

MULTIFAMILY Energy Performance: BENCHMARKING

BIG DATA has been making the rounds 2013 the complete raw data as a buzz phrase lately. Private companies and municipal governments have been developing new approaches to informed decision making based on firm evidence. Municipalities across the country and the world are establishing new legislation to provide the raw data that will lead to more efficient and effective sustainability measures.

New York City passed the Greener Greater Buildings Plan in 2009, based on hard work and forethought by the Department of Buildings and the Office of Long-Term Planning and Sustainability, becoming the first U.S. city to impose mandatory regulations to reduce carbon emissions from existing buildings. Because New Yorkers depend heavily on public transit and seldom drive cars, roughly 80% of citywide carbon emissions come from buildings. NYC set the goal of cutting carbon emissions by 30% by 2030, and the citywide legislation on existing buildings is projected to contribute 5% total carbon savings to this goal.

The first law implemented from the plan, NYC LL84, establishes an annual building benchmarking requirement. All buildings over 50,000 square feet are required to submit whole-building energy usage via EPA's Portfolio Manager online tool every year. These data are then scrubbed and analyzed by academics at the University of Pennsylvania and New York University. A team of professionals from the building science fields collaborates over the analysis, and annual reports are released to the public (see Figure 1). In late September



A typical NYC prewar multifamily building with steam heat.



A typical NYC postwar multifamily building with hydronic heat.

set was released for multifamily buildings, disclosing individual building usage for the first time. This will allow energy usage characteristics to become part of the real estate valuation process, and will provide a market-driven incentive for improving energy efficiency. (I have been involved in this

benchmarking process as an energy engineer at Steven Winter Associates.)

Many parties benefit from benchmarking, including legislators and the real estate industry. In addition, benchmarking provides energy professionals with a real basis for comparing retrofit work done on buildings and for conducting savings estimates. Auditors who propose a package of measures projected to save 30% of energy usage need to reexamine their analyses at a building that benchmarks in the best 25% of multifamily buildings. Projecting this level of savings at a building that benchmarks in the lowest 25% seems more reasonable. This ability to provide quick checks on savings projections has implications for quality control in auditing, and for the possibility of underwriting financing against proposed retrofit savings.

Trends in Multifamily Buildings

The NYC bulk multifamily building data analysis released in the city's annual benchmarking reports since 2012 suggests surprising trends. Source energy use intensity (EUI) is the sum of the total energy use at a building per unit of gross area, adjusted for inefficiencies in energy production and distribution. The oldest multifamily buildings tend to show slightly lower source EUIs than newer ones (see Figure 2), with total source EUI peaking in the 1971-90 building stock (see Figures 2 and 3).

There is huge variation in performance of buildings of every age, but statistical analysis does indicate that on balance the older building stock is using less source energy per square foot than the newer building stock. This is likely due to a combination of factors, including an increase in the implementation of mechanical ventilation in modern buildings, the shift in fuel availability following the oil crisis, and the adoption of building amenity spaces. NYC's first benchmarking report shows very clearly that the lowest-performing multifamily buildings are also getting the highest percentage of their total building energy in the form of electricity (see Figure 4). Electricity has a high site-to-source conversion factor, and is used heavily both in buildings constructed

during the 1960s-1970s and in modern luxury buildings with large amenity areas. Amenity areas in these buildings often include fitness centers, steam rooms, and pools-all of which use a lot of electricity. Electricity is less efficient than gas on a source Btu basis, so spaces using more electricity have higher source EUIs than those using more gas. The two modern building cohorts described above as heavy in electricity usage likely contribute to the increase in source EUI seen in newer multifamily buildings.

Steven Winter Associates has frequently seen this pattern in the field. Repeated internal benchmarking has shown us that older buildings tend to have higher relative fuel use, while newer buildings have greater electricity use. These competing trends tend to cancel each other out when we look at the larger picture, but they are much clearer when we take a closer look.

A Tale of Two Buildings

A typical NYC prewar building uses steam heat from a high-mass boiler. These boilers often contain a coil for making domestic hot water (DHW), so the boiler must run at part load through the summer months to keep a large volume of boiler water hot at all times. This building has no street front commercial spaces, and its only common areas are a laundry room, an open stairwell that receives ambient light, and corridors. Apartments typically have no mechanical ventilation or central air conditioning.

A common construction style in newer NYC buildings is to use a modular sealedcombustion gas-fired boiler plant to provide DHW and hydronic heat. These buildings have mechanical exhaust in many apartments, and they seldom have central cooling for the apartments. A packaged rooftop makeup air unit for the corridors provides heated and cooled outside air year round. This building has numerous common areas, including a large lobby, a playroom, a fitness center, a resident storage room, and well-lit enclosed stairwells.

While many new buildings are being constructed to high equipment efficiency standards, exceeding ASHRAE baselines, they tend to still have greater energy loads than older buildings. This is because these efficiency standards are based on individual systems and not on the whole-building context. In other words, there is no means of accounting for the imbalance in the sheer number of systems that is frequently seen between differ-

ent vintages and styles of multifamily construction. A simple prewar building with 5 low-efficiency systems can use less energy than a complex modern building with 15 high-efficiency systems (see Table 1).

These nuances are what keep energy auditors busy. A single benchmarking score is useful for starting to decide which buildings should be targeted for

improvement, but it does not identify potential improvements. An auditor should couple the benchmarking score with a review of base building systems, heating intensity, electricity intensity, and DHW usage; and he or she should know the normal bounds on any





Prewar, dimmer, naturally-lit stairwell (left); postwar, brighter, illuminated stairwell (right).

Table 1. Comparison of Energy-Using Systems in Two NYC Archetypal Buildings

FUEL USE		ELECTRICITY USE		
Prewar building	The high-mass boiler must run year-round for DHW production in the summer.	The use of natural ventilation saves on electricity used.		
	The steam system is prone to undetectable leaks.	No commercial space means no energy-intensive retail activities on-site.		
	Steam distribution is unbalanced; building maintenance staff often increases steam pressure and delivery in response to complaints of cold rooms. This leads to overheating throughout most spaces, wasting fuel.	Limited common areas require minimal lighting and equipment.		
Modern building	The modulating low-mass boiler plant operates at higher efficiency for DHW production and heating.	Mechanical ventilation significantly increases building electricity demand.		
	Sealed-combustion boilers have lower standby and purging cycle losses than are found with many older options.	Street-front retail spaces have high lighting demands and equipment electrical demands.		
	Leaks are quickly detected and repaired in hydronic systems.	Common and amenity spaces have high lighting, cooling, and equipment electrical demands.		
	Resident controls are easier to implement on hydronic systems, minimizing overheating.	The hydronic heating loop requires large house pumps.		
	Street-front retail spaces have high lighting demands and equipment electrical demands.	Corridor makeup air units use fan power and summer cooling electricity.		

Table 2. Energy Usage Metrics for Two Example Buildings

	Heat Slope*	Electricity Index (Apartments)	Electricity Index (Common Areas)	DHW Load	Source EUI
Prewar building	12 Btu/ft²/HDD	4.3 kWh/ft ²	2 kWh/ft²	21 kBtu/ft²	149 kBtu/ft²
Modern building	10.1 Btu/ft²/HDD	4.3 kWh/ft ²	3.4 kWh/ft ²	14 kBtu/ft²	149 kBtu/ft²

Note: Metrics based on actual data gathered from Steven Winter Associates projects. *Heat slope is a measure of the heating energy used per square foot. It is weather normalized to be independent of the severity of the winter during which utility data were collected.

indices for the specific building type. For example, knowledge of the systems described above tells us that we would expect the heating energy use intensity to be higher in the prewar building than in the modern building, and we would expect the converse to be true for owner-paid electricity usage. The antagonistic effects of over- and underperforming individual systems like this can mask savings opportunities and lead to similar EUIs in these dissimilar buildings (see Table 2). Multilayered benchmarking provides a strong indicator not only of how a building fares compared to a national or citywide database, but also of how its systems compare to other similar systems.

Meeting the Benchmarking Challenge

Varying levels of benchmarking make it difficult to develop a national multifamily Energy Star score. Scores are already available for commercial buildings, but not for multifamily buildings. Portfolio Manager calculates EUI numbers, but users must choose a comparable yardstick themselves. The multifamily building source EUIs in the NYC LL84 database were quite normally distributed, as shown in Figure 1, with a median of 132.2 kBtu/ft2 in the 2011 data set. The Residential Energy Consumption Survey (RECS) 2005 source EUI for Northeastern multifamily buildings has a value of 130 kBtu/ft2. Anecdotally speaking, auditors typically see more overheating in NYC buildings than in buildings elsewhere, which should boost EUIs in NYC compared to buildings in other cities with a similar climate. Other factors and fuel usages may be masking this impact when the NYC LL84 and RECS data are viewed side by side.

More data will help clarify these points and make possible more accurate comparisons as more municipalities begin to implement benchmarking legislation. Out of eight cities that currently regulate benchmarking (NYC, San Francisco, Washington, D.C., Philadelphia, Minneapolis, Boston, Austin, and Seattle), NYC accounts for over half of all benchmarked square footage. Expanding the benchmarking movement to more cities will help to create a balanced baseline energy usage in multifamily buildings across the country.

There are still notable roadblocks to implementing benchmarking programs across the country. Many utility companies have legacy systems that cannot quickly or easily provide whole-building billing data. This creates challenges in a multifamily setting, where tenants may all have individual meters and private

utility accounts. It is not feasible for building management to get utility releases and histories for every apartment in a building. Utility companies in cities with benchmarking legislation have developed workarounds for their systems that allow practitioners to request whole-building aggregated usage data. Some states, including California, have taken this a step further and are piloting utility company direct upload of aggregated data for benchmarking. These improvements greatly reduce the chance of error in reporting data, and increase the chances that complete data will be submitted for buildings covered by the benchmarking mandate in those service

Choosing where to launch benchmarking programs is also a challenge. Some experts believe that any city with a population of over 50,000 should have mandatory benchmarking. Commonly, only big buildings (roughly greater than 25,000 square feet) have dedicated management staff who are capable of completing the benchmarking requirements, and few of these big buildings are found in small cities.

It is vital to ensure that the data collected through these programs are correct, complete, and usable. The academic team analyzing NYC's benchmarking data began with 10,016

Northwest Region Multifamily Source EUI

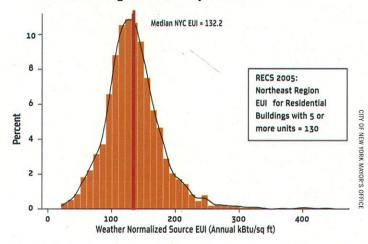
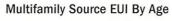


Figure 1. Northeast Region Source EUI for multifamily buildings with 5 or more units.



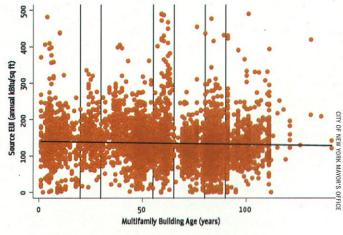


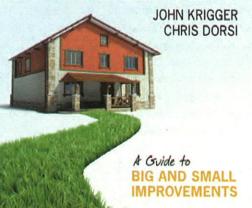
Figure 2. Annual Source EUI for multifamily buildings by age.

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Multifamily Source EUI By Year Built

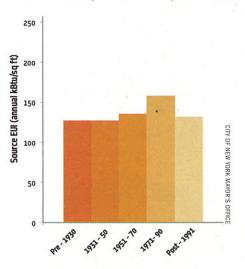


Figure 3. Total Source EUI peaks in the 1971–90 building stock for multifamily buildings.

properties in its original 2011 data set. This number was reduced by 26% during the scrubbing process, where buildings with incomplete or highly suspicious data were removed from analysis. In NYC, roughly 30 practitioners were responsible for benchmarking over two-thirds of compliant buildings during the first year. Any misunderstanding on the part of these practitioners can skew significant portions of the data set, but training for these practitioners could potentially have a big impact on the accuracy of the data. To achieve this goal, DOE is currently developing a benchmarking certification that will create some level of quality control among all benchmarking providers.

DOE is also working to establish a nationwide database to serve as a repository for all municipal benchmarking data. This, together with the universal adoption of a single benchmarking tool (Portfolio Manager), will render these data uniformly accessible. This standardization across states will create a larger cohesive data set and will prevent the barriers to comparison seen in Europe, where each country uses a different system.

Finally, the auditor must estimate potential energy savings using the baseline that is established through benchmarking. Numerous methods of doing so have been proposed. They include the following:

- Proportional Savings. In this method, buildings with the highest EUIs and worst benchmarking scores are assumed to be capable of saving the greatest percentage of their energy usage.
 A fixed scale is chosen relating existing performance to savings potential.
- 2. Absolute Goal. In this method, all buildings in a data set are assumed to be capable of attaining a fixed energy usage goal—reducing EUI to meet the existing top 25% cutoff, for example
- 3. Data-Based Savings Projections. This method was developed by the Deutsche Bank Living Cities project. The project analyzed pre- and postretrofit energy use in New York

Energy Use Type in Multifamily Buildings

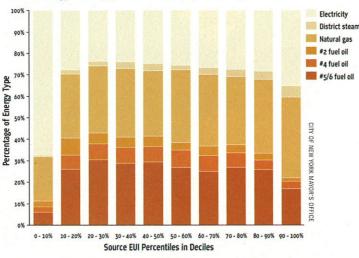


Figure 4. NYC's first benchmarking report shows that the lowest-performing multifamily buildings are also getting the highest percentage of their total building energy in the form of electricity.

State affordable housing that underwent state-sponsored energy efficiency work. The project then developed equations and parameters for estimating the potential savings from more detailed starting metrics than EUI alone.

Savings potential can come from three main areas: load reduction, efficiency increases, and distributed generation. Most work on estimating savings potential focuses on the first two, ignoring the added benefits derived from renewable technologies or cogeneration. Distributed generation may also have implications for future benchmarking data sets, driving them toward bimodal EUI distributions centering around sites with on-site generation and those without. This is an important distinction, as incentive money, improved economics, and resiliency concerns are leading more owners to evaluate distributed generation.

The modern interest in sustainability and the push for right-to-know legislation will lead to the adoption of mandatory benchmarking in more and more cities nationwide. There is a growing likelihood that building energy professionals will find themselves asked to benchmark a site or use these data sets to draw deeper conclusions about their clients' properties. Professionals who understand the strengths and weaknesses of these data sets will be better able to characterize those properties and to calculate their savings potential.

-Nicole Ceci

Nicole Ceci is an energy engineer at the New York City office of Steven
Winter Associates, a building science consulting firm specializing in energyefficient, cost-saving, and resource-conserving buildings.

The team of over 90 sustainability practitioners has audited more than 50 million square feet of existing buildings across the Northeast over the last five years. Steven Winter Associates has performed over 450 analyses and submissions of building data since New York City's benchmarking legislation was enacted.

To download the NYC LL84 data reports and view disclosed building data, go to www.nyc. gov/II84data.

To read an overview of NYC LL84, visit www.nyc.gov/II84.

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