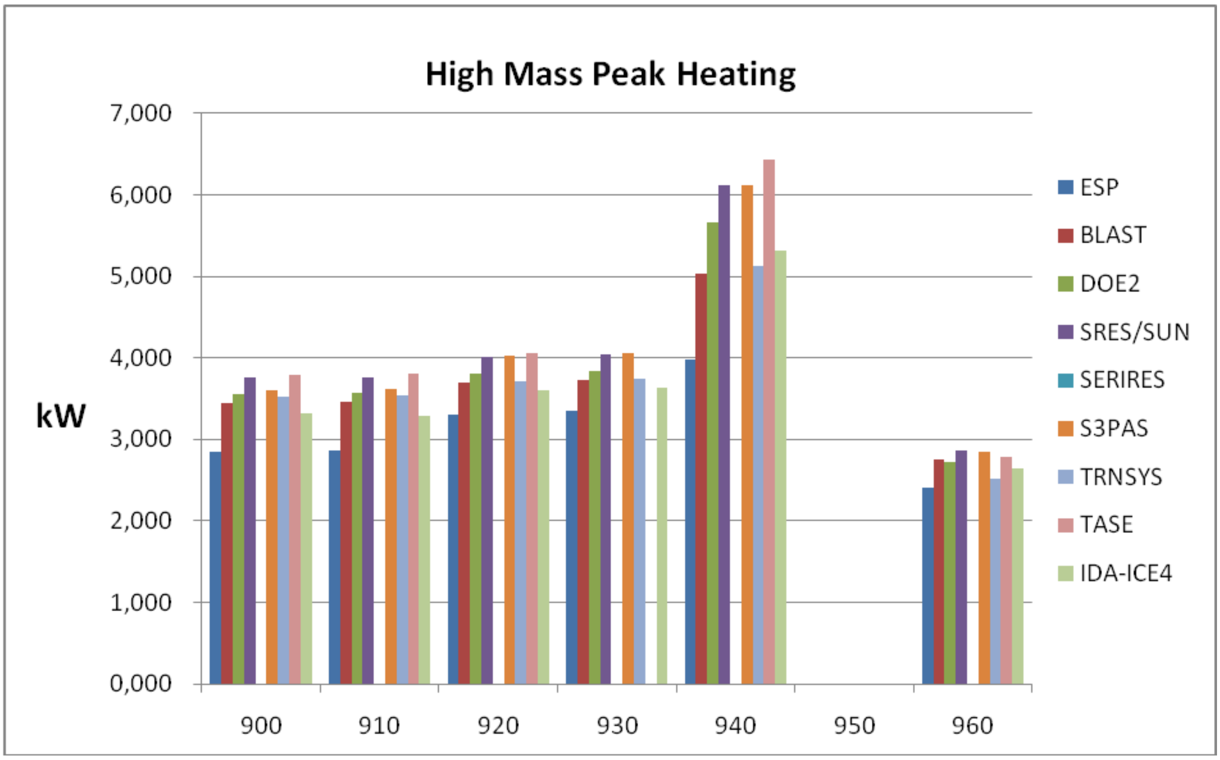
Lightweight cases (kW)

Case	600	610	620	630	640	650
Min	3,437	3,437	3,591	3,592	5,232	0
Max	4,354	4,354	4,379	4,280	6,954	0
IDA ICE 4	3,861	3,859	3,875	3,892	5,885	0



Heavyweight cases (kW)

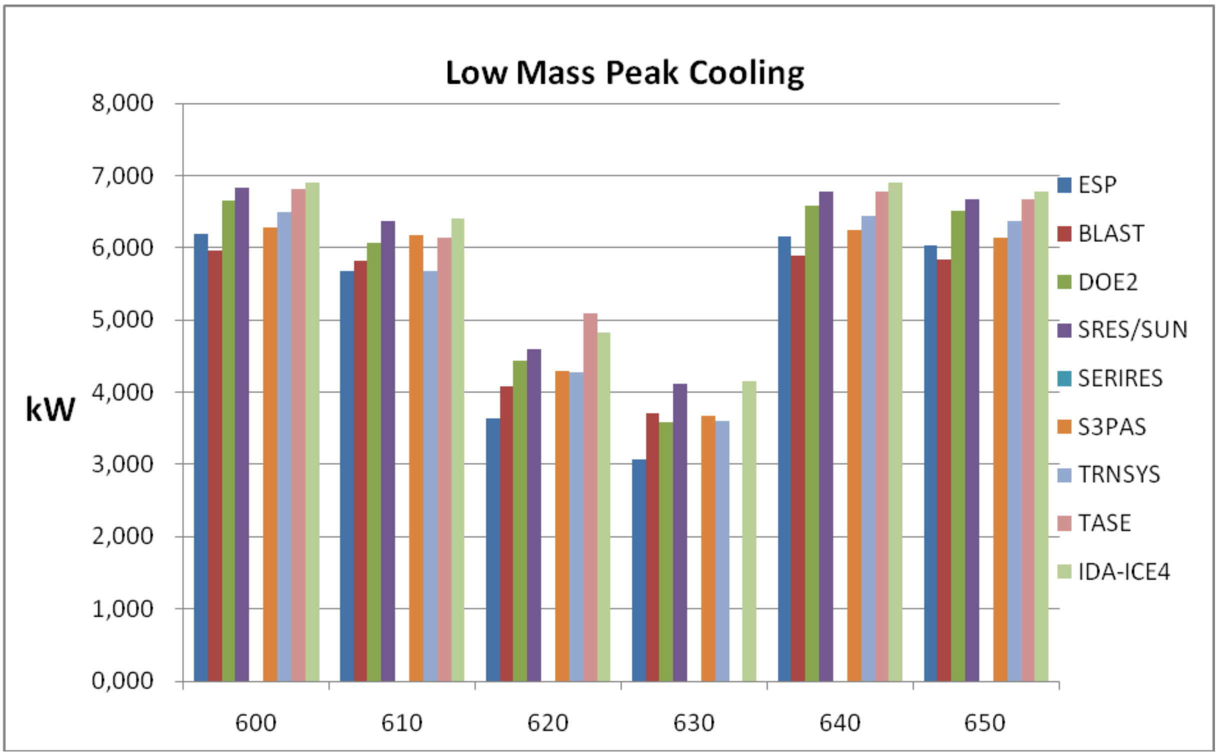
Case	900	910	920	930	940	950	960
Min	2,850	2,858	3,308	3,355	3,980	0	2,410
Max	3,797	3,801	4,061	4,064	6,428	0	2,863
IDA ICE 4	3,313	3,289	3,595	3,640	5,323	0	2,649



Peak Cooling loads

Lightweight cases (kW)

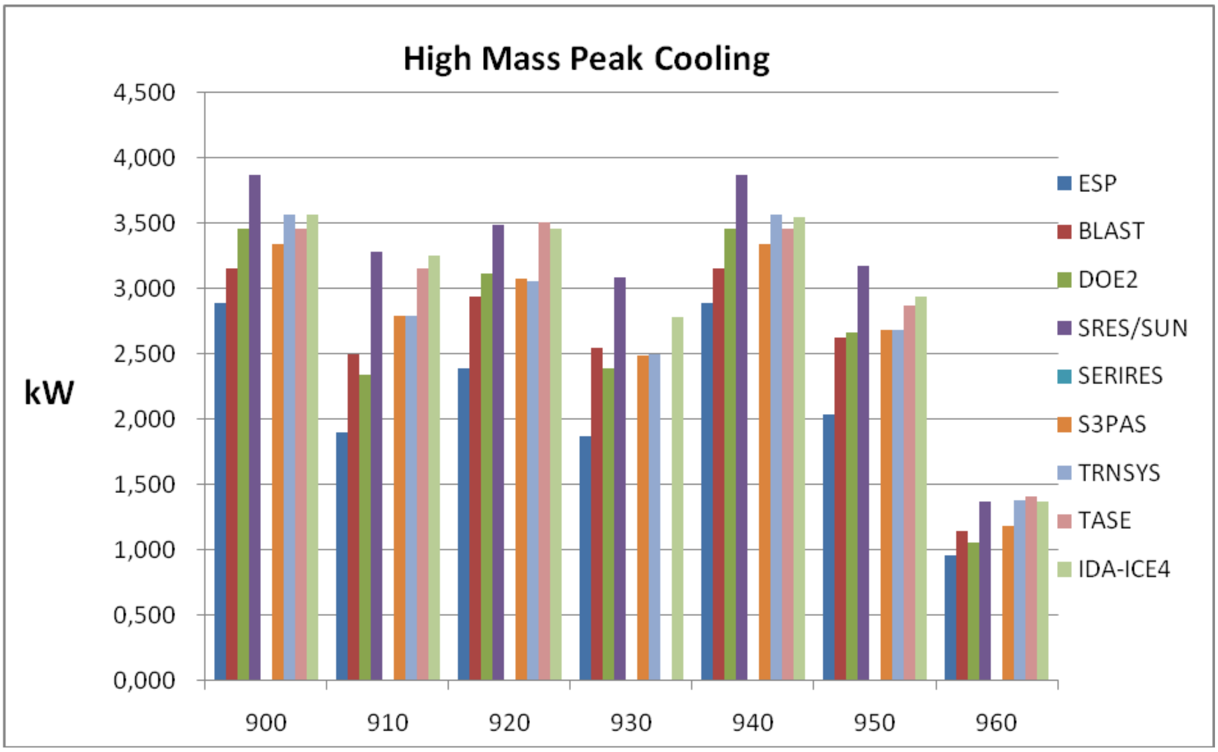
Case	600	610	620	630	640	650
Min	5,965	5,669	3,634	3,072	5,892	5,831
Max	6,827	6,371	5,096	4,116	6,776	6,679
IDA ICE 4	6,910	6,410	4,820	4,160	6,900	6,770



The peak cooling loads are slightly larger for a number of cases.

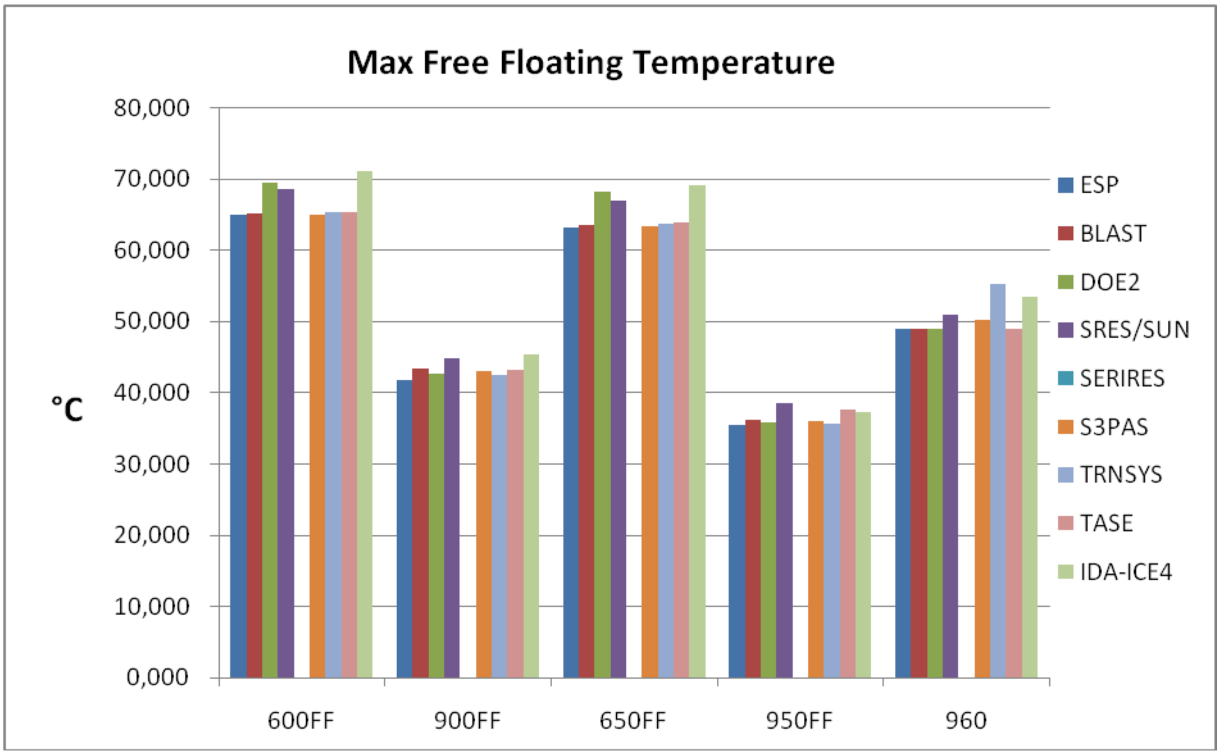
Heavyweight cases (kW)

Case	900	910	920	930	940	950	960
Min	2,888	1,896	2,385	1,873	2,888	2,033	0,953
Max	3,871	3,277	3,505	3,080	3,871	3,170	1,403
IDA ICE 4	3,560	3,254	3,459	2,783	3,545	2,932	1,373



Free float and case 960 Maximum zone temperature

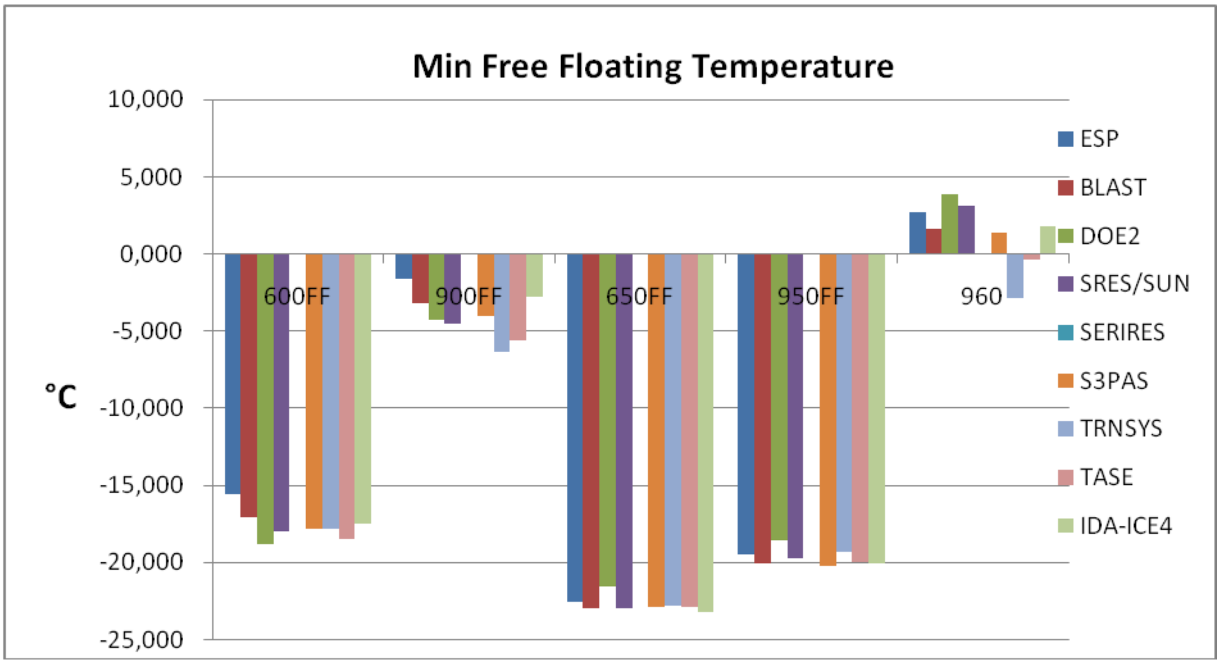
Case	600FF	900FF	650FF	950FF	960
Min	64.9	41.8	63.2	35.5	48.9
Max	69.5	44.8	68.2	38.5	55.3
IDA ICE 4	71.0	45.3	69.2	37.2	53.5



IDA ICE has a higher maximum zone temperature for the cases 600FF, 900FF, and 950FF.

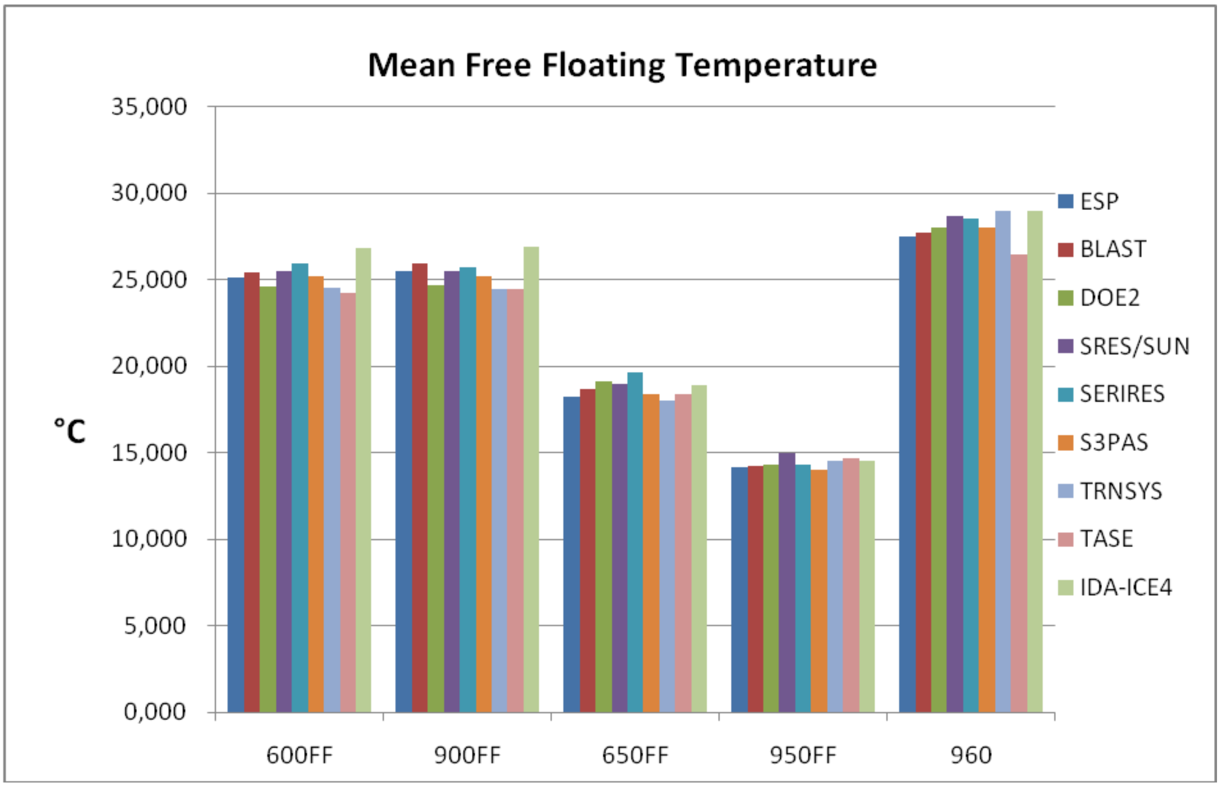
Free float and case 960 Minimum zone temperature

Case	600FF	900FF	650FF	950FF	960
Min	-18.8	-6.4	-23.0	-20.2	-2.8
Max	-15.6	-1.6	-21.6	-18.6	3.9
IDA ICE 4	-17.5	-2.8	-23.2	-20.1	1.8



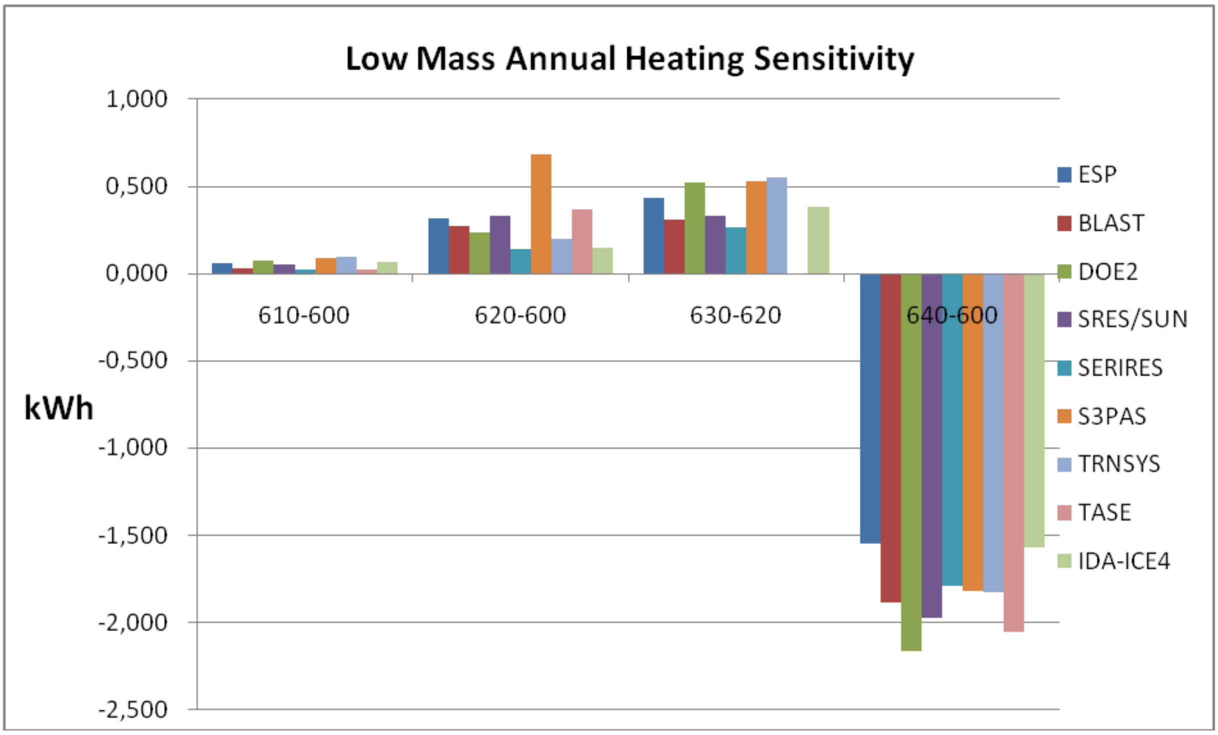
Free float and case 960 Average zone temperature

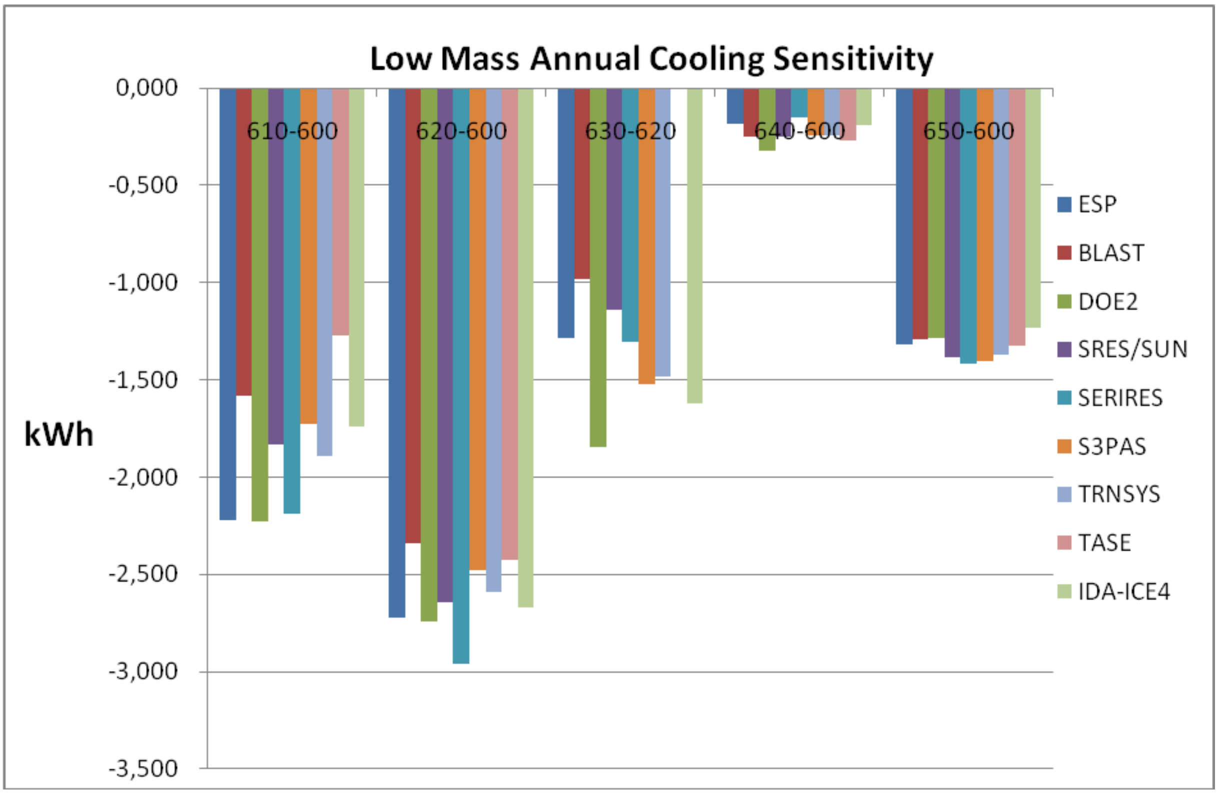
Case	600FF	900FF	650FF	950FF	960
Min	24.2	24.5	18.0	14.0	26.4
Max	25.9	25.9	19.6	15.0	29.0
IDA ICE 4	26.8	26.9	18.9	14.5	29.0

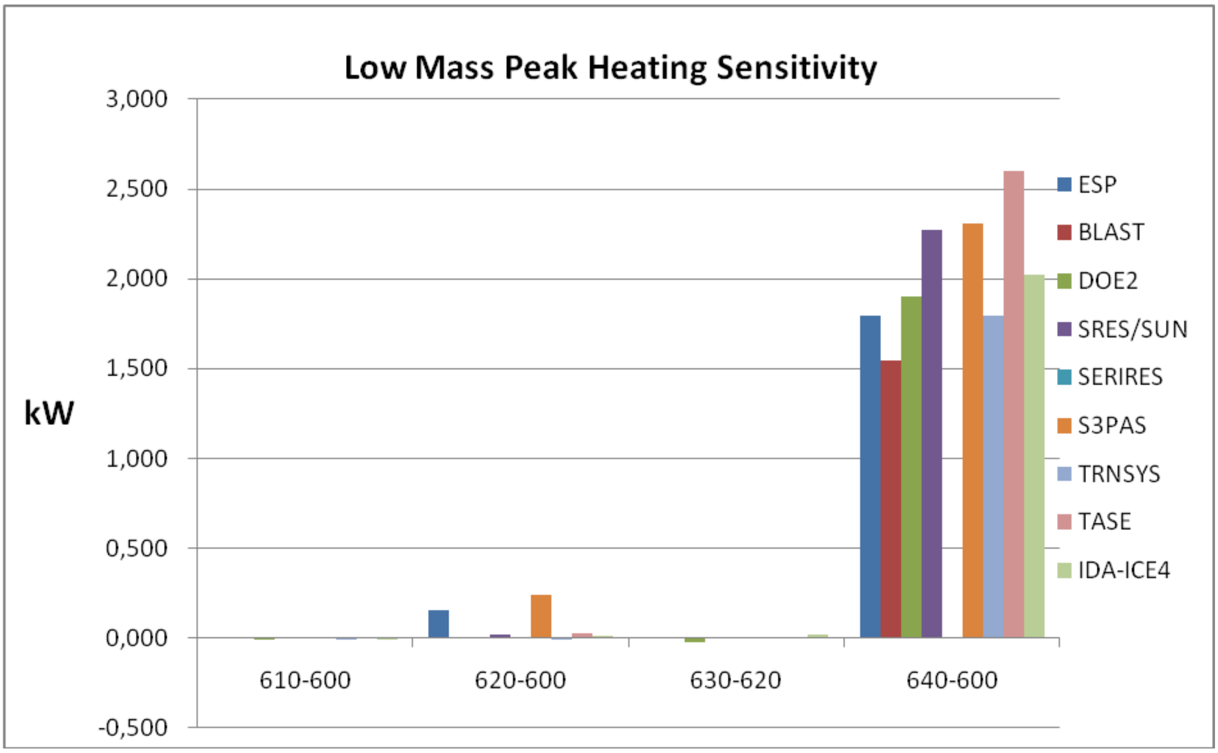


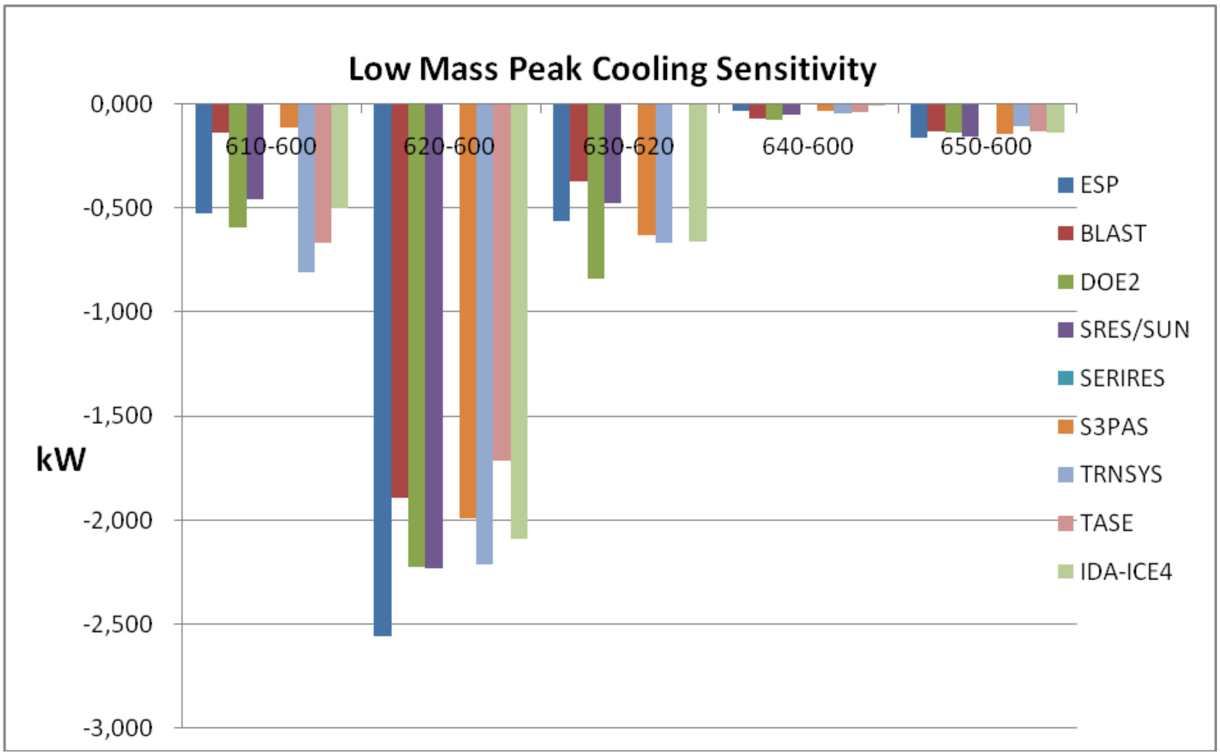
Again, IDA ICE 4 has slightly high numbers for a few cases.

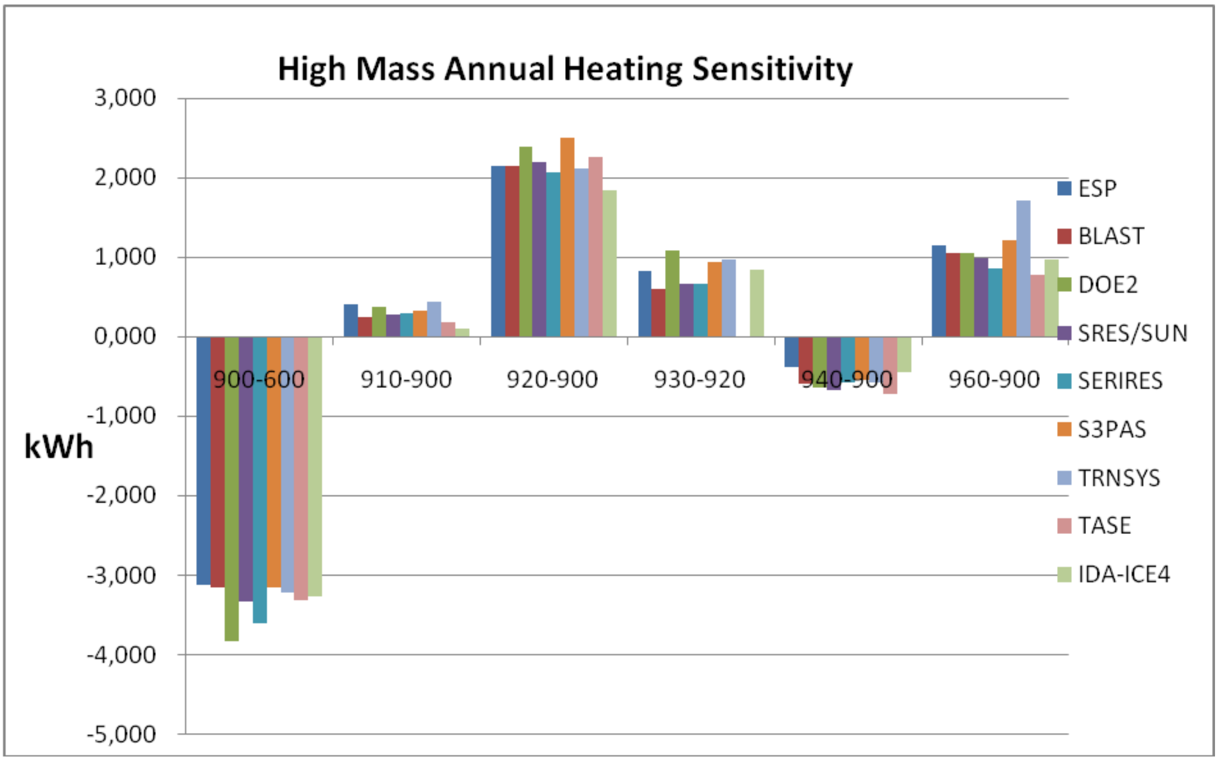
The sensitivity comparisons are shown in the diagrams below:

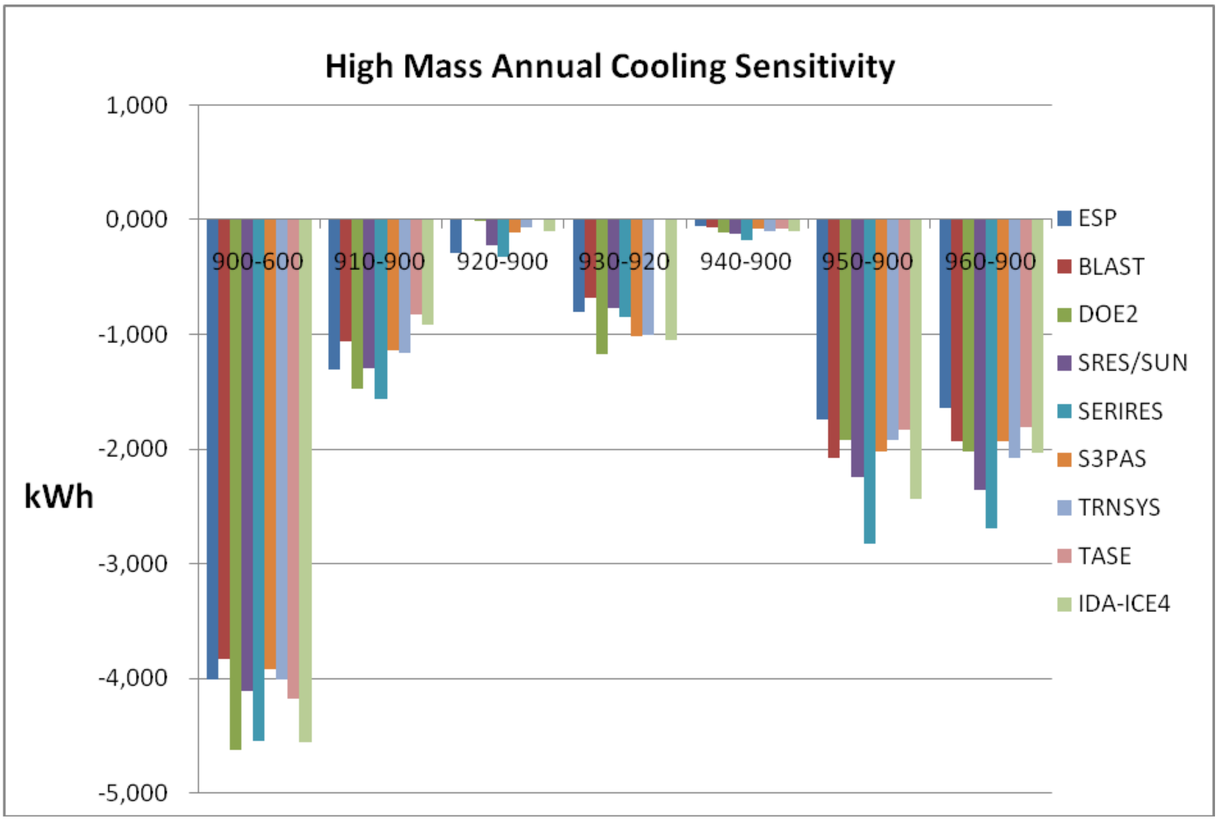

Low Mass Annual Heating Sensitivity
kWh
1,000
0,500
0,000
-0,500
-1,000
-1,500
-2,000
-2,500
610-600
620-600
630-620
640-600
ESP
BLAST
DOE2
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4

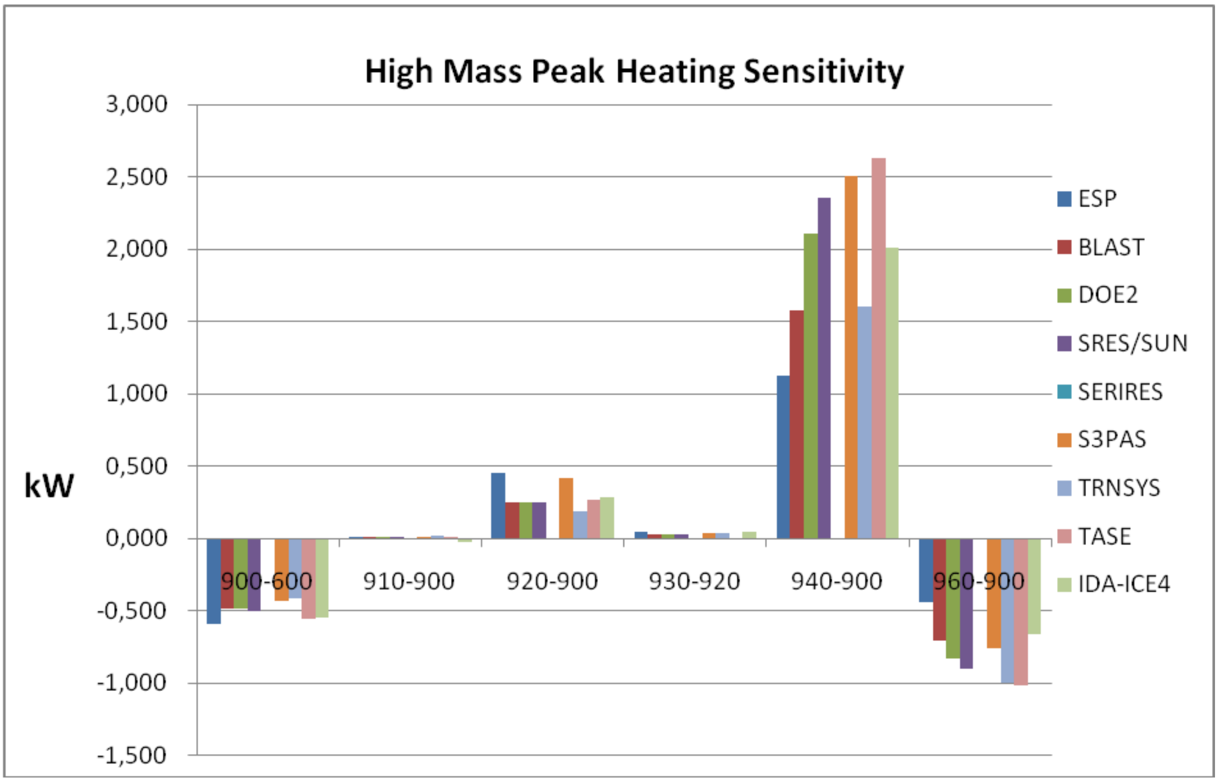

Low Mass Annual Cooling Sensitivity
kWh
0,000
-0,500
-1,000
-1,500
-2,000
-2,500
-3,000
-3,500
610-600
620-600
630-620
640-600
650-600
ESP
BLAST
DOE2
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4

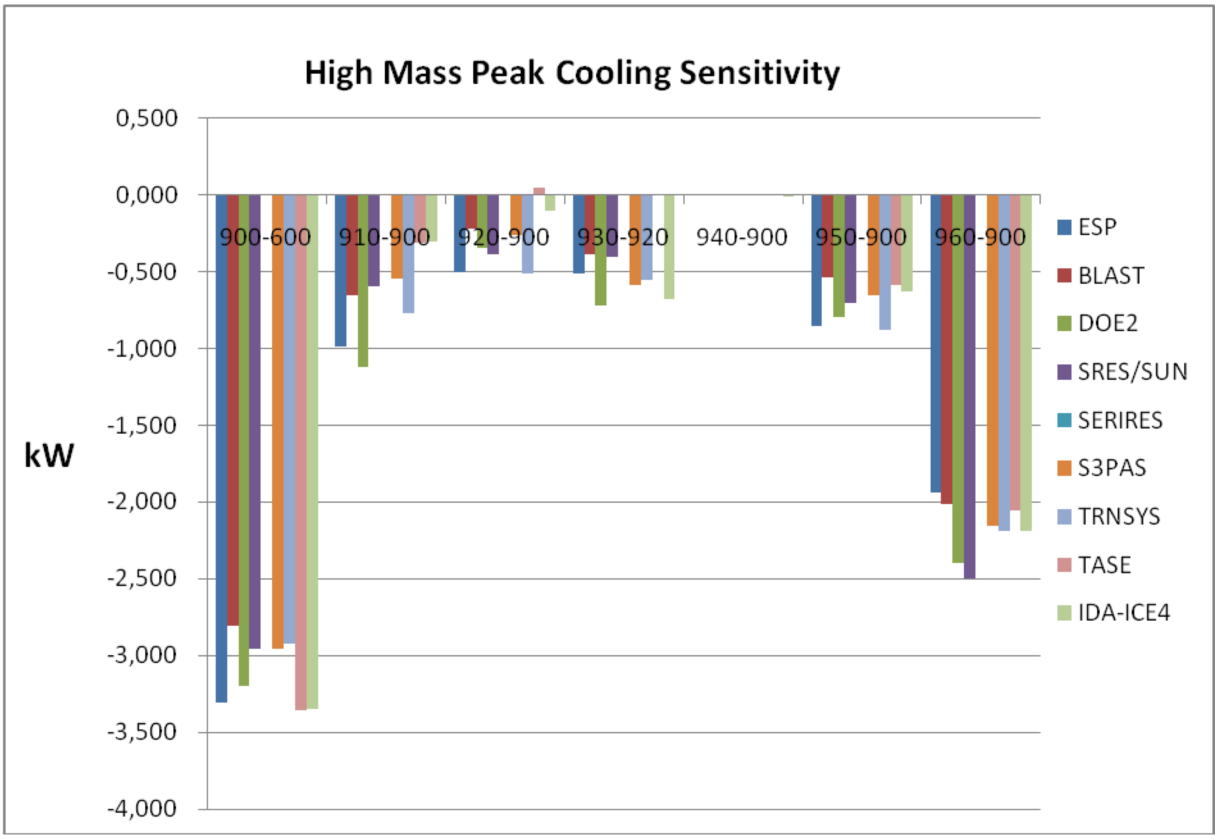

Low Mass Peak Heating Sensitivity
kW
3,000
2,500
2,000
1,500
1,000
0,500
0,000
-0,500
610-600
620-600
630-620
640-600
ESP
BLAST
DOE2
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4


Low Mass Peak Cooling Sensitivity
kW
0,000
-0,500
-1,000
-1,500
-2,000
-2,500
-3,000
610-600
620-600
630-620
640-600
650-600
ESP
BLAST
DOE2
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4

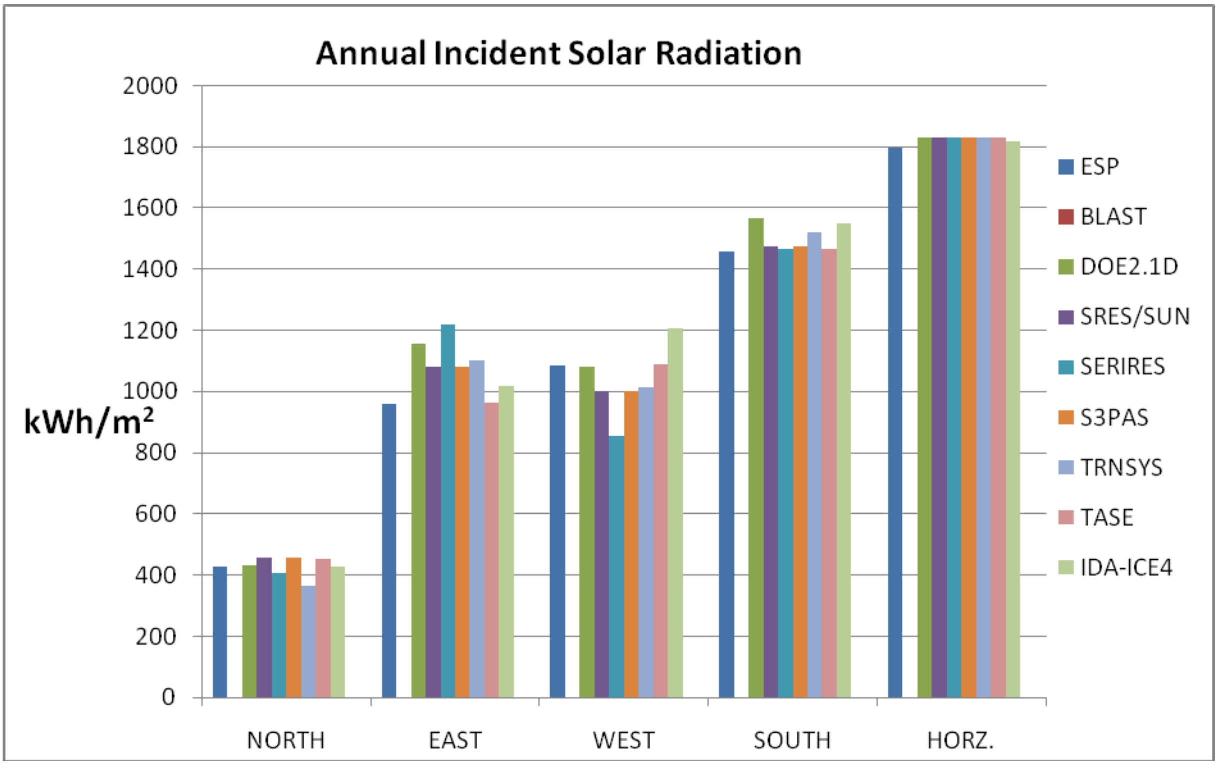

High Mass Annual Heating Sensitivity
kWh
3,000
2,000
1,000
0,000
-1,000
-2,000
-3,000
-4,000
-5,000
900-600
910-900
920-900
930-920
940-900
960-900
ESP
BLAST
DOE2
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4

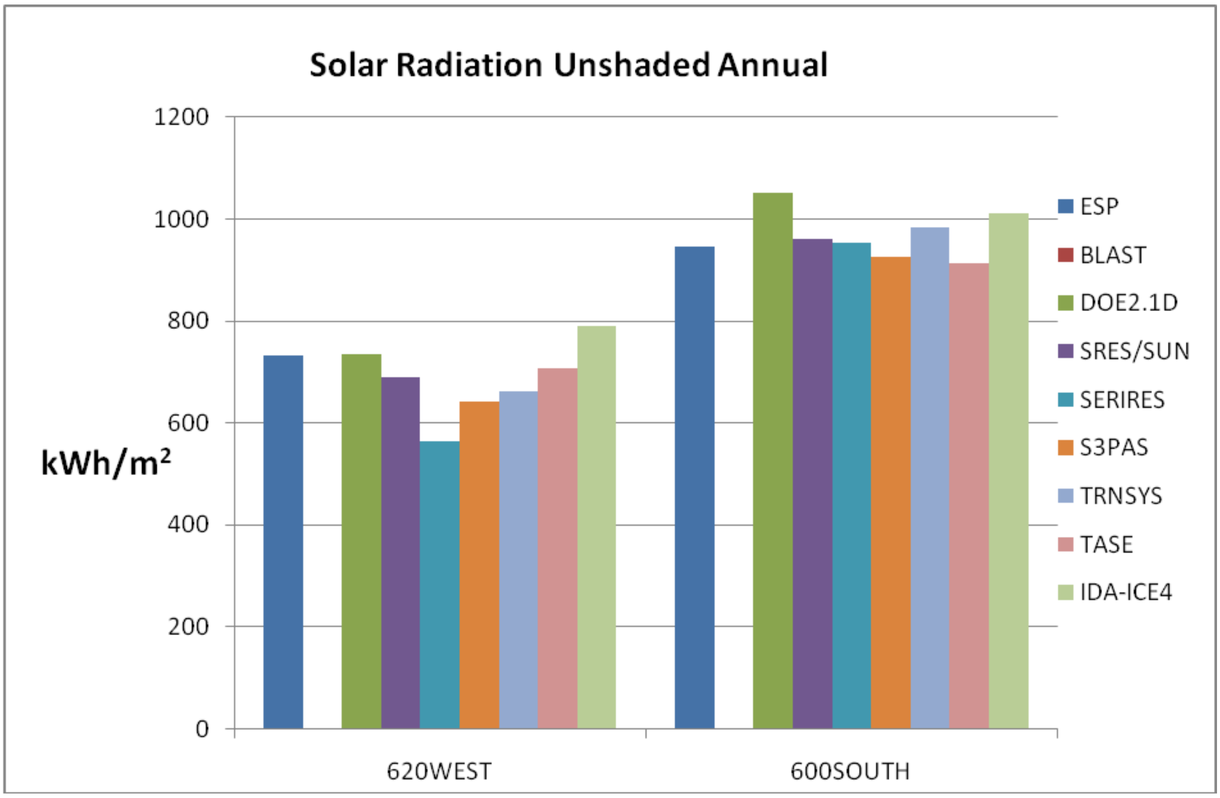

High Mass Annual Cooling Sensitivity
kWh
1,000
0,000
-1,000
-2,000
-3,000
-4,000
-5,000
900-600
910-900
920-900
930-920
940-900
950-900
960-900
ESP
BLAST
DOE2
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4

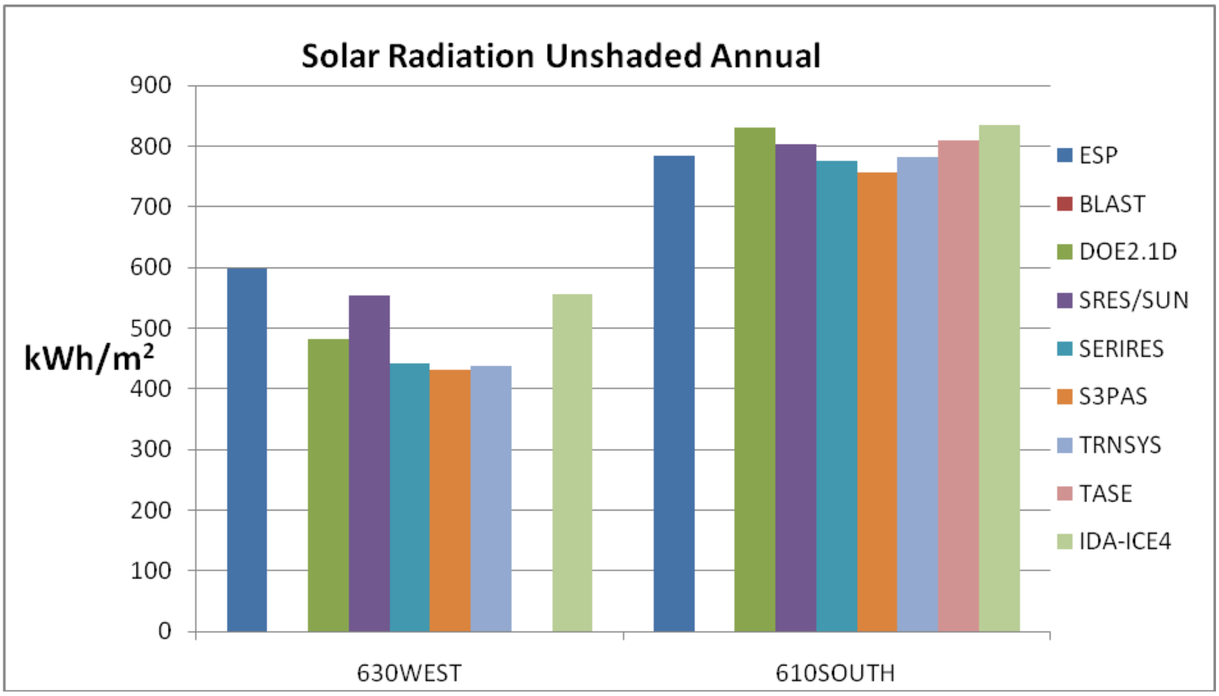


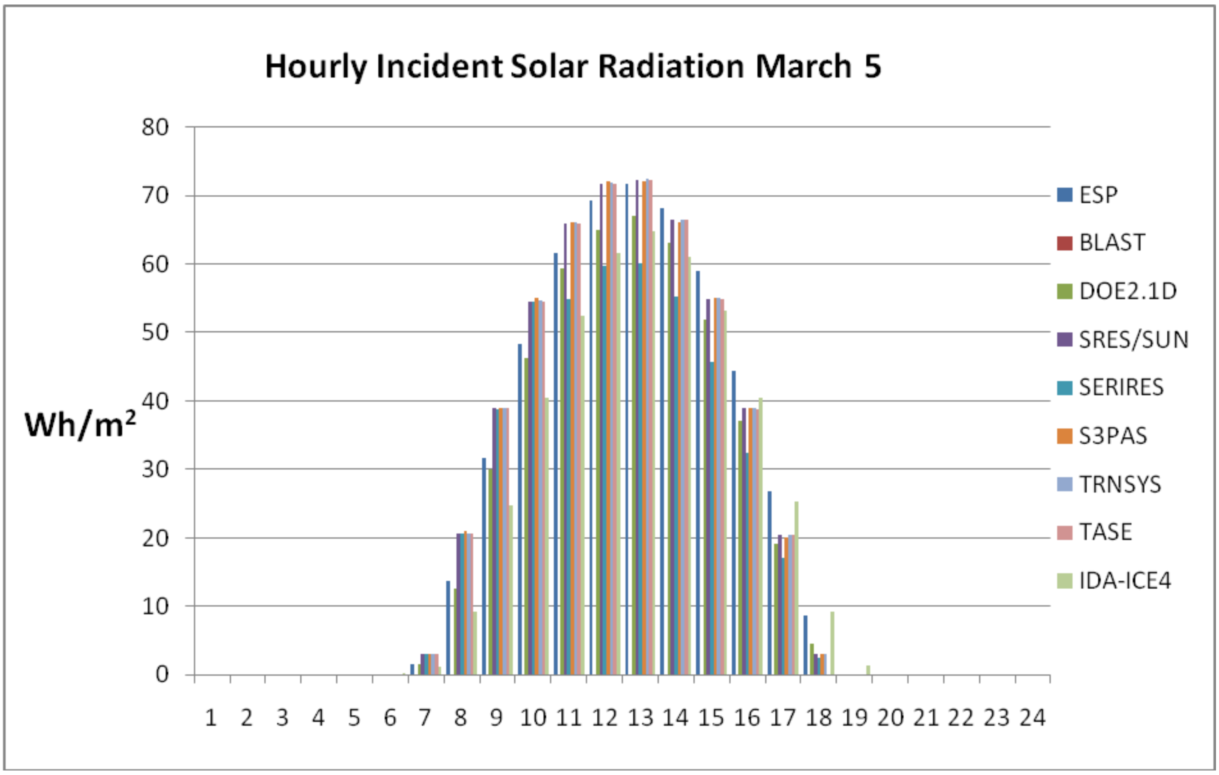


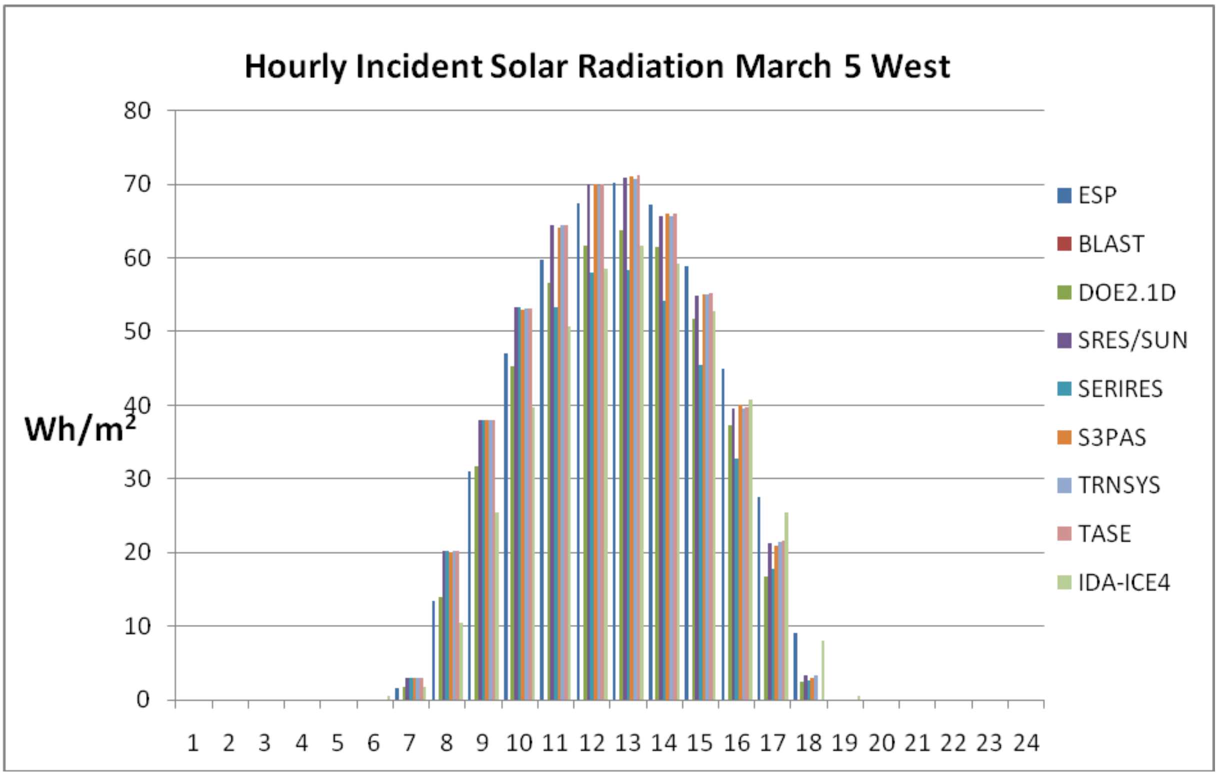
The solar radiation numbers are presented in the diagrams below:

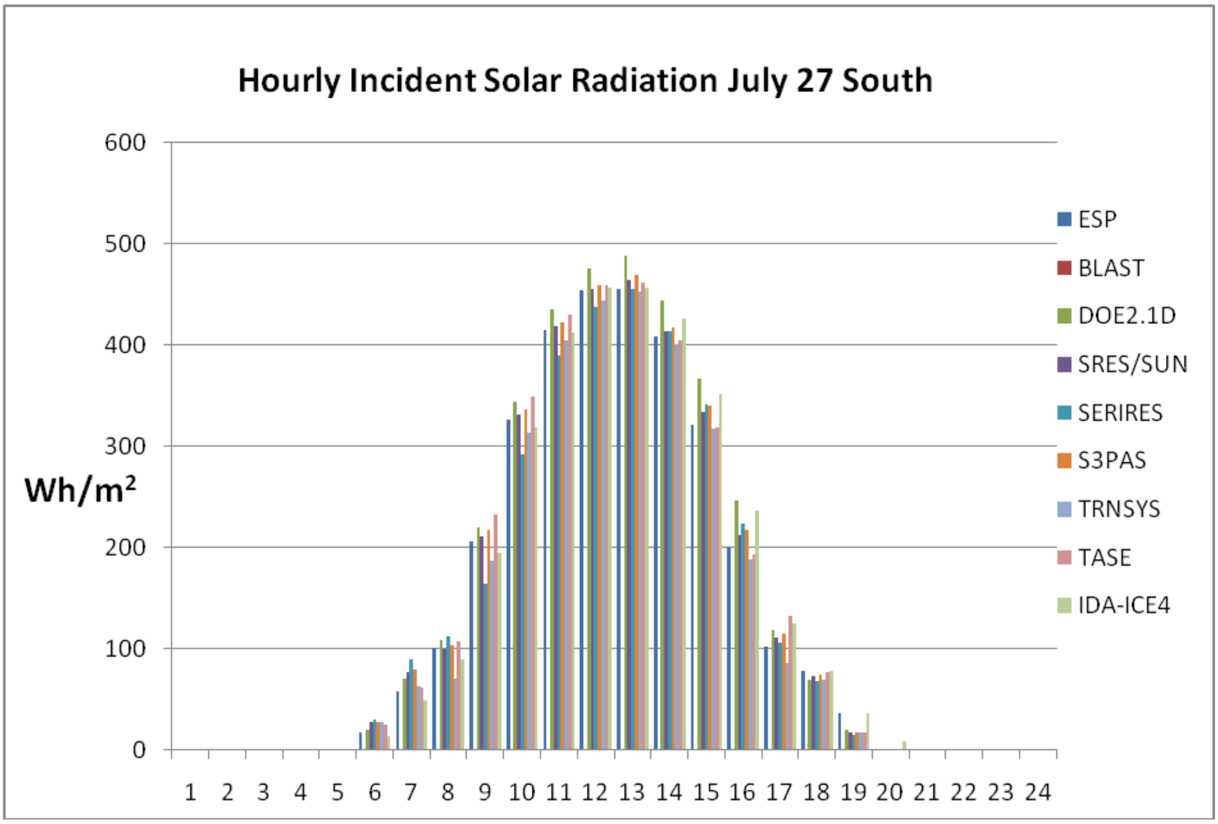

Annual Incident Solar Radiation
kWh/m²
2000
1800
1600
1400
1200
1000
800
600
400
200
0
NORTH
EAST
WEST
SOUTH
HORZ.
ESP
BLAST
DOE2.1D
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4

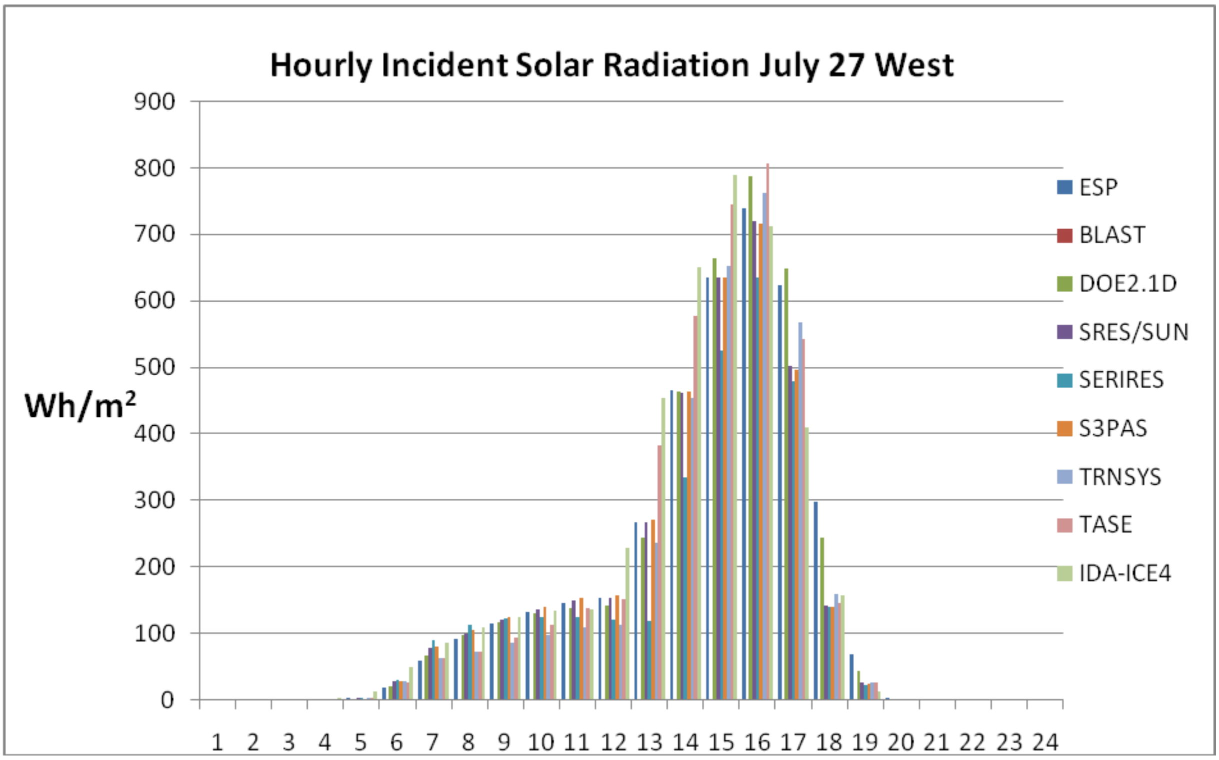

Solar Radiation Unshaded Annual
kWh/m²
1200
1000
800
600
400
200
0
620WEST
600SOUTH
ESP
BLAST
DOE2.1D
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4


Solar Radiation Unshaded Annual
kWh/m²
900
800
700
600
500
400
300
200
100
0
630WEST
610SOUTH
ESP
BLAST
DOE2.1D
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4

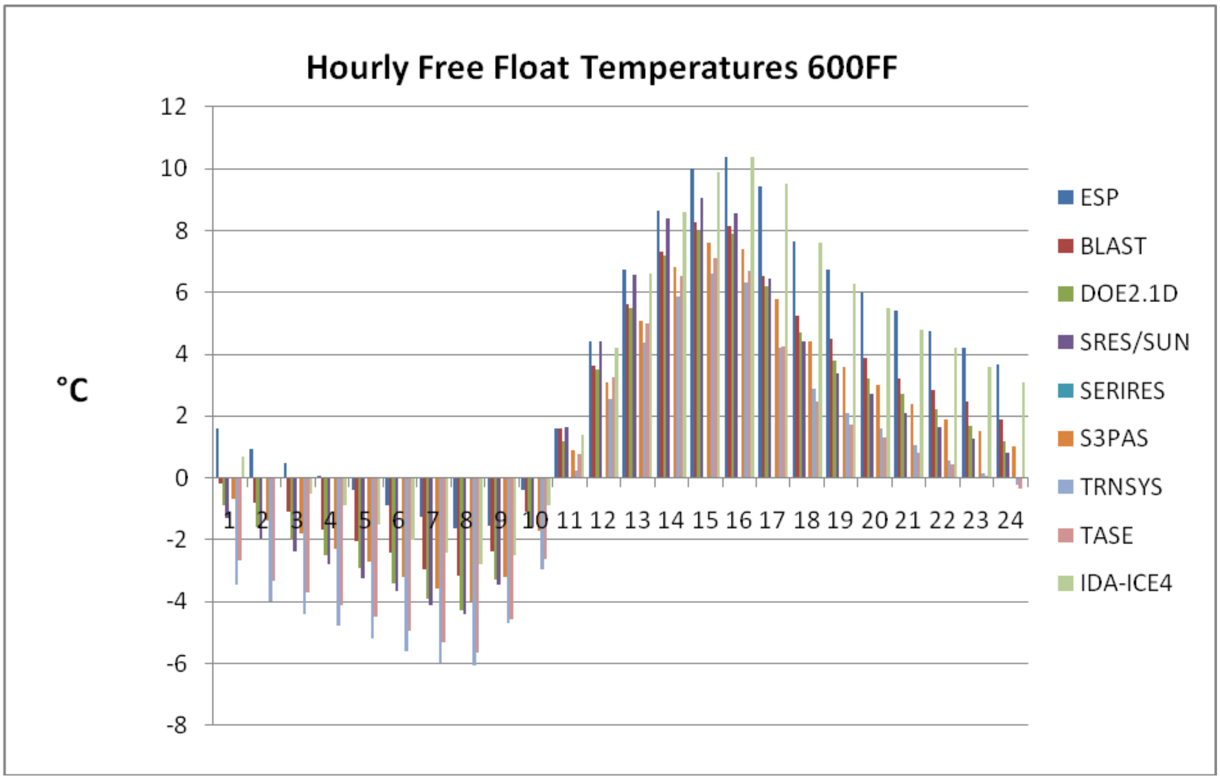

Hourly Incident Solar Radiation March 5
Wh/m²
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ESP
BLAST
DOE2.1D
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4

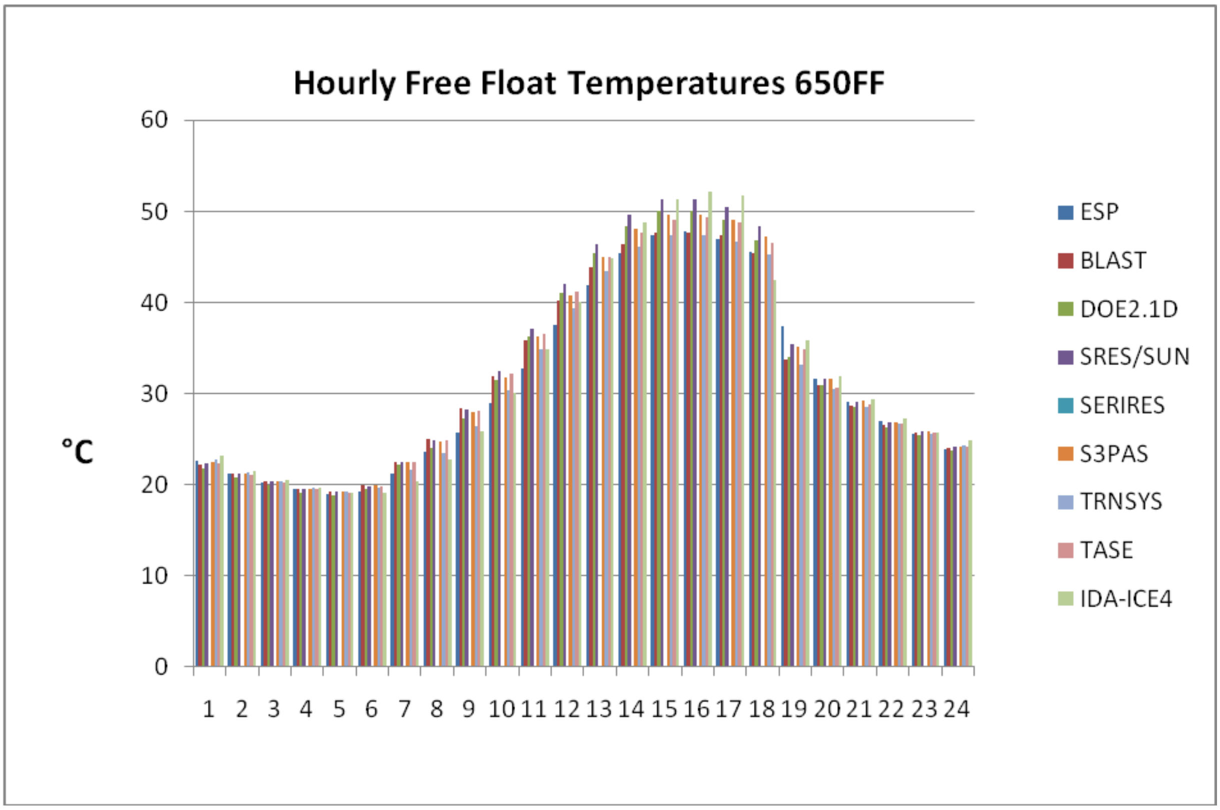

Hourly Incident Solar Radiation March 5 West
Wh/m2
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ESP
BLAST
DOE2.1D
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4

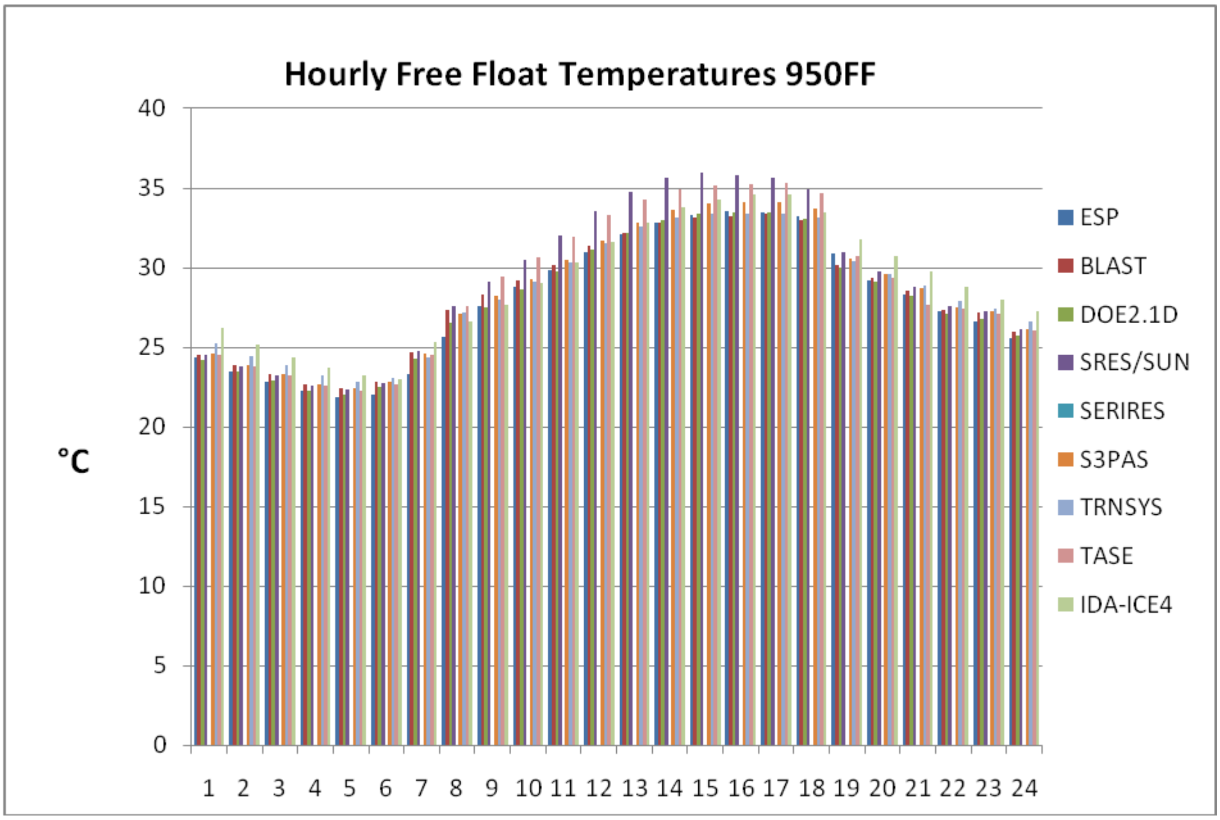

Hourly Incident Solar Radiation July 27 South
Wh/m2
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ESP
BLAST
DOE2.1D
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4

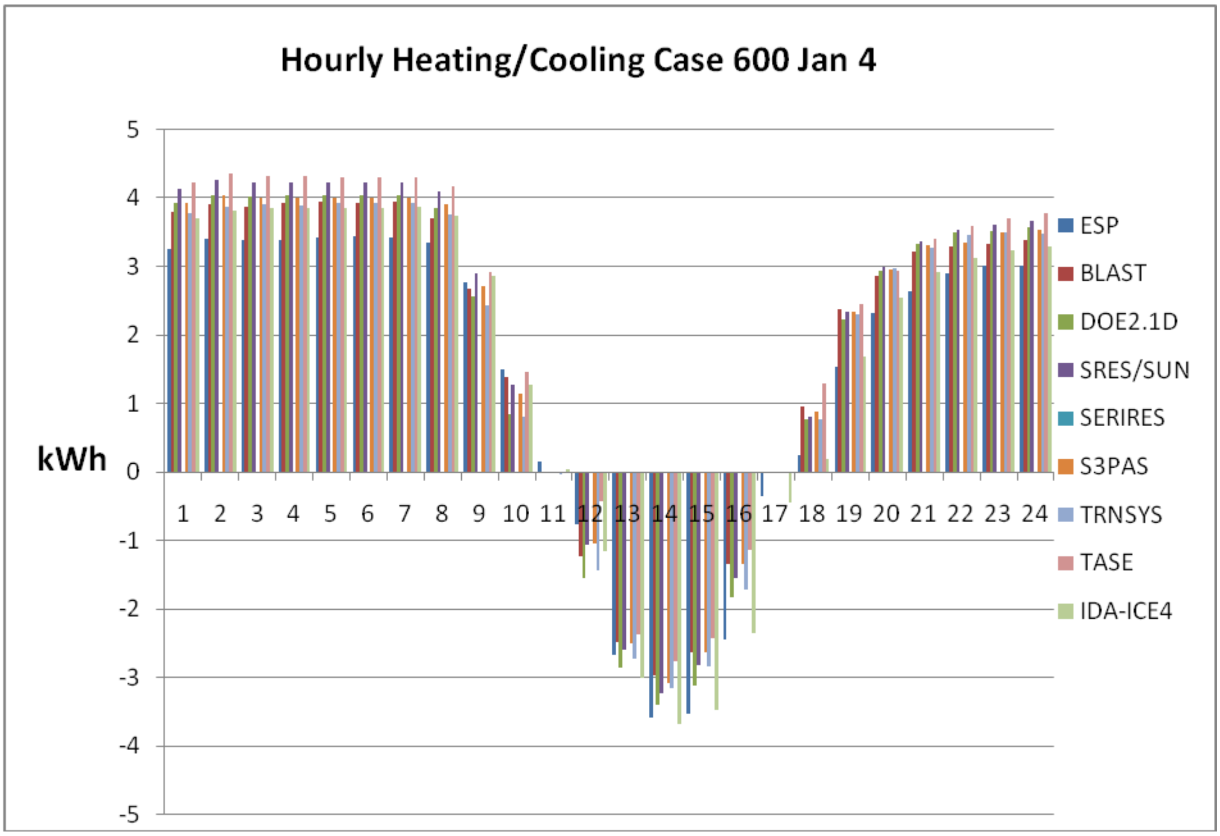


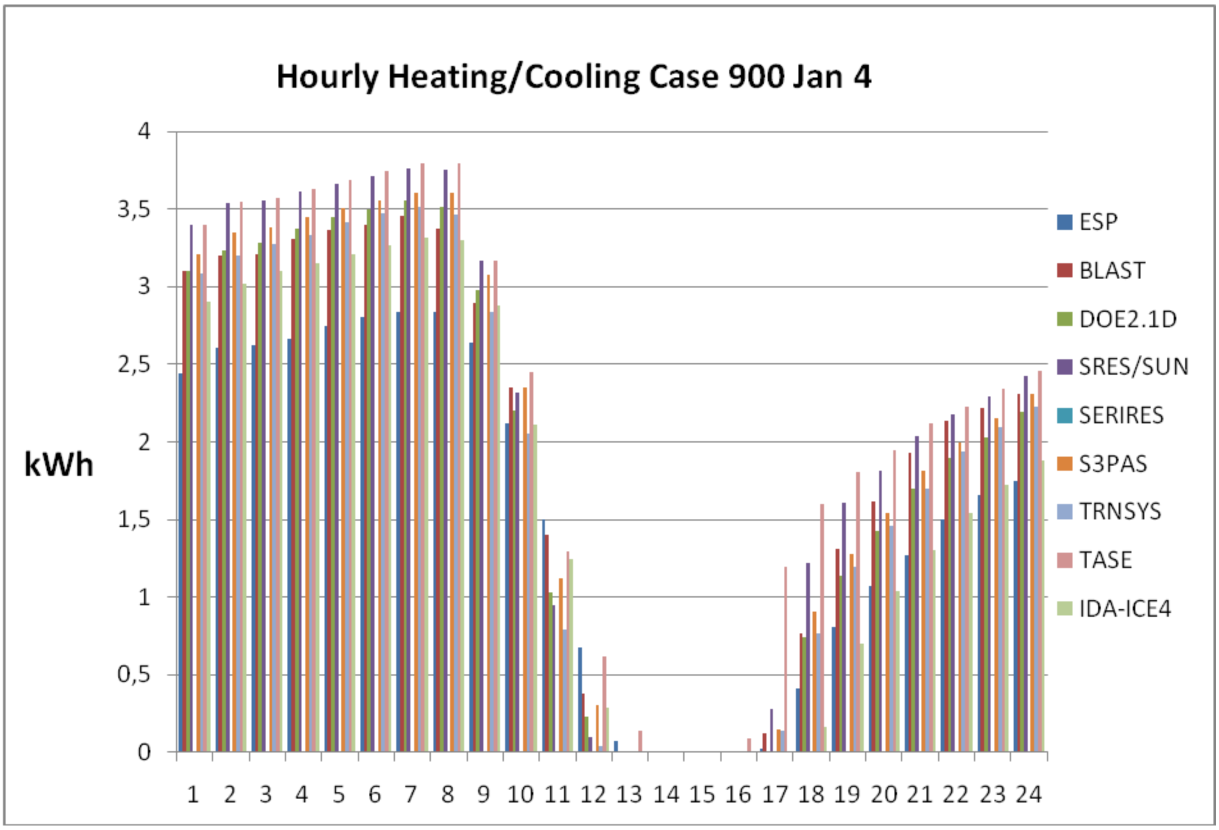
The hourly temperatures/heating/cooling are presented in the diagrams below:

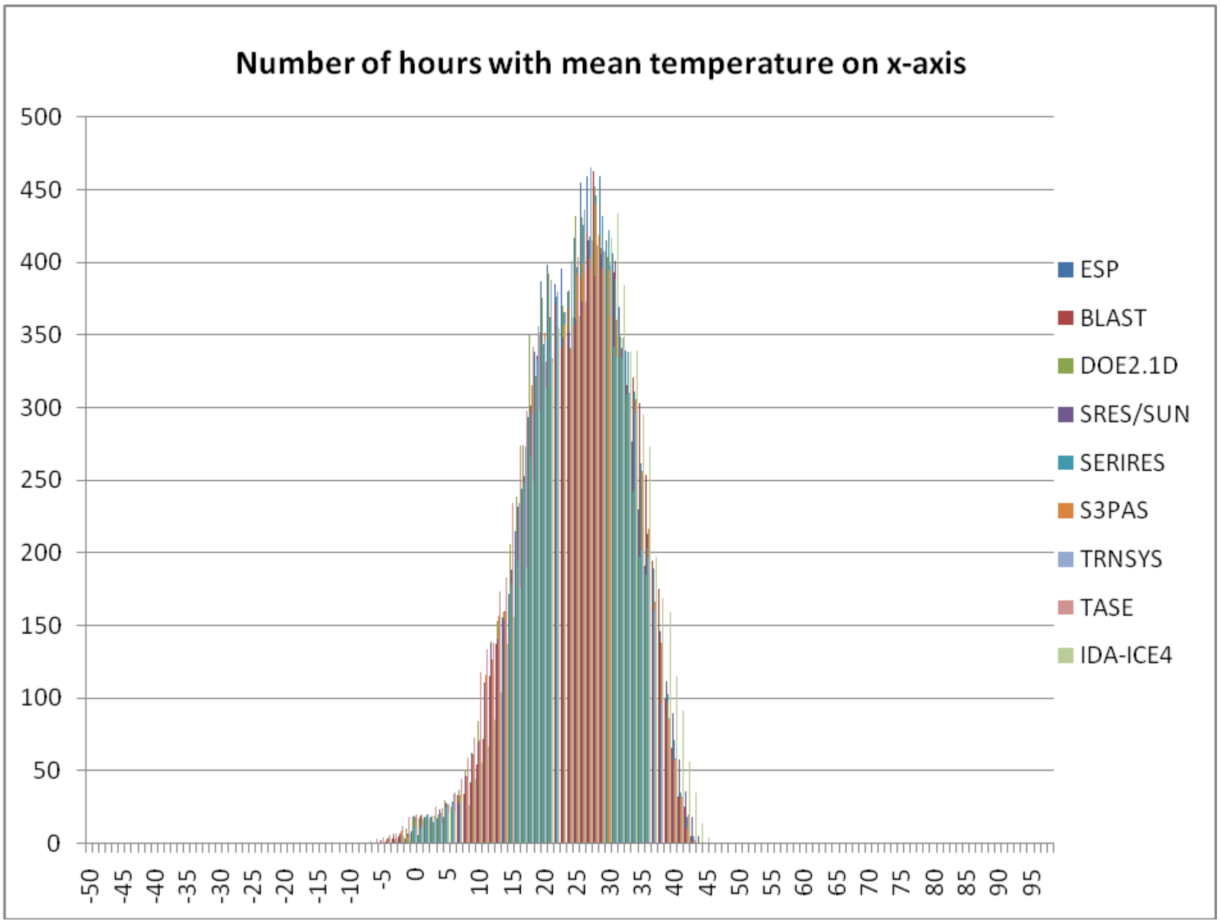



Hourly Free Float Temperatures 650FF
°C
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ESP
BLAST
DOE2.1D
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4


Hourly Free Float Temperatures 950FF
°C
0
5
10
15
20
25
30
35
40
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ESP
BLAST
DOE2.1D
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4


Hourly Heating/Cooling Case 600 Jan 4
kWh
5
4
3
2
1
0
-1
-2
-3
-4
-5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ESP
BLAST
DOE2.1D
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4


Hourly Heating/Cooling Case 900 Jan 4
kWh
4
3,5
3
2,5
2
1,5
1
0,5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ESP
BLAST
DOE2.1D
SRES/SUN
SERIRES
S3PAS
TRNSYS
TASE
IDA-ICE4



Solar radiation annual incident (kWh/m^2)

Surface	ESP	DOE2.1D	SRES/SUN	SERIRES	S3SPAS	TRNSYS	TASE	IDA ICE4
North	427	434	456	407.3	457	367.4	453	429.3
East	959	1155	1083	1217.3	1082	1101	962	1016.9
West	1086	1079	1003	856.5	1002	1012	1090	1206.7
South	1456	1566	1476	1467.7	1474	1522	1468	1551.4
Horiz.	1797	1831	1832	1831.8	1832	1832	1832	1817.1

	ESP	DOE2.1D	SRES/SUN	SERIRES	S3SPAS	TRNSYS	TASE	IDA ICE4
Total	5725	6065	5850	5780.6	5847	5834.4	5805	6021.4
East/West	0.88	1.07	1.08	1.42	1.08	1.09	0.88	0.84

There are remarkable differences between programs for the incident solar radiation, in both total and also the radiation on the East/West surfaces. The differences in total radiation is at most 6% and the East/West ratio vary from 1.42 to 0.84.

2.4 Conclusions

In general, IDA ICE 4 performs well in the test series. No conversion of the weather files from the provided solar time to the standard time used by IDA ICE has been done. The validation exercises of some of the programs have included such conversion. The programs that have East/west solar ratios that are far from unity in the table above, have generally not converted the given solar time data.

3 Space Cooling Equipment Performance Tests

3.1 Test Suite: ANSI/ASHRAE Standard 140-2004 Space Cooling Equipment Performance Tests

Section 5.3 of the ASHRAE standard describes a series of fourteen experiments which each tries to isolate a single factor in the space cooling equipment. The following tests were performed as described in the ASHRAE standard:

- Case CE100 – Base Case Building and Mechanical System
- CaseCE110 – Reduced Outdoor Dry-Bulb
- Case CE120 – Increased Thermostat Set-point
- Case CE130 – Low Part-Load Ratio
- Case CE140 – Reduced Outdoor Dry-Bulb Temperature at Low Part-Load Ratio
- Case CE150 – Latent Load at High Sensible Heat Ratio
- Case CE160 – Increased Thermostat Set-point at High Sensible Heat Ratio
- Case CE165 – Variation of Thermostat Set-point and Outdoor Dry-Bulb Temperature at High Sensible Heat Ratio
- Case CE170 – Reduced Sensible Load
- Case CE180 – Increased Latent Load
- Case CE185 – Increased Outdoor Dry-Bulb Temperature at Low Sensible Heat Ratio
- Case CE190 – Low Part-Load Ratio at Low Sensible Heat Ratio
- Case CE195 – Increased Outdoor Dry-Bulb Temperature at Low Sensible Heat Ratio and Low Part-Load Ratio.
- Case CE200 – Full-Load Test at ARI Conditions

3.1.1 Case CE100 – Base Case Building and Mechanical System

The basic test building is a rectangular 6 x 8 meters single zone with no internal partitions or widows. The building is set up as a near adiabatic cell, with heavy insulating materials in all surfaces. For more information about the building materials, see Section 5.3.1 in the Standard 140-2004.

Mechanical System: The mechanical system is a vapor compression cooling system, using a split air-conditioning system consisting of an air-cooled condensing unit and an indoor evaporator coil, as specified in Section 5.3.1.10.

3.2 Modeler Report

3.2.1 IDA modeling approach

The most straightforward approach to the modeling of the air conditioner is to use a table lookup procedure, where the actual performance of the device is found by interpolation (and extrapolation) in the given performance map. It is likely that all other reported results have been obtained in this way since they show such small deviations.

We have instead chosen to identify (automatically adapt) the parameters of a physical model to the given performance data. In the given performance points, the adapted model differ on average by about a percent from the given data. The implemented model utilizes wet and dry heat exchanger models from the ASHRAE Secondary Toolkit in combination with an IDA-specific semi-empirical model for the actual vapor compression cycle.

The main advantages of the chosen approach in comparison to table lookup are the following:

- It is possible to use the selected modeling approach to physical devices where only a single or a much smaller number of performance points are known. This is a common practical dilemma, especially for small devices.
- The model will respond in a realistic way to changes in mass flow on both the condenser and evaporator sides. This feature is not exhibited in the given test series, where all flows are kept constant, but makes the model much more versatile.
- The model will respond in a more realistic way to conditions outside of the given performance map.
- It is possible to estimate the impact of changing physical parameters, e.g. heat exchanger areas.

3.2.2 Important parameters in IDA ICE and deviations from the problem formulations

A minor bug where the sensible part of the water vapor enthalpy was not correctly calculated was found. This was rectified by a small correction in the sensible loads. The bug has no impact in practical situations and will be fixed in the near future.

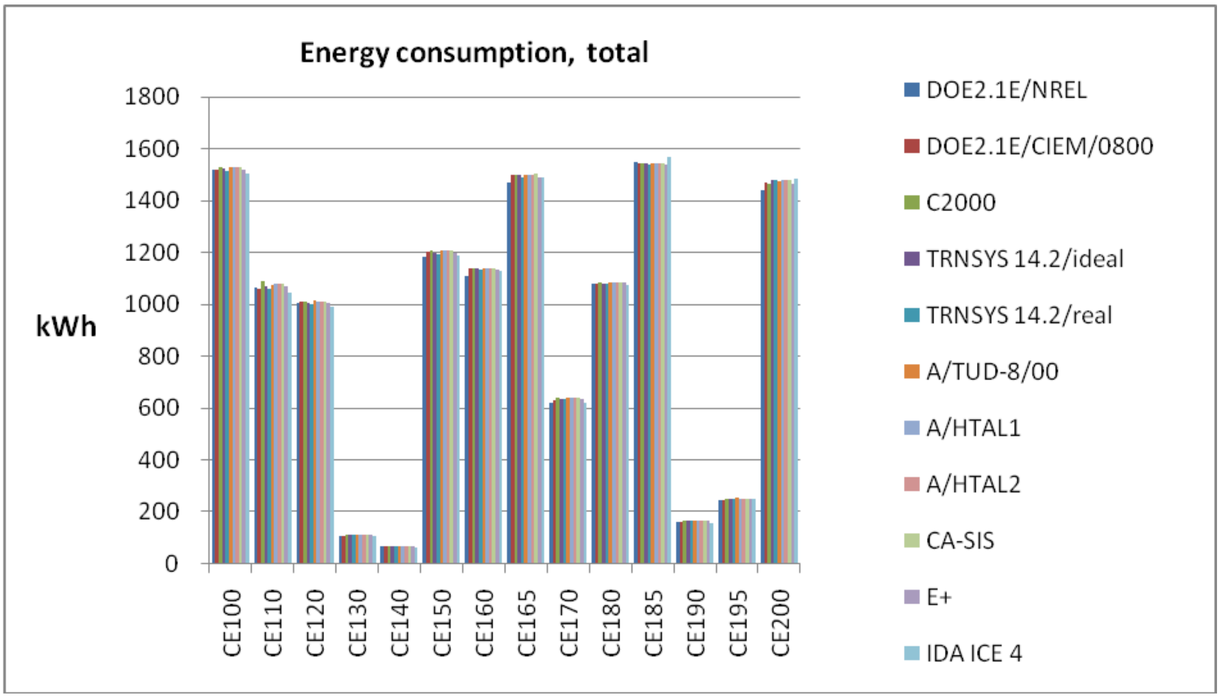
3.3 Results and Discussion

The results for the test cases are presented in the tables and diagrams below:

Energy Consumption, total (kWh)

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	1519	1061	1003	105	65	1183	1107
Max	1531	1089	1013	111	69	1208	1140
IDA ICE	1504	1045	990	105	63	1187	1126

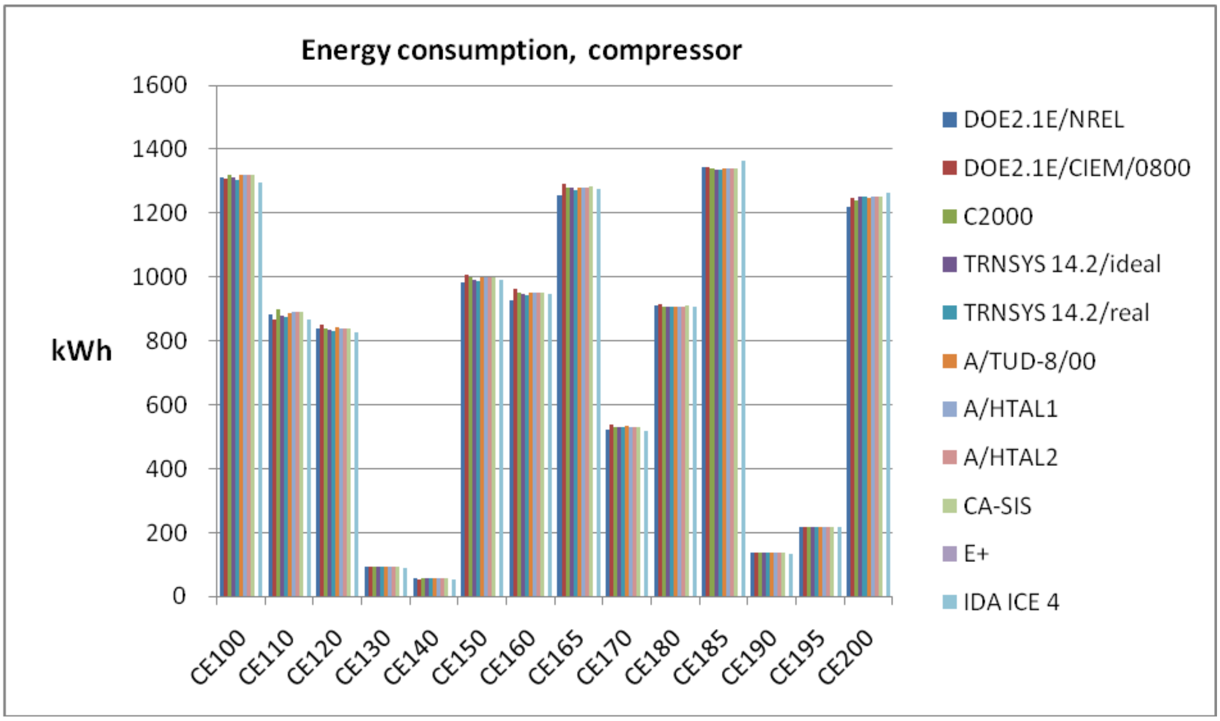
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	1470	620	1077	1538	160	245	1440
Max	1502	641	1083	1547	165	252	1480
IDA ICE	1490	618	1075	1568	158	251	1484



Energy Consumption, compressor (kWh)

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	1303	866	832	93	55	982	926
Max	1319	899	850	95	57	1007	963
IDA ICE	1295	868	826	90	52	991	945

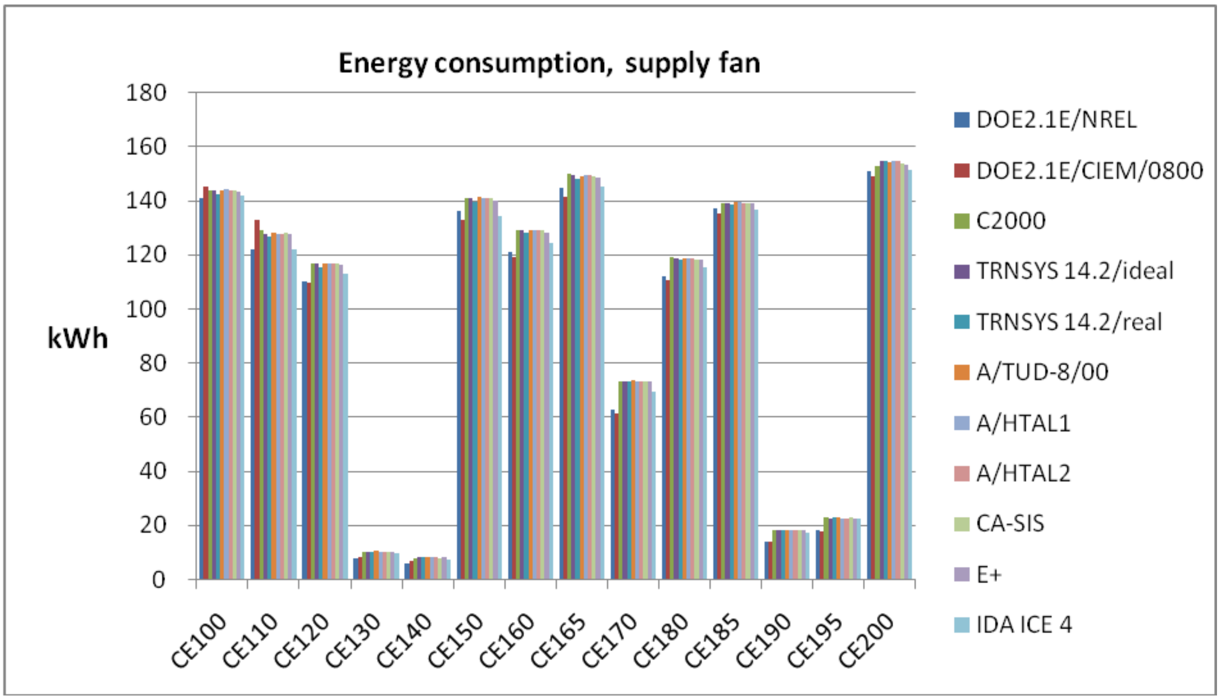
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	1256	523	906	1334	138	216	1218
Max	1291	539	914	1344	139	219	1253
IDA ICE	1276	517	907	1365	132	217	1263



Energy Consumption, Supply fan (kWh)

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	141	122	110	8	6	133	119
Max	145	133	117	10	8	141	129
IDA ICE	142	122	113	10	7	134	124

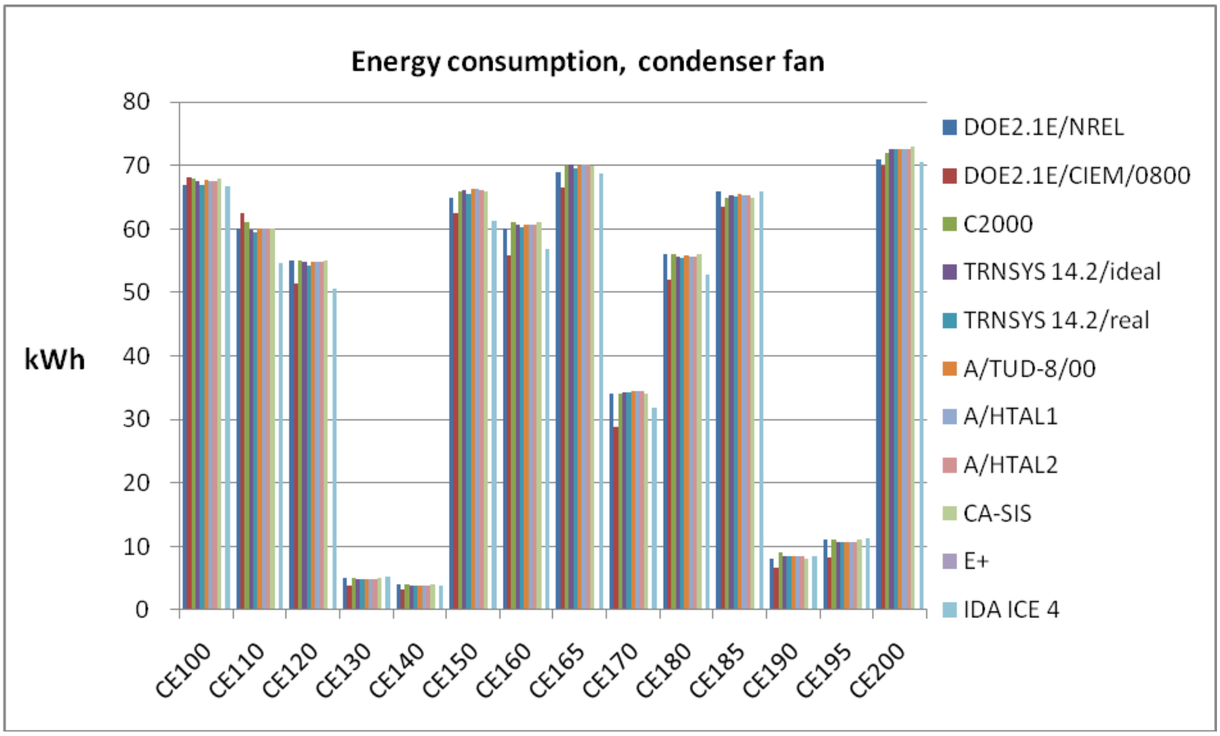
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	142	61	111	135	14	18	149
Max	150	74	119	139	18	23	155
IDA ICE	145	69	115	137	17	22	151



Energy Consumption, Condenser fan (kWh)

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	67	59	51	4	3	62	56
Max	68	62	55	5	4	66	61
IDA ICE	67	55	51	5	4	61	57

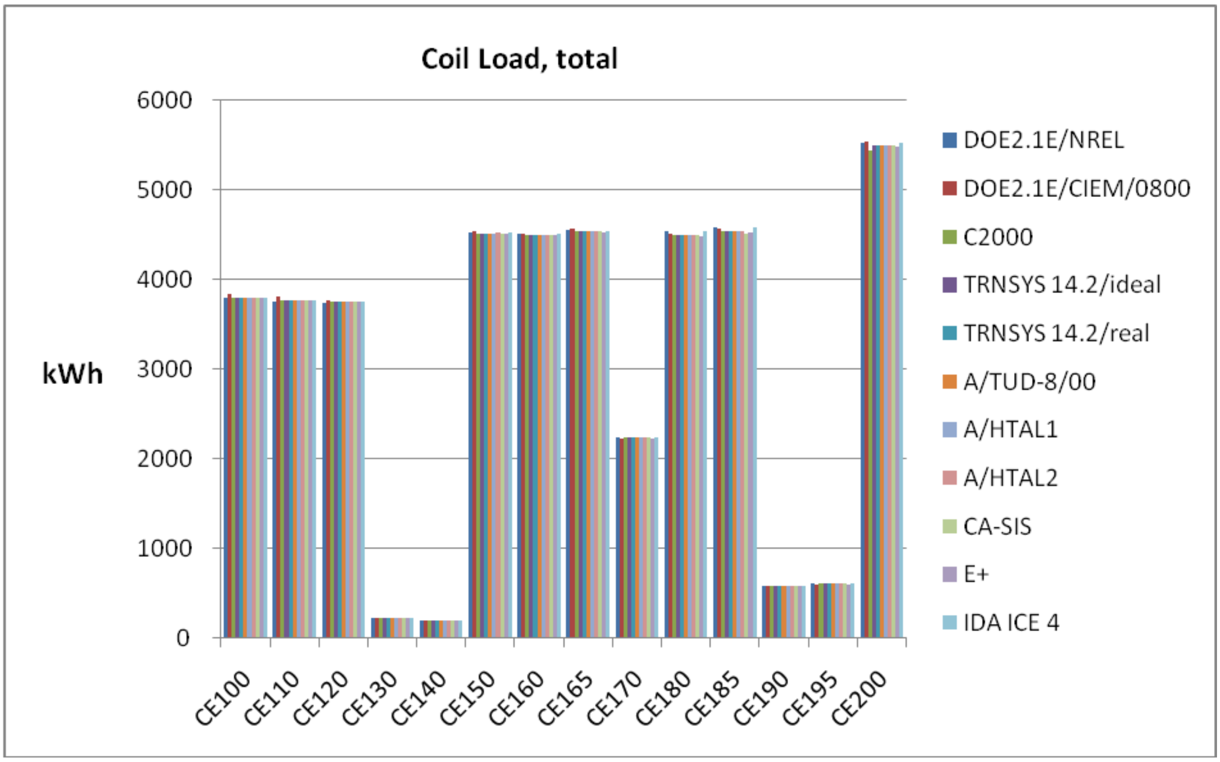
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	67	29	52	63	7	8	70
Max	70	35	56	66	9	11	73
IDA ICE	69	32	53	66	8	11	70



Coil Load, total (kWh)

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	3794	3756	3739	215	195	4509	4491
Max	3841	3804	3763	220	199	4543	4516
IDA ICE	3798	3761	3746	218	198	4524	4509

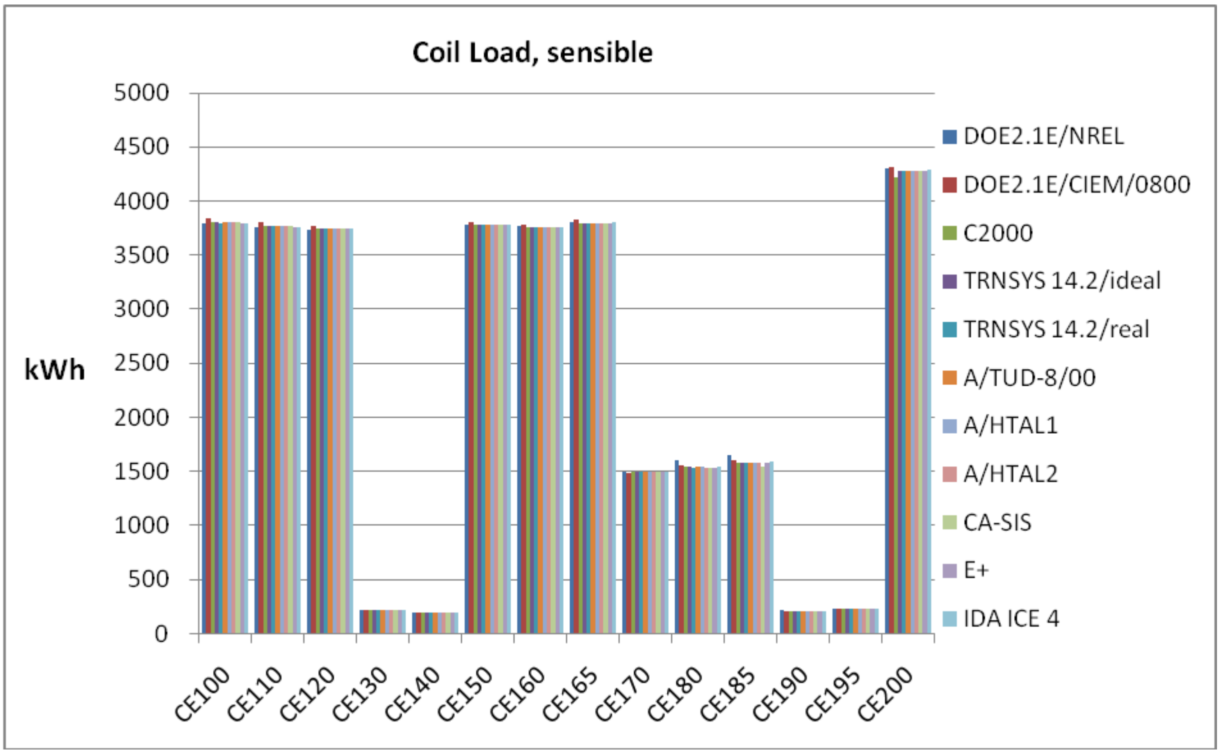
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	4529	2225	4481	4507	573	595	5436
Max	4567	2237	4535	4583	579	602	5534
IDA ICE	4545	2240	4540	4579	583	605	5520



Coil Load, Sensible (kWh)

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	3794	3756	3739	215	195	3776	3759
Max	3841	3804	3763	220	199	3804	3777
IDA ICE	3798	3761	3746	218	198	3779	3762

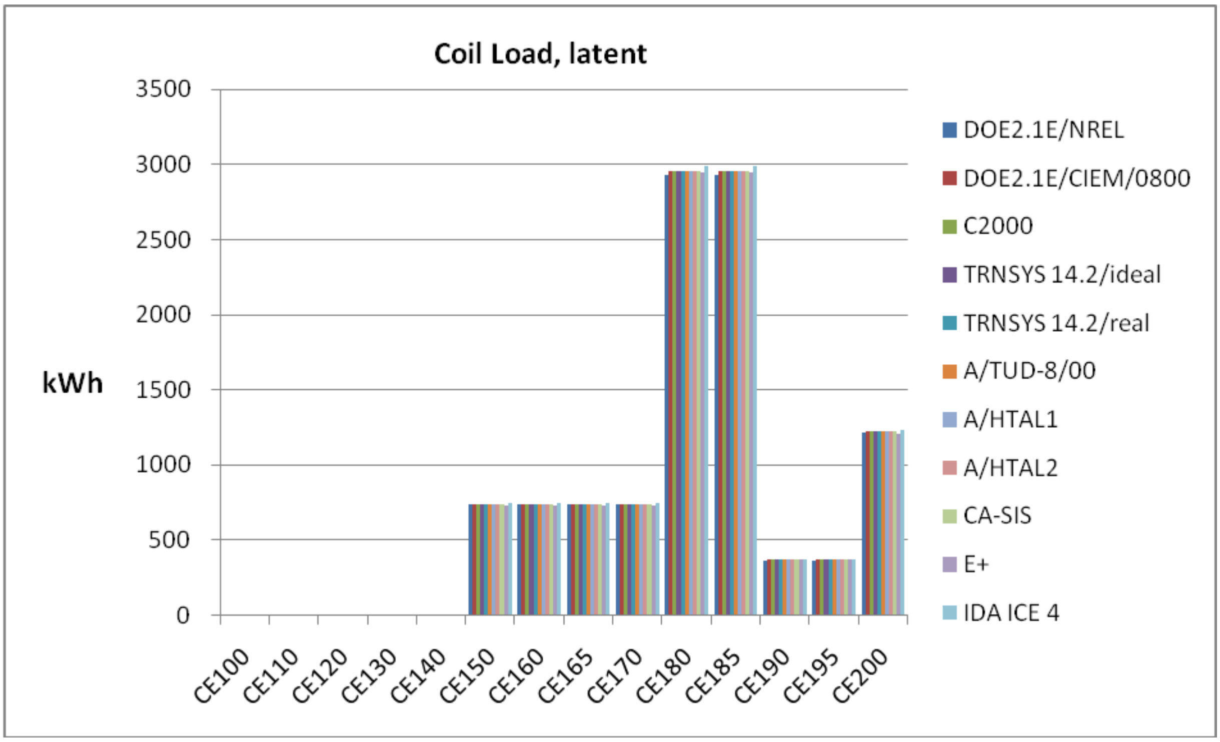
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	3795	1487	1537	1548	203	226	4215
Max	3828	1498	1607	1653	212	235	4313
IDA ICE	3799	1494	1549	1587	208	231	4287



Coil Load, Latent (kWh)

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	0	0	0	0	0	733	732
Max	0	0	0	0	0	742	740
IDA ICE	0	0	0	0	0	745	747

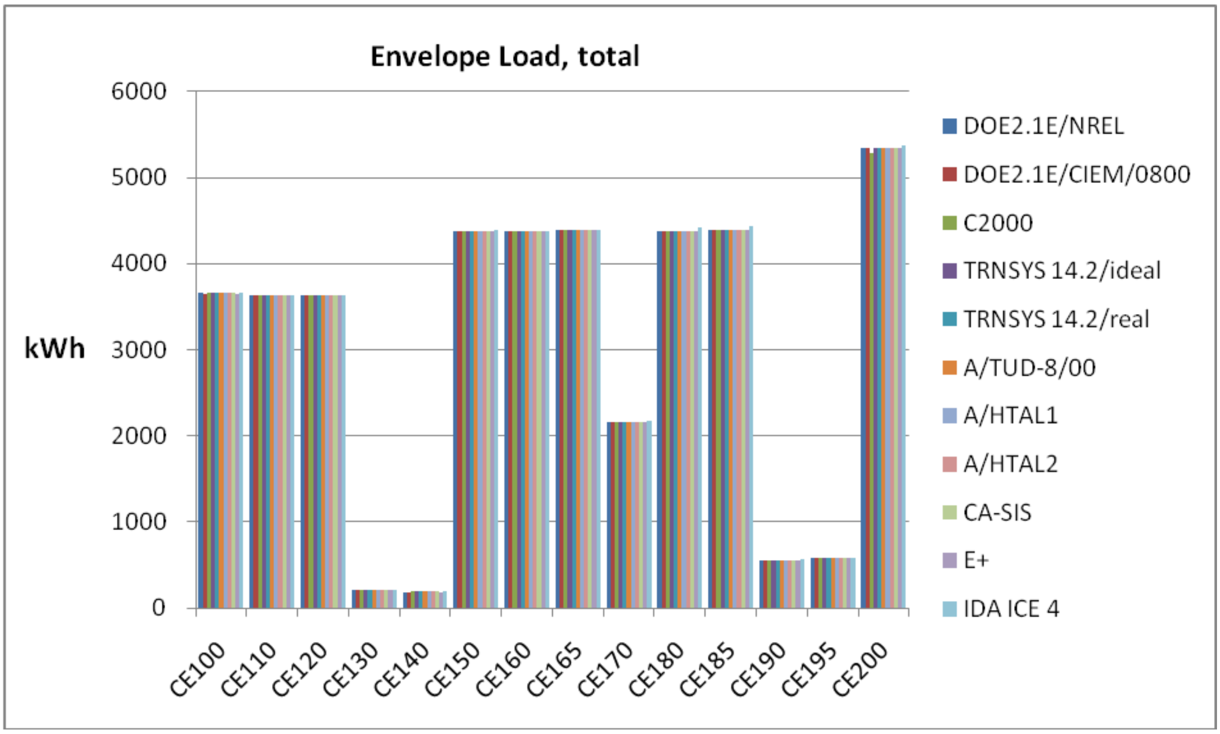
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	733	734	2928	2930	366	367	1210
Max	740	740	2958	2959	370	370	1222
IDA ICE	746	746	2991	2993	374	375	1234



Envelope Load, total (kWh)

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	3654	3636	3630	207	188	4375	4370
Max	3656	3637	3632	209	190	4376	4371
IDA ICE	3656	3638	3633	208	191	4388	4382

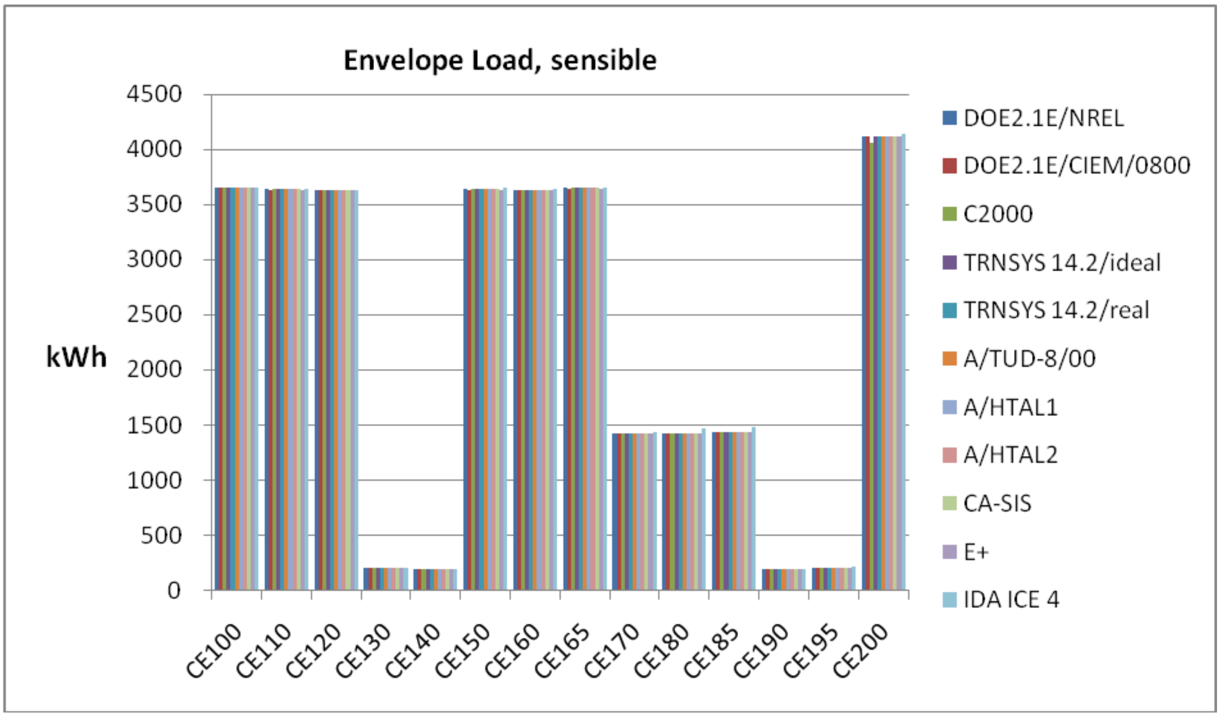
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	4386	2157	4375	4393	557	576	5283
Max	4388	2159	4376	4396	559	579	5343
IDA ICE	4398	2170	4422	4440	565	582	5366



Envelope Load, Sensible (kWh)

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	3654	3636	3630	207	188	3636	3630
Max	3656	3637	3632	209	190	3637	3632
IDA ICE	3656	3638	3633	208	191	3648	3643

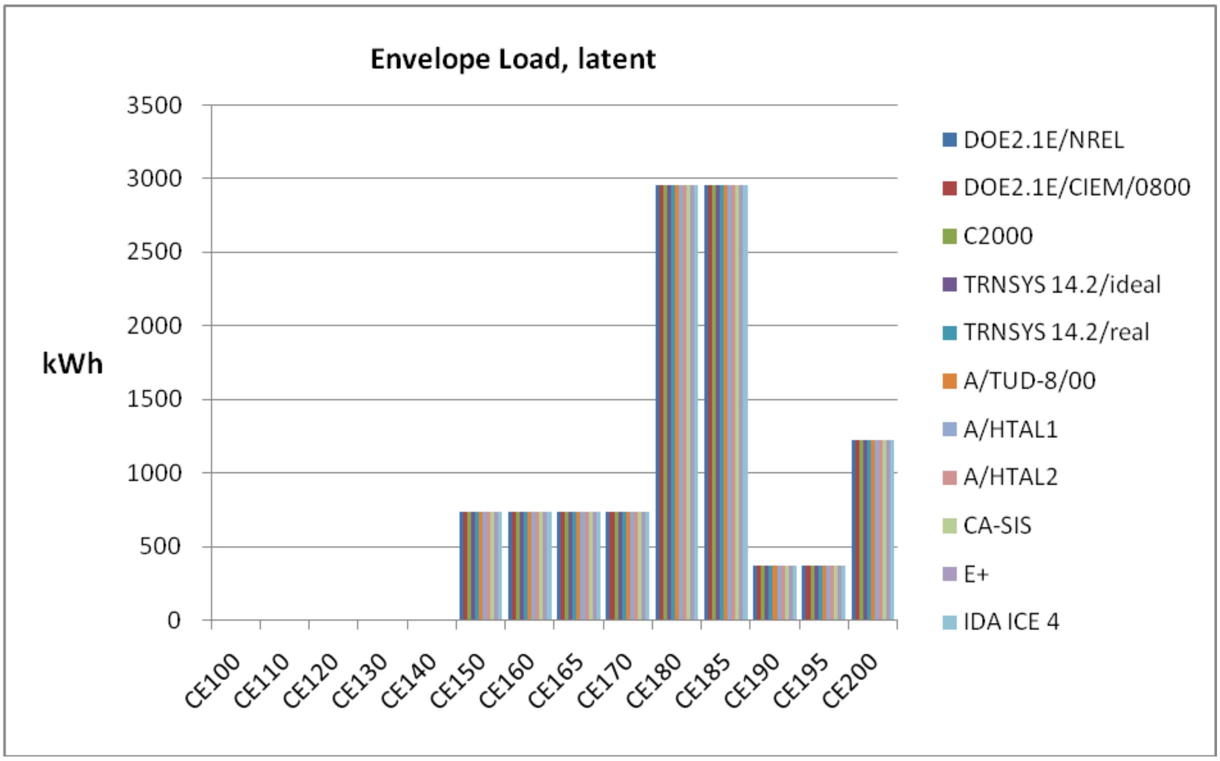
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	3647	1418	1418	1437	188	207	4062
Max	3649	1420	1420	1439	190	209	4122
IDA ICE	3658	1431	1466	1483	195	213	4145



Envelope Load, Latent (kWh)

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	0	0	0	0	0	739	739
Max	0	0	0	0	0	739	739
IDA ICE	0	0	0	0	0	740	740

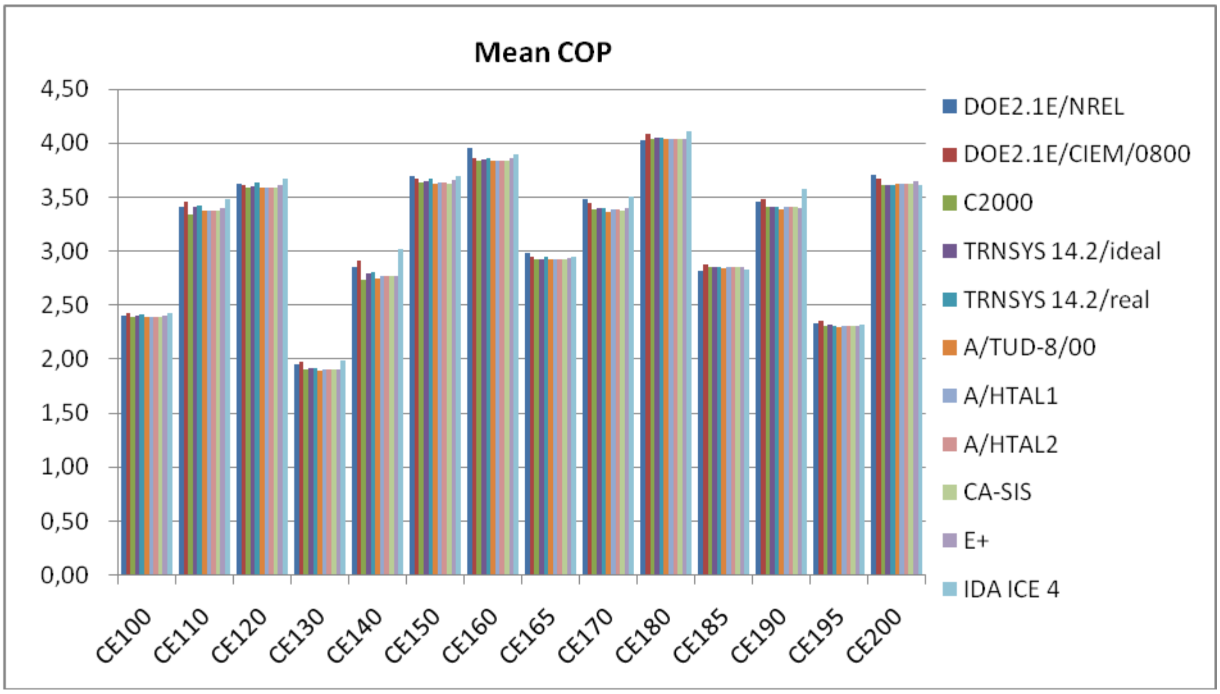
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	739	739	2957	2957	367	367	1221
Max	739	739	2958	2958	370	370	1221
IDA ICE	740	740	2956	2956	370	370	1221



Mean COP

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	2.39	3.34	3.59	1.89	2.73	3.62	3.83
Max	2.43	3.46	3.63	1.98	2.92	3.70	3.95
IDA ICE	2.43	3.48	3.67	1.99	3.01	3.70	3.89

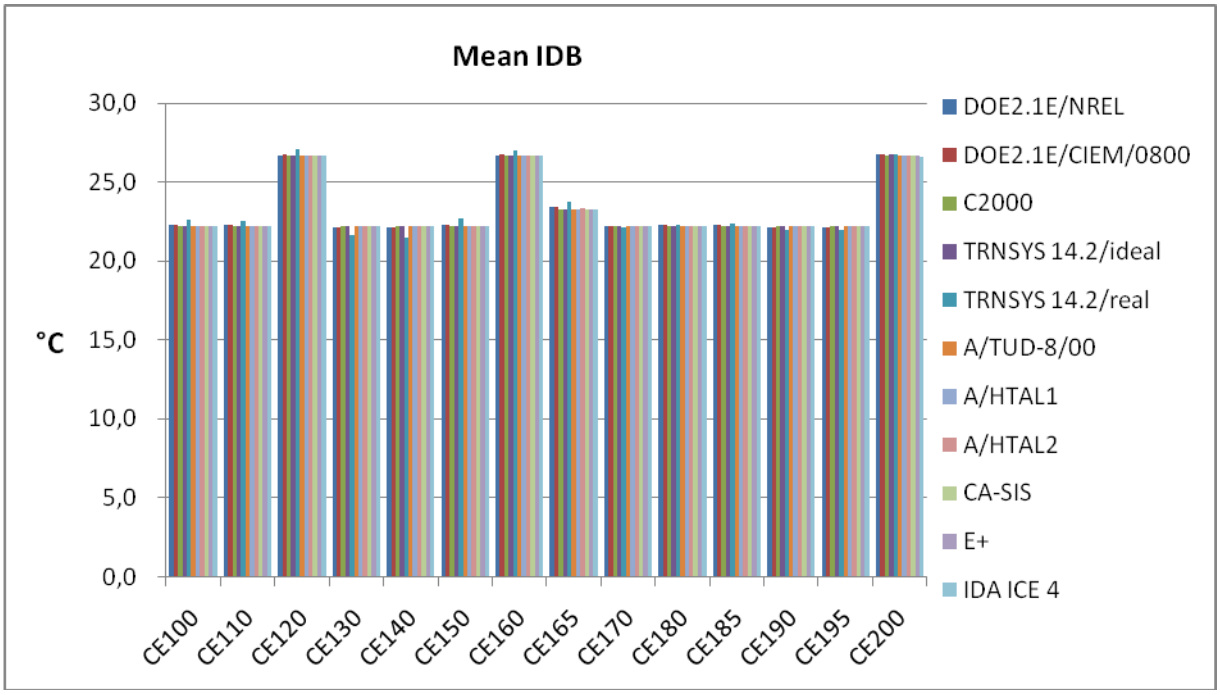
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	2.92	3.37	4.03	2.82	3.39	2.29	3.61
Max	2.99	3.48	4.08	2.87	3.49	2.36	3.71
IDA ICE	2.95	3.51	4.11	2.83	3.58	2.32	3.62



Mean IDB (°C)

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	22.2	22.2	26.7	21.6	21.5	22.2	26.7
Max	22.6	22.5	27.1	22.2	22.2	22.7	27.0
IDA ICE	22.2	22.2	26.7	22.2	22.2	22.2	26.7

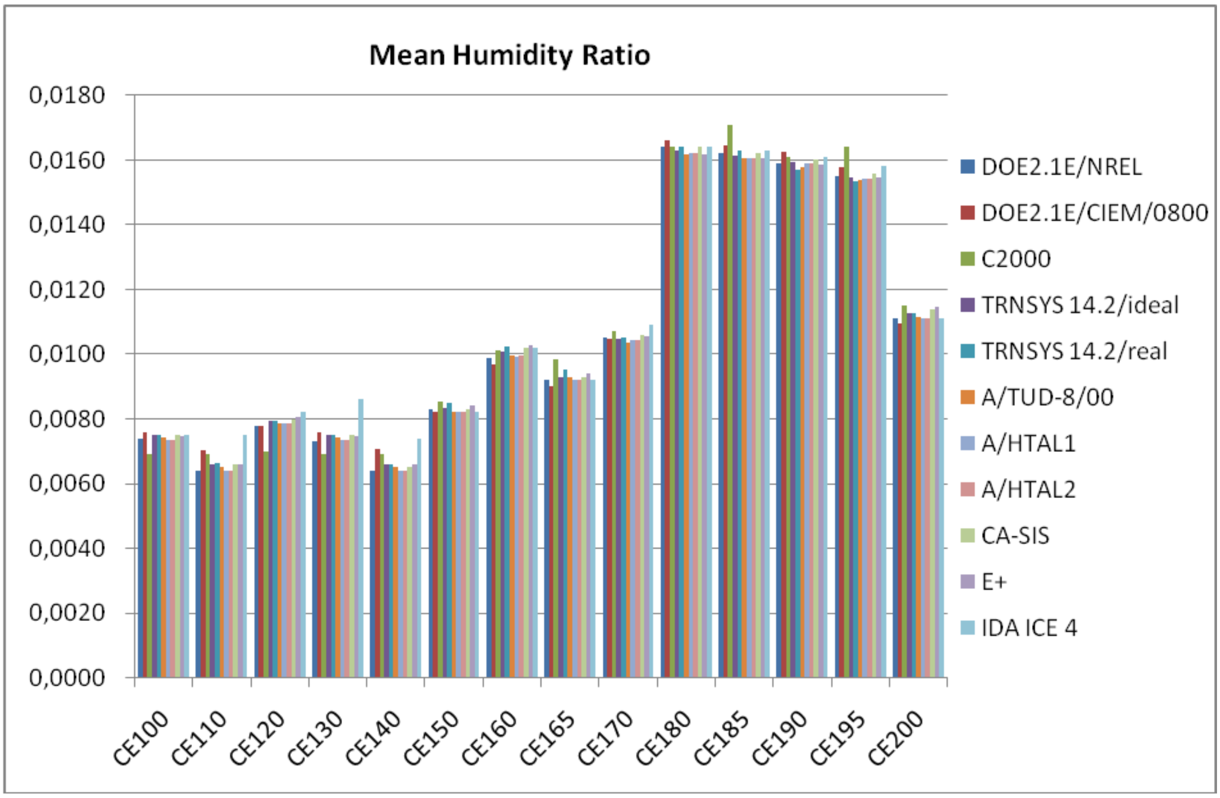
Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	23.3	22.1	22.2	22.2	21.9	22.0	26.72
Max	23.8	22.2	22.3	22.4	22.2	22.2	26.8
IDA ICE	23.3	22.2	22.2	22.2	22.2	22.2	26.6



Mean Humidity Ratio

Case	CE100	CE110	CE120	CE130	CE140	CE150	CE160
Min	0.0069	0.0064	0.0070	0.0069	0.0064	0.0082	0.0097
Max	0.0076	0.0070	0.0080	0.0076	0.0071	0.0085	0.0103
IDA ICE	0.0075	0.0075	0.0082	0.0086	0.0074	0.0082	0.0102

Case	CE165	CE170	CE180	CE185	CE190	CE195	CE200
Min	0.0090	0.0104	0.0162	0.0161	0.0157	0.0153	0.0109
Max	0.0099	0.0107	0.0166	0.0171	0.0163	0.0164	0.0115
IDA ICE	0.0092	0.0109	0.0164	0.0163	0.0161	0.0158	0.0111



Max and mean Humidity ratio, IDB and COP are the same as the mean values for IDA ICE and many other programs, and are therefore not shown here.

As a general comment, results are in rather good agreement with both analytical/semi-analytical results and with other simulated results.

3.4 Conclusions

In general, IDA ICE 4 performs well in the test series.

5 Conclusions

In all cases, IDA ICE performs on a similar level as analytical/semi-analytical models and as other software programs.