

HEED Validated Against the ASHRAE/BESTEST Standard 140

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The current release of HEED 4.0 (Build 16, Aug 11, 2011) was validated using ASHRAE Standard 140, 2007. It consists of 34 different building design cases that were originally run using seven different building energy performance programs including DOE-2 and ESP. These same cases were also run using EnergyPlus, and the results were published separately.

The acceptance criteria defined for HERS BESTEST were used to calculate if the HEED results fell within an acceptable range. The aggregated calculations for the seven programs included with ASHRAE 140-2007 were used as reference results. The maximum of the acceptable range is the greater of the (maximum reference result + 4 MBtu) and the upper 90% confidence interval based on the sample of reference results. The minimum of the acceptable range is the lesser of the (minimum reference result - 4 MBtu) and the lower 90% confidence interval based on the sample of reference results. This methodology was used to establish acceptable validation ranges for both the annual heating and annual cooling results, as well as the delta tests results. No formal criteria are set by ASHRAE Standard 140-2007 to determine a range of acceptable results (ANSI/ASHRAE 2007, Section 4.4.1) so the HERS-Bestest criteria was used as described above (HERS BESTEST 1995, Appendix H).

Six of the cases could not be run using HEED (195, 200, 210, 280, 440, and 810) because HEED does not provide for modification of the interior infrared emittance or interior shortwave absorption. Another case (215) could also not be run because HEED does not provide for modification of the exterior combined radiative and convective surface coefficients for the special case of opaque windows. All (100%) of the cases that HEED ran fell within the acceptance range for both heating and cooling. All results are included in Table 1, and in Figure 1 and Figure 2.

Delta tests can also be used to evaluate whether or not differences in annual heating or cooling levels are acceptable. The delta tests isolate the effects of the changes made between cases. Of the delta cases that HEED ran 97% fell within the acceptance range for both heating and cooling. All results are included in Table 3, and in Figure 3 and Figure 4.

References:

- ANSI/ASHRAE 2007. Standard 140-2007, *Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs*, American Society of Heating, Refrigerating, and Air-Conditioning Engineers. Atlanta, GA.
- EnergyPlus2010. *EnergyPlus Testing with Building Thermal Envelope and Fabric Load Tests from ANSI/ASHRAE Standard 140-2007*. U.S. Department of Energy, Energy Efficiency and Renewable Energy, Office of Building Technologies.
- HERS BESTEST 1995. *Home Energy Rating System Building Energy Simulation Test*. National Renewable Energy Laboratory. Golden, CO. November 1995.

Figure 1.

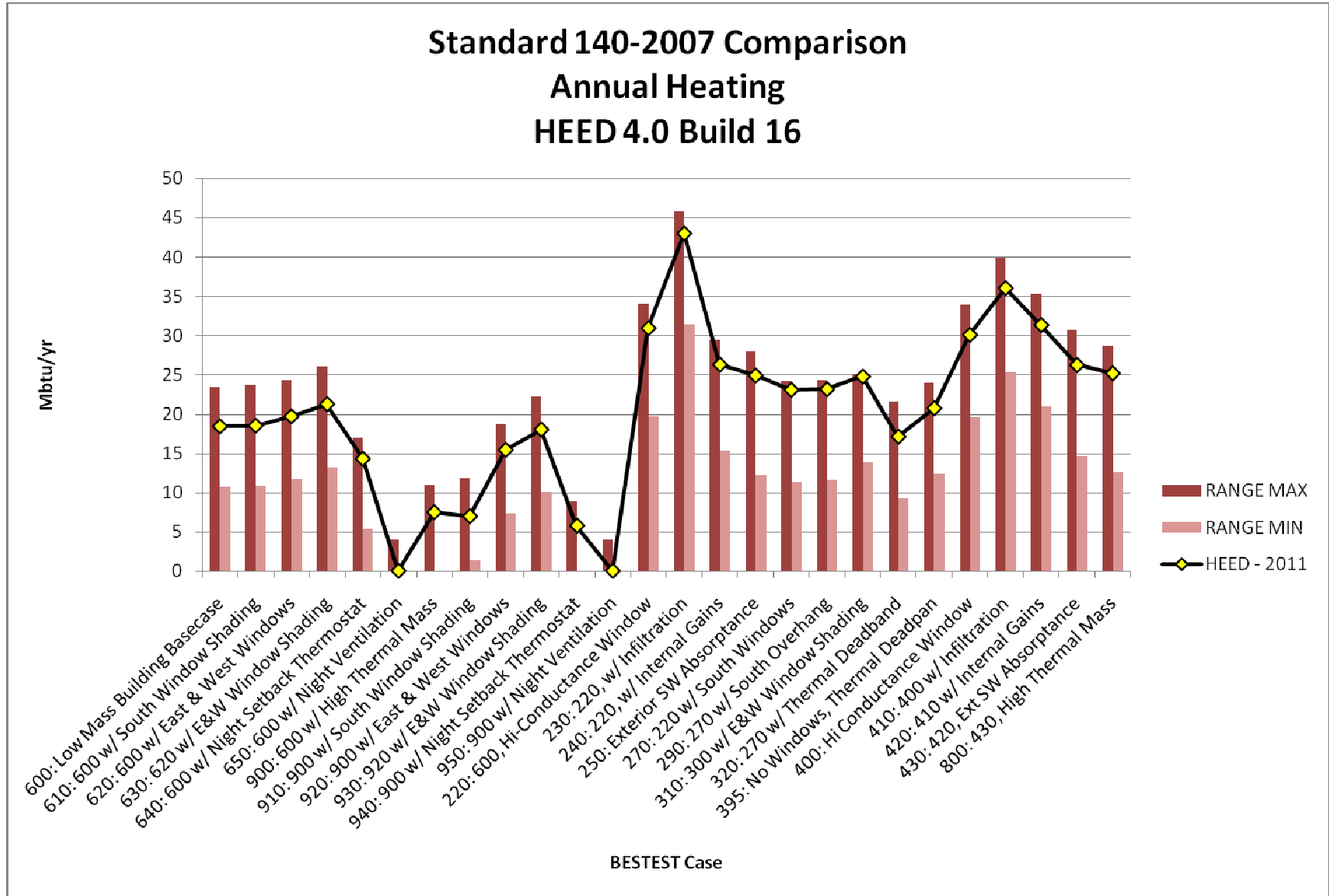


Figure 2.

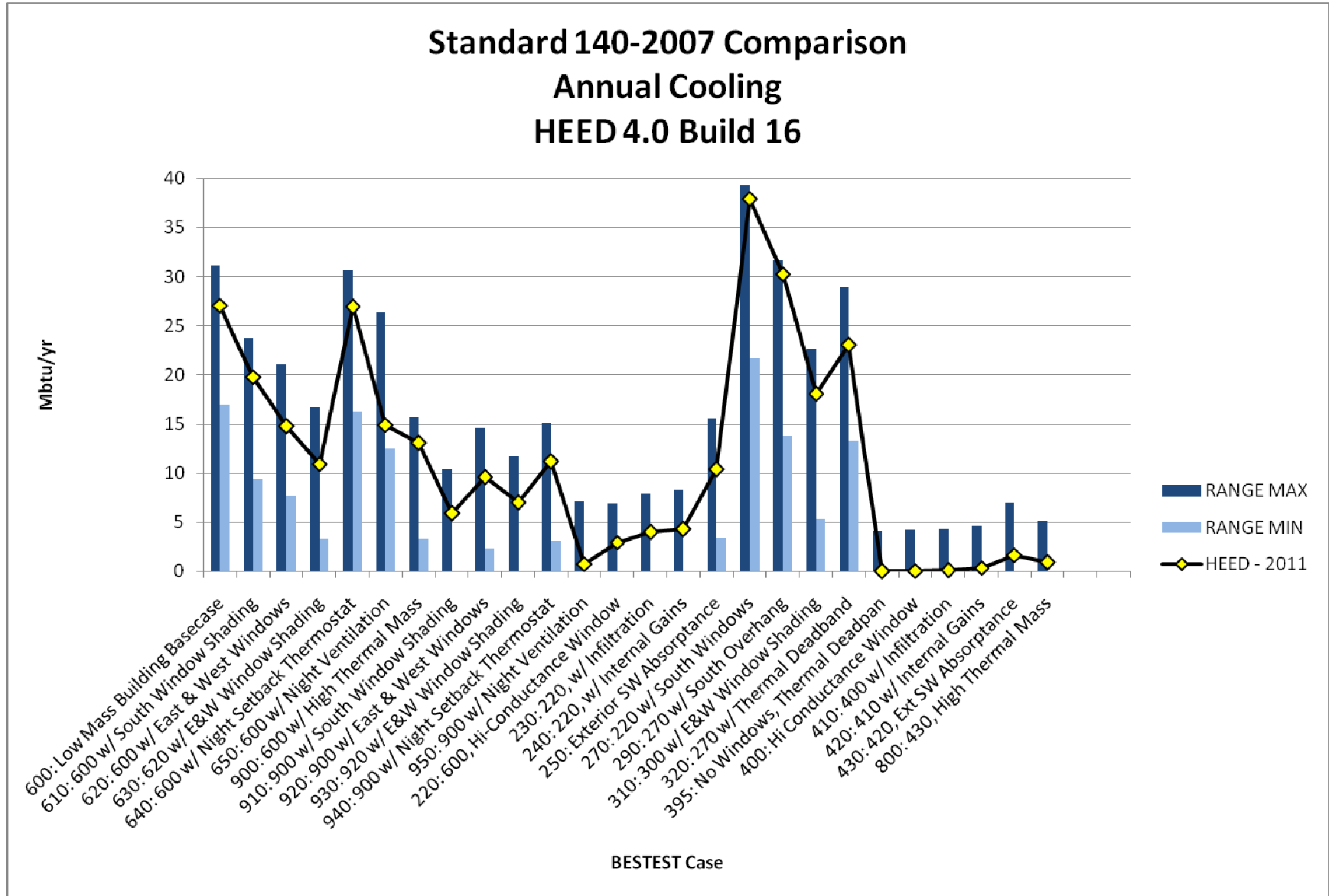


Figure 3.

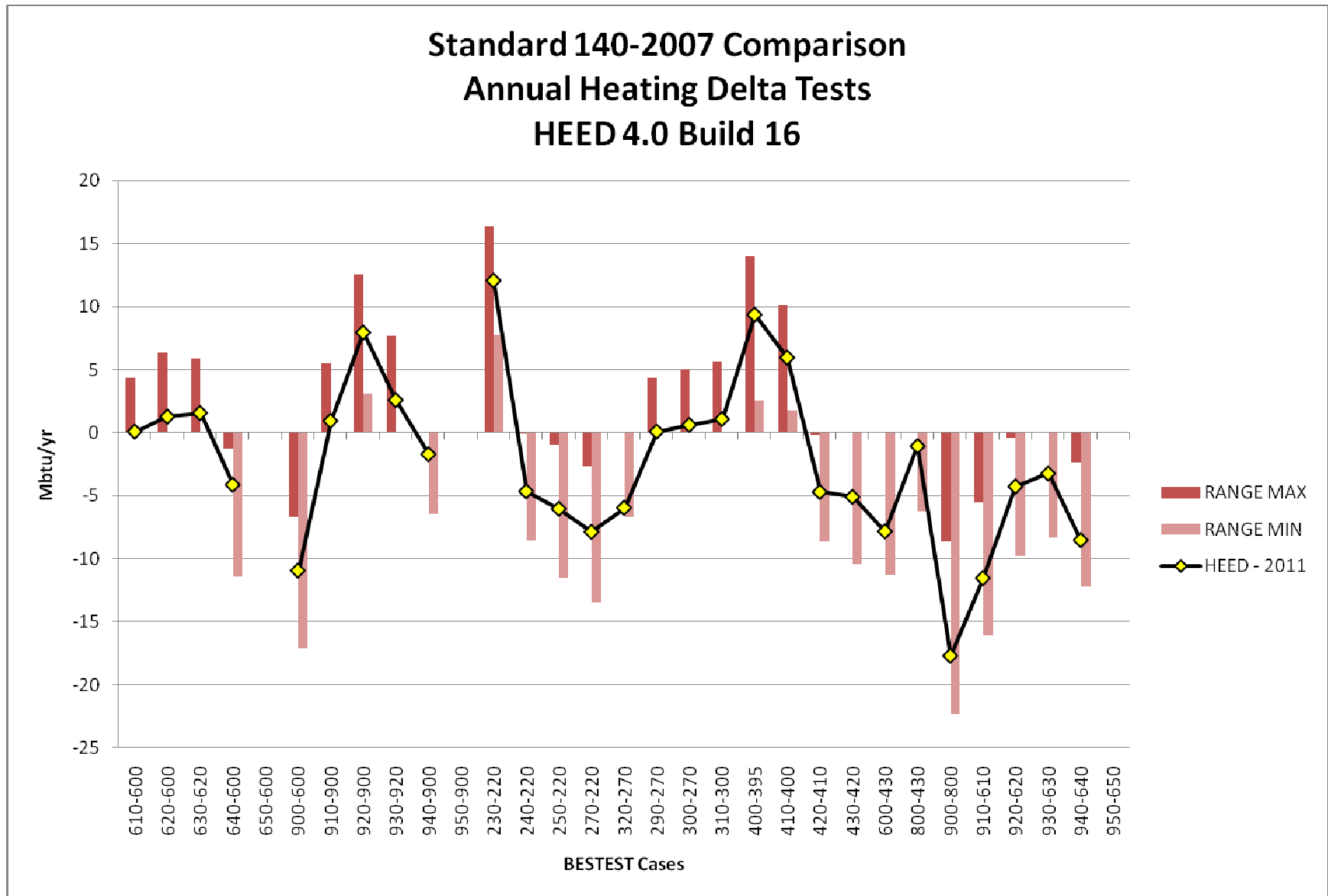


Figure 4.

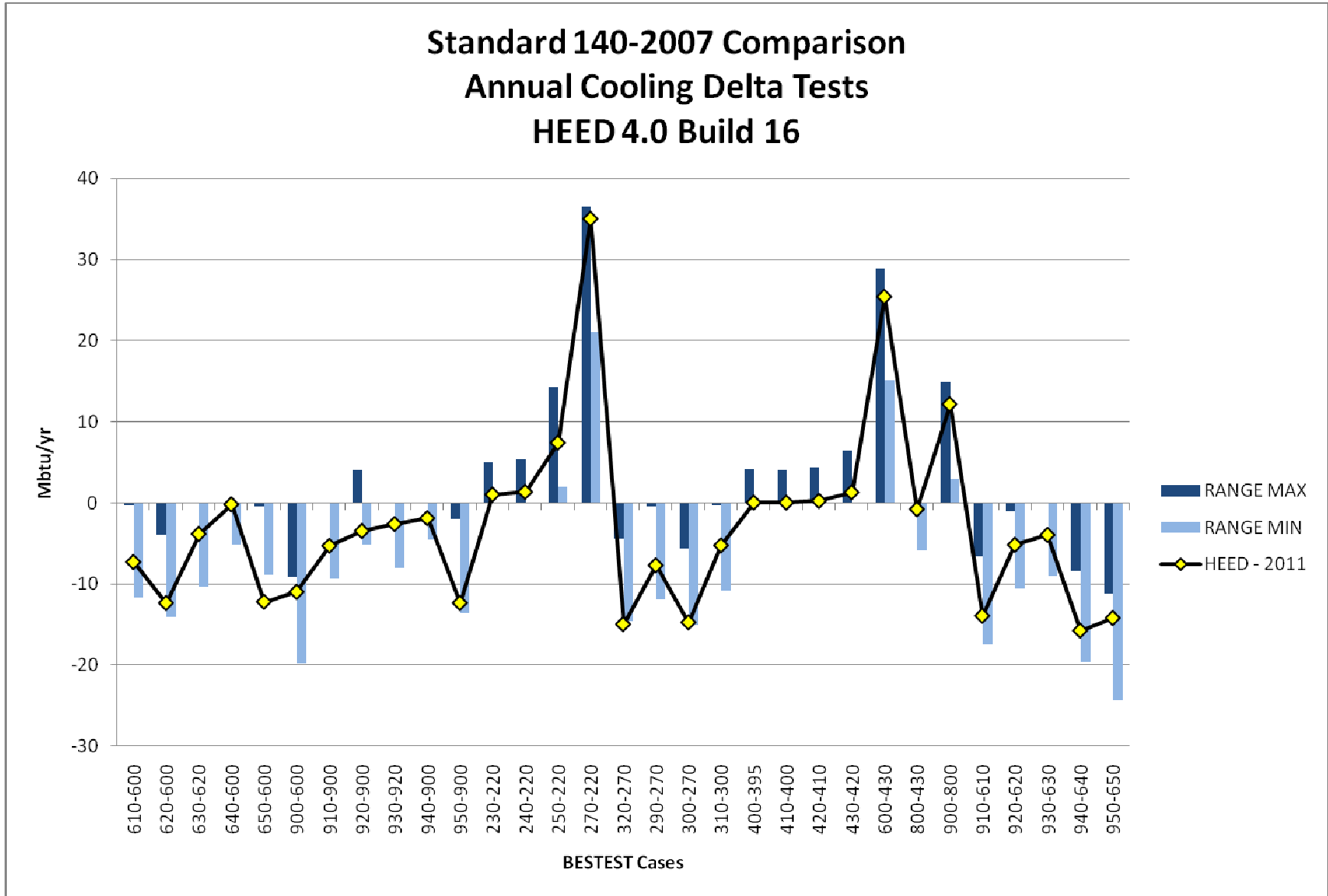


Table 1. Annual Heating and Cooling Validation Results

Case Number	Annual Heating Bestest Range		HEED HVAC Total Heating Loads Output			Annual Cooling Bestest Range		HEED HVAC Total Cooling Loads Output		
	Max	Min	kBtu/sf/yr	Mbtu/yr	PASS	Max	Min	kBtu/sf/yr	Mbtu/yr	PASS
	Mbtu/yr	Mbtu/yr				Mbtu/yr	Mbtu/yr			
600: Low Mass Building Basecase	23.4848	10.6622	35.72	18.4315	YES	31.1811	16.9456	52.48	27.0797	YES
610: 600 w/ South Window Shading	23.7476	10.8636	35.89	18.5192	YES	23.7203	9.3619	38.37	19.7989	YES
620: 600 w/ East & West Windows	24.2869	11.7442	38.19	19.7060	YES	21.0787	7.6622	28.59	14.7524	YES
630: 620 w/ E&W Window Shading	26.0787	13.2357	41.21	21.2644	YES	16.6315	3.2663	21.19	10.9340	YES
640: 600 w/ Night Setback Thermostat	16.9796	5.3892	27.71	14.2984	YES	30.6589	16.3142	52.14	26.9042	YES
650: 600 w/ Night Ventilation	4.0000	0.0000	0.00	0.0000	YES	26.3381	12.4370	28.89	14.9072	YES
900: 600 w/ High Thermal Mass	10.9659	0.0000	14.50	7.4820	YES	15.6554	3.2765	25.29	13.0496	YES
910: 900 w/ South Window Shading	11.7885	1.3755	13.50	6.9660	YES	10.3891	0.0000	11.43	5.8979	YES
920: 900 w/ East & West Windows	18.6759	7.3073	29.91	15.4336	YES	14.5530	2.2799	18.59	9.5924	YES
930: 920 w/ E&W Window Shading	22.2084	10.1401	34.92	18.0187	YES	11.6383	0.0000	13.56	6.9970	YES
940: 900 w/ Night Setback Thermostat	8.8157	0.0000	11.18	5.7689	YES	15.0615	3.0956	21.66	11.1766	YES
950: 900 w/ Night Ventilation	4.0000	0.0000	0.00	0.0000	YES	7.1434	0.0000	1.41	0.7276	YES
220: 600, Hi-Conductance Window	33.9900	19.6999	60.01	30.9652	YES	6.8499	0.0000	5.70	2.9412	YES
230: 220, w/ Infiltration	45.7854	31.4133	83.41	43.0396	YES	7.8874	0.0000	7.73	3.9887	YES
240: 220, w/ Internal Gains	29.4200	15.2800	50.99	26.3108	YES	8.2526	0.0000	8.34	4.3034	YES
250: Exterior SW Absorptance	27.9729	12.2152	48.29	24.9176	YES	15.5359	3.4301	20.10	10.3716	YES
270: 220 w/ South Windows	24.2050	11.3926	44.74	23.0858	YES	39.3246	21.6931	73.58	37.9673	YES
290: 270 w/ South Overhang	24.2800	11.6213	44.91	23.1736	YES	31.6078	13.7613	58.69	30.2840	YES
300: 270 w/ East & West Windows	24.3551	12.2493	45.94	23.7050	YES	28.2323	10.6827	45.07	23.2561	YES
310: 300 w/ E&W Window Shading	25.0411	13.8193	48.03	24.7835	YES	22.6725	5.3243	34.93	18.0239	YES
320: 270 w/ Thermal Deadband	21.5462	9.1708	33.18	17.1209	YES	28.9286	13.2732	44.63	23.0291	YES
395: No Windows, Thermal Deadpan	23.9149	12.3790	40.19	20.7380	YES	4.0546	0.0000	0.02	0.0103	YES
400: Hi Conductance Window	33.9320	19.5497	58.35	30.1086	YES	4.2082	0.0000	0.11	0.0568	YES
410: 400 w/ Infiltration	39.8570	25.3381	69.90	36.0684	YES	4.2867	0.0000	0.18	0.0929	YES
420: 410 w/ Internal Gains	35.2324	20.9081	60.78	31.3625	YES	4.6451	0.0000	0.67	0.3457	YES
430: 420, Ext SW Absorptance	30.7136	14.5292	50.90	26.2644	YES	6.9864	0.0000	3.21	1.6564	YES
800: 430, High Thermal Mass	28.6692	12.6145	48.83	25.1963	YES	5.1092	0.0000	1.72	0.8875	YES

Table 2. Cases that Could Not Be Run with HEED

195: 200, Solid Building	Could not define interior infrared emittance (in base case 200)
200: 210, IR	Could not define interior infrared emittance (in base case 210) --> identical to case 215
210: 220, Interior IR	Could not define interior infrared emittance --> identical to base case 220
215: 220, Exterior IR	Could not define exterior combined surface coefficient for high conductance wall that replaced windows.
280: 270, Int SW Absorptance	Could not define interior shortwave absorptance --> identical to case 270
440: 430, Int SW Absorptance	Could not define interior shortwave absorptance --> identical to case 430
810: 900, Int SW Absorptance	Could not define interior shortwave absorptance --> identical to case 900

Table 3. Delta Heating and Cooling Validation Results

Delta Cases	Annual Heating, Bestest Range		HEED HVAC Total Heating Loads Output			Annual Cooling Bestest Range		HEED HVAC Total Cooling Loads Output		
	Max	Min				Max	Min			
	Mbtu/yr	Mbtu/yr	kBtu/sf/yr	Mbtu/yr	PASS	Mbtu/yr	Mbtu/yr	kBtu/sf/yr	Mbtu/yr	PASS
610-600	4.3345	0.0000	0.17	0.0877	YES	-0.3413	-11.6008	-14.11	-7.2808	YES
620-600	6.3277	0.0000	2.47	1.2745	YES	-3.9898	-14.1025	-23.89	-12.3272	YES
630-620	5.8806	0.0000	3.02	1.5583	YES	0.0000	-10.2970	-7.40	-3.8184	YES
640-600	-1.2731	-11.3926	-8.01	-4.1332	YES	0.0000	-5.0922	-0.34	-0.1754	YES
650-600					--	-0.3823	-8.8430	-23.59	-12.1724	NO
900-600	-6.6690	-17.0957	-21.22	-10.9495	YES	-9.0820	-19.7817	-21.22	-10.9495	YES
910-900	5.5085	0.0000	1.82	0.9391	YES	0.0000	-9.3277	-10.23	-5.2787	YES
920-900	12.5496	3.0649	15.41	7.9516	YES	4.0546	-5.1024	-6.70	-3.4572	YES
930-920	7.6860	0.0000	5.01	2.5852	YES	0.0000	-8.0069	-5.03	-2.5955	YES
940-900	0.0000	-6.4505	-3.32	-1.7131	YES	0.0000	-4.5939	-3.63	-1.8731	YES
950-900					--	-1.9557	-13.6451	-23.88	-12.3221	YES
230-220	16.3380	7.7134	23.40	12.0744	YES	5.0376	0.0000	2.03	1.0475	YES
240-220	-0.1058	-8.5768	-9.02	-4.6543	YES	5.4062	0.0000	2.64	1.3622	YES
250-220	-0.9420	-11.4847	-11.72	-6.0475	YES	14.3312	1.9796	14.40	7.4304	YES
270-220	-2.6485	-13.4233	-15.27	-7.8793	YES	36.4747	21.0582	67.88	35.0261	YES
320-270	0.0000	-6.6587	-11.56	-5.9650	YES	-4.4199	-14.5905	-28.95	-14.9382	NO
290-270	4.2901	0.0000	0.17	0.0877	YES	-0.3789	-11.9318	-14.89	-7.6832	YES
300-270	5.0137	0.0000	1.20	0.6192	YES	-5.6724	-15.0923	-28.51	-14.7112	YES
310-300	5.6587	0.0000	2.09	1.0784	YES	-0.3209	-10.8055	-10.14	-5.2322	YES
400-395	14.0172	2.5393	18.16	9.3706	YES	4.1536	0.0000	0.09	0.0464	YES
410-400	10.1366	1.7884	11.55	5.9598	YES	4.0887	0.0000	0.07	0.0361	YES
420-410	-0.1707	-8.6451	-9.12	-4.7059	YES	4.3584	0.0000	0.49	0.2528	YES
430-420	0.0000	-10.3789	-9.88	-5.0981	YES	6.4983	0.0000	2.54	1.3106	YES
600-430	0.0000	-11.2287	-15.18	-7.8329	YES	28.8466	15.0957	49.27	25.4233	YES
800-430	0.0000	-6.2150	-2.07	-1.0681	YES	0.0000	-5.8772	-1.49	-0.7688	YES
900-800	-8.6213	-22.2800	-34.33	-17.7143	YES	14.8977	2.8908	23.57	12.1621	YES
910-610	-5.4881	-16.0547	-22.39	-11.5532	YES	-6.5598	-17.3926	-26.94	-13.9010	YES
920-620	-0.4267	-9.7646	-8.28	-4.2725	YES	-1.0376	-10.5257	-10.00	-5.1600	YES
930-630	0.0000	-8.3447	-6.29	-3.2456	YES	0.0000	-8.9932	-7.63	-3.9371	YES
940-640	-2.3721	-12.1639	-16.53	-8.5295	YES	-8.4472	-19.5974	-30.48	-15.7277	YES
950-650					--	-11.1162	-24.3278	-27.48	-14.1797	YES

Night ventilation

Thermostat setback