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NEW YORK CITY LOCAL LAW 84 BENCHMARKING REPORT

SEPTEMBER 2014

A GREENER, GREATER NEW YORK

The City of New York
Mayor Bill de Blasio

Cover Photo: The Flatiron Building, New York CIty
Credit: John H. Lee

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Acknowledgements

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For more information, please visit: www.nyc.gov/ll84data

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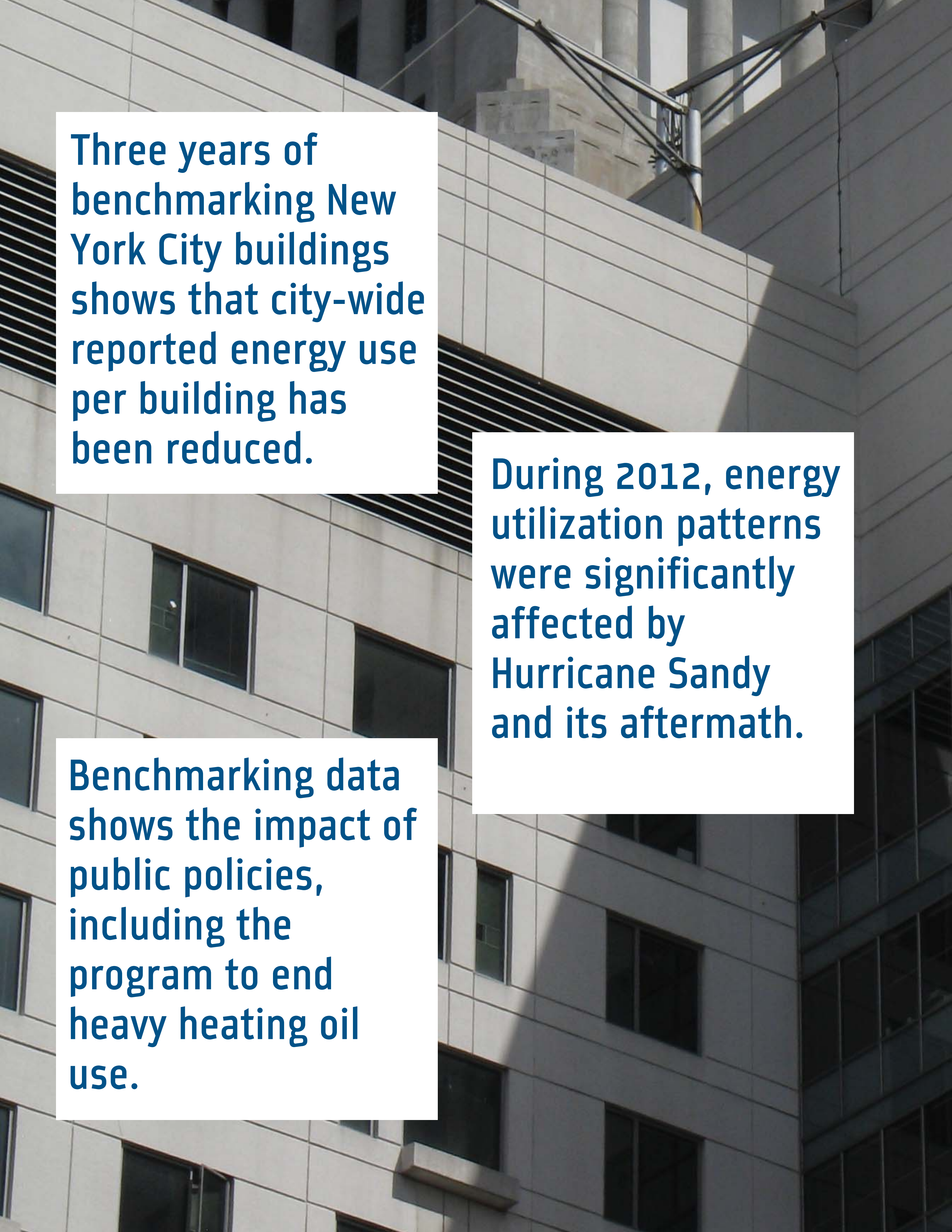


Three years of benchmarking New York City buildings shows that city-wide reported energy use per building has been reduced.

During 2012, energy utilization patterns were significantly affected by Hurricane Sandy and its aftermath.

Benchmarking data shows the impact of public policies, including the program to end heavy heating oil use.

Executive Summary

In 2007, the City of New York established *PlaNYC,* a comprehensive plan to prepare the city for population growth, strengthen the economy, combat climate change, and enhance the quality of life for all New Yorkers. *PlaNYC* brought together over 25 City agencies to work toward the vision of a greener, greater New York, with a commitment to a carbon reduction goal of 30 percent by the year 2030. The plan provides a roadmap for growth in an expanding economy while improving and managing our resources for a more sustainable future. This calls for forward-thinking in new developments with fundamental change in the conventional methods by which existing assets are managed. The plan's aggressive energy efficiency and emissions reduction goals will require a new paradigm in the operation and management of systems across New York City. In order to understand how to reshape future outcomes, the City must first establish benchmarks of present conditions and repeatedly measure progress.

Energy used in buildings far outweighs the energy used in any other sector in New York City – a distribution that differs from the United States at large where energy used in transportation commands a much larger share. Due to the density and transit infrastructure afforded by New York City, the energy used within the City's boundaries is concentrated in activities occurring within buildings. Therefore, in order to achieve the emissions reduction goals of *PlaNYC*, the policies and programs developed by the City must focus on buildings as the source for the most significant efficiency gains. Improvements in efficiency not only reduce overall greenhouse gas emissions, but also reduce operational expenses, improve building performance, and free up capital to invest in other opportunities.

A building's owners, tenants, and operators must first understand how much energy and water is being used in order to identify where improvements in utilization can be made. In New York City, building owners have been mandated by law since 2010 to annually record energy and water use, and this information is then publicly disclosed by the City. This is the first step in providing the marketplace with actionable intelligence so that owners, service providers, and consumers can make informed transactional decisions that account for energy performance of building assets.

This report is the third annual report of the analysis of energy use and water use data in New York City's largest buildings. The data drawn upon for analysis comes from the New York City Benchmarking Local Law 84 of 2009, and is comprised of annual energy and water use reporting to Portfolio Manager, an online reporting system provided by the U.S. Environmental Protection Agency (EPA). The energy and water use data analyzed in this report is from consumption during calendar year 2012 of the largest properties in New York City, and, for analytical purposes, the data has been merged with land use characteristics data maintained by the City.

Key Findings

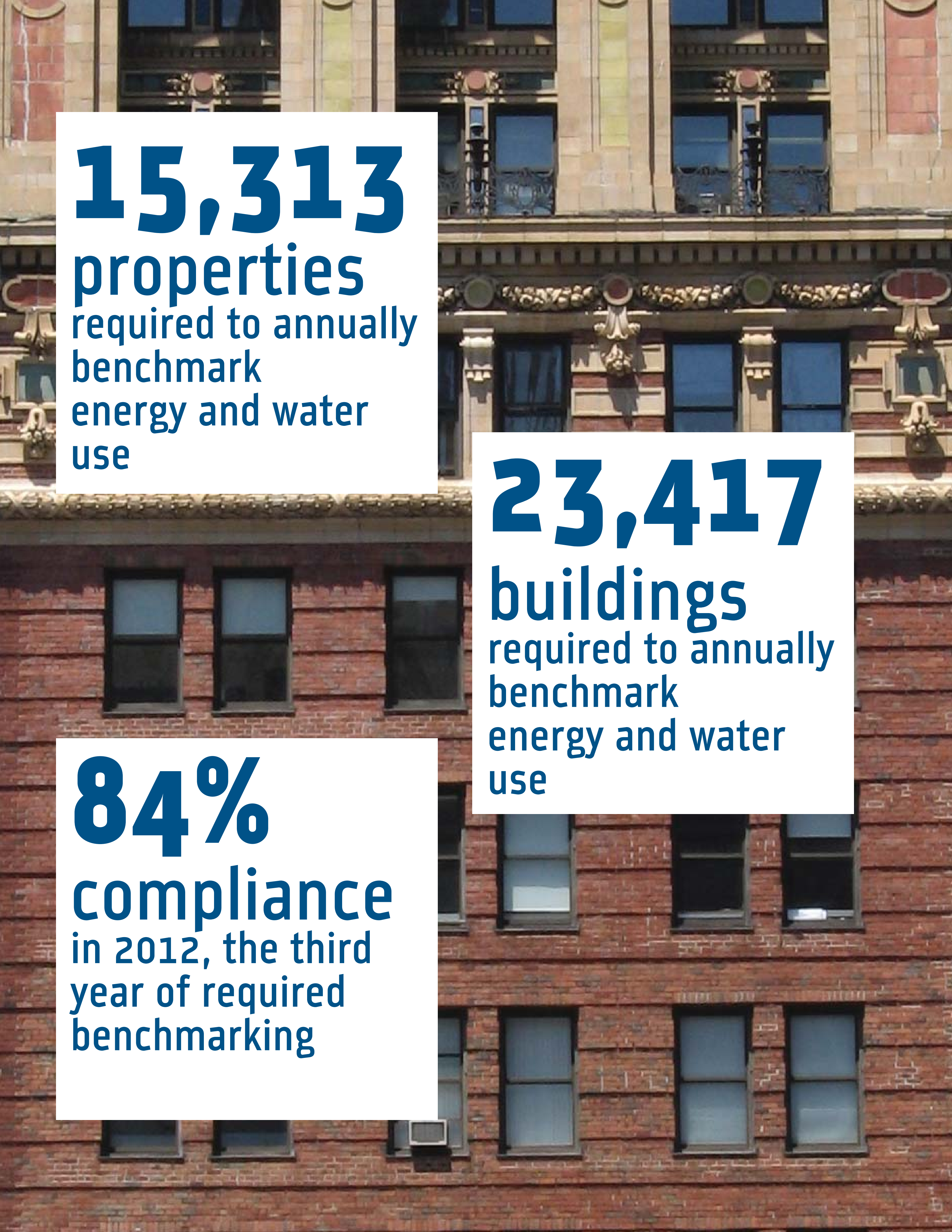
Among the more than 13,000 properties subject to the benchmarking ordinance, the majority of properties are classified as multifamily residential. This corresponds with the overall city inventory of buildings where the majority of properties are classified as residential. The opportunities for the greatest absolute gains in energy efficiency reside within multifamily buildings due to their proportional land use share. However, the residential sector is also the most difficult to initiate investments in building improvements due to governance structure among owner-occupied properties and limited tenant control among rental properties. Analysis of the benchmarking data has already afforded new insights into market segmentation of the residential sector. By identifying construction types and systems characteristics across the portfolio of multifamily buildings, policies and programs can be directed towards the greatest energy efficiency opportunities and optimized cost-savings.

Water use per square foot recorded through the benchmarking ordinance to date reveals a correlation with energy utilization; meaning that high intensity energy consumers are also high intensity water consumers. Through further analysis of water utilization and correlations to specific building characteristics, finely tuned market segmentation can emerge to also identify optimal water-savings opportunities and strategies for policy implementation. Over time, as more covered buildings become eligible for automatic uploading of water use data, the inputs for analysis will become increasingly accurate and comprehensive.

The first two years of benchmarking data exhibited consistencies in reported data that suggested an emerging trend in energy use patterns among covered buildings. These observations would be validated by consistent data in the third year; however the third reporting year yielded energy use data that varied significantly from the first two reporting years. This deviation may be attributable to several unassociated factors. In calendar year 2012, New York City was subjected to the most significant coastal storm in recorded history – an event that incurred wide-spread power outages, extensive damage to electrical and mechanical systems in buildings, and pervasive losses of operational capacities. The immediate aftermath and recovery operations following the storm impacted the energy use profiles of buildings across the city, and the resultant aggregated energy use data reveals a citywide profile that varies substantially from the prior two years' data.

The third year energy use data by fuel type does however corroborate other evidence that has emerged from the City's program to eliminate heavy fuel oil use. The program, entitled NYC Clean Heat, has been extremely effective in accelerating fuel oil conversions in buildings subject to the heavy fuel oil ban, well in advance of the actual deadlines. As a result of City programs like NYC Clean Heat, particulate matter measurements across the City have reduced dramatically, yielding the cleanest local air quality in over fifty years. The effects of NYC Clean Heat are not only measurable by the air monitors placed throughout the City, but are also measured through the evidenced reductions in heavy fuel oil use among benchmarked buildings.

Programs and policies such as NYC Clean Heat prove to be overwhelmingly effective when based upon quality data that can be leveraged to design and implement strategies. The data gathered from the benchmarking ordinance continues to provide essential information that will allow the City to pursue increasingly aggressive programs and policies to drive down energy and water consumption as well as utility cost expenditures. Only through these sorts of high-impact programs that reach deep carbon reductions, resource conservation, and significant efficiency upgrades will the City be able to attain the ambitious climate change mitigation goals set forth by *PlaNYC*.



15,313
properties
required to annually benchmark energy and water use

23,417
buildings
required to annually benchmark energy and water use

84%
compliance
in 2012, the third year of required benchmarking

Background and Context

Leading the national trend of building information disclosure, New York City collects and publicly discloses the largest data set of building energy and water consumption data in the U.S., covering more built area than any other benchmarking jurisdiction (Fig. 1). This report provides overview and analyses of data collected for calendar year 2012, or "Year Three."[1]

Benchmarking

In New York City, owners of large buildings have benchmarked and reported energy and water consumption data under New York City Local Law 84: Benchmarking (LL84). The law has been applicable since 2010 for public sector buildings and since 2011 for large private sector buildings. LL84 is one of four laws within the Greener, Greater Buildings Plan (GGBP), the most comprehensive local legislation addressing energy efficiency and water utilization in the U.S. The City's water utility, the Department of Environmental Protection (DEP), is the first in the nation to provide widescale automated meter reading and uploads of water utilization data, which has assisted property owners across the city to accurately report water usage and comply with the local law.

Borough, Block, and Lot (BBL)
A borough, block, and lot number is a ten digit number that identifies the location of a property based on the borough (signified by the first digit, the block (signified by the following five digits), and the lot (signified by the last four digits) information.

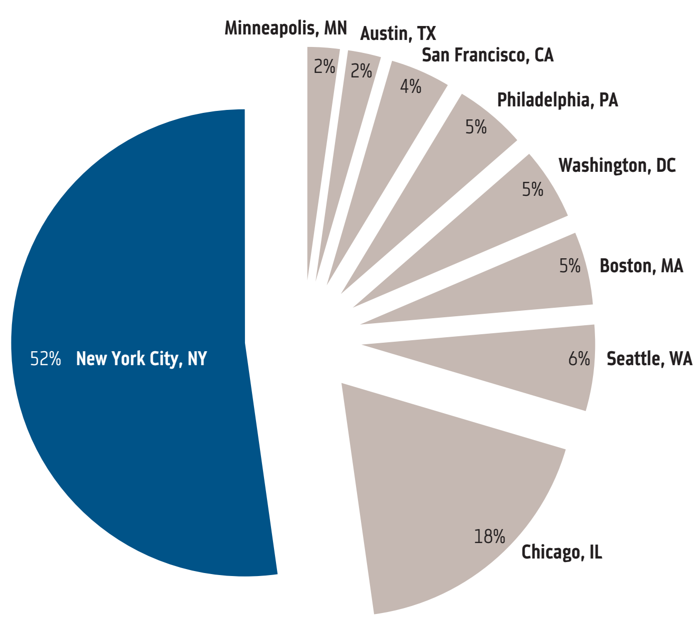
Building
A building is a permanent structure located within a lot. A lot may have more than one building. A building can also reside on more than one lot.

Covered Buildings
All private properties with buildings required to comply with LL84 are described as "covered buildings." Covered buildings are identified based on their gross floor area records in the Department of Finance's (DOF) property database, which regularly updates to reflect changes in building ownership, characteristics, etc. The list of covered buildings changes annually to maintain accuracy.

Lot
A lot is a parcel of land with a unique BBL number.

Property
A property refers to one or more buildings located within a single lot owned by a single owner. Most of the analysis is done on the basis of properties, unless otherwise noted.

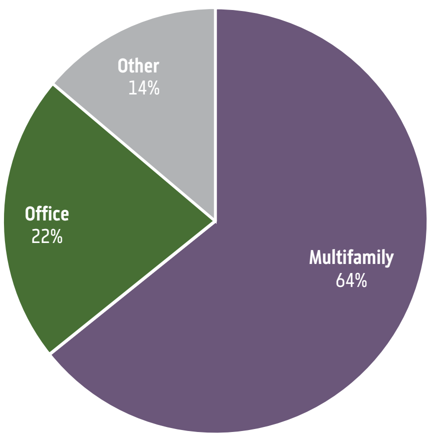
[Fig. 1] **Gross Floor Area Impacted by U.S. Benchmarking Regulations**



Source: Institute for Market Transformation and NYC Mayor's Office

According to LL84, public sector properties (single or multiple buildings on a lot,[2] or a single parcel of land) over 10,000 square ft (sq ft), single private sector properties over 50,000 sq ft, and multiple private sector properties totalling over 100,000 sq ft must annually comply. In 2013, the City of New York (the City), required 13,196 private sector properties (20,320 buildings) and 2,117 public sector properties (3,097 buildings)[3] to comply by May 1. The square footage required to benchmark included 2.3 billion sq ft of private sector buildings and over 281 million square feet of public sector buildings. Of the 13,196 private sector, 5,385 properties were required to report their water usage and were eligible for automatic uploading of water utilization data to ENERGY STAR Portfolio Manager.

[Fig. 2] **Proportion of Gross Floor Area**



Gross Floor Area

Source: NYC Mayor's Office

Covered Buildings by Sector

This report divides covered buildings, or properties required to comply, into three main building sectors: multifamily, office, and "other," which includes, but is not limited to, retail, hospital, hotel, warehouse, educational, and other uses. These use classifications are self-reported by building owners using the U.S. Environmental Protection Agency's (EPA) ENERGY STAR Portfolio Manager benchmarking tool. The multifamily sector includes residential properties that have more than 50 percent of their gross floor area devoted to residences; the office sector includes properties with more than 50 percent devoted to office space. Multifamily properties make up the largest percentage of built area required to comply at 64 percent, followed by office properties at 22 percent, and other properties at 14 percent (Fig. 2).

Publicly disclosed benchmarked data is available online at www.nyc.gov/ll84data and includes the following metrics for each property in compliance. Additional information on Portfolio Manager metrics is available online at www.energystar.gov/portfoliomanager.

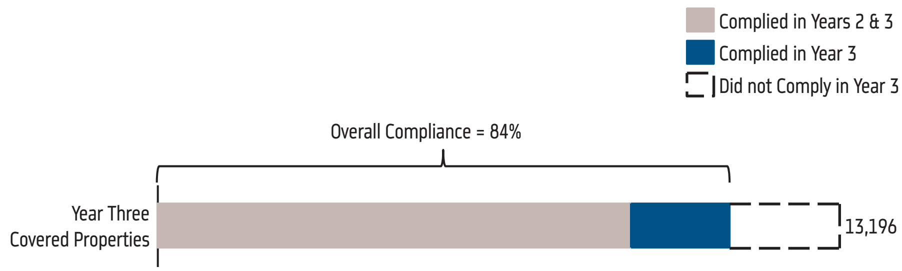
- **ENERGY STAR scores[4] for eligible properties** - a property's energy performance score that compares against national surveys of verified energy data
- **total greenhouse gas (GHG) emissions[5]** - carbon dioxide, methane, and nitrous oxide generated from on-site energy consumption within a property
- **site energy use intensity (site EUI)[6]** - energy consumption per sq ft within a property
- **weather normalized source (source EUI)[7]** - or energy consumption per sq ft within a property in addition to energy consumed during production, transmission, and delivery, and accounting for weather
- **indoor water use intensity (WUI)[8]** - or water consumption per sq ft within a property
- **property floor area** - gross floor area of a property
- **self-reported property type** - property type information as reported
- **number of buildings** - count of buildings within a property

Compliance with Local Law 84

In Year Three, building owners achieved an 84 percent compliance rate by August 1, 2013.[9] LL84 compliance for private sector properties is verified by the Department of Finance (DOF) through a data matching process between the City's Primary Land Use Tax Lot Output (PLUTO) data files and ENERGY STAR Portfolio Manager data. Not only is the rate an increase from 75 percent in Year Two (and in Year One), but a majority of covered buildings consistently reported in both years, with 92 percent of the same building owners in Year Two complying in Year Three (Fig. 3). As buildings owners and service providers become more familiar with the benchmarking requirements and utilities streamline their aggregated data request processes, overall compliance is expected to increase every year.

[Fig. 3] **Overall Year Three Compliance Rate**

Source: NYC Mayor's Office

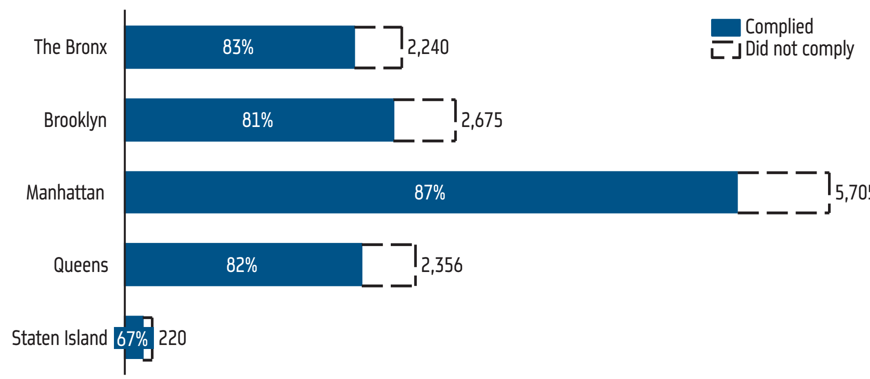


Compliance by Borough

Understanding compliance becomes more complicated when examining where covered properties are located. The distribution of LL84 covered properties by borough reflects the uneven scatter of large buildings throughout New York City. Within this distribution, Manhattan has the highest concentration of large buildings, and consequently the highest number of covered properties under LL84, more than twice the number of covered properties in the Bronx, Brooklyn, or Queens, and more than 26 times the number of covered properties in Staten Island. Thus it is important to understand compliance in relation to each borough's total number of covered properties (Fig. 4). Additionally, the covered buildings list updates annually due to factors that change a property's eligibility status for LL84 compliance, therefore the total number of properties per borough will slightly shift from year to year. In this context, compliance across boroughs in Year Three ranged from 67 to 87 percent (Fig. 4).

[Fig. 4] **Compliance Rates by Borough**

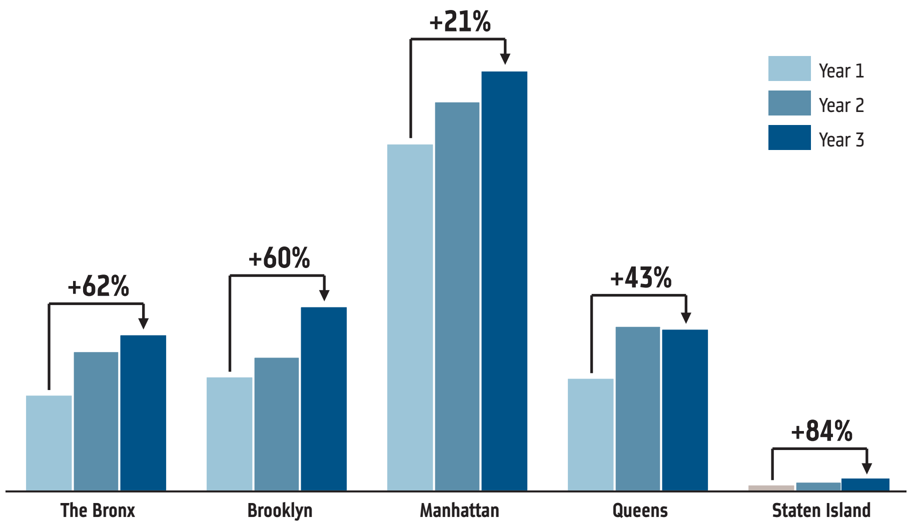
Source: NYC Mayor's Office



Despite the inconsistent grouping of properties across the boroughs and shifts in the covered buildings list, compliance rates have generally moved in an upward trend over the past three years (Fig. 5). However, the incremental increase in compliance from year to year shrinks for properties in all boroughs, except Brooklyn, and in the case of properties in Queens, compliance actually decreased by one percent from Year Two to Year Three. In other words, the increase in compliance by borough was more notable from Year One to Year Two than from Year Two to Year Three. If this trend continues, the compliance gap may close more slowly every year, leading to consistent year over year rates.

[Fig. 5] **Year over Year Increased Rates of Compliance by Borough**

Source: NYC Mayor's Office



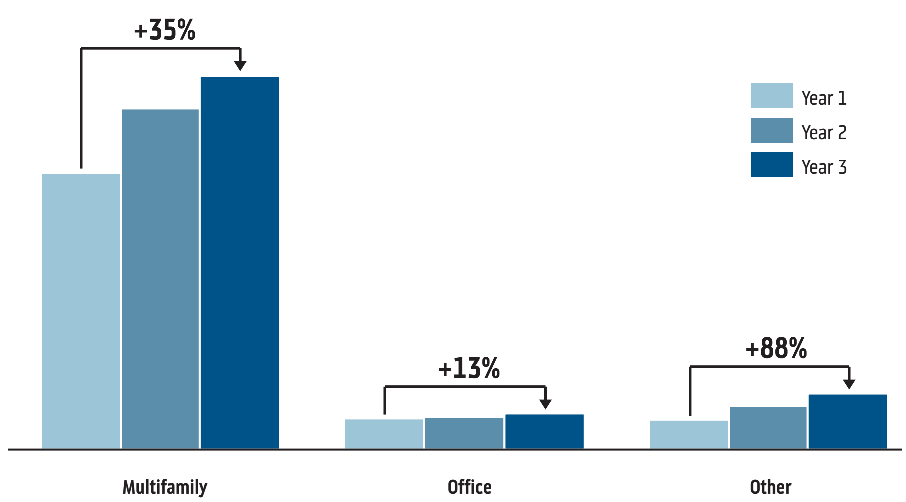
Compliance by Building Sector

Compliance rates also vary depending on the properties' building sectors. More than three-quarters of large private properties under LL84 are multifamily properties, thus leading again to uneven groupings of covered properties. The range of compliance by sector is much wider than by borough, from 60 percent averaged among various sector types grouped as "other" properties to 89 percent among multifamily properties (Fig. 6).

Similar to the observations seen in compliance by borough, compliance by sector rates have also shown a positive trend over the past three years, with the greatest increase occurring from Year One to Year Three (88 percent) in the "other" properties category. The incremental increase in compliance from year to year also shrinks across all sectors, except for office properties. Again, a similar trend of gradual, rather than exponential increases may occur in following years as rates become more consistent.

[Fig. 6] **Compliance Rate by Use Sector**

Source: NYC Mayor's Office



Buildings Characteristics

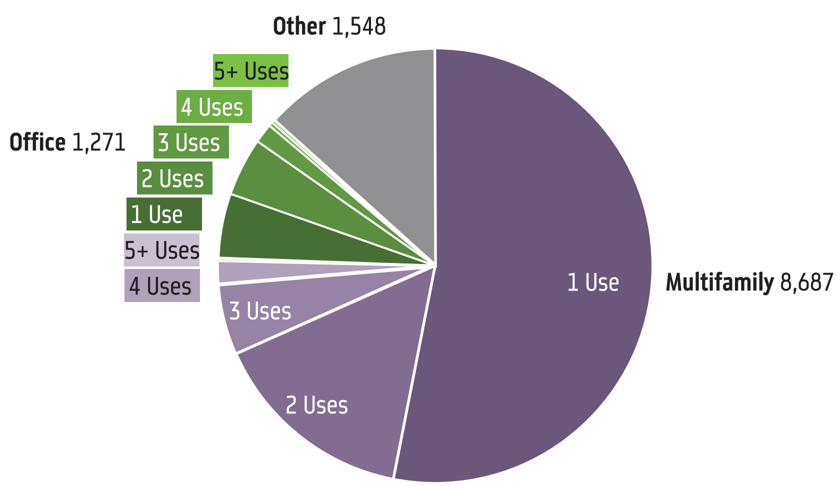
For purposes of analysis in this report, private sector building benchmarking data for Year Three was verified by the Department of Finance (DOF) to ensure correct building addresses and identification, and merged with building data from the Department of City Planning's (DCP) Primary Land Use Tax Lot Output (PLUTO) database. The benchmarking data was then cleaned and analyzed by a research team consisting of the New York University Center for Urban Science and Progress (NYU/CUSP) and NYC Mayor's Office. Further details on the data cleaning process can be found in Appendix A: Data Accuracy.

Mixed Uses within Covered Buildings

Many properties in New York City are mixed use, containing various combinations of space uses such as residential units, office space, retail, industrial, etc. While more than two-thirds of multifamily properties and one third of office properties are single use, the remaining properties are mixed use (Fig. 7).

[Fig. 7] **Mixed Uses in Multifamily and Office Properties**

Source: New York University and NYC Mayor's Office



Lots with Multiple Buildings

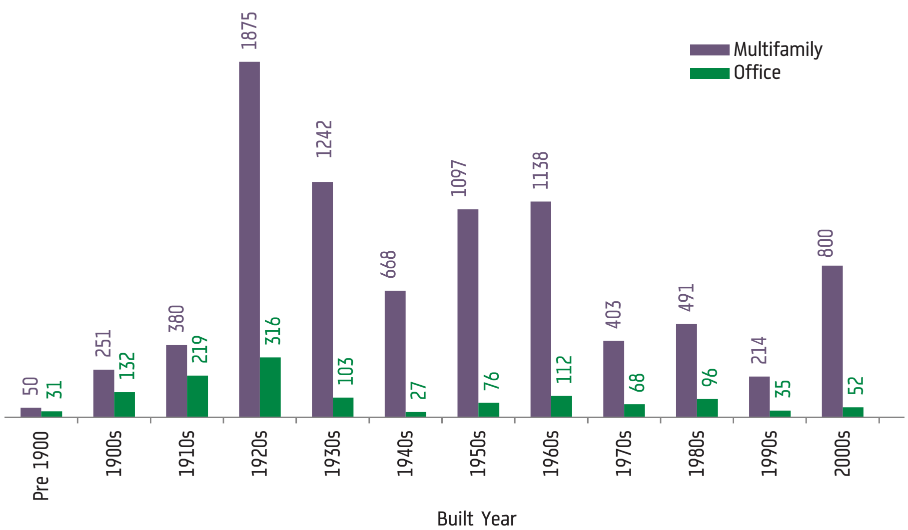
Covered buildings are identified according to their assigned tax lots, which can contain multiple buildings. Because energy systems and meters are often shared among buildings on a single lot, building owners have the option to benchmark each building individually, or aggregate the data and benchmark buildings together. When multiple buildings are benchmarked together, it gives the appearance of single, larger-sized buildings.[10] Thus it is important to recognize that 20% percent of covered properties are recorded as more than one building in the City land use database.

Covered Buildings by Year Built

The era in which a building was constructed, and the preferences for system types and space configurations prevailing of that time, often dictate many fundamental building characteristics. While large properties were built throughout the last hundred years, the majority of benchmarked properties were built in the 1920s, while the smallest groups of properties were built in the 1930s and in the 1950-1960s (Fig. 8). Newer properties, built after 2000, make up a small percentage of all benchmarked properties; indicating that the majority of buildings are older with much longer lifespans in a local real estate market where demolition rates are lower than the national average. In fact, an estimated 85 percent of all currently existing buildings in New York City are expected to be remaining in 2030. Therefore, policies that will meaningfully reduce energy consumption must emphasize existing buildings.

[Fig. 8] **Number of Multifamily and Office Properties Benchmarked by Year Built**

Source: NYU and NYC Mayor's Office

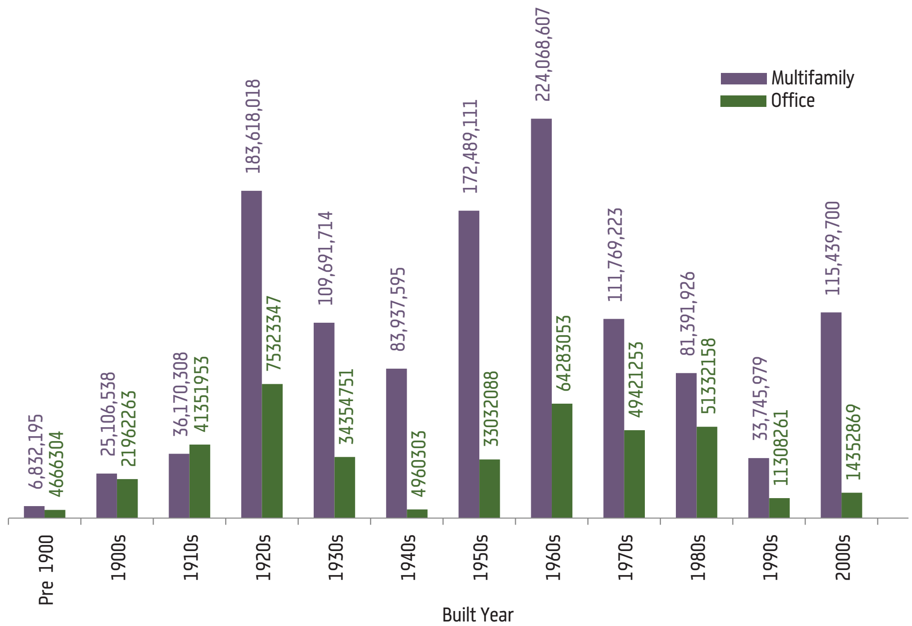


Gross Floor Area by Year Built

To simply enumerate large properties by year built does not provide a complete picture. A comparison of construction era with gross floor area of properties indicates that while the greatest number of real estate was constructed in the 1920s, the largest built area was constructed during the 1960s (Fig. 9).

[Fig. 9] **Gross Floor Area of Multifamily and Office Properties by Year Built**

Source: NYU and NYC Mayor's Office

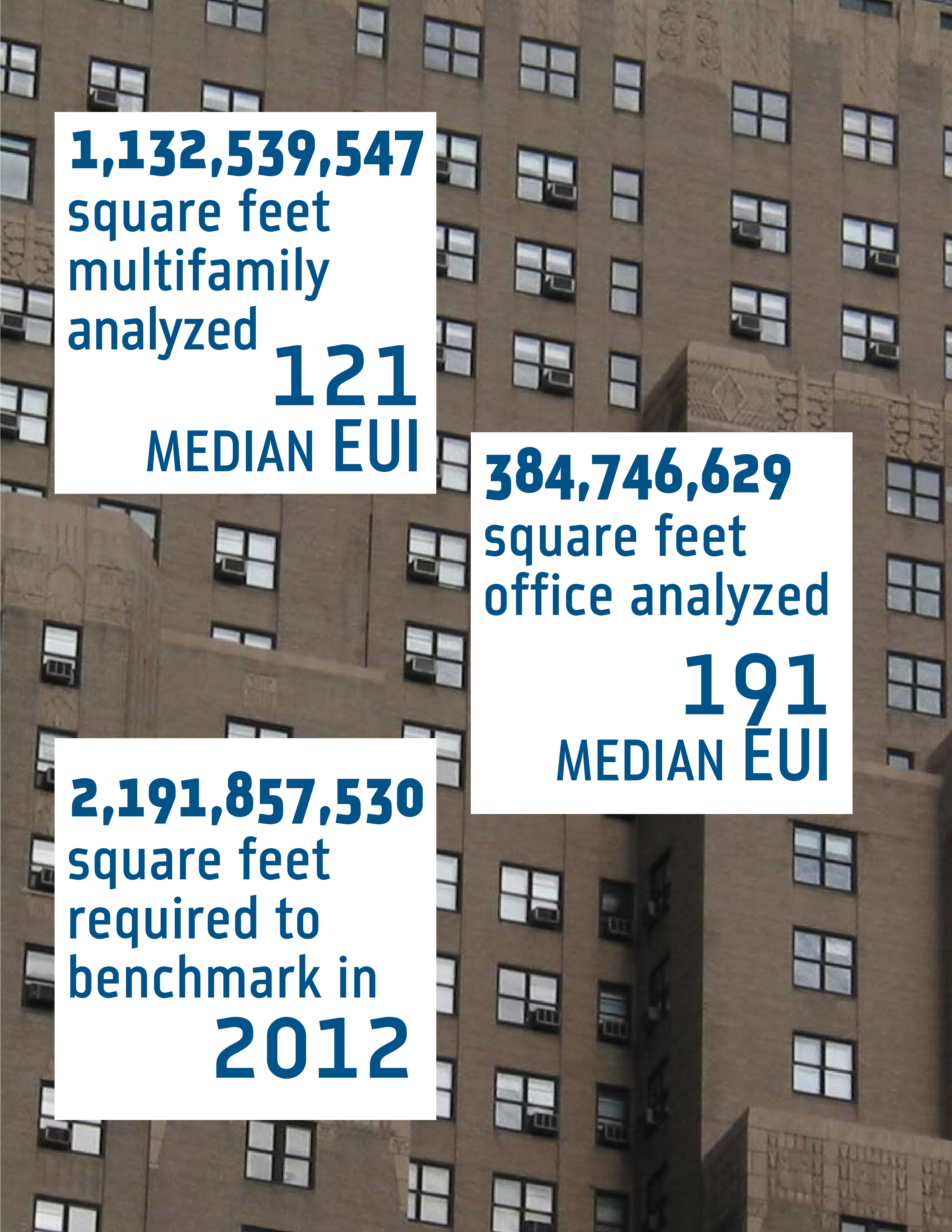


Covered Buildings by Size

Smaller-sized properties comprise the highest frequency of covered buildings in both multifamily and office sectors. Some buildings are less than 50,000 sq ft because a number of smaller buildings on lots with multiple buildings were benchmarked separately. Multifamily properties significantly outnumber office properties between 100,000 and 500,000 sq ft in area. The frequency of properties between the office and multifamily sectors are similar among properties where floor area exceeds 700,000 sq ft (Fig. 10).

[Fig. 10] **Number of Multifamily and Office Properties Benchmarked by Property Size**

Source: NYU and NYC Mayor's Office



1,132,539,547
square feet multifamily analyzed

121
MEDIAN EUI

384,746,629
square feet office analyzed

191
MEDIAN EUI

2,191,857,530
square feet required to benchmark in

2012

Year Three Benchmarking Results

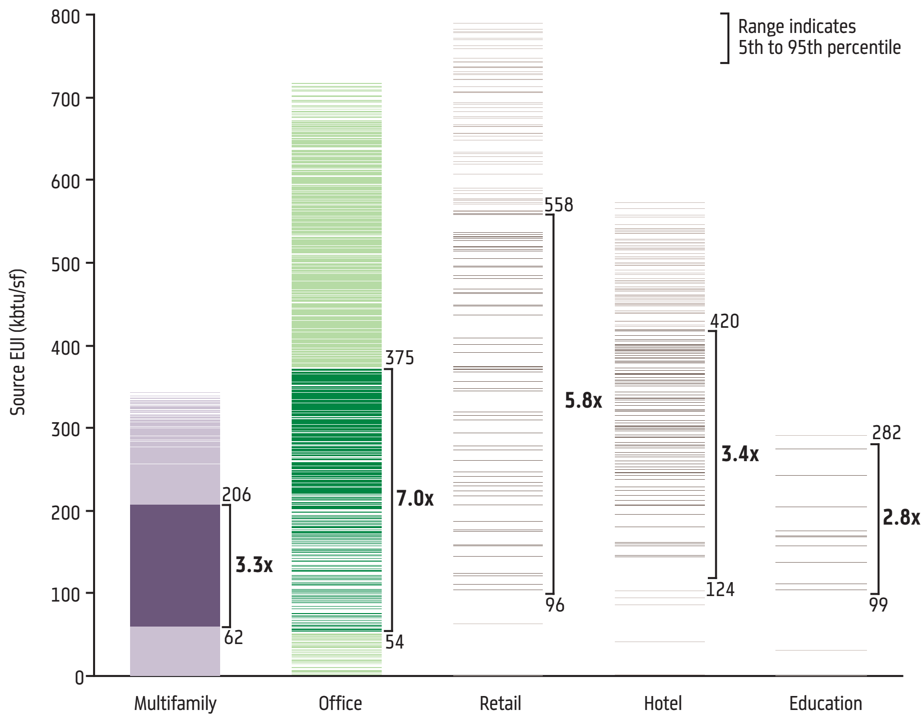
Variation in Source Energy Use Intensity

A comparison of the properties reporting the highest weather normalized source energy use per sq ft or energy use intensity (referred to as EUI throughout the rest of this report) at the 95th percentile and properties reporting the lowest EUI at the 5th percentile reveals that energy use varies by a factor of about 3 to 7 among properties within the top five most common use sectors (Fig. 11).

[Fig. 11] **Variation in Source EUI by Use Sector**

(5th-95th percentile)

Source: NYC Mayor's Office

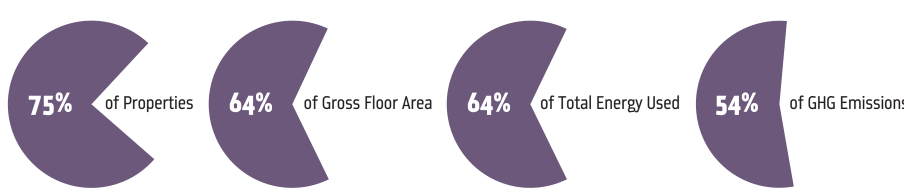


Sector Impacts

Multifamily properties continue to make up the majority of benchmarked properties, gross floor area, energy use, and GHG emissions, comprising 75.5 percent of the total number of buildings, 64.2 percent of the gross floor area, 64.4 percent of the energy used, and 54.2 percent of GHG emissions (Fig. 12).

[Fig. 12] **Multifamily Share of Benchmarked Properties**

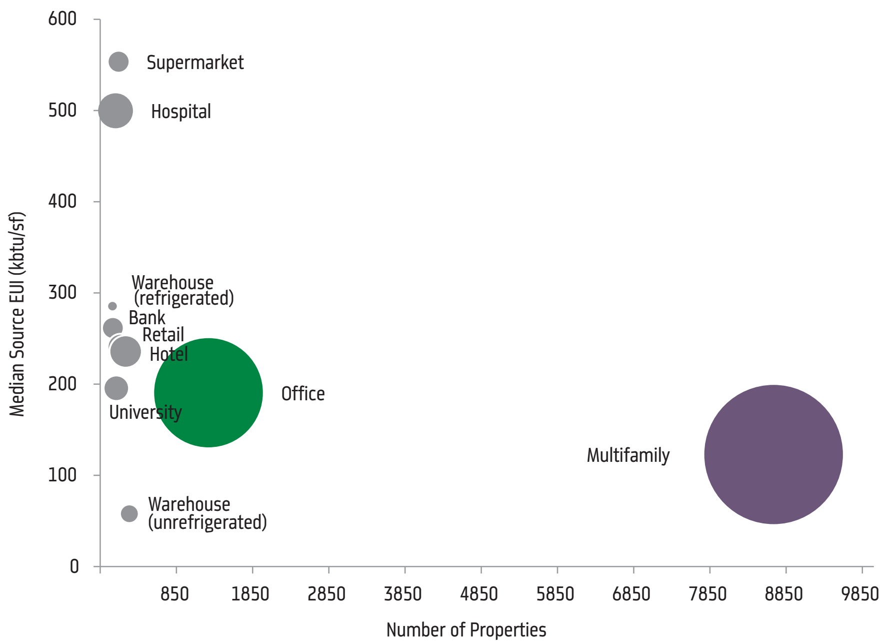
Source: NYC Mayor's Office



The proportional dot plot (Fig. 13) summarizes the number of properties for multi-family, office and eight other property sectors and their respective median EUI. The area of the circles indicates the total amount of energy consumed by sector, plotted against the number of properties (x-axis) and the median source EUI in each facility sector (y-axis). While total energy use is less among non-multifamily properties, all sectors show higher median EUIs than the multifamily sector except for unrefrigerated warehouses.

[Fig. 13] **Number of Properties, Median Source EUI, and Total Energy (Area of Circle Proportional to Energy Consumed)**

Source: NYU and NYC Mayor's Office

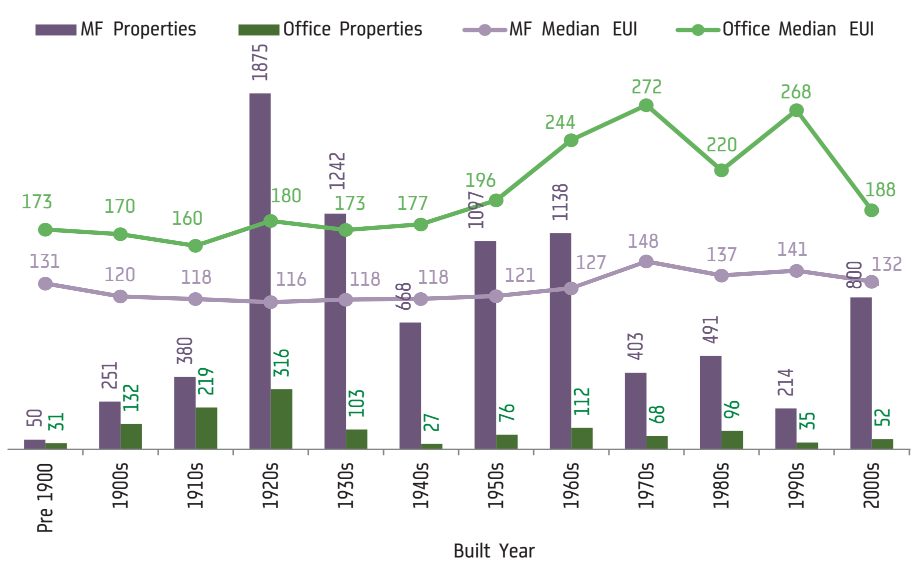


Energy Use Intensity and Year Built

When comparing the median EUI for multifamily and office properties by year built, median EUIs fall within consistent ranges for most properties, except for notable peaks and dips in EUI for both multifamily and office properties built in the 1960s-2000s. The peaks of high EUI for a relatively low number of properties in the 1970s and 1990s, particularly for offices, indicate that the properties built in those years are more energy intensive than properties built in other years (Fig. 14).

[Fig. 14] **Number of Multifamily and Office Properties by Year Built and EUI**

Source: NYU and NYC Mayor's Office

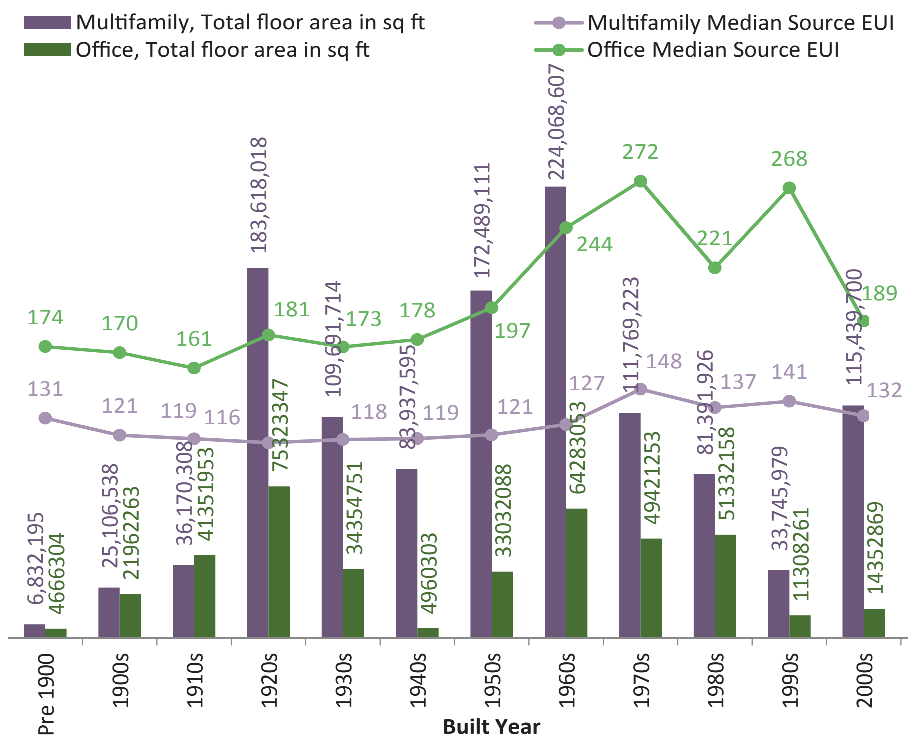


Energy Use Intensity and Floor Area

The relatively flat line of the multifamily median source EUI, regardless of the respective size of the multifamily properties and built year, indicates a consistent use of energy by residents. In other words, New Yorkers live, act, behave, and consume energy in similar ways in their homes despite size or age of their homes (Fig. 15). Contrastingly, office properties exhibit a general upward use of energy, even while the gross sq ft decreases for certain periods of built decades. This suggests that newer office properties have denser work environments, increased use of energy-intensive technology and longer work hours.

[Fig. 15] **Number of Multifamily and Office Properties by Year Built and EUI**

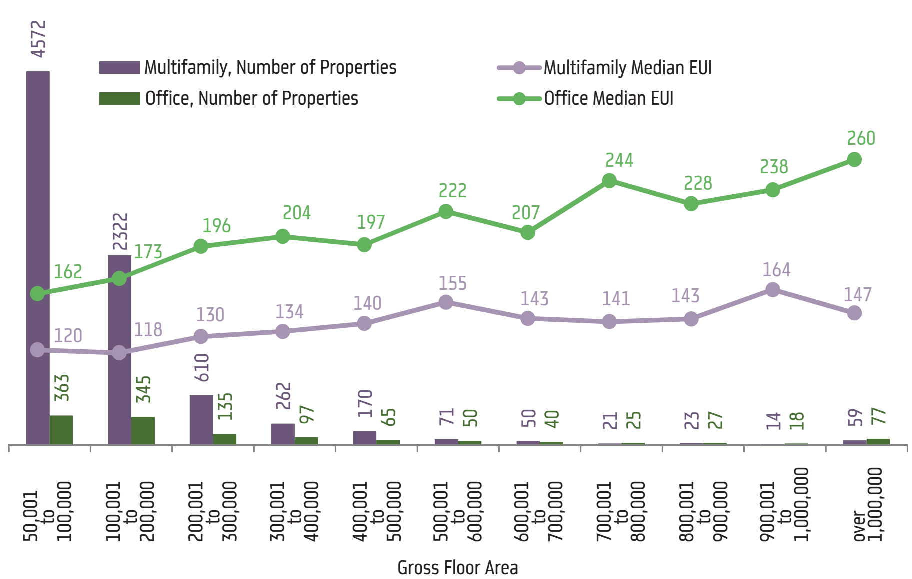
Source: NYU and NYC Mayor's Office



When comparing median EUI of groupings of properties by size, there is a direct relationship between size and energy use intensity (Fig. 16). Especially among office use, larger properties use more energy per square foot than smaller properties.

[Fig. 16] **Number of Multifamily and Office Properties by Gross Floor Area (square feet) and Median EUI**

Source: NYU and NYC Mayor's Office



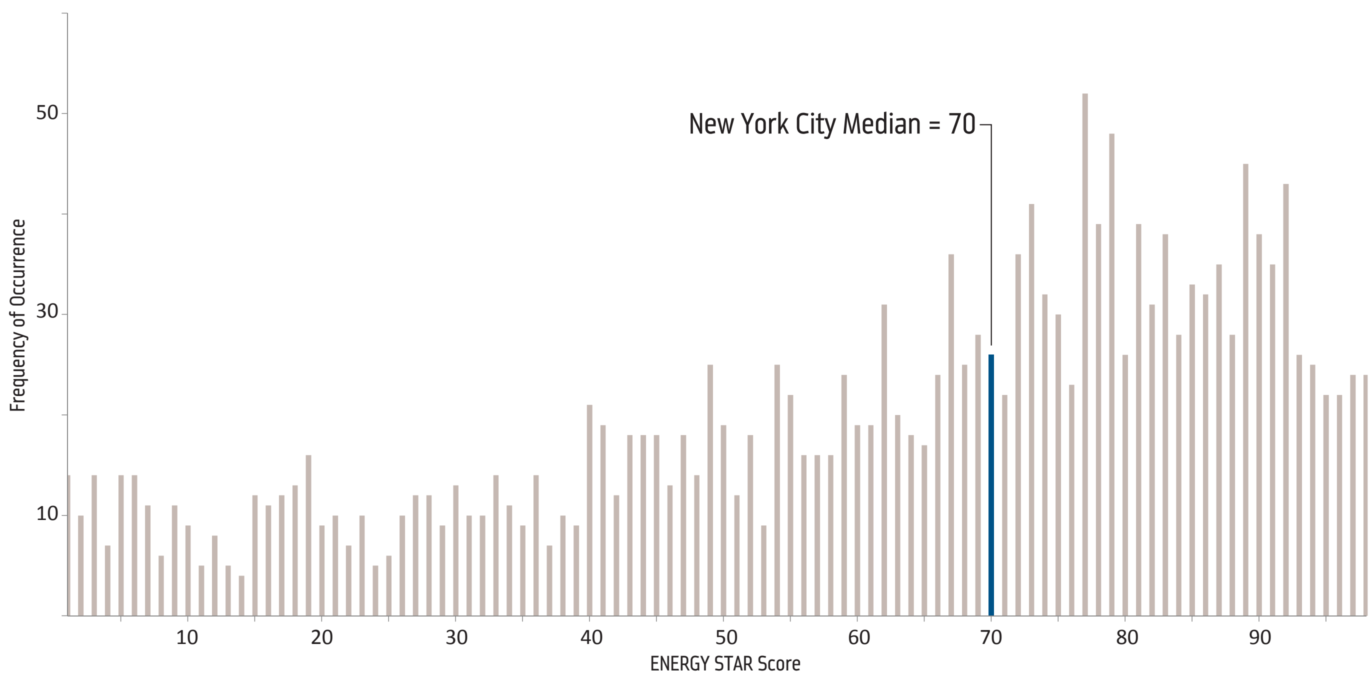
Office properties that are between 50,000 and 100,000 sq ft in size recorded a median EUI of 152 while properties larger than 1,000,000 sq ft recorded a median EUI of 260, approximately 75% more energy used per square foot, with a remarkably consistent energy use increase with size increase exhibited among buildings between 100,000 and 1,000,000 square feet.

Distribution of ENERGY STAR Scores

Of the eligible properties that benchmarked in Year Three, 2,049 commercial properties received ENERGY STAR scores.[12] A new 1-100 ENERGY STAR score for multifamily properties was just launched by the EPA on September 16, 2014. Additional information on the ENERGY STAR score and ENERGY STAR certification for multifamily housing is available online at www.energystar.gov/multifamily.

The median ENERGY STAR score for Year Three is 70, higher than the national median of 50 (Fig. 17). For the purpose of analysis, and consistency with the previous report, buildings that earned an ENERGY STAR score of 1 or 100 are omitted in calculating the median due to the uncertainty of data entry errors.

[Fig. 17] **New York City Benchmarked Buildings Median ENERGY STAR Score**



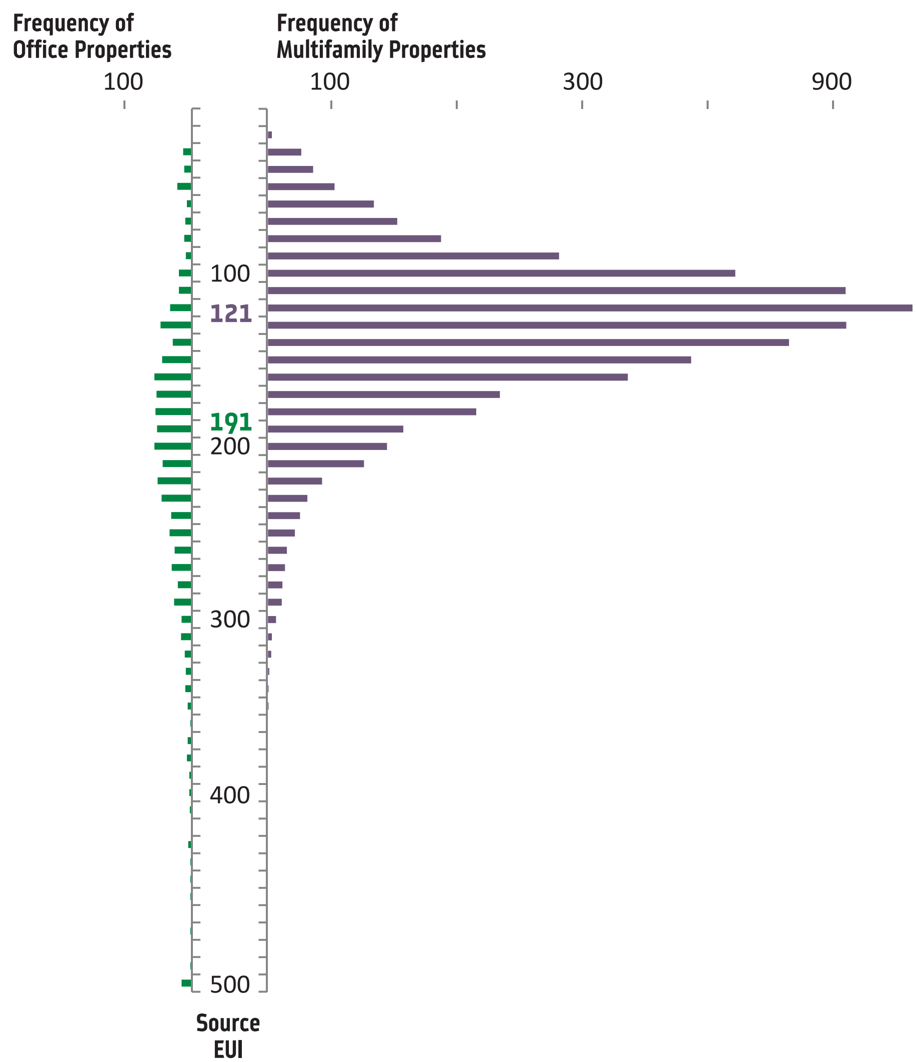
Source: NYU and NYC Mayor's Office

Distribution of Energy Use Intensity

In Year Three, multifamily properties had a median EUI of 121, lower than the national median source EUI of 130 for the Residential Energy Consumption Survey (RECS) 2005 database. Office properties reported at the median EUI of 191, also lower than the Northeastern Region median source EUI of 210 for the Commercial Building Energy Consumption Survey (CBECS) 2003 database (Fig. 18).

[Fig. 18] **Distribution of Source EUI Scores for Multfamily and Office Properties**[11]

Source: NYU and NYC Mayor's Office



Water Consumption

LL84 requires reporting of water consumption only if the covered property has been equipped with an Automated Meter Reading (AMR) device for a full calendar year. Properties that meet this requirement have the option to report the automated data provided by DEP or gather data from monthly meter readings and report manually. In Year Three, 5,385 properties (40 percent of all covered properties) had AMR devices installed for the entire calendar year of 2012 and were eligible and required to report water consumption data. Of these properties, 3,093 reported automated data, 1,803 reported manually, and 489 did not report data. Due to the smaller sample size and lesser reliability of manually reported data, only automated data was used for this analysis.

Automated Meter Reading

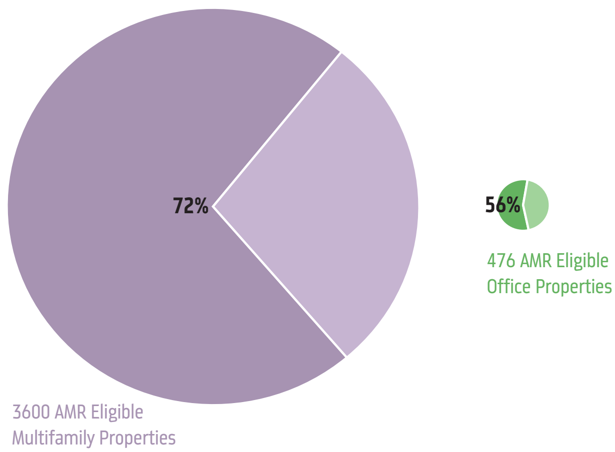
In 2009, DEP began to install AMRs citywide to reduce the number of water bills based on estimated readings, and provide more accurate consumption data. The AMR installation process was made possible by the Department of Information Technology and Telecommunications' (DOITT) creation of the New York City Wireless Network (NYCWiN), a broadband wireless network to support essential City operations. DEP uses NYCWiN to receive daily readings of individual water meters from AMR devices installed on properties and send them to DEP's computerized billing system. This system also allows customers to access their hourly consumption data in the online application "My DEP Account."

Since 2012, over 96% of almost a million properties citywide have had AMR devices installed; the remaining 4% of the properties have not had AMR devices installed due to missing or incompatible meters, hazards preventing installation, plumbing changes necessary for installation, or denial of access. Although New York City is not the first water utility to install AMR devices, the scale of this program is unprecedented and its efforts have transformed DEP's billing and customer operations, as well as its water demand management programs. DEP now utilizes consumption data it collects through the AMR system to conduct targeted water demand management programs such as the Municipal Water Efficiency Program for public buildings, and the Toilet Replacement Program, as described in DEP's Water Demand Management Plan. Property owners benefit from access to direct reporting which not only facilitates benchmarking, but also identifies anomalous consumption through the DEP Leak Notification Program, which is tied into the AMR data, and can proactively notify owners of potential leaks. EPA offers a complete application programming interface (API) to allow software providers, utilities, and building management to exchange data with Portfolio Manager. New York City is currently the only municipality that imports water use using Portfolio Manager web services, upon customer request.

Reporting Rates of Water Consumption Data

A majority of eligible building owners reported automated data in Year Three. The share that used automated data reporting will grow as more building owners install AMR devices and become eligible to report automated data. The highest frequency of reporting automated data occurred in the multifamily properties (2,607) sector, followed by the office properties (267) sector (Fig. 19). Across other property sectors, most or all bank, hospital, and supermarket properties that were equipped with AMR devices for a full year reported automated data. More than half of AMR-installed warehouses reported automated data. Conversely, 66 % of eligible hotels and 79% of eligible retail properties reported data manually (Fig. 20).

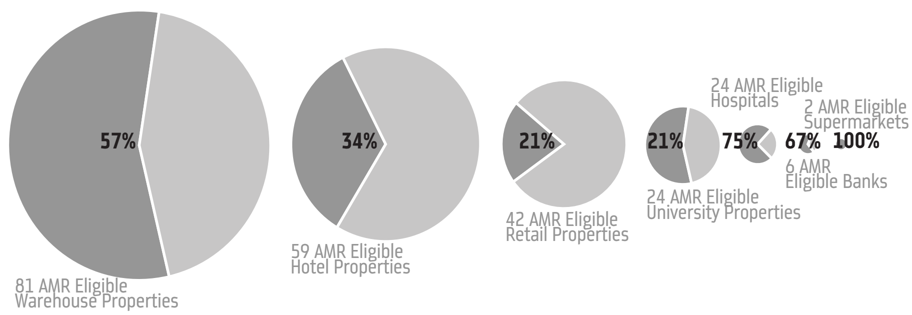
[Fig. 19] **Rates of Automated Data Reporting among Eligible Multifamily and Office Properties**



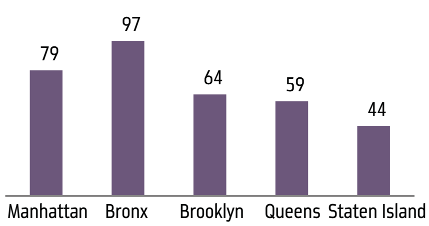
Source: NYC Mayor's Office

[Fig. 20] **Rates of Automated Data Reporting among Eligible 'Other' Property Types**

Source: NYC Mayor's Office



[Fig. 21] **Median Multifamily Water Use by Borough in Gallons per Capita per Day**



Source: NYC Mayor's Office

Multifamily Water Consumption per Capita

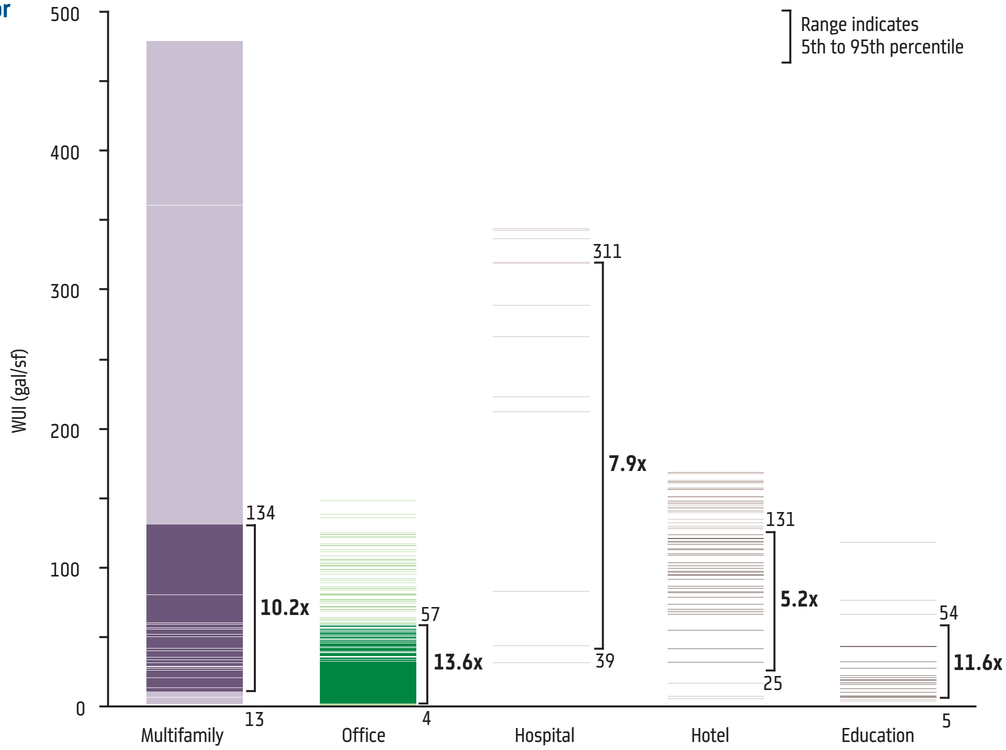
Water consumption is compared using a variety of metrics. The EPA Portfolio Manager measures water use intensity (WUI) as gallons per gross square foot. For quantitative and comparative analytics, DEP uses a per capita (per person) metric for multifamily properties and per room metric for hotels. EPA also analyzes specific sector consumption, such as office water use by gallons per worker per day.

Based on DEP's methodology for per capita consumption, residents of automated data reporting multifamily buildings had median consumption rates between 44 and 97 gallons of water per day (gal/person/day) in 2012, depending on the borough (Fig. 21).

Variation in Water Use Intensity by Sector

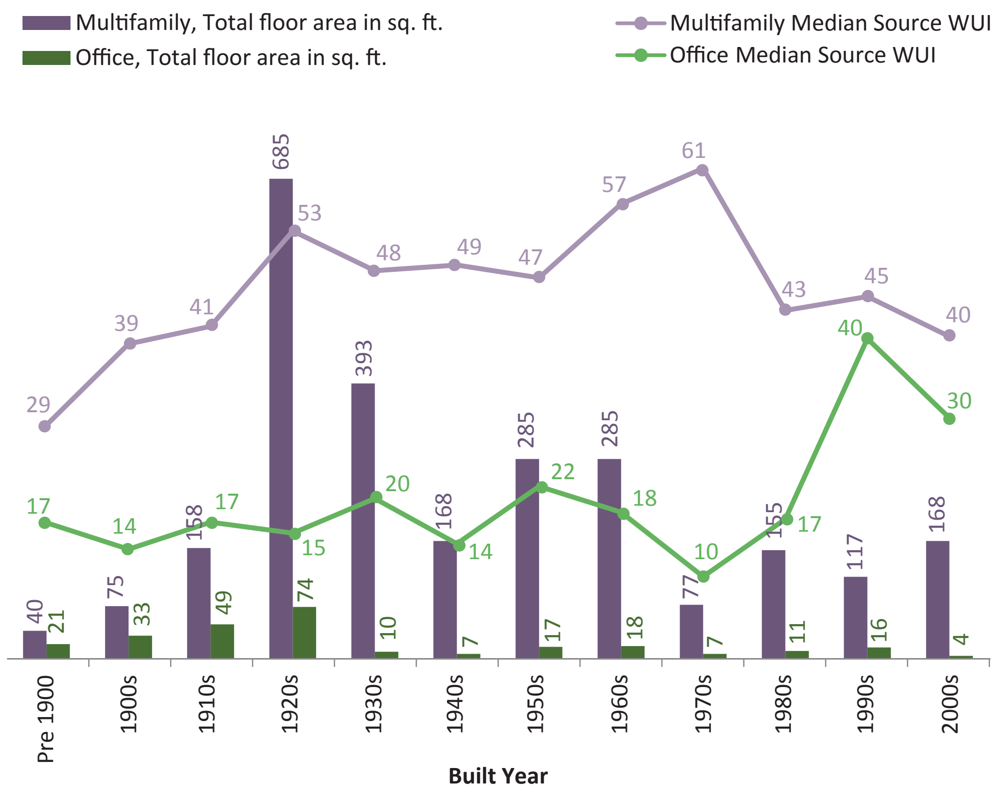
Ranges in WUI, as with EUI, vary according to property sector. Multifamily properties showed a difference of 9.4 times between the least intensive and most intensive levels of water consumption per square foot. For offices, the highest users consumed 14.9 times more than the lowest users. Hotels, retail, and university properties showed differences in water consumption rates within these extremes. Interestingly, the sectors with the largest difference in consumption (office, retail, and college/university properties) have similar ranges of outliers and follow closely in median WUI of about 17 gal/sq ft (Fig. 22).

[Fig. 22 **Variation in WUI by Use Sector (5th-95th percentile)**

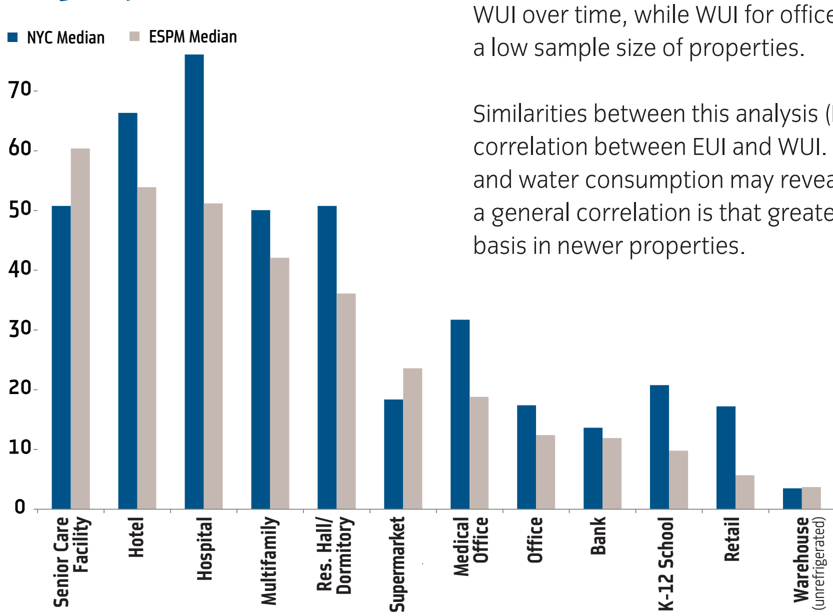


[Fig. 23] **Number of Multifamily and Office Properties by Year Built and WUI**

Source: NYU and NYC Mayor's Office



[Fig. 24] **Comparison of Median Water Use Intensity (Gallons per Square Foot) between NYC Properties and All Energy Star Portfolio Manager Properties Nationwide**



Source: NYU and NYC Mayor's Office

Median Multifamily and Office Water Use Intensity versus Year Built

Multifamily properties tend to use more water on a per square foot basis and therefore have overall higher median WUIs than offices due to household activities such as showers, laundry, and dish washing. Multifamily properties show relatively consistent WUI over time, while WUI for office properties are presently difficult to assess due to a low sample size of properties.

Similarities between this analysis (Fig. 23) and the EUI vs. Year Built analysis suggest a correlation between EUI and WUI. While further, in-depth analysis of monthly energy and water consumption may reveal closer, even seasonal, ties between the two uses, a general correlation is that greater energy and water utilization occurs on a per sq ft basis in newer properties.

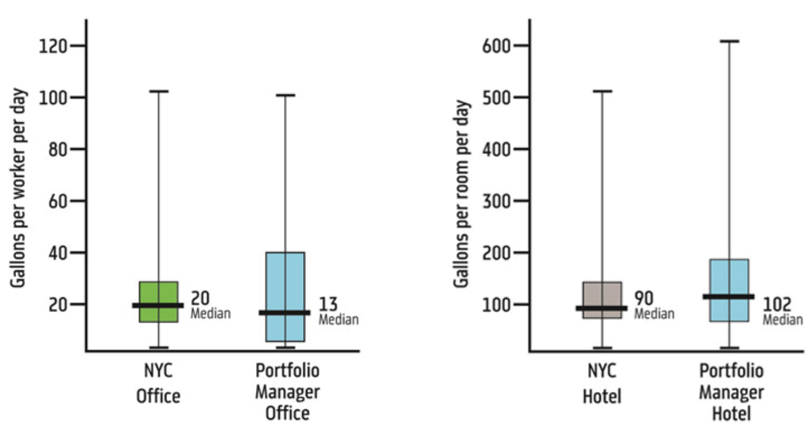
New York City and Portfolio Manager Comparisons of Water Use Intensity

Presently, there is insufficient data to conduct year to year comparison of water consumption. However, water consumption can be compared locally and nationally through the EPA Portfolio Manager. The EPA Portfolio Manager water data set contains data on properties throughout the U.S. and is significantly larger than the New York City data set, with 53,306 properties. It is important to note that these properties within the EPA Portfolio Manager are not nationally representative, but are still useful for comparison. More information on EPA's water use trends is available online at www.energystar.gov/datatrends.

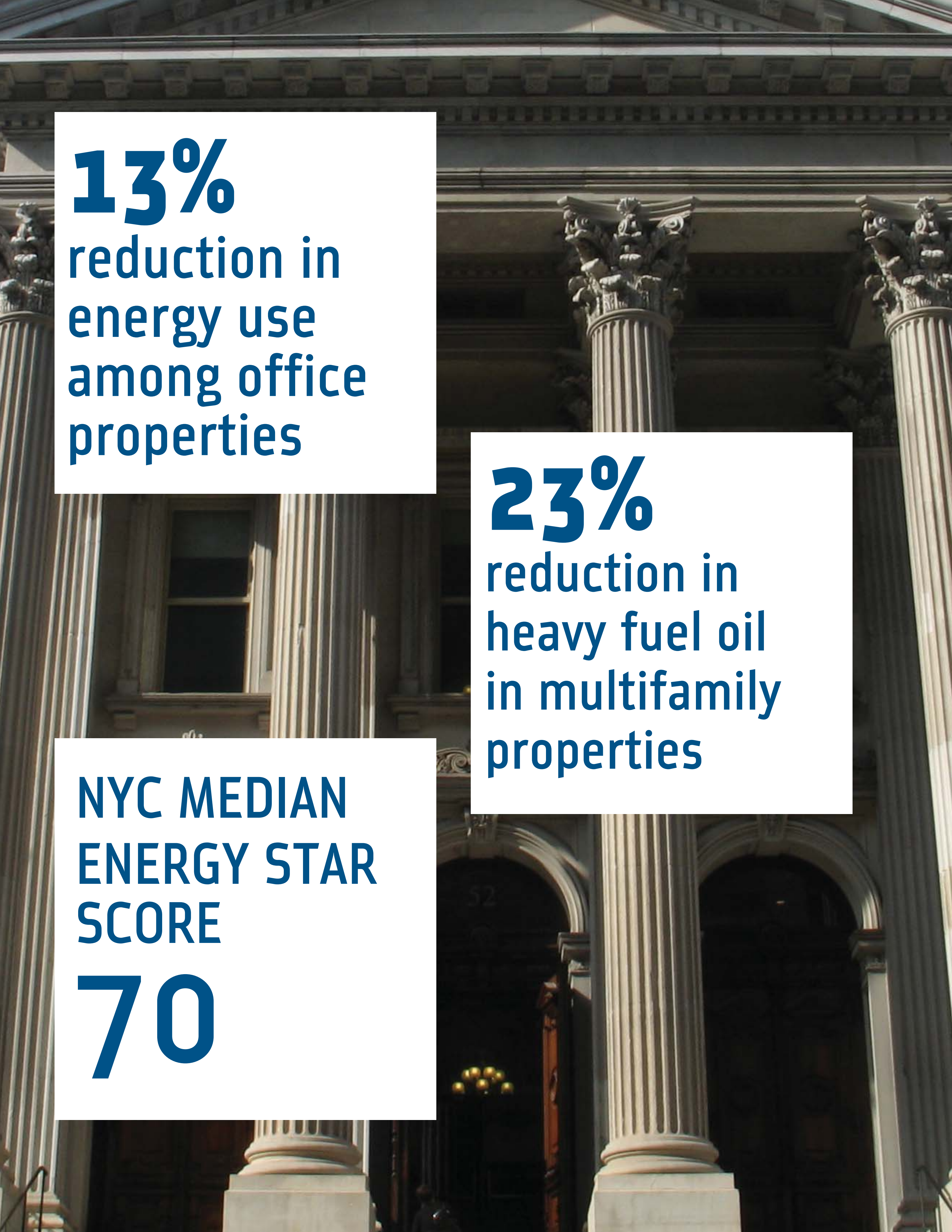
The five property sectors with the highest median WUI in New York City in 2012 match the five property sector within the EPA Portfolio Manager: dormitory, hospital, hotel, multifamily, and senior care facility properties. However, senior care facilities within the EPA Portfolio Manager have the highest median WUI at about 60 gal/sq ft, while New York City hospitals have the highest local median WUI at 76 gal/sq ft. New York City medians, in general, are higher than Portfolio Manager medians; as the data set of New York City properties increases in later years, these results will be reassessed and verified (Fig. 24).

A closer look at the office and hotel sectors shows similarities in distribution, with the city's median slightly higher for office water use and lower for hotel water use than the Portfolio Manager medians (Fig. 25). Again, additional years' worth of data and larger sample sizes will provide a clearer picture of New York City's water consumption with respect to water use measured in Portfolio Manager.

[Fig. 25] **Comparison of Median Water Use Intensity between NYC Office and Hotel Properties and All ENERGY STAR Portfolio Manager Office and Hotel Properties**



Source: NYU and NYC Mayor's Office



13%
reduction in energy use among office properties

23%
reduction in heavy fuel oil in multifamily properties

NYC MEDIAN ENERGY STAR SCORE
70

Years One Through Three Compared

Changes in Number of Covered Properties; Changes in Number of Buildings Analyzed

Analysis of the submittals by sector (multifamily, office, and other properties) reveals noteworthy shifts between Year Two (2011) and Year Three (2012). Proportional to total submittals, the aggregated "other" properties exhibits the greatest increase in submittals at 43 percent, followed by the office sector at 21 percent, and the multifamily sector with a 13 percent increase. Overall, there is a 17 percent increase, which is relatively similar across the sector types. Reported gross floor area also displays similar relative percentages across the sectors.

Comparison of Source Energy Use Intensity

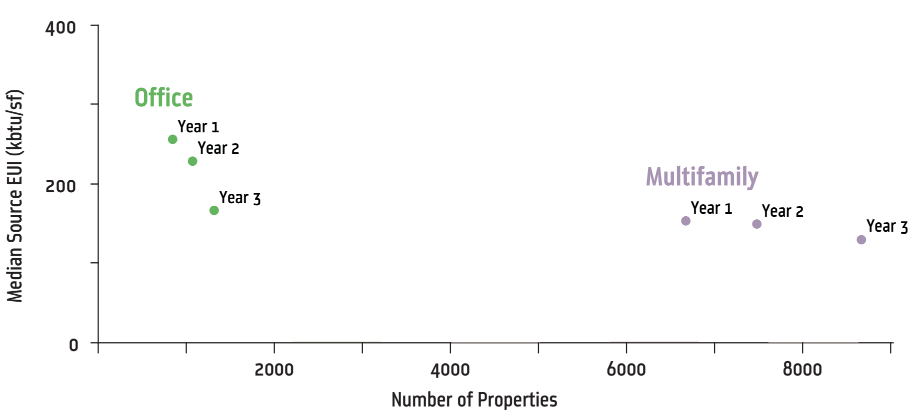
One of the greatest potentials of benchmarking is to provide owners with a means of observing whole building energy use over time, and to then drive owners to take action to better manage energy consumption and thereby yield lower reported EUIs.

In Year Three, the median office EUI went down 13% to 191 kBtu/sq ft, as compared to the office median EUI of 220 kBtu/sq ft in Year Two. This is a dramatic decline, especially as compared to the relatively consistent EUI for office reported samples in Years One and Two, 234 kBtu/sq ft and 220 kbtu/sq ft, respectively (Fig. 26). For multifamily properties, the median EUI in the Year Three reported sample set was also 12% lower at 121 kBtu/sq ft, as compared to the median EUI 137 kBtu/sq ft and 138 kBtu/sq ft, in Years One and Two reported sample sets, respectively. It should be noted that the universe of specific properties within each year's sample set are not completely consistent from year to year.

Operational changes and capital investments to improve energy performance among benchmarked buildings may have occurred at the level of certain individual buildings, however there is little evidence to support that such response had occurred at scale to result in the dramatic decline in median EUI observed among benchmarked buildings in Year Three.

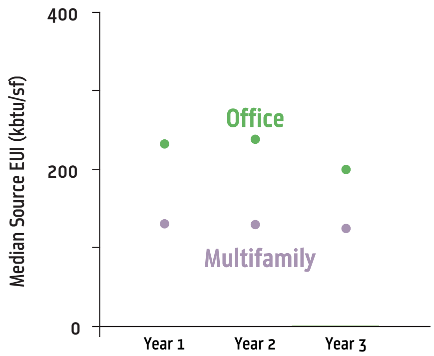
[Fig. 26] **Three Year Median EUI for Office and Multifamily Properties**

Source: NYU and NYC Mayor's Office



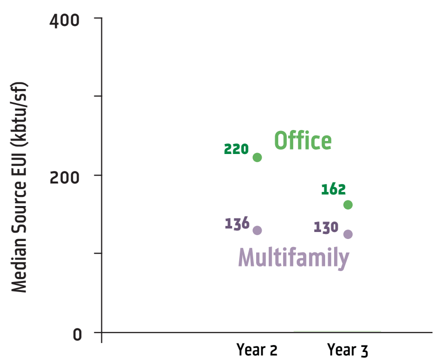
[Fig. 27] **Three Year Median EUI for Office and Multifamily Properties**

Limited to Properties reporting in all Three Years



Source: NYU and NYC Mayor's Office

[Fig. 28] **Median EUI for Office and Multifamily Properties in the Hurricane Sandy Inundation Area, Years 2 and 3**



Source: NYU and NYC Mayor's Office

The group of properties that were considered for this analysis was not necessarily consistent throughout the three years. For reasons such as change of ownership and the construction or demolition of properties, the properties subject to the benchmarking law changes on an annual basis; however the majority of the properties remain consistent. Furthermore, due to the data cleaning methodology used in the benchmarking reports, the group of properties considered for analysis will also vary over time.

Therefore, by limiting the analysis to only those properties that reported in all three years and that also met the data cleaning criteria, a less dramatic trend of EUIs year over year emerges (Fig. 27). Within this subgroup of approximately 5,000 properties, the median EUI for multifamily and office properties was 127 kBtu/sq ft and 204 kBtu/sq ft, respectively, which are relatively consistent as compared to the median EUIs for the prior two reporting years among multi-family uses, but still notably lower for office properties. Due to a number of factors, it would be premature to draw the conclusion that owners are actively pursuing energy efficiency actions in response to benchmarking data. Data quality issues must be fully resolved to ensure that accurate information is being recorded before any definitive conclusions can be drawn. Furthermore, 2012 brought the most significant coastal storm to the northeastern United States that adversely affected the region at an unprecedented scale.

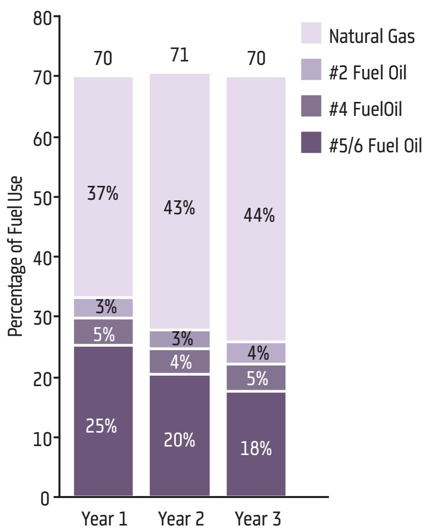
Factors to Consider

Hurricane Sandy. In late October 2012 Hurricane Sandy, the biggest storm surge in recorded history to strike the region, landed on New York City's southern shores. The coastal storm had a significant impact on waterfront properties, with a particularly acute impact on office properties. The coastal flood inundation area encompassed 1,270 of the covered properties (approximately 8%). Many of these properties suffered damage to electrical equipment housed below the flood elevation that resulted in long-term power losses and reduced operational capacity. Some of the largest covered properties are located within the inundation area, and many of the properties were without electrical service for more than three weeks. Over 2,400 , or roughly 16 percent, of the covered properties were located in areas affected by prolonged power losses due to utility damage.

When comparing properties located within the inundation area, the cleaned data set for Year Three includes only 25 percent of the number of properties as compared to the number of properties in Year Two. Within the multifamily sector, the cleaned data set includes 556 properties in Year Two, whereas Year Three includes only 140 multifamily properties; and within the office sector, the Year Two cleaned dataset includes 81 properties as compared to 22 properties in Year 3. In other words, fewer properties that were affected by Hurricane Sandy benchmarked in the following year. The sharp reduction in number of properties for which benchmarking data is available factors into the inconsistencies observed in Year Three data.

Furthermore, for multifamily properties located in the storm inundation area, the median EUI went down from 136 kBtu/sq ft in Year Two to 130 kBtu/sq ft in Year Three, representing a 5 percent decline. Among the office properties, a sharper decline of 26 percent in median EUI was observed, decreasing from 220 kBtu/sq ft in Year Two to 162 kBtu/sq ft in Year Three (Fig. 28). This median EUI for office properties was measured across only 22 properties in Year Three, again a much smaller sampling than the 81 office properties in Year Two.

[Fig. 29] **Fuel Use Distribution in Multifamily Properties, Years 1 through 3**



Source: NYU and NYC Mayor's Office

Impact of NYC Clean Heat in Declining Use of Heating Fuel Oils

New York City recently announced the achievement of the cleanest air quality in over 50 years and a current national ranking of 4th cleanest air, up from 7th in the previous year. Improving New York City's air quality is a top public priority and a major health consideration. Through air quality monitors mounted across the City, data is constantly collected on levels of common combustion related pollutants, including fine particulate matter (PM2.5), oxides of nitrogen (NOx), sulfur dioxide (SOx), ozone (O3), and elemental carbon (EC). These monitors allow researchers to evaluate and identify sources that contribute to neighborhood air pollution and develop targeted policies to reduce their emissions. The initial findings revealed emissions from burning residual oil (#4 and #6 oil) were large contributors to air pollution in areas of the city with many large buildings. These findings resulted in changes to local and state regulations requiring cleaner heating fuels and the creation of NYC Clean Heat, an outreach and marketing public program to assist building owners in the conversion to cleaner fuels and equipment well ahead of the deadlines that phase out No. 6 oil in 2015 and No. 4 oil in 2030. A September 2013 air quality report showed that Clean Heat and other programs are working to accelerate fuel oil conversions resulting in cleaner air for New Yorkers. From Winter 2008-09 to Winter 2012-13, SOx concentrations (generated from the burning of sulfur containing fuels) fell by 69 percent while levels of nickel in fine particulate matter (an indicator of residual oil combustion (PM) declined by 35 percent. These reductions in fuel oil use over time as equipment is converted to cleaner fuels such as No. 2 oil or natural gas are reflected in the benchmarking data where breakdown of energy use by fuel source is recorded (Fig. 29); this decline is most clearly indicated in the multi-family sector where fuel oil consumption is most prevalent. Through programs such as NYC Clean Heat, public resources are successfully utilized to leverage critical data around energy consumption and emissions to accelerate private sector investments in clean energy that support public interests and policy goals.

Future Developments

Changes to City's Local Law and Rule

Tenant Letter. In the second benchmarking report, the Mayor's Office suggested removing the requirement of building owners to send aggregated data request letters to their non-residential tenants. The three utilities serving the covered buildings, Con Edison, National Grid, and PSEG/ Long Island Power Authority, now all provide aggregated energy data with the proper letter of authorizations. In 2014, the fourth year of reporting of benchmarking data, the City removed the requirement for building owners to utilize the tenant letter. The City will formally remove this requirement in a future iteration of the Local Law.

Changes to EPA's Portfolio Manager

Portfolio Manager Upgrade. In July 2013, EPA released a comprehensive upgrade for Portfolio Manager to improve the interface and functionality. A more recent version of EPA's Emissions & Generation Resource Integrated Database (eGRID) allowed for updating of all greenhouse gas (GHG) factors, and updated reference data from the DOE improves site and source factors. All reference data was updated, including the process to annualize data and the kBtu site conversion factors. Therefore, following the upgrade, many of the Portfolio Manager submissions will report slightly different values for their GHG and EUI, without making adjustments to the underlying values. Future year over year analyses will need to account for the changes in reporting methodology.

Building Identification. At the request of several cities using Portfolio Manager for their mandatory benchmarking ordinances, EPA created city-specific building identification fields. Previously, this building identification for New York City was housed in the Unique Building Identifier (UBI) and Property Notes fields. At the launch of the upgraded Portfolio Manager in summer 2013, EPA implemented personalized Standard IDs for New York and several other national cities, including Washington, D.C., Austin, Seattle, Chicago, Philadelphia, Minneapolis, and San Francisco. The new personalized fields for New York City are "NYC Borough, Block and Lot (BBL)," and "NYC Building Identification Number (BIN)." The IDs were made available after the City had already published the 2012 reporting template, so constituents were unable to utilize the new fields for third year reporting. For fourth year reporting, the Mayor's Office worked with EPA to facilitate the transition into the use of these newly created fields by doing a back-end migration of most of the 10-digit BBLs and 7-digit BINs from the UBI and Property Notes fields into the new standard ID fields.

Creating a Multifamily Building ENERGY STAR Score. Portfolio Manager currently provides a 1-100 score for 21 property types, based on the Commercial Building Energy Consumption Survey (CBECS). Properties that achieve a score of 75 or greater indicate a top performer, and may be eligible for ENERGY STAR certification. Since multifamily properties were not included in CBECS, they were not available to be rated, excluding the largest sector of Local Law 84 covered properties. The City has supported the expansion of the ENERGY STAR rating system to include the multifamily sector. EPA has partnered with Fannie Mae Multifamily Mortgage Business to develop a national ENERGY STAR building performance scale. In March 2014 the EPA announced that a 1-100 ENERGY STAR score for multifamily housing properties will be released in the fall of 2014, which will allow for the first time the comparison of energy performance of multifamily properties against similar properties nationwide.

High Intensity Space Types. High intensity uses including data centers, trading floors and television studios that exceed 10 percent of the floor area can elect to withhold the public disclosure of their energy utilization ratings. EPA released a 1-100 score for data centers in 2010, and as a result of this development, the City will remove the disclosure exemption for data centers for fourth year reporting (disclosure in fall of 2015). The other two space types, trading floors and television studios, are not specifically defined space types in Portfolio Manager. Trading floors and television studios will continue to be studied to address how to accurately report energy consumption in such spaces without unduly penalizing building owners as energy inefficient for inherently energy intensive uses.

Creating a National Energy Efficiency Data System U.S. Department of Energy

The Building Performance Database (BPD) is an online visualization tool based on a national database of information about building performance, which the U.S. Department of Energy (DOE) launched in spring of 2013. This platform enables statistical analysis of commercial and residential buildings and comparisons of performance trends across peer buildings. In 2013, the City contributed anonymized benchmarking data from the public municipal buildings and the private covered building database. It also contains data from other benchmarking programs, energy efficiency programs, the Better Building Challenge, and other initiatives. Other software tools can also access the BPD to run their own analyses, while the anonymity of individual records will be maintained. The New York City benchmarking data can now be accessed and analyzed in the BPD at http://buildings.energy.gov/BPD.

The Standard Energy Efficiency Database (SEED) is a free, open source software tool developed by the Department of Energy that provides a standardized format for cleaning, storing and analyzing building energy performance information about large groups of buildings. The platform provides a private repository for each user to manage information about building characteristic and energy consumption data and analytics for large portfolios, like New York City's. The platform will allow for customized modification to suit NYC's needs, and for seamless integration with the DOE Building Performance Database (BPD) and EPA Portfolio Manager. In 2014, New York City will evaluate the SEED platform, to understand its utility with compliance analysis for local law 84 and 87 in future reporting years and as a data integration tool for a wider range of energy consumption data. More information about the tool is available online at https://buildings.energy.gov/SEED.

The Building Energy Data Exchange Specification (BEDES) is a common set of data terms, definitions, and field formats designed to support analysis of the measured energy performance of commercial, multifamily, and residential buildings, and covers building characteristics, efficiency measures, and energy use information. By providing a common data format, BEDES will facilitate the utilization and sharing of empirical building energy performance data among software tools and data collection and analysis activities, more easily and consistently and at lower cost. It aligns with many Federal tools such as EPA's Portfolio Manager and DOE's Building Performance Database, SEED Platform and Asset Scoring Tools and Green Button, and also utilizes definitions from Home Performance XML, ASHRAE, the Real Estate Transaction Standard, and other common data formats. BEDES version 1 will be released in October 2014, and the City has been actively engaged with DOE throughout its development. More information is available online at https://buildings.energy.gov/BEDES.

The Energy Data Accelerator is a program launched through the U.S. Department of Energy's Better Buildings Initiative which aims for 20% energy savings across commercial and industrial sectors and to catalyze significant energy efficiency improvements. The data accelerator works with city-utility pairs to demonstrate low-cost, standardized approaches for providing energy data for the purpose of whole building energy performance benchmarking. New York City and National Grid joined as partners in 2013 both as leaders that have already achieved whole building energy data access and as educators to share lessons learned and best practices.

Water Reporting

As of March 2014, the City Department of Environmental Protection (DEP) has installed Automated Meter Reading (AMR) devices for over 96 percent of City properties and is in the process of replacing over 26,000 large water meters. The AMR installation project is substantially complete. As LL84 states, DEP is required to use Portfolio Manager web services to import customer water use data for covered buildings equipped with equipment for the entirety of the previous calendar year. As the installation completion approaches 100%, and DEP exchanges data for a growing number of building owners using Portfolio Manager web services, the water consumption data will be the most comprehensive of any municipality in the nation. There is also potential to be very influential as EPA continues to explore the possibility of a 1-100 water score. With thousands of property's auto uploaded water consumption data, it is anticipated that the New York City LL84 database will become increasingly useful in promoting water efficiency.

Data Quality

The quality and accuracy of benchmarking data has been a paramount concern every year of reporting, particularly for energy use reporting. After the upgrade of Portfolio Manager, a new verification function was introduced called, “the Data Quality Checker,” which inspects all entered information and identifies errors. The City continues to strongly encourage all users of Portfolio Manager to run this new function and correct any errors before submittal.

In partnership with the Natural Resource Defense Council (NRDC) and New Jersey Institute of Technology (NJIT), EPA is also supporting a benchmarking certification program currently in development with the Department of Energy and the National Institute of Building Sciences. This proposed certification program would consist of training modules in Portfolio Manager and respective benchmarking ordinances, and an exam which would issue a Certificate of Proficiency in the use of Portfolio Manager when successfully passed. This credential makes the service provider more marketable to building owners, who could feel more assured that the benchmarking of their building would be done thoroughly and accurately.

The City also supports additional staff and resources allocated to the compliance and enforcement side. Particularly with the annual growth in energy audit and retro-commissioning reports, there will be ample opportunity to cross-reference data points and explore new research opportunities.

Policy Impact

Implementation of the City's Greener, Greater Buildings Plan has provided an unprecedented level of information about our large buildings and created transparency around energy and water use in these buildings for the first time in New York City. With three years of benchmarking complete, the City has analyzed the largest set of privately owned building energy and water use data of any single jurisdiction in the U.S., and we now know much more about our buildings than was ever possible before. This benchmarking data has allowed us to identify major variations and trends in energy and water use that help point to the key opportunities for improving building performance, reducing utility costs for residents, and improving our environmental quality.

The benchmarking data has already allowed us to implement and track the progress of programs that are aimed at helping building owners increase the efficiency of their buildings and switch to cleaner fuels. Recognizing the importance of the multifamily sector, the City expanded the NYC Carbon Challenge to multifamily buildings in 2013 and is now using benchmarking data to track participants' progress toward their carbon reduction goals. Benchmarking data has also shown the progress of the universities and hospitals in the Challenge and has allowed the City to measure the impact of the NYC Clean Heat program, which has resulted in a significant reduction in heavy heating oil use.

Additional opportunities to use benchmarking data will certainly continue to arise in the coming years. One promising opportunity is the development of the New York City Energy Efficiency Corporation's Energy Savings Potential (ESP) Tool, which uses a building's benchmarking data to predict energy savings based on the building type and its fuel consumption. The ESP tool will provide loan originators with greater trust in a building's projected energy savings and has the potential to help standardize energy efficiency loan products, which will be necessary to bring them to scale. The City will continue to pursue additional opportunities to use the benchmarking data to help buildings improve their performance and invest in their energy and water efficiency.

In the coming years, the City will begin receiving even more information about its buildings. In 2013, the City received the first round of Local Law 87 energy audits and retro-commissioning reports, which provide a detailed assessment of the energy reduction opportunities in each building and require the building's energy-using systems to be tuned up to perform as originally intended. These reports will continue to be submitted on a rolling basis for large buildings over the next ten years. In addition, by 2025, implementation of Local Law 88 will require large commercial building owners to install sub-meters in non-residential tenant space, providing commercial tenants with greater control over their energy use and the ability to directly control associated costs.

These provisions are aimed at providing building owners and residents with the information that they need to make investments to reduce energy costs and improve building performance—but this information alone is not necessarily enough to motivate action to realize these benefits.[13] There are numerous barriers that will prevent decision-makers from making efficiency upgrades to buildings, including (but not limited to) a limited understanding of the benefits of energy and water efficiency, lack of awareness about financing and incentives available for capital costs, complexity of navigating the process of investing in efficiency upgrades, fragmented decision-making processes, and limited capacity for project management.

The City has a role to play to help decision-makers overcome these barriers and translate information into action. To guarantee that the information provided to building owners and residents deliver the greatest benefits, decision-makers can execute informed action with City assistance to interpret their energy audit results, understand the specific opportunities in their buildings, navigate the process of investing in efficiency, and identify the financing and incentive programs available to cover capital costs.

Next Steps in Data Analysis

Since the City first began requiring energy and water use benchmarking, resulting in the nation's largest dataset of energy and water consumption in buildings, the aggregated data has been of great interest to academic researchers. The City has partnered with multiple academic institutions and entered into data share agreements to encourage quantitative research into the factors that contribute to energy consumption. Through a deeper understanding of how energy is used across the City, policy makers and regulators can better refine the approaches to achieve energy efficiency goals.

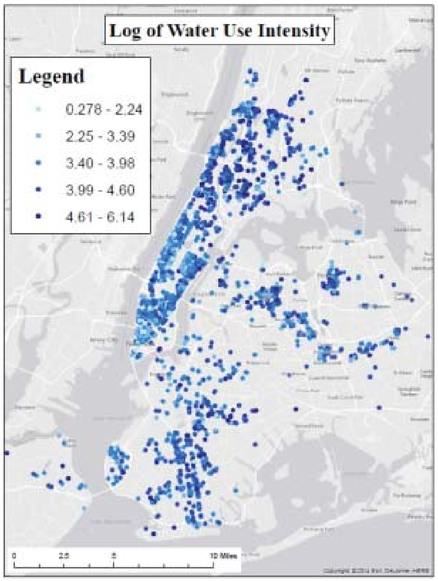
In the following pages, the NYU Center for Urban Science and Progress, the City's research partner in producing this report, has contributed brief descriptions of several research projects incorporating New York City Local Law 84 data, part of an ongoing body of research that investigates the intersection of benchmarking data and a wide range of datasets across land use, real estate, and socio-economic conditions across a wide range of cities.

As this body of research continues to proliferate among all of the City's academic partners, the City will continue to work with researchers to advance the collective knowledge derived from the benchmarking and disclosure ordinance and share the implications of this knowledge with the growing community of jurisdictions who have mandated similar laws in order to gain a more profound understanding of the solutions that will bring New York City towards a more energy efficient built environment.

The Determinants of Building Water Use: A Geographically Weighted Model of Asset, Occupant, and Neighborhood Socioeconomic Characteristics

Constantine E. Kontokosta and Rishee K. Jain

[Fig. A1] **Natural Log of Water Use Intensity, by Property**



Source: Kontokosta and Jain

For the first time in history, the majority of the world's population resides in cities[1]. This influx of people to urban centers has intensified the consumption – and strain – on key natural resources, including water. This increasing demand for water represents a daunting challenge for cities, with only 60% of global demand for potable water expected to be met in 2030[2]. Despite having substantial natural water resources, the United States is facing significant water shortages especially in the western states[3] and current water conservation projects are not expected to meet goals set by the United States Environmental Protection Agency (EPA)[4]. Additionally, taking into the account the impact of climate change effects a large part of the country is projected to be at high risk of not meeting water demand in 2050[5]. Buildings are increasingly becoming major contributors of water consumption in United States with residential and commercial buildings accounting for over 95% of all consumption growth from 1985 to 2005[6]. Increasing water efficiency of the built environment offers significant opportunities to reduce overall water usage and meet the conservation targets necessary to enhance the sustainability of our cities.

In this paper, we examine the determinants of water consumption in multi-family buildings located in New York City through analysis of data from over 2,000 large residential buildings. Using geographic weighted regression techniques (see Fig. A1), this study explores the influence of occupancy, building, and neighborhood socioeconomic indicators on water use and develops a preliminary measure of water performance. We aim to provide insight into the primary drivers of water consumption in multi-family buildings that can inform policy measures aimed at increasing water efficiency in buildings. In addition, this work provides the foundation for a water performance score to compare the relative water efficiency of similar (peer-group) buildings.

References

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(4) Lee, M.; Tansel, B.; Balbin, M. Goal based water conservation projections based on historical water use data and trends in Miami-Dade County. Sustain. *Cities Soc. 2011*, 1, 97–103.

(5) Roy, S. B.; Chen, L.; Girvetz, E. H.; Maurer, E. P.; Mills, W. B.; Grieb, T. M. Projecting water withdrawal and supply for future decades in the U.S. under climate change scenarios. Environ. Sci. Technol. 2012, 46, 2545–2556.

(6) U.S. Department of Energy. *Buildings Energy Data Book* http://buildingsdatabook.eren.doe.gov/.

Housing Affordability and Energy Cost Burdens: Are Poor Households Disproportionately Affected by Energy Inefficiency in Multifamily Buildings?

Constantine E. Kontokosta

While building energy consumption has significant implications for carbon emissions and climate change[1], households increasingly face financial burdens associated with utility expenses and the cost of energy. This challenge is most pronounced for low-income households, where the additional costs associated with energy-inefficient housing, coupled with existing housing cost burdens, can have significant implications for household financial stability. In New York City, almost 30% of renters face what is considered a severe housing cost burden, paying more than 50% of their household income on rent[2].

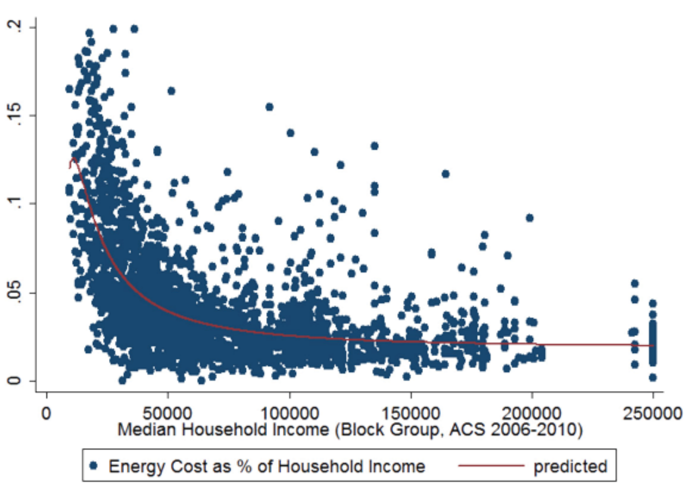
Using data from New York City's Local Law 84 database, integrated with data from New York City's PLUTO database and the U.S. Census, this paper analyzes the spatial, economic, and demographic patterns of energy efficiency and energy cost burdens in multifamily housing across New York City. It examines the financial impacts of energy costs on households (see Fig. A2) and outlines strategies to incentivize energy improvements in multifamily buildings. In particular, this study focuses on energy cost burdens of low-income households and the state of energy efficiency in subsidized housing, presenting the social and economic implications of achieving greater energy efficiency in affordable housing.

References

(1) UNEP. 2009. Buildings and Climate Change: Summary for Decision-Makers Paris: United Nations Environment Progamme.

(2) New York City Housing and Vacancy Survey Data, 2011.

[Fig. A2] **Energy Cost as a % of Household Income, by Property**



Source: C. Kontokosta

The Building Energy Visualization Tool – An Interactive Data Analysis Platform

Constantine E. Kontokosta and Huy T. Vo

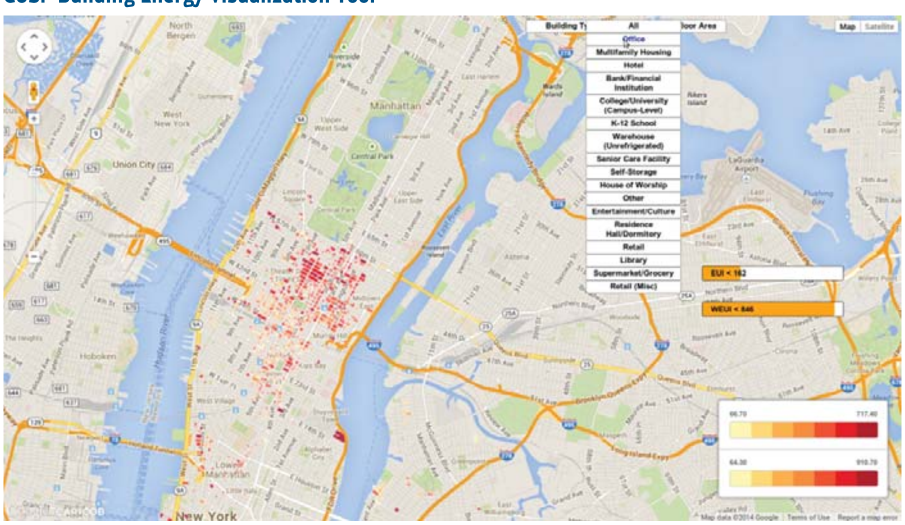
The value of building energy disclosure is predicated on the power of measurement and information to shift market behavior around resource consumption and thus generate greater demand for more efficient, or “green”, properties.[1] Much as with calorie labeling for ‘chain’ restaurants and fuel efficiency ratings in the automotive industry, data transparency can support behavior change and decision-making processes that incorporate previously unknown, or uncertain, information. However, for this information to be effectively used in this way, it must be communicated to, and understood by, those stakeholders that will ultimately use these newly-available data in their energy investment decisions.

We are developing the CUSP Building Energy Visualization Tool, a web-based, interactive platform to visualize and analyze building energy data. Beginning with data for New York City, combining energy use profiles with property-specific information from City records, the tool allows users to explore energy consumption patterns in New York City at the property, neighborhood, borough, and city scale. Users can select individual properties for in-depth statistics on property and energy characteristics, as well as generate queries to compare energy use in similar buildings and similar neighborhoods. It also provides an intuitive interface for visualizing aggregate energy profiles for user-selected groupings of buildings and property characteristics. A screenshot of a beta version of the tool is provided below in Figure A3.

References

(1) Kontokosta, Constantine E. 2013. Energy disclosure, market behavior, and the building data ecosystem. Annals of the New York Academy of Sciences, 1295(1), 34-43.

[Fig. A3] **Screenshot of beta version of the CUSP Building Energy Visualization Tool**



Source: NYU CUSP

A Market-Specific Methodology for a Commercial Building Energy Performance Index

Published in *The Journal of Real Estate Finance and Economics*

Constantine E. Kontokosta

The scaling of energy efficiency initiatives in the commercial building sector has been hampered by data limitations, information asymmetries, and benchmarking methodologies that do not adequately model patterns of energy consumption, nor provide accurate measures of relative energy performance. The reliance on simple metrics, such as Energy Use Intensity (EUI), fails to account for significant variation across occupancy, construction characteristics and other elements of a building – both its design and its users – that influence building energy consumption. Using a unique dataset of building energy consumption, physical, spatial, and occupancy characteristics – collected from New York City's Local Law 84 energy disclosure database, the Primary Land Use Tax Lot Output (PLUTO) database, and the CoStar Group – this paper analyzes energy consumption across commercial office buildings and presents a new methodology for a market-specific benchmarking model to measure relative energy performance across peer buildings. A robust predictive model is developed to normalize across multiple building characteristics and to provide the basis for a multivariate energy performance index. The paper concludes with recommendations for data collection standards, computational approaches for building energy disclosure data, and targeted policies using k-means clustering and market segmentation.

Big Data + Big Cities: Graph Signals of Urban Air Pollution

Published in *IEEE Signal Processing Magazine*

Rishee K. Jain, Jose Moura, and Constantine E. Kontokosta

Large amounts of data at a high degree of granularity (i.e., "big data") – such as energy and water usage, environmental emissions and human activity – are rapidly becoming available for cities around the world. Urban informatics – applying big data analytics to the urban challenges – offers an unprecedented opportunity to understand, analyze, and improve how our cities develop and operate. Processing unstructured and high-dimensional data from urban systems will require combining expertise from the fields of signal processing, graph theory, and data science with the application domains of civil engineering, environmental science, and urban planning, among others. In this paper, we consider unstructured data sets from the urban built environment and propose a methodology to represent them as a high-dimensional and geometrically structured graph signal. We illustrate the impact and merits of this approach by applying it to a pertinent sustainability and health issue in New York City – air pollution from the burning of heavy fuel oils in buildings.

We apply signal processing and data science methodologies to study the environmental impact of burning different types of heating oil in New York City. Currently, in New York City the burning of heavy fuel oil in buildings produces more annual black carbon, a key component of PM2.5, emissions, than all car and trucks combined. The data utilized in the paper are collected through New York City's Local Law 84 (LL84) energy disclosure mandate and represents actual heating oil consumption data for calendar year 2012. The LL84 dataset was merged with land use and geographic data at the tax lot level from the Primary Land Use Tax Lot Output (PLUTO) dataset from the New York City Department of City Planning. This study contributes to the literature in the emerging field of urban informatics and aims to catalyze future research on how urban data can be collected, processed, represented and analyzed to make cities more sustainable and resilient.


MetLife

Appendix A: Data Accuracy

Data Cleaning Methodology

The data set of properties that submitted by August 1, 2013 for energy and water use data in calendar year 2012 includes information for 14,144 properties–948 more entries than in the Year Three covered buildings list, due to duplicate submissions. In order to conduct analysis for this report, NYU developed a cleaning methodology to remove entries with missing information, errors, and outliers. The cleaning process resulted in 11,507 remaining properties that were used for the report.

CLEANING STEPS - TOTAL DATA SET	REMOVED	PROPERTIES REMAINING
Covered Buildings List	--	13,196
Original dataset based on submittals	--	14,144
(-) Zero square footage	84	14,060
(-) Missing or zero EUI	1,251	12,809
(-) Duplicates	719	12,090
(-) EUI below 5 or above 1,000 kBtu/sq ft	203	11,887
(-) Removal of top and bottom 1%	295	11,592
(-) Flagged data points	85	11,507

Initial steps included removal of missing information such as square footage and EUI, removal of duplicate entries, removal of extreme EUI counts, and careful parsing of EUI outliers. EUI ranges are relative to property types; for example, an EUI of 100 kBtu/sq ft may appear to be high within one sector while appearing low another sector. Thus outliers within the top and bottom one percent (99th and 1st percentiles, respectively), were identified with respect to each property type before being removed.

An unprecedented amount of water consumption data also required cleaning for data analysis. After taking the previously described steps, which focused on energy data, similar steps were taken for water data. Cleaning steps included removal of blank entries and zero water consumption, and outliers with respect to property type.

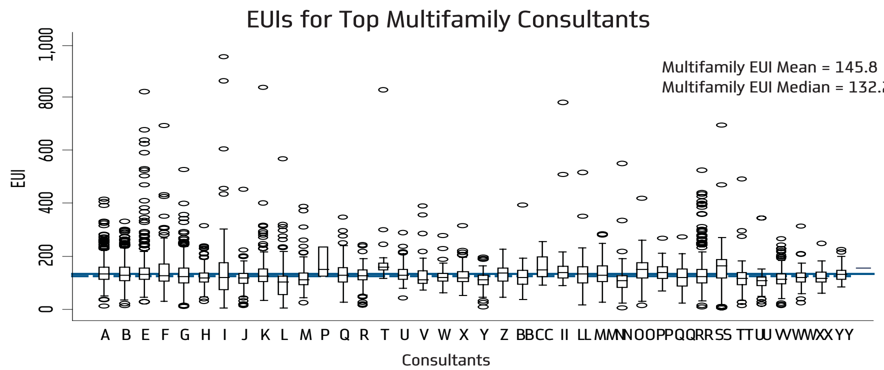
CLEANING STEPS - WATER	REMOVED	PROPERTIES REMAINING
Dataset after EUI cleaning	--	11,507
(-) Missing or zero water usage	6,467	5,040
(-) Removal of top and bottom 1% for each property type	144	4,896

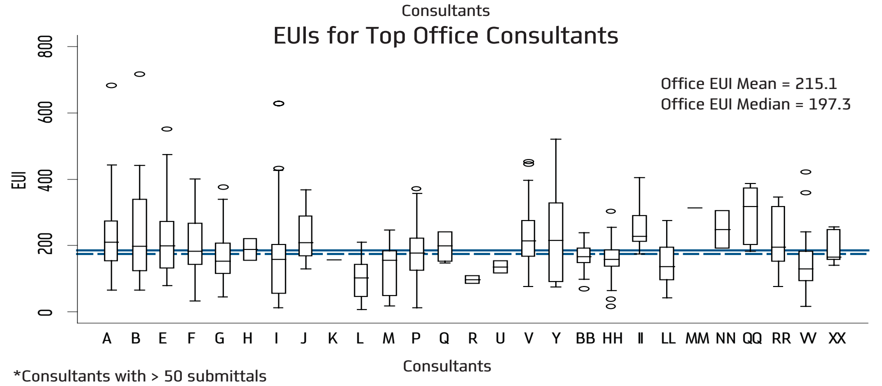
Service Provide Data Accuracy

As seen from Years One and Two, a majority of the reported data was submitted by a concentrated group of service providers. Due to the significant number of properties benchmarked by these firms, the Mayor's Office conducted analysis for data accuracy to interpret the accuracy of the overall data set as well as identify common errors that the service providers should avoid in order to improve the accuracy of their reporting.

Using the top 36 service provider firms that submitted data for more than 50 properties, the Mayor's Office compared the EUI distribution of each service provider's portfolio of benchmarked properties. Multifamily and office box-and-whisker charts compare the range of EUIs from the 25th to the 75th percentile (the top and bottom of each box), the median EUI value (the line in the middle of the each box), one and a half times the interquartile range (the two lines, or whiskers, extending outside of each box), and outliers (circles at ends of either whisker of each box). The horizontal solid and dashed lines across the graph indicate the overall group's mean and median, respectively.

Data Accuracy Issues





*Consultants with > 50 submittals

Source: New York University

Multiple Service Addresses. Buildings in New York City often have more than one service address. When utility information is tied to multiple service addresses, energy consumption data is disaggregated among the addresses, causing complications in the aggregated data request process with utilities. Therefore, property owners must identify all service addresses in order to obtain complete aggregated energy data.

Under-reporting of Gross Floor Area. Because the City's database does not include square footage information of subgrade spaces in buildings, the gross floor area figures in the covered buildings list does not accurately reflect total gross floor area. Property owners must provide any sub-grade or unaccounted gross floor area information in order to report accurate data.

Multiple Buildings on Multiple Lots that Share Systems (i.e. campus reporting). It is a common occurrence for New York City buildings to share base building systems, or building facilities when large buildings span across more than one tax lot. This building arrangement, however, is difficult to report in Portfolio Manager, thus requiring a pro-rating methodology, as specified in the rule for Local Law 84. Property owners must follow this methodology or risk reporting data that appear to be outliers, such as when shared energy usage and floor area is assigned to one building rather than divided across multiple buildings. Campus metrics are now available in Portfolio Manager custom retports and data reports, and future efforts will focus on improving the City's reporting methodology for campus properties.

Appendix B: Definitions

Entities:

DCAS – New York City Department of Citywide Administrative Services

DCP – New York City Department of City Planning

DEP – New York City Department of Environmental Protection

DOB – New York City Department of Buildings

DOF – New York City Department of Finance

EPA – United States Environmental Protection Agency

NYU CUSP – New York University Center for Urban Science and Progress

The City – The City of New York, city government

The Mayor's Office – New York City Mayor's Office of Long-Term Planning and Sustainability

Acronyms:

AMR – Automatic Meter Reading

BBL – borough, block, and lot number

BIN – building identification number

CBECS – Commercial Building Energy Consumption Survey

eGRID – New York City's EPA Emissions & Generation Resource Integrated Database

EUI – energy use intensity

GGBP – Greener, Greater Buildings Plan

GHG – greenhouse gas

kBtu – one thousand British thermal units

LL84 – Local Law 84: Benchmarking

LL85 – Local Law 85: New York City Energy Conservation Code

LL87 – Local Law 87: Audits & Retro-commissioning

LL88 – Local Law 88: Lighting & Sub-metering

mmBtu – one million British thermal units

NYCECC – New York City Energy Conservation Code

PLUTO – NYC Primary Land Use Tax Lot Output Database

RECS – Residential Energy Consumption Survey

sq ft – square feet

WUI – water use intensity

Appendix C: Endnotes

1. New York City's first complete year of data, or Year One, was 2010. According to the Department of Finance's (DOF) database of taxable properties and the Department of Citywide Administrative Services' (DCAS) database of City buildings, New York's citywide gross floor area is estimated to be 5.75 billion square feet. Proportionally, properties required to comply under the Greener, Greater Buildings Plan (GGBP) make up 2.58 billion sq ft, which is 45 percent, or nearly half of citywide gross floor area.
2. According to the Department of City Planning (DCP), a *lot* is a "parcel of land identified [by the City] with a unique borough, block, and lot number for property tax purposes." *Building* refers to a permanent "structure that has one or more floors and a roof…and is bounded by open areas or the lot lines of a zoning lot." There can be multiple buildings on a single lot. For the purposes of this report, the term *property* is also used and refers to one or more buildings on the same lot that are owned by a single owner. Most analysis is done on the basis of properties, unless otherwise noted. New York City Department of City Planning (2013). NYC Zoning - Glossary. Retrieved from http://www.nyc.gov/html/dcp/html/zone/glossary.shtml
3. City properties are benchmarked separately by DCAS Division of Energy Management (DEM), and the Department of Education (DOE). In 2012, Non-DOE properties and campuses benchmarked by DEM totaled 127.62 million sq ft. In 2012, schools and other DOE properties benchmarked by DOE totaled 154.19 million sq ft. This area includes CUNY senior colleges and HHC facilities, which the City is not responsible for benchmarking. Together, all City properties total 281.81 million sq ft.
4. ENERGY STAR is a measure of efficiency in the form of a 1-to-100 percentile ranking for specified building types, such as offices, hospitals, and retail, with 100 as the best score and 50 as the median. The ranking compares a building's energy performance against a nationally representative survey, the Commercial Buildings Energy Consumption Survey (CBECS), and independent industry surveys of buildings. The ENERGY STAR score is normalized for weather and building attributes.
5. Portfolio Manager calculates emissions with the carbon coefficient based on New York City's EPA Emissions & Generation Resource Integrated Database (eGRID) sub region, which includes Westchester. The coefficient used in EPA calculations differs slightly from the coefficient used in the annual *Inventory of New York City Greenhouse Gas Emissions*, which applies solely to New York City.
6. Site Energy Use Intensity (Site EUI) equals the amount of energy consumed on site (in kBTU, per year, per gross sq ft), in addition to the energy lost in the generation and transmission process. Site EUI in the report is weather-normalized, unless it is specified otherwise.
7. Source Energy Use Intensity (Source EUI) is the amount of energy needed to create all the energy consumed on the site, per square foot. For example, this accounts for energy lost due to the generation and transmission of electricity. All references to Source EUI in this report are weather-normalized unless otherwise noted.
8. Water use per square foot gives a measure of how efficiently a building uses water.

9. The compliance deadline for 2012 reporting under LL84 was May 1, 2013. Building owners who failed to comply by this deadline could clear their violations after paying the fine(s) triggered by failure to comply by May 1, 2013 and submitting their benchmarking data by August 1, 2013. This report is an analysis of all benchmarking data submitted by August 1, 2013.
10. Due to varying options for reporting lots with multiple buildings (e.g. benchmarking each building on the lot individually, benchmarking some buildings together while reporting others independently, benchmarking all buildings on the lot as a single building, etc.), the number of buildings will differ from the original covered buildings count.
11. Note that these histograms were created from properties that remained after final data cleaning, which removed EUIs below five and above 1000 kBtu/sq ft, in addition to two percent outliers at the tails. These histograms also exclude buildings with gross floor area larger than one million sq ft.
12. The ENERGY STAR score accounts for use characteristics and operational patterns to provide a comparative metric across multiple buildings, and therefore is an indicator of relative efficiency.
13. Kontokosta. 2013. “Energy Disclosure, Market Behavior, and the Building Data Ecosystem,” *Annals of the New York Academy of Sciences* 1295: 34-43.

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