White Paper

Developing Building Equivalent Full Load Hour (BEFLH) Values for Commercial and Multi-Family Buildings in NYS

Using Results from EnergyPlus Simulation Runs from ARUP developed for NYSERDA CNBR and BEEM Analysis

Revised

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Prepared by:

Hugh I. Henderson, Jr. , P.E.
Owahgena Consulting, Inc.
Cazenovia, NY 13035

Overview

This white paper provides the background and basis for developing new Building Equivalent Full Load Hour (BEFLH) values for commercial and multi-family buildings that can be used in the Technical Resource Manual (TRM) for New York State. Currently, Appendix G of the current TRM provide equivalent full load hour (EFLH) values based on the SIZE or capacity of the heating and cooling systems, for instance:

$$EFLHh = \frac{\text{Annual Heating Load (Btu)}}{\text{Boiler/Furnace Capacity (Btu/h)}} \qquad EFLHc = \frac{\text{Annual Cooling Load (Btu)}}{\text{Cooling Equipment Capacity (Btu/h)}}$$

Appendix A in the current TRM provides a detailed description of the commercial building assumptions that went into the DOE-2 runs that were the basis for determining the current EFLH values in Appendix G.

Our goal here is to develop BEFLH values that are independent of equipment size and instead depend only on the peak loads in the building. The coincident peak heating and cooling loads are typically determined in accordance with zone loads calculated with appropriate commercial load calculations, such as from the 2017 ASHRAE Fundamentals[1]. The Building EFLH is defined as:

$$BEFLHh = \frac{\text{Annual Heating Load (Btu)}}{\text{Building Peak Heating Load (Btu/h)}} \qquad BEFLHc = \frac{\text{Annual Cooling Load (Btu)}}{\text{Building Peak Cooling Load (Btu/h)}}$$

Where the peak loads are maximum coincident hourly value of the combined zone loads in the building.

The Commercial and Multi-Family Buildings

ARUP has run EnergyPlus models for 12 commercial building types and 3 multi-family buildings for NYSERDA as part of the Carbon Neutral Building Roadmap (CNBR) and for the BEEM analysis. The models are based on the DOE Reference buildings developed by NREL for existing (both Pre-1980 and Post-1980) buildings[2] These building models are well documented and all input assumptions to the models have been well vetted by NREL. The low- and mid-rise multi-family buildings were developed the multi-family DOE Reference building as the starting point. The new construction (NC) versions of these buildings are modified by PNNL as part of their code development work.

Table 1 lists the size of the building types as well as the default HVAC system used with each building.

[1] 2017 ASHRAE Fundamentals Handbook, Chapter 18. Non-residential heating and cooling loads
[2] https://www.energy.gov/eere/buildings/commercial-reference-buildings.

Table 1. Summary of Commercial Buildings Simulated by ARUP

Commercial Building Typology	Floor Area (sq ft)	Typical HVAC System
Academic (12 floors)	498,558	VAV w/ HW Reheat. Central Chiller, Tower, Boiler
Low-Rise Office (3 floors)	53,628	VAV w/ Electric Reheat. Packaged RTU w/ gas htg
Mid-Rise Office (12 floors)	498,558	VAV w/ HW Reheat. Central Chiller, Tower, Boiler
Grocery (1 floor)	45,000	CV Packaged RTU w/ gas furnace
Hospital (5 floors)	241,351	VAV w/ HW Reheat. Central Chiller, Tower, Boiler
Large Hotel (6 floors)	112,120	Guest rooms 4-pipe FCU & DOAS. Air-cooled Chiller, Boiler. Common areas VAV w/ HW Reheat
Small Hotel (4 floors)	43,200	PTACs w/elect resist heat in guest rooms, RTUs in common areas (gas & electric heat)
Outpatient Medical (3 floors)	40,946	VAV w/ HW Reheat. AHUs w/ DX cooling, Condensing Units, boiler
Full-Service Restaurant (1 floor)	5,500	CV Packaged RTU w/ gas furnace
Stand Alone Retail (1 floor)	24,962	CV Packaged RTUs w/ gas furnace
Secondary School (2 floors)	210,887	VAV w/ HW Reheat. Packaged RTU w/ gas Heating, Boiler, CV RTUs on gyms, etc.
Warehouse (1 floor)	52,045	CV Packaged RTU w/ gas furnace
MF Low-Rise (7 floors)	59,046	PTAC with HW coils
MF Mid-Rise (20 floors) with & w/o Brick)	168,702	PTAC with HW coils

CV - Constant Volume, VAV – Variable Air Volume, HW – Hot water, RTU – Rooftop Unit, Reheat – heating provided at zone terminal to compensate for overcooling or provide dehumidification

The HVAC system type varies widely and depends on the level of zoning required in each building. For instance, a retail building is a large open space that uses constant volume packaged equipment (e.g. Rooftop units, RTUs) that are controlled by a simple thermostat – similar to a single family home. In contrast, an office building uses a central air handler to distribute cooled, recirculated and outdoor air to the building. Variable air volume (VAV) terminals or boxes serve in each zone to control the amount of air into the zone based on the space temperature. The terminal can also provide heat to each zone as needed. Heat can be provided by a hot water coil or by electric resistance heating element. VAV systems often result in simultaneous cooling and heating depending on the differences in load between the zones. Cooling can be provided by a packaged DX coil or by a central chiller plant distributing chilled water to air handler coils in the AHU. Yet another variation are small hotels where Packaged Terminal AIr Conditioners (PTACs) separately serve each room. Heating is provided by resistance elements in the PTAC unit. As a result, the buildings can use a mix of electric resistance heating or fuel-fired boilers/furnaces to provide heating.

The models were run for three weather locations: NY JFK (zone 4A), Buffalo (zone 5A) and Massena (zone 6A). For the 12 commercial building types with 3 vintages and 3 climates lead to a total of 108 simulation runs. The three multi-family buildings add an additional 27 runs.

Hourly Simulation Results

The hourly simulation results were used to determine the BEFLH values. Hourly data were available for heating fuel use, heating electrical use, and cooling electrical use.

To find the total heating we combined fuel and electric use using the boiler/furnace efficiency used for each run, which are given in Table 2. The hourly heating load was calculated using:

Heating Load = 3.412 x [Electric Resistance kWh use] + [natural gas use] x [boiler eff]

Table 2. Assumed Boiler/Furnace Efficiency Using Natural Gas for Each Simulation Run

	Pre-1980			**Post-1980**			**NC**		
	4A	**5A**	**6A**	**4A**	**5A**	**6A**	**4A**	**5A**	**6A**
Academic	0.76	0.76	0.76	0.7	0.7	0.7	0.81	0.81	0.81
Office-Low-Rise	0.78	0.78	0.78	0.8	0.8	0.8	0.81	0.81	0.81
Office-Mid-Rise	0.76	0.76	0.76	0.7	0.7	0.7	0.81	0.81	0.81
Grocery	0.78	0.78	0.78	0.78	0.78	0.78	0.81	0.81	0.81
Hospital	0.7	0.7	0.7	0.7	0.7	0.7	0.81	0.81	0.81
Hotel-Large	0.74	0.74	0.74	0.7	0.7	0.7	0.81	0.81	0.81
Hotel-Small	0.78	0.78	0.78	0.78	0.78	0.78	0.81	0.81	0.81
Outpatient	0.74	0.74	0.74	0.7	0.7	0.7	0.84	0.84	0.84
Restaurant	0.78	0.78	0.78	0.78	0.78	0.78	0.81	0.81	0.81
Retail	0.78	0.78	0.78	0.78	0.78	0.78	0.81	0.81	0.81
School	0.78	0.78	0.78	0.78	0.78	0.78	0.81	0.81	0.81
Warehouse	0.78	0.78	0.78	0.78	0.78	0.78	0.81	0.81	0.81
MF Low-Rise	0.78	0.78	0.78	0.78	0.78	0.78	0.80	0.80	0.80
MF Mid-Rise	0.78	0.78	0.78	0.78	0.78	0.78	0.80	0.80	0.80
MF Mid-Rise Brick	0.78	0.78	0.78	0.78	0.78	0.78	0.80	0.80	0.80

Then BEFLH was determined using total annual sum of the heating load divided by the peak hourly heating load, or:

$$BEFLHh = \frac{\text{Annual Heating Load (MBtu)}}{\text{Peak Hour Heating Load (MBtu/h)}}$$

The cooling can also be determined from the cooling electricity use by assuming a peak EER and a seasonal average EER:

$$BEFLHc = \frac{[\text{Total Cooling Electric Use (kWh)}] \times [\text{ Seasonal EER }]}{[\text{Peak Cooling Demand (kW)}] \times [\text{Peak Cooling EER }]}$$

$$= \frac{[\text{Total Cooling Electric Use (kWh) }]}{[\text{Peak Cooling Demand (kW) }]} \times \frac{[\text{ Seasonal EER }]}{[\text{Peak Cooling EER }]}$$

Table 3 below shows the resulting BEFLH values determined from the hourly data. In this case we assumed a seasonal-to-peak efficiency ratio of 1.1. This value was selected because it minimized the error between the BEFLH determined by this method and an BEFLH determined by an alternate method that relied on the peak and annual cooling zone load data from the EnergyPlus runs[3].

Table 4 compares the EFLH values from Appendix G to the BEFLH values. The name of each building type is slightly different in the TRM. Appendix G provided EFLH values by weather city but not by vintage, so we average all three vintages of BEFLH to compare to EFLH. For larger buildings, the HVAC system had to be specified. For this comparison we always selected the EFLH value corresponding to the “VAV with economizer” option.

The BEFLH values are generally larger than the EFLH values, confirming some amount of equipment oversizing in both heating and cooling. For heating the median BEFLH-to-EFLH ratio is 122%. For cooling the median BEFLH-to-EFLH ratio is 138%.

For the multi-family buildings, Appendix G of the TRM has EFLH values available by vintage. Table 5 compares the BEFLH and EFLH values from Appendix G for all vintages.

[3] The zone load data was found to be incomplete and in some cases incorrect – perhaps because some zone loads were inadvertently excluded. Therefore, this data source was not used for the primary analysis. The median error between the BEFLH determined from hourly data and the zone load data was 4% for heating and 8% for cooling.

Table 3. Resulting Values of BEFLH for Heating and Cooling from Hourly ARUP Results (assuming seasonal-to-Peak EER ratio is 1.1)

	BEFLH Heating			BEFLH Cooling		
	Pre-1980	**Post-1980**	**NC**	**Pre-1980**	**Post-1980**	**NC**
Academic	635	597	690	1238	1225	2400
	864	858	1071	683	690	1787
	848	834	1316	664	668	1666
Office-Low-Rise	351	537	285	1000	1186	984
	545	793	505	634	778	786
	599	790	521	495	641	672
Office-Mid-Rise	628	449	300	1316	1266	1962
	726	689	548	748	745	1367
	744	679	562	662	663	1365
Grocery	1029	1055	1269	609	622	656
	1206	1204	1447	358	343	506
	1130	1130	1344	277	263	355
Hospital	2902	2670	1389	4516	4491	2111
	2556	2526	1688	3809	3807	1579
	1997	1997	946	3014	3021	1651
Hotel-Large	1442	1641	707	2096	2082	1776
	1837	2050	893	1642	1653	1223
	1801	1916	573	1487	1530	1175
Hotel-Small	386	916	649	1956	2141	2056
	619	1127	893	1916	1958	1818
	502	942	919	1650	1760	1625
Outpatient	3324	3294	1147	2563	2543	1779
	3611	3594	1346	2175	2154	1459
	3137	3140	1210	1834	1847	1194
Restaurant	1153	1236	778	767	788	1141
	1481	1508	1183	545	547	808
	1413	1386	1142	381	417	663
Retail	760	779	579	705	705	941
	987	983	858	466	440	662
	969	970	838	362	363	617
School	550	558	178	552	632	1160
	688	729	394	362	394	885
	690	709	275	327	323	818
Warehouse	875	876	637	243	230	498
	1161	1159	915	97	93	276
	1049	1047	972	82	77	247
MF-Low-Rise	1332	1324	1100	900	935	987
	1713	1668	1320	631	666	497
	1449	1393	1450	453	470	542
MF-Mid-Rise	1242	1216	1144	965	1007	1192
	1625	1563	1391	693	738	638
	1375	1301	1406	494	523	697
MF-Mid-Rise-Brick	1431	1317	1198	1141	1074	1212
	1793	1668	1430	752	777	639
	1606	1382	1478	573	572	699

Notes: The green-shaded table cells correspond to commercial buildings that used Packaged Single Zone (PSZ) or commercial RTU systems. The red cells for MF-Low-Rise, NC were estimated so they are shown as red.

Table 4. Comparing BEFLH Values to EFLH Values in Appendix G of the Current TRM

		TRM Building Name	TRM App G EFLH_h	BEFLH-to-EFLH ratio	TRM App G EFLH_c	BEFLH-to-EFLH ratio
Academic	NYC	University	684	94%	690	235%
	Buffalo	University	1206	77%	518	203%
	Massena	University	1224	82%	413	242%
Office-Low-Rise	NYC	Small Office	431	91%	955	111%
	Buffalo	Small Office	760	81%	745	98%
	Massena	Small Office	861	74%	671	90%
Office-Mid-Rise	NYC	Large Office	291	158%	716	212%
	Buffalo	Large Office	485	135%	504	189%
	Massena	Large Office	544	122%	505	178%
Grocery	NYC	Grocery	191	585%	1279	49%
	Buffalo	Grocery	557	231%	826	49%
	Massena	Grocery	620	194%	688	43%
Hospital	NYC	Hospital	296	784%	1217	305%
	Buffalo	Hospital	642	351%	1026	299%
	Massena	Hospital	739	223%	962	266%
Hotel-Large	NYC	Hotel	229	552%	2929	68%
	Buffalo	Hotel	518	308%	2702	56%
	Massena	Hotel	661	216%	2745	51%
Hotel-Small	NYC	Motel	619	105%	1233	166%
	Buffalo	Motel	789	112%	1084	175%
	Massena	Motel	832	95%	997	168%
Outpatient	NYC					
	Buffalo					
	Massena					
Restaurant	NYC	Full Service Restaurant	821	129%	574	157%
	Buffalo	Full Service Restaurant	1567	89%	460	138%
	Massena	Full Service Restaurant	1746	75%	389	125%
Retail	NYC	Small Retail	545	130%	882	89%
	Buffalo	Small Retail	1020	92%	666	78%
	Massena	Small Retail	1134	82%	599	75%
School	NYC	Primary School	840	51%	394	198%
	Buffalo	Primary School	1357	44%	244	224%
	Massena	Primary School	1311	43%	257	190%
Warehouse	NYC	Warehouse	452	176%	400	81%
	Buffalo	Warehouse	940	115%	212	73%
	Massena	Warehouse	1094	94%	228	59%
MF-Low-Rise	NYC	MF-Low-Rise	723	173%	550	171%
	Buffalo	MF-Low-Rise	1215	129%	274	218%
	Massena	MF-Low-Rise	1326	108%	228	214%
MF-Mid-Rise	NYC	MF-High-Rise	395	304%	843	125%
	Buffalo	MF-High-Rise	813	188%	637	108%
	Massena	MF-High-Rise	873	156%	571	100%

Notes: The EFLH for large commercial buildings from Appendix G of the TRM correspond to VAV systems with economizers. The multi-family (MF) building values are compared to Post-1980 from Appendix G. The BEFLH values are the average of all vintages.

Table 5. Comparing BEFLH Values to EFLH Values in Appendix G of the Current TRM – MF for All Vintages

			BEFLH Heating			Appendix G EFLH					
			Pre-1980	**Post-1980**	**NC**	**Prior 1979**	**1979 to 2006**	**2007 to present**	**Pre-1980**	**Post-1980**	**NC**
MF-Low-Rise	NYC	MF-Low-Rise	1332	1324	1100	757	723	503	176%	183%	219%
	Buffalo	MF-Low-Rise	1713	1668	1320	1219	1215	883	141%	137%	149%
	Massena	MF-Low-Rise	1449	1393	1450	1306	1326	964	111%	105%	150%
MF-Mid-Rise	NYC	MF-High-Rise	1242	1216	1144	526	395	219	236%	308%	522%
	Buffalo	MF-High-Rise	1625	1563	1391	966	813	471	168%	192%	295%
	Massena	MF-High-Rise	1375	1301	1406	1016	873	552	135%	149%	255%

			BEFLH Cooling			Appendix G EFLH					
			Pre-1980	**Post-1980**	**NC**	**Prior 1979**	**1979 to 2006**	**2007 to present**	**Pre-1980**	**Post-1980**	**NC**
MF-Low-Rise	NYC	MF-Low-Rise	900	935	987	507	550	562	177%	170%	176%
	Buffalo	MF-Low-Rise	631	666	497	270	274	256	234%	243%	194%
	Massena	MF-Low-Rise	453	470	542	230	228	218	197%	206%	248%
MF-Mid-Rise	NYC	MF-High-Rise	965	1007	1192	793	843	954	122%	119%	125%
	Buffalo	MF-High-Rise	693	738	638	572	637	773	121%	116%	83%
	Massena	MF-High-Rise	494	523	697	532	571	668	93%	92%	104%

The buildings simulated by ARUP did have perfect correspondence to the building types and vintages described in Appendix A and the results given in Appendix G of the TRM. Table 4 compares the names and shows slight differences in the naming conventions where there was good correspondence. Some of the most significant differences:

- The ARUP runs included an “Outpaient” medical building while the TRM did not
- Appendix G of the TRM includes three Large Commercial Buildings (Community College, Dormitory and Large Retail) that were not available from the ARUP runs.
- Appendix G of TRM offers different EFLH values by various system types for Large Commercial Buildings. In the ARUP runs, all systems have economizer and are VAV.
- The ARUP runs always ran all three vintages (Pre-1980, Post-1980 and New Construction) while the Appendix G results for commercial buildings did not consider vintage (see the footnote on Table 4). In contrast, the multifamily buildings in Appendix G did include results by vintage.
- Appendix G of the TRM included several Small Commercial Buildings that were not part of the ARUP, including: Assembly, Auto Repair, Fast Food Restaurant, Light Industrial, and Religious Worship)
- There are slightly different definitions for Multifamily. In Appendix G of the TRM, the Low-Rise Multifamily buildings that are 3 stories and less and the High-Rise Multifamily buildings are 4 stories and greater. In the ARUP runs, Low Rise is 7 stories and Mid-Rise is 20 stories.

Table 6 shows the peak heating and cooling loads from the ARUP runs normalized per unit floor area. These data are useful for confirming the peak coincident loads for any given project or applicant are consistent with the reference buildings used in this analysis.

Table 6. Peak Heating and Cooling Loads for the Simulated Buildings

		Peak Heating (Btu/ft2-h)			Peak Cooling (Btu/ft2-h)		
		Pre-1980	Post-1980	NC	Pre-1980	Post-1980	NC
Academic	4A	41.6	35.8	10.8	67.2	60.8	22.7
	5A	40.8	39.4	11.6	59.2	56.9	21.7
	6A	52.7	50.8	13.6	62.5	60.4	22.9
Office-Low-Rise	4A	21.3	21.6	15.3	28.7	26.4	18.6
	5A	21.5	22.6	14.5	18.9	21.5	14.9
	6A	28.3	28.0	17.8	22.9	25.4	17.5
Office-Mid-Rise	4A	18.7	16.2	10.8	27.9	23.9	18.4
	5A	18.0	17.1	9.9	21.9	21.2	19.9
	6A	22.7	21.1	12.2	25.3	24.3	19.4
Grocery	4A	50.7	47.7	32.8	23.7	19.5	10.2
	5A	55.8	54.0	37.0	15.7	14.4	6.9
	6A	72.2	69.5	46.6	20.9	19.2	9.7
Hospital	4A	14.0	12.3	6.7	37.1	37.1	28.4
	5A	14.9	14.2	7.3	31.2	32.8	28.9
	6A	20.6	19.0	16.0	36.5	38.4	26.6
Hotel-Large	4A	12.8	13.1	3.1	33.3	34.2	17.6
	5A	14.1	14.8	4.2	27.8	29.3	15.9
	6A	18.3	19.3	9.6	30.4	32.1	16.2
Hotel-Small	4A	9.0	7.8	5.1	18.0	18.0	11.0
	5A	8.7	9.9	6.1	13.2	14.5	9.3
	6A	15.8	15.6	7.8	14.7	15.4	10.1
Outpatient	4A	17.8	15.1	12.0	53.7	52.9	33.5
	5A	18.3	16.6	13.3	42.9	45.7	29.0
	6A	22.5	19.9	19.4	47.8	50.0	34.3
Restaurant	4A	89.8	74.9	64.9	88.0	68.8	74.0
	5A	97.6	84.4	67.4	56.2	47.9	59.3
	6A	137.5	115.0	93.8	72.0	62.4	71.7
Retail	4A	47.4	42.5	21.6	39.6	31.8	22.9
	5A	50.4	47.8	22.6	28.9	25.2	18.7
	6A	65.6	60.0	28.3	35.8	31.2	20.9
School	4A	47.8	42.8	11.1	46.7	45.9	21.1
	5A	52.4	48.1	10.6	31.6	35.4	18.6
	6A	64.6	60.1	19.9	34.6	42.8	20.2
Warehouse	4A	28.5	25.3	13.7	8.1	7.0	2.8
	5A	31.9	29.1	16.1	5.8	5.1	2.0
	6A	47.3	43.2	16.4	8.2	7.4	2.4
MF-Low-Rise	4A	19.3	16.6		19.3	14.6	9.4
	5A	19.4	17.9		11.7	10.2	9.0
	6A	28.2	25.9		15.7	13.8	9.2
MF-Mid-Rise	4A	17.5	14.9	2.5	18.1	14.6	10.9
	5A	17.4	16.0	3.1	11.0	10.3	10.7
	6A	25.5	23.3	3.3	15.0	13.9	11.0
MF-Mid-Rise-Brick	4A	19.3	14.7	2.5	18.1	14.8	10.8
	5A	21.0	16.1	3.2	12.4	10.4	10.7
	6A	28.6	23.3	3.3	16.5	13.7	11.0

Notes: Cooling loads determined assuming peak cooling COPs are 5.5 for chillers and 3.8 for packaged equipment and MF. These COPs were selected to provide the best match to the available peak zone load data.

Balance Point Temperatures

The hourly simulation results were also used to determine the balance point temperatures for both heating and cooling operation in all the cases. This balance point data is useful when doing a temperature bin analysis to evaluate HVAC systems. The hourly data was aggregated into daily average values for outdoor temperature, cooling electric use, and heating energy use (both fuel and electric). Figure 1 shows scatter plots of the daily data for heating and cooling. A regression analysis using data when daily energy values are greater than zero was used to find the heating and cooling balance point temperatures; in this case for the MF-Mid-Rise Pre-1980 case in climate 6A.

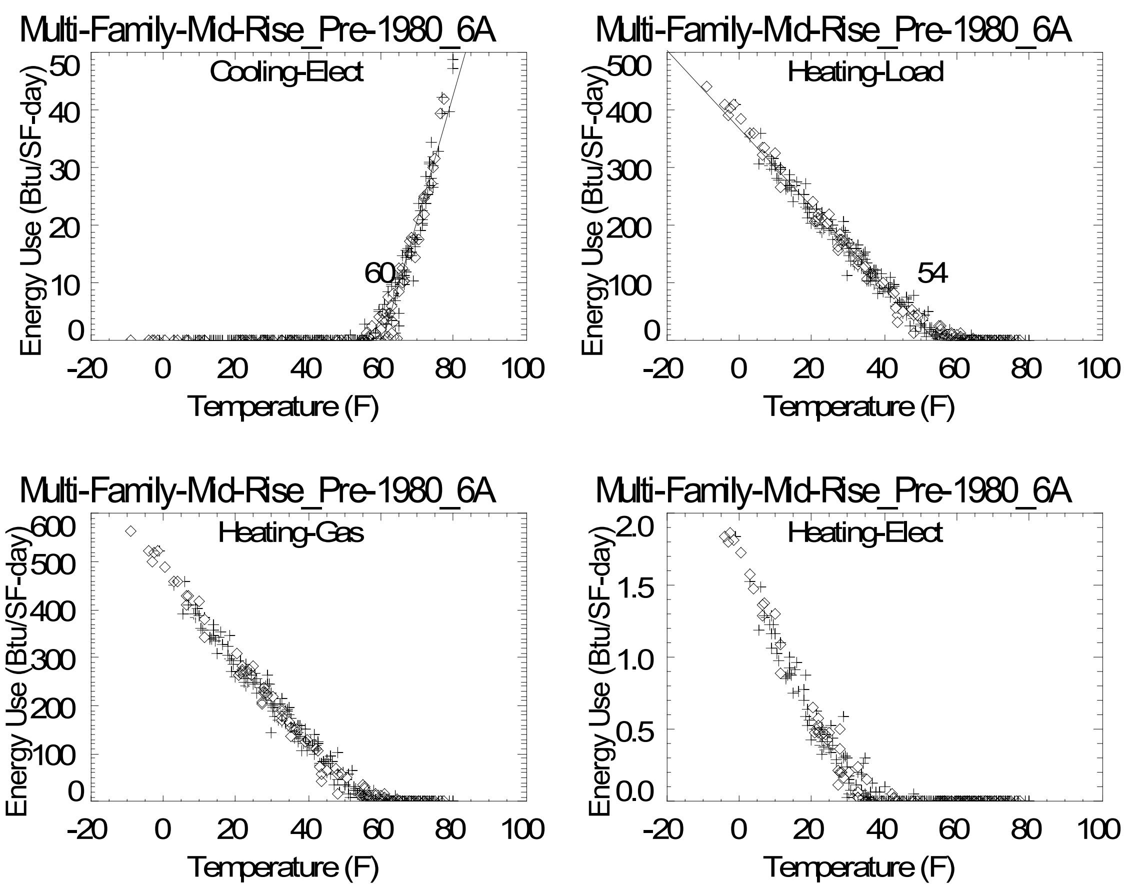

Figure 1. Typical Plots Showing Daily Energy Use vs. Outdoor Temperature for Heating and Cooling (Use to Find Balance Points)

This process shown in Figure 1 was repeated for each case. The resulting balance point temperatures are given in Table 7. In general, the balance point values are higher for cooling than for heating, as would be expected. The table also shows the difference or spread between the heating and cooling balance point values. In some cases the spread is small, indicating that the switch between heating cooling happens in the narrow temperature band. The cases with a negative difference or spread indicates that simultaneous heating and cooling is required for some hours of the year.

For the hospital and outpatient building, the balance points were abnormal (i.e., very high for heating, or very low for cooling). This is primarily driven by the year-round need for reheat and/or year-round need cooling in some spaces. Note that the warehouse shows the largest balance point difference of all the buildings, because ventilation needs are low and internal gains are small in this envelope-dominated building.

Table 7. Summary of Cooling and Heating Balance Points for Each Building, Vintage and Climate

		Balance Point COOLING (F)			Balance Point HEATING (F)			Balance Point Difference: C-H (F)		
		Pre-1980	Post-1980	NC	Pre-1980	Post-1980	NC	Pre-1980	Post-1980	NC
Academic	NY JFK	56.8	56.9	50.5	53.8	53.2	52.5	3.0	3.7	-2.0
	Buffalo	57.3	57.4	53.3	52.6	52.5	51.4	4.7	4.9	1.9
	Massena	58.4	58.5	53.2	54.4	54.2	54.9	4.0	4.3	-1.7
Office-Low-Rise	NY JFK	55.3	54.3	55.6	50.0	53.9	51.3	5.3	0.4	4.3
	Buffalo	56.9	55.1	55.1	48.6	52.6	49.9	8.3	2.5	5.2
	Massena	57.8	56.2	55.4	48.1	52.0	51.5	9.7	4.2	3.9
Office-Mid-Rise	NY JFK	55.7	56.0	51.6	55.8	52.6	50.7	-0.1	3.4	0.9
	Buffalo	56.8	56.8	54.2	51.9	51.3	49.7	4.9	5.5	4.5
	Massena	57.7	57.7	53.7	51.9	50.7	51.0	5.8	7.0	2.7
Grocery	NY JFK	62.3	62.4	60.5	60.2	61.1	69.2	2.1	1.3	-8.7
	Buffalo	61.9	62.0	58.8	59.1	59.6	68.2	2.8	2.4	-9.4
	Massena	61.8	61.9	59.5	57.8	58.2	66.6	4.0	3.7	-7.1
Hospital	NY JFK	32.6	32.4	48.5	110.8	107.7	59.1	-78.2	-75.3	-10.6
	Buffalo	35.7	35.7	50.6	91.4	93.2	58.0	-55.7	-57.5	-7.4
	Massena	36.9	36.8	51.2	78.6	79.1	57.1	-41.7	-42.3	-5.9
Hotel-Large	NY JFK	54.8	55.8	56.6	56.4	58.1	52.0	-1.6	-2.3	4.6
	Buffalo	54.1	54.9	56.5	56.0	57.9	49.3	-1.9	-3.0	7.2
	Massena	54.6	55.2	56.0	56.0	58.2	46.4	-1.4	-3.0	9.6
Hotel-Small	NY JFK	51.2	51.3	49.9	48.1	54.1	50.7	3.1	-2.8	-0.8
	Buffalo	48.9	49.5	48.1	46.7	52.6	49.8	2.2	-3.1	-1.7
	Massena	48.5	48.6	47.3	44.8	51.3	49.0	3.7	-2.7	-1.7
Outpatient	NY JFK	45.4	45.9	49.5	126.9	132.5	57.4	-81.5	-86.6	-7.9
	Buffalo	45.8	46.4	49.6	117.3	117.4	55.8	-71.5	-71.0	-6.2
	Massena	46.7	46.9	51.1	112.1	110.1	54.5	-65.4	-63.2	-3.4
Restaurant	NY JFK	61.8	62.2	59.5	57.3	59.3	52.4	4.5	2.9	7.1
	Buffalo	60.5	60.5	58.5	57.3	59.1	52.0	3.2	1.4	6.5
	Massena	60.8	60.5	58.2	58.2	58.6	51.4	2.6	1.9	6.8
Retail	NY JFK	60.9	61.9	59.8	55.1	55.1	52.1	5.8	6.8	7.7
	Buffalo	60.5	61.1	58.6	54.3	54.4	51.8	6.2	6.7	6.8
	Massena	61.0	61.2	57.9	53.5	53.2	51.4	7.5	8.0	6.5
School	NY JFK	58.8	59.7	44.1	55.5	56.1	48.9	3.3	3.6	-4.8
	Buffalo	56.8	58.1	43.9	54.3	54.8	47.1	2.5	3.3	-3.2
	Massena	59.1	59.7	50.3	59.5	60.7	48.7	-0.4	-1.0	1.6
Warehouse	NY JFK	65.7	65.9	64.1	52.6	52.7	49.2	13.1	13.2	14.9
	Buffalo	64.2	64.2	61.7	50.9	50.8	48.8	13.3	13.4	12.9
	Massena	63.9	64.0	61.1	49.2	49.1	48.7	14.7	14.9	12.4
MF-Low-Rise	NY JFK	62.0	62.5	63.7	57.0	56.4		5.0	6.1	
	Buffalo	61.1	61.1	62.3	56.3	55.7		4.8	5.4	
	Massena	60.8	60.8	61.3	55.6	54.7		5.2	6.1	
MF-Mid-Rise	NY JFK	61.6	62.1	62.8	55.8	54.9	54.2	5.8	7.2	8.6
	Buffalo	60.8	60.7	61.5	55.1	54.2	54.0	5.7	6.5	7.5
	Massena	60.4	60.3	60.0	54.3	53.1	53.0	6.1	7.2	7.0
MF-Mid-Rise-Brick	NY JFK	61.7	62.0	62.8	56.7	55.3	54.5	5.0	6.7	8.3
	Buffalo	61.1	60.8	61.6	56.1	54.5	54.3	5.0	6.3	7.3
	Massena	60.4	60.1	60.1	55.7	53.6	53.4	4.7	6.5	6.7

Note: Abnormal balance points shown as red. The balance point difference (cooling minus heating) is negative in some cases, indicating that simultaneous heating and cooling is sometimes required. These cells are shaded as red.