Multifamily Benchmark

A fuel study provides benchmarking information for multifamily buildings.

by Marc Zuluaga

Benchmarking—comparing the energy use of a building to that of similar buildings—can be a helpful first step in any energy audit. However, for multifamily buildings, that kind of data is hard to find. Recently, Steven Winter Associates (SWA) had the opportunity both to fill a corner of this data void, and to improve the future energy use of a large cross-section of multifamily affordable housing in New York.

In the 1960s and early 1970s, New York experienced a miniboom in affordable housing, with the construction of more than 200 buildings. Because these developments received mortgage subsidies, the buildings fell under the supervision of the New York State Division of Housing and Community Renewal (DHCR). They are collectively referred to as Mitchell-Lama buildings, after the two New York politicians who helped secure their financial assistance. In the late '90s, DHCR became concerned about the repeated requests for rent increases from the managers of these buildings, to cover increasing energy costs that they did not understand. In response, they asked SWA to conduct five-day classes on energy management practices that would be mandatory for one member of maintenance and one member of management from each Mitchell-Lama building. From February 2001 to December 2001, SWA trained 550 building managers and supers in classes that were paid for by the building owners.

Fuel Histories

One of the students' early assignments was to collect two years of fuel records from their buildings. With these records, class participants learned how to conduct a fuel analysis of their own buildings and to compare the performance of their buildings with those of their classmates. This task also allowed SWA to compile a database of the energy usage of these buildings that was analyzed for DHCR with funding from the New York State Energy Research and Development Authority (NYSERDA).

From the more than 200 buildings represented by class attendees, SWA collected complete and accurate energy use data, along with floor area, for 103 buildings in New York City and upstate New York, using gas, oil, or electric energy as a primary fuel source (see Table 1). The buildings ranged from 20,000 ft^2 to 2,000,000 ft^2 and were typically of masonry construction with double-pane windows. One-third of all Mitchell-Lama buildings were built as senior housing. A small fraction of the buildings in the study had centralized cooling, and all were master-metered for electricity. Even in the same class of buildings there was a large difference between the normalized energy performance of the best and worst buildings.

Heating and Domestic Hot Water Energy Use

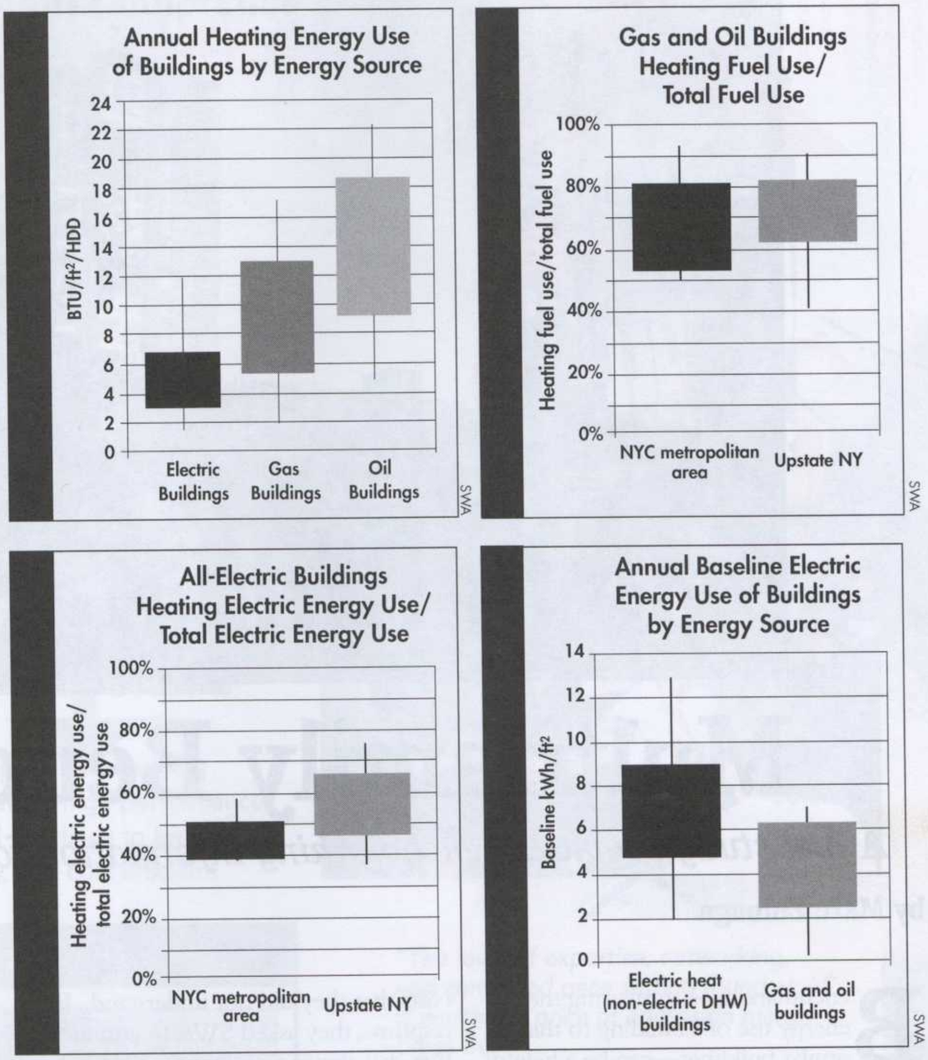
For comparative purposes, floor area and annual heating degree-days (HDD) were used to normalize the heating energy use of the buildings studied.

SWA matched energy bills with monthly heating degree data for the various New York locations to calculate heating energy per square foot per HDD (Btu/ft^2/HDD). (During 1999 and 2000, the average upstate building experienced 6,700 annual HDD, while New York City buildings experienced 4,600 annual HDD.) In addition to being subjected to a colder climate, the average size of upstate buildings studied was 160,000 ft^2, compared to 460,000 ft^2 for the average New York City building.

For gas- or oil-heated buildings, base fuel use was calculated with data from nonheating months. Heating fuel use was then determined by subtracting this base fuel use from the total amount of fuel used during the heating months of October through May. (For a simple method for calculating fuel use normalized for weather and heated area, see "The Math," *HE* Nov/Dec '99, p. 30.) For buildings with electric heat, the two months with the lowest electric use were used to calculate base electric use. This method may slightly overestimate the actual baseline electric energy use of electrically heated buildings, as is discussed in greater detail later in this article.

Despite differences in climate and average building size, the average amount of heating Btu/ft^2/HDD was similar for upstate and New York City buildings of the same fuel type. The average New York City and upstate electrically heated building used 4.8 heating Btu/ft^2/HDD. The average New York City gas-heated building used 9.9 heating Btu/ft^2/HDD compared to 8.8 heating Btu/ft^2/HDD for the average upstate gas-heated building. Unfortunately, the study included only one upstate building that used oil, so it was impossible to make a valid comparison of energy performance for buildings with oil heat.

The findings concerning electric and gas buildings suggest that dividing heating energy use by building floor area and then by heating degree-days is indeed a good method for comparing the heating season energy performance of different-sized multifamily buildings in somewhat different climates. It is important to note that others have found buildings in severely cold climates to be generally more efficient in terms of heating Btu/ft^2/HDD than those in cold climates. If indeed an increase in HDD tends to result in a disproportionate increase in heating energy efficiency, then the heating Btu/ft^2/HDD of buildings in climates significantly different from New York should not be compared to the efficiency of the buildings in this study.



Figures 1-4. *(clockwise from upper left)* In these graphs, the thick bar indicates the range for typical buildings (within one standard deviation of the average) and the thin line indicates the range for all of the buildings studied.

As expected, the cost of fuel strongly influenced the energy efficiency of the buildings surveyed. The actual energy costs of the buildings studied could not be calculated, since, due to deregulation, the bills that we received from many buildings reflected either only commodity charges or only delivery charges. The state average energy prices for residential consumers are a rough indicator of the prices paid by the Mitchell-Lama buildings (see Table 2). Electricity and gas rates were slightly more expensive around New York City than they were upstate. From a site energy use perspective, the average electrically heated building was approximately twice as efficient as the average gas-heated building and 3 times as efficient as the average oil-heated building (see Figure 1). However, if source energy use is considered, the all-electric buildings were approximately as inefficient as their oil-heated counterparts.

Fuel type strongly affected the domestic hot water (DHW) energy use of the buildings studied. Buildings that used gas to heat their DHW were typically more efficient than buildings that used oil. SWA calculated annual DHW energy use by multiplying the average daily fuel use during summer months by 365. In buildings with electric heat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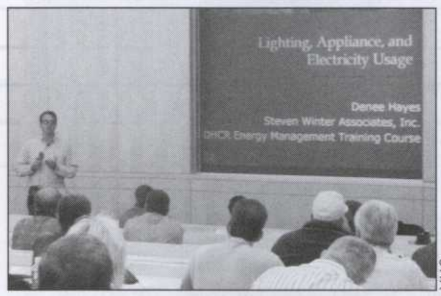

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(left) Lionel Hampton is a 350-unit electrically heated building in Harlem. *(upper right)* St. Simeon is a 100-unit gas heated building complex for seniors in Poughkeepsie. *(lower right)* Andy Padian teaches 100 building managers and superintendents in Syracuse about energy management.

Table 1. Overview of Buildings Studied

Primary Heating Energy Source	NYC Metro Area	Upstate NY	Total for All Sites
Electricity	22	24	46
Gas	9	26	35
Oil	21	1	22
Total for all Energy Sources	**52**	**51**	**103**

and hot water, it was not possible to determine DHW energy use from electric bills. Of the buildings that used gas, there was no significant difference in the DHW energy consumption/ft^2 between those in New York City and those upstate. Again, it was not possible to compare buildings that used oil, because there was only one upstate building in this category.

As part of the study, SWA also compared the amount of energy used for space heating to the amount of energy used for DHW heating in the buildings that relied on gas or oil. It was found that space heating accounted for 60%–80% of total fuel use, with the remainder being made up by DHW (see Figure 2). It is important to note that, all else being equal, a building in a colder climate will use a higher proportion of its total fuel for heating than one in a warmer climate. The average New York City building in this study used 67% of its total fuel for space heating, compared to 72% for the average building located in the colder climate upstate. We had expected there to be a greater difference in these two values, since the New York City buildings studied experienced 30% fewer annual HDD than those upstate, but this was not the case.

The following example explains this unexpected result. If heating energy use is proportional to HDD, a typical upstate building that uses 72 units of heating energy and 28 units of DHW energy would use 50 units of heating energy and 28 units of DHW energy if located in a New York City climate with 30% fewer HDD. This same upstate building that uses 72% of its fuel for heating would then use 64% of its fuel for heating if it were located in New York City. Thus, a large difference in HDD results in a relatively small difference in the heating fuel use fraction, making this parameter excellent for comparing the performance of buildings even if they experience slightly different climates.

Baseline Electrical Energy Use

For electrically heated buildings, we compared the electricity used for heating with the total electricity used. Since all the buildings studied were master metered, total electricity use included equipment, common area, and apartment use. We excluded the few buildings with electric-resistance DHW from this particular calculation. Again, colder upstate buildings would be expected to use a greater proportion of their total electric energy use for heating (see Figure 3). It is interesting to note that electric energy for heating accounted for only about 50% of total electric energy use in the buildings surveyed. This suggests that while electric heat may be inefficient, it is not the only reason for high electric bills in these multifamily buildings. Even if a complete retrofit to gas or oil heat is prohibitively expensive or too disruptive to occupants, it is important for owners of all-electric buildings to realize that there is also great energy saving potential in addressing lighting and equipment efficiency and apartment electric use.

SWA calculated the baseline, nonheating- and cooling-related electrical energy use for all the buildings studied, using data from the two lowest electric bills as described above. With this calculation procedure, the electrically heated buildings typically used more baseline energy than gas- and oil-heated buildings (see Figure 4). This may mean that baseline electricity use is actually higher in all-electric buildings, due to the operation of electric ranges that were not usually present in the gas- or oil-heated buildings studied. It could also mean that a portion of the lowest monthly electric bills used to calculate baseload was due to occupant-controlled electric radiators or fan coil units being turned on in mild weather. If, in fact, this method overestimates baseline electrical energy use in all-electric buildings, then it must also underestimate heating energy use in these buildings. The difference between the average baseline electrical energy use for electrically heated buildings and that for gas- and oil-heated buildings is 2.7 kWh/ft² per year (or 4,600 BTU per square foot per six-month heating season). Thus, in a 5,000 HDD climate, the calculation methods used may actually underpredict the heating energy used in an all-electric building by approximately 1 BTU/ft²/HDD. Similarly, the fraction of the total electric energy use made up by heating electric energy may be approximately 10% higher than is indicated in Figure 2.

Whether or not the methods used in our study slightly overestimate baseline electric energy use of all-electric buildings is somewhat of a moot point, since any bias affects all buildings similarly and the results of the study are most useful for comparing the relative performance of buildings. In the case of one electrically heated Mitchell-Lama building audited by SWA, a comparison of the building's energy use with the fuel study results indicated that its baseline electric usage/ft² was much higher than the range for a typical building in Figure 4, even for a master-metered building.

Table 2. Average New York State Energy Prices for Residential Consumers During 2000 and 2001

	Unit Cost	Cost per MMBTU
Electricity	$0.14 per kWh	$41.03
Gas	$1.20 per therm	$12.00
# 2 Oil	$1.40 per gallon	$10.14

Source: NYSERDA

Furthermore, this building was not particularly efficient in terms of heating Btu/ft²/HDD, yet it used a relatively small fraction of its total electricity for heating. We surveyed the pumps, motors, and common-area lighting in the building and could not account for such a high baseload. This observation, combined with the results of our fuel study, suggests that apartment lights and appliances are probably not being turned off enough—and that the building is a prime candidate for electric submetering.

Good judgment should be exercised when comparing the performance of other buildings to those in this study. Any hunches concerning the energy usage of a building being audited that arise from a comparison with similar buildings in this study should be followed up with other diagnostics. In this context, we hope that the results presented here will be useful to other practitioners.

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