

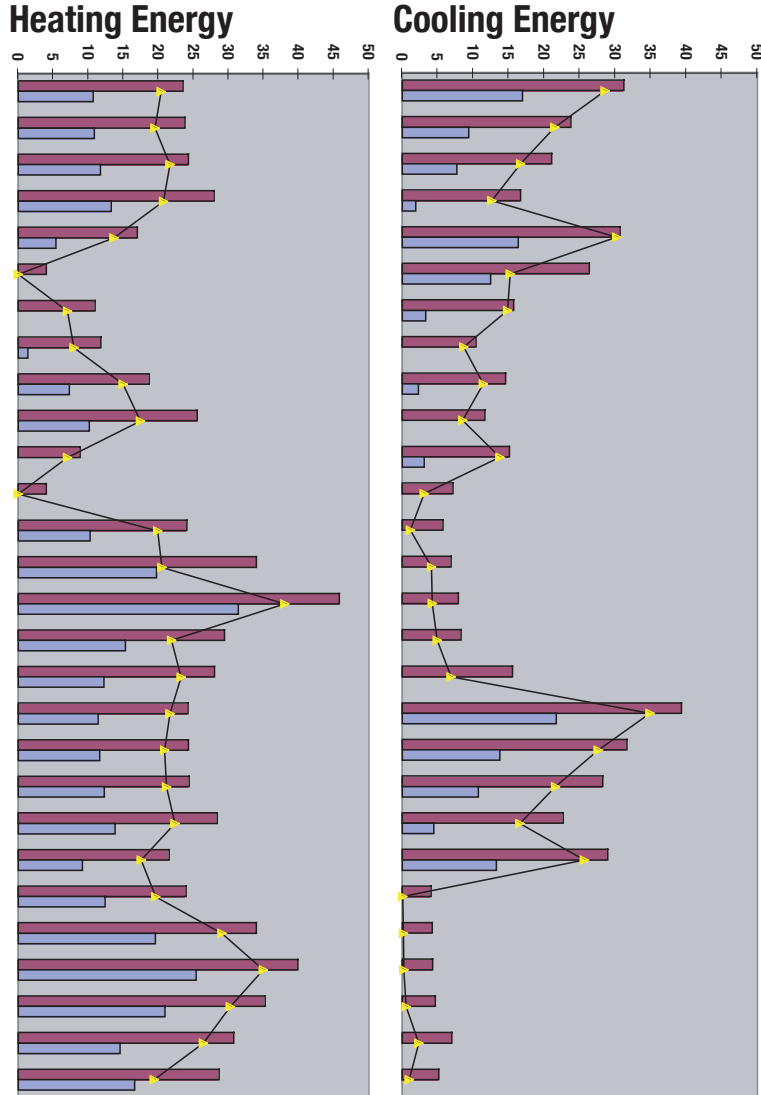
# HEED Validated against the ASHRAE/BESTEST Standard

Grace Tsai and Murray Milne, UCLA Department of Architecture and Urban Design, 2003

HEED (Home Energy Efficient Design) is an easy-to-use tool that helps homeowners and architects design more energy efficient homes. It uses a state of the art hourly heat balance technique for calculating the energy consumption. When HEED was tested using the ASHRAE/ BESTEST evaluation protocol, the results in all 28 of the following test buildings fell within the acceptance range:

## Test Cases

- 600: Low Mass Building Basecase
- 610: 600 w/ South Window Shading
- 620: 600 w/ East & West Windows
- 630: 620 w/ E&W Window Shading
- 640: 600 w/ Night Setback Thermostat
- 650: 600 w/ Night Ventilation
- 900: 600 w/ High Thermal Mass
- 910: 900 w/ South Window Shading
- 920: 900 w/ East & West Windows
- 930: 900 w/ E&W Window Shading
- 940: 900 w/ Night Setback Thermostat
- 950: 900 w/ Night Ventilation
- 195: 600 w/ No Windows, Fixed Temp.
- 220: 195 w/ Opaque Glass Windows
- 230: 220 w/ 1.0 Air Change Infiltration
- 240: 220 w/ 200 Watts Internal Gain
- 250: 220 w/ 0.9 Solar Absorptance
- 270: 220 w/ Clear South Windows
- 290: 270 w/ South Window Overhang
- 300: 270 w/ East & West Windows
- 310: 300 w/ E&W Window Shading
- 320: 270 w/ Thermostat Deadband
- 395: 320 w/ No Windows
- 400: 395 w/ Opaque Window Glass
- 410: 400 w/ 0.5 Air Change Infiltration
- 420: 410 w/ 200 Watts Internal Gain
- 430: 420 w/ 0.6 Solar Absorptance
- 800: 430 w/ High Mass, No Windows



- BESTTEST Range Maximum Mbtu/year
- BESTTEST Range Minimum Mbtu/year
- HEED Annual Energy Prediction Mbtu/year

HEED uses as its thermal analysis computation kernel a program called Solar-5, developed at UCLA.. It calculates an hourly heat balance for each of the 8760 hours in a year using the standard ASHRAE Manual J calculations, the Mackey and Wright time lag and decrement factor method of accounting for heat flow through opaque walls, and the Admittance Factor Method to account for internal thermal mass. It uses a successive approximation method to calculate the indoor air temperatures. Thus it can integrate loads and energy calculations at each time step, similar to the new EnergyPlus technique, which means that the HVAC system only adds heating or cooling energy if the indoor air temperature has floated beyond the upper or lower comfort limits.

HEED has been validated using the procedure as specified in the ANSI/ASHRAE Standard 140-2001, Standard Method of Test for the Evaluation of Energy Analysis Computer Programs. This method was developed by the International Energy Agency Solar Heating and Cooling Program, Task 12, and was adopted by DOE as the accepted basis for verifying the credibility of computer simulation programs,

The ASHRAE/BESTEST technique involves calculating the annual heating and cooling energy for a series of 35 different test case buildings, ranging from extremely abstract to quite realistic. HEED ran all of the realistic cases, but it does not accommodate atypical values of internal short wave absorptance or external infrared emittance, and it cannot simulate a sunspace. In ASHRAE/BESTEST eight different simulation programs were run to establish the maximum and minimum values for each test building, including ESP, BLAST, DOE2, SSRE/SUN, SERIRES, S3PAS, TRANSYS, and TASE. The ASHRAE/BESTEST Standard states that “there is no formal criteria for when results agree or disagree.” Therefore we applied the acceptance range of HERS, another application of BESTEST that uses these same typical buildings. The HERS acceptance range is created by adding 4 MBTU to the maximum value and subtracting up to 4 MBTU from the minimum value.

HEED was run for the 28 test buildings, each intended to test the ability of the program to simulate a different situation (high mass or low mass, thermostat deadband, internal loads, infiltration rates, surface color, glass area, window orientation, glazing properties, and window shading). In all 28 cases the HEED results fell within the acceptance range (see following chart).

Case number	Bestest Range		HEED HVAC Total Cooling Loads Output			Bestest Range		HEED HVAC Total Cooling Loads Output		
	max	min				max	min			
	Mbtu/year	Mbtu/year	Kbtu/sqft-yr.	Mbtu/year		Mbtu/year	Mbtu/year	Kbtu/sqft-yr.	Mbtu/year	
600 [Low Mass base case]	23.479	10.658	39.79	20.37248	PASS	31.173	16.939	55.79	28.56448	PASS
610 [600 w/ south shading]	23.742	10.859	38.08	19.49696	PASS	23.715	9.358	41.89	21.44768	PASS
620 [600 w/ east/west win]	24.281	11.74	42.29	21.65248	PASS	21.047	7.659	32.5	16.64	PASS
630 [620 w/ e/w win shading]	27.945	13.231	40.41	20.68992	PASS	16.628	1.872	24.59	12.59008	PASS
640 [600 w/ night setback]	16.976	5.386	26.63	13.63456	PASS	30.651	16.308	58.92	30.16704	PASS
650 [600 w/ night vent]	4	0	0	0	PASS	26.332	12.432	29.62	15.16544	PASS
900 [heavy mass base case]	10.964	0	13.72	7.02464	PASS	15.652	3.274	28.96	14.82752	PASS
910 [900 w/ south shading]	11.786	1.374	15.55	7.9616	PASS	10.387	0	16.85	8.6272	PASS
920 [w/ east west win]	18.672	7.304	29.22	14.96064	PASS	14.55	2.278	22.3	11.4176	PASS
930 [with e/w window shade]	25.516	10.136	33.98	17.39776	PASS	11.636	0	16.56	8.47872	PASS
940 [w/ night setback]	8.814	0	13.74	7.03488	PASS	15.058	3.094	26.82	13.73184	PASS
950 [w/ night vent]	4	0	0	0	PASS	7.142	0	6	3.072	PASS
960 [w/ sunspace]	15.509	3.885	not run	not run	not run	6.74	0	not run	not run	not run
990 [900/ground coupling]	18.753	3.581	not run	not run	not run	10.281	0	not run	not run	not run
195 [solid building]	24.032	10.218	38.82	19.87584	PASS	5.74	0	2.2	1.1264	PASS
200 [tests IR]	24.481	13.92	not run	not run	not run	6.441	0	not run	not run	not run
210 [tests IR]	27.771	18.028	not run	not run	not run	6.3245	0	not run	not run	not run
215 [tests IR]	31.102	14.926	not run	not run	not run	6.91	0	not run	not run	not run
220 [Hi Conductance Window]	33.981	19.693	40.05	20.5056	PASS	6.849	0	8.04	4.11648	PASS
230 [220 w/ infiltration]	45.773	31.403	74.27	38.02624	PASS	7.886	0	8.19	4.19328	PASS
240 [220 w/ internal gains]	29.413	15.274	42.64	21.83168	PASS	8.251	0	9.56	4.89472	PASS
250 [220 w/ absorptance]	27.966	12.21	45.3	23.1936	PASS	15.533	0	13.41	6.86592	PASS
270 [220 w/ south windows]	24.199	11.388	42.28	21.64736	PASS	39.314	21.686	68.06	34.84672	PASS
280 [w/ internal absorptivity]	24.977	11.951	not run	not run	not run	28.273	12.627	not run	not run	not run
290 [270 w/ south overhang]	24.247	11.617	40.72	20.84864	PASS	31.6	14	53.87	27.58144	PASS
300 [270 w/ e/w windows]	24.349	12.245	41.32	21.15584	PASS	28.225	10.678	42.11	21.56032	PASS
310 [300 w/ e/w shading fins]	28.345	13.814	43.62	22.33344	PASS	22.667	4.431	32.33	16.55296	PASS
320 [270 w/ thermal deadband]	21.541	9.167	34.26	17.54112	PASS	28.921	13.268	50.08	25.64096	PASS
395 [no win, thermal deadband]	23.909	12.374	38.28	19.59936	PASS	4.055	0	0.11	0.05632	PASS
400 [Hi Conductance Window]	33.93	19.543	56.67	29.01504	PASS	4.208	0	0.27	0.13824	PASS
410 [400 w/ infiltration]	39.846	25.33	68.26	34.94912	PASS	4.287	0	0.39	0.19968	PASS
420 [410 w/ internal gains]	35.223	20.901	59.07	30.24384	PASS	4.645	0	1.06	0.54272	PASS
430 [420 w/ absorptance]	30.706	14.524	51.56	26.39872	PASS	6.986	0	4.53	2.31936	PASS
440 [600 w/ internal absorptivity]	23.827	11.18	not run	not run	not run	21.756	9.535	not run	not run	not run
800 [430 w/high mass]	28.662	16.61	37.91	19.40992	PASS	5.1209	0	1.85	0.9472	PASS
810 [900 w/ internal absorptivity]	14.25	2.275	not run	not run	not run	9.838	0	not run	not run	not run

References:

HEED is available at no cost from [www.aud.ucla.edu/heed](http://www.aud.ucla.edu/heed):

ANSI/ASHRAE Standard 140-2001, ASHRAE Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs, 90 pages, American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329